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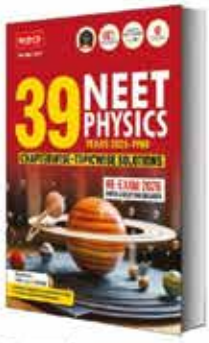
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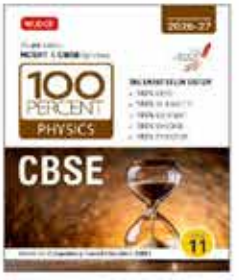














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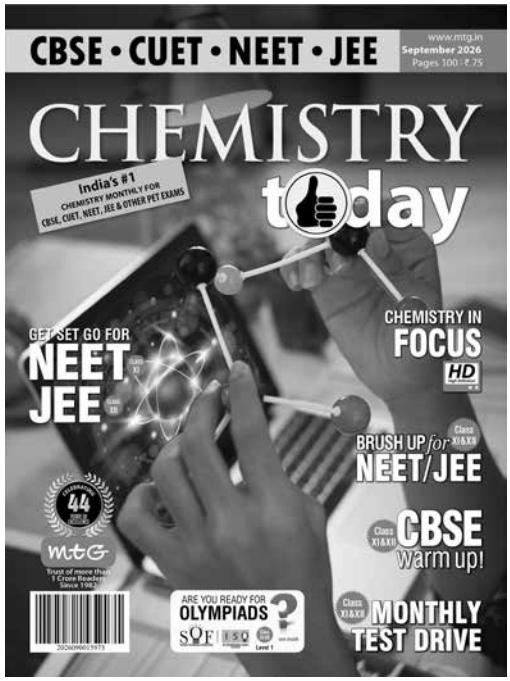
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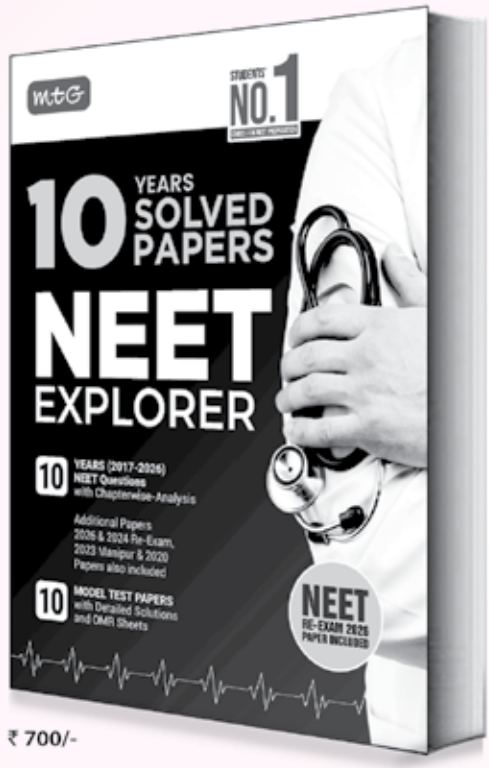
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Class XI

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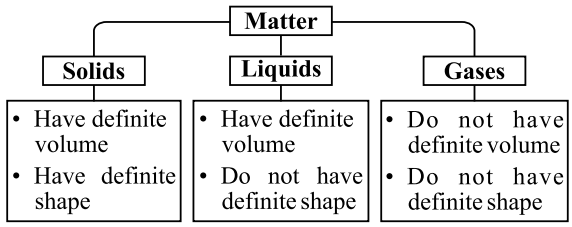
Unit 3 Some Basic Concepts of Chemistry | Structure of Atom

SOME BASIC CONCEPTS OF CHEMISTRY

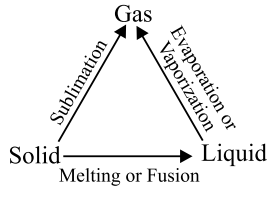
Introduction

- Chemistry deals with the composition, structure and properties of matter which can be described and understood in terms of basic constituents of matter *i.e.*, **atoms** and **molecules**.
- Anything which has mass and occupies space is called **matter**.

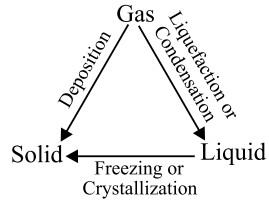
Physical Classification of Matter



- The three states of matter can be interconverted by changing the conditions of temperature and pressure as follows :

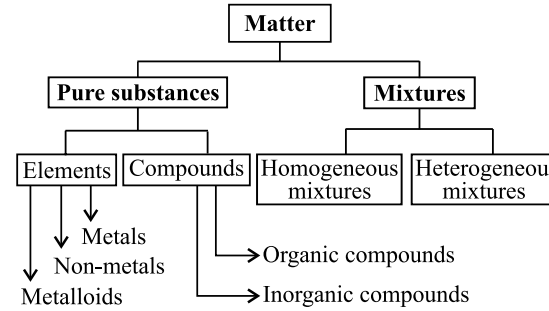


Endothermic state changes



Exothermic state changes

Chemical Classification of Matter



Units and Measurements

- The units of mass, length and time are called **fundamental units** since they are independent units and cannot be derived from any other units. They are also called **basic units**.
- The units for other quantities which can be derived from fundamental units are called **derived units**.
- The units adopted by the General Conference of Weights and Measures are known as **SI unit** or **systeme internationale**.

Physical quantity	Symbol for quantity	Name of unit	Symbol for unit
Length	*l*	metre	m
Mass	*m*	kilogram	kg
Time	*t*	second	s
Temperature	*T*	kelvin	K

Electric current	I	ampere	A
Luminous intensity	I_v	candela	cd
Amount of substance	n	mole	mol

Precision and Accuracy

Every experimental measurement has some amount of uncertainty associated with it. However, one would always like the results to be precise and accurate.

- **Precision :** It refers to the closeness of various measurements for the same quantity.
- **Accuracy :** It is the agreement of a particular value to the true value of the result.

Significant Figures

- Significant figures are meaningful digits which are known with certainty. The uncertainty is indicated by writing the certain digits and the last uncertain digit.

Determination of Significant Figures

All non-zero digits as well as zeros between the non-zero digits.	Significant figure
Zeros to the left of the first non-zero digit.	Non-significant figures
Zeros to the right of the decimal point.	Significant figures
Zeros to the right of the number but without decimal point.	May or may not be significant, write the number in scientific notation to get the correct number of significant figures.
Addition or Subtraction	Reported answer have the same number of decimal places as are present in the term with least number of decimal places.
Multiplication or Division	Reported answer have the same number of significant figures as present in the term with least number of significant figures.

Dimensional Analysis

- The expression of any particular quantity in terms of fundamental quantity is known as **dimensional analysis.**
- This can be done by method called **factor label method** or **unit factor method**.
- This is done by using conversion factor (C.F.), which is a factor equal to one that converts a quantity in one unit to the same quantity in another unit. Some conversion factors are as follows :

Common units of mass and weight :
1 mg = 10^{-3} g
1 metric tonne = 10^3 kg
1 lb = 453.6 g
1 kg = 1000 g = 2.205 pounds
1 gram = 6.022×10^{23} amu
1 amu = 1.66×10^{-24} g

Common units of length :
1 ft = 12 inch
1 yd = 3 ft
1 mile = 5280 ft, 1 m = 39.37 inch, 1 Å = 10^{-10} m,
1 inch = 2.54 cm
1 yard = 36 inches = 0.9144 metre
1 km = 1000 metres = 1094 yards = 0.6215 mile

Common units of volume :
1 quart = 0.9463 L
1 L = 1.056 quarts
1 m^3 = 10^3 L; 1L = 1 dm^3 = 1000 cm^3 = 0.001 m^3
1 cubic foot = 28.316 L = 29.92 quarts

Common units of pressure :
1 atm = 760 mm of Hg = 1.013×10^5 pascals
1 bar = 10^5 pascals
1 torr = 1 mm of Hg
1 Pascal = 1 kg/ms^2 = 1N/m^2

Laws of Chemical Combinations

Law of Conservation of Mass

- The law was first established by French chemist Lavoisier.
- This law states "In all chemical changes, the total mass of the system remains constant" or "In a chemical change, mass is neither created nor destroyed". This law was verified by Landolt.

Law of Definite Proportions or Constant Composition

- This law was proposed by Proust.
- This law states "elements always combine in fixed ratio of their weights" or "a pure chemical compound contains the same elements in the fixed proportion of their weights regardless the mode of preparation".
- **Example :** In CO_2, C and O combine in fixed 3 : 8 ratio of weight and in H_2O, H and O combine in 1 : 8 ratio by weight.

Law of Multiple Proportions

- This law was established by Dalton.
- It states "if two elements can combine to form two or more than two compounds, then the masses of one of the elements which combine with a fixed mass of the other, bear a simple whole number ratio".

Gay Lussac's Law of Gaseous Volumes

It states that when gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume provided all gases are at same temperature and pressure.

Avogadro's Law

Avogadro proposed that equal volumes of gases at the same temperature and pressure should contain equal number of molecules.

Dalton's Atomic Theory

- In 1808, Dalton published 'A New System of Chemical Philosophy' in which he proposed that
  - Matter consists of definite particles called atoms.
  - Atoms are indestructible.
  - All atoms of one particular element are identical.
  - Atoms of different elements have different masses.
  - When bound together in different ways, atoms form compounds in definite ratios by atoms (from which it follows that they must have definite proportions by mass).

Atomic and Molecular Masses

Atomic Mass

- Atomic mass of an element is a number which indicates as to how many times an atom of that element is heavier on an average, as compared with 1/12 of the mass of an atom of carbon-12 ($_6C^{12}$). Since the atomic mass is a ratio, it has no unit. However it is expressed in a.m.u. (atomic mass unit) or u (unified mass).
- **Atomic mass unit :** One atomic mass unit is defined as a mass exactly equal to one twelfth the mass of one carbon-12 atom.

$$1 \text{ a.m.u.} = \frac{1}{12} \times \text{mass of C - 12 atom}$$

$$= \frac{1}{12} \times \frac{12\text{ g}}{6.022 \times 10^{23}} = 1.66 \times 10^{-24}\text{ g}$$

At. mass of an element

$$= \frac{\text{Mass of one atom of the element}}{1 \text{ amu}}$$

- **Gram atomic mass :** It is the mass in gram of one mole of atoms in a monoatomic element. It is numerically equal to the atomic mass in amu.
No. of gram atoms or mole atoms

$$= \frac{\text{Mass of an element in g}}{\text{Gram atomic mass}}$$

- **Average atomic mass :** Average atomic mass of an element can be calculated as
Average atomic mass

$$= \frac{\text{R.A.}(1) \times \text{At. mass } (1) + \text{R.A. } (2) \times \text{At. mass } (2)}{\text{R.A. } (1) + \text{R.A. } (2)}$$

Here R.A. = Relative abundance

Molecular Mass

- The average mass of a molecule of a substance in atomic mass unit is called its molecular mass (M).
- **Relative molecular mass :** The relative molecular mass of a substance is the average relative mass of its molecule as compared with the mass of a ^{12}C atom taken as 12 units.

Equivalent Mass

i. For elements, Equivalent mass = $\frac{\text{Atomic mass}}{\text{Valency}}$

ii. For acids, Equivalent mass = $\frac{\text{Molecular mass}}{\text{Basicity of acid}}$

iii. For bases, Equivalent mass = $\frac{\text{Molecular mass}}{\text{Acidity of base}}$

iv. For salts, Equivalent mass

$$= \frac{\text{Formula mass}}{\text{Total positive or negative charge}}$$

v. For oxidising agents, Equivalent mass

$$= \frac{\text{Formula mass}}{\text{Number of electrons it gains}}$$

vi. For reducing agent, Equivalent mass

$$= \frac{\text{Formula mass}}{\text{Number of electrons it loses}}$$

Mole Concept

Mole may be defined as, the amount of the substance which contains same number of elementary units (atoms, molecules, ions) as the number of atoms present in 12 gram of carbon (C-12). Thus

1 mole = 6.022×10^{23} particles irrespective of their nature.

i.e., 1 mole of oxygen atom = 6.022×10^{23} atoms of oxygen

1 mole of hydrogen atom = 6.022×10^{23} atoms of hydrogen

1 mole of oxygen molecules = 6.022×10^{23} molecules of oxygen = $2 \times 6.022 \times 10^{23}$ atoms of oxygen

1 mole = Gram atomic mass of the element

1 mole = Gram molecular mass of the substance

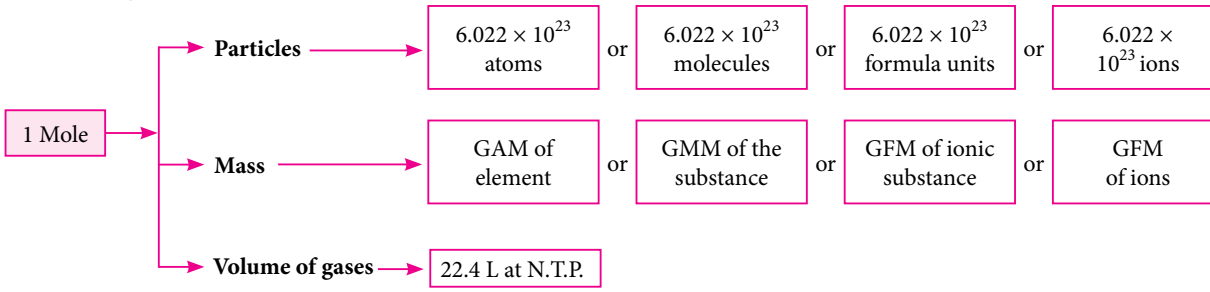
Molar volume : It is the volume occupied by one mole molecule of any substance. It is also called **gram molecular volume** (GMV). One mole molecule of all gases occupy 22.4 L at 273 K and 760 mm Hg pressure (NTP). Hence molar volume of all gases at NTP is 22.4 L.

Mole concept in ionic compounds

- One mole of an ionic compound represents 6.023×10^{23} formula units and weighs equal to its gram formula mass (GFM). For example

  1 mole of $CaCl_2$ = Formula mass of $CaCl_2$
  = 111 grams
  = 6.022×10^{23} $CaCl_2$ units
  = 6.022×10^{23} Ca^{2+} ion + $2 \times 6.022 \times 10^{23}$ Cl^- ions.

Summary of Mole Concept



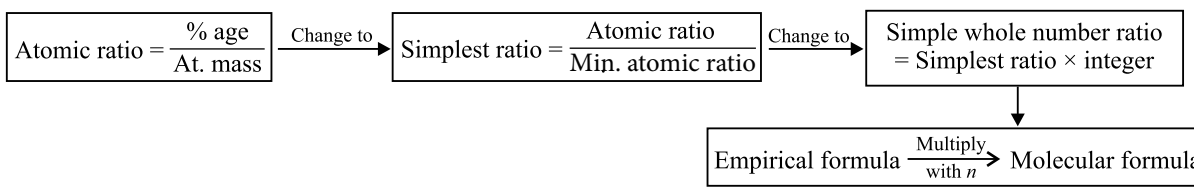
Percentage Composition

- Percentage composition of the element is the relative mass of each of the constituent element in 100 parts of it. It can be calculated if we know the molecular mass of compound.
- Suppose the molecular mass of a compound be M and X be the mass of an element in the molecule.

  % of element

$$= \frac{\text{Mass of the element}}{\text{Molecular mass of compound}} \times 100 = \frac{X}{M} \times 100$$

Empirical and Molecular Formulae



Stoichiometry and Stoichiometric Calculations

Stoichiometry

Calculations based on chemical equations are known as stoichiometric calculations.

Calculations Involving Mass-Mass Relationship

In general, the following steps are adopted in making necessary calculations :

(i) Write down balanced chemical equation of the chemical change.

(ii) Write down the number of moles below the formula of each of the reactants and products

(iii) Write down the relative masses of the reactants and products with the help of formula below the respective formula.

Limiting Reagent

The reagent that gives the least number of moles of the product is the limiting reagent. With the help of limiting reagent, the amount of the excess reagent which has been utilised and the amount remaining can be calculated.

Reactions in Solutions

The concentration of a solution or the amount of substances present in its given volume can be expressed by the following ways :

- Strength of solution $= \frac{\text{mass of solute in g}}{\text{volume of solution in L}}$
- Molarity, $M = \frac{w_B}{M_B \times V_{(mL)}} \times 1000$
- Molality, $m = \frac{w_B \times 1000}{M_B \times w_A (\text{in g})}$
- Normality $= \frac{w_B}{M_{(\text{equivalent})} \times V_{(\text{in mL})}} \times 1000$
- Normality $= \frac{\text{Molarity} \times \text{Molar mass}}{\text{Equivalent mass}}$
- Normality of an acid = Molarity × Basicity
- Normality of a base = Molarity × Acidity
- ppm $= \frac{w_B}{w_A + w_B} \times 10^6$
- Mole fraction of component A, $x_A = \frac{n_A}{n_A + n_B}$
- Mole fraction of component B, $x_B = \frac{n_B}{n_A + n_B}$

STRUCTURE OF ATOM

Introduction

The word atom is a Greek word meaning indivisible. According to Dalton's atomic theory, atom is the smallest indivisible part of matter which takes part in chemical reactions. In 1833, Michael Faraday showed that there is a relationship between matter and electricity. The discovery of electrons, protons and neutrons discarded the indivisible nature of atom proposed by John Dalton.

Characteristics of Sub-atomic particles (Electrons, Protons and Neutrons)

Properties	Electron Ernest	Proton	Neutron
Discoverer	J.J. Thomson (1897)	Rutherford (1919)	James Chadwick (1932)
Position	Moves around the nucleus	Constituent of nucleus	Constituent of nucleus
Symbol	e or e^-	p	n
Approximate relative mass	1/1836	1	1
Approximate relative charge	–1	+1	0

Mass (in kg)	9.109×10^{-31}	1.672×10^{-27}	1.674×10^{-27}
Mass (in amu)	0.00054	1.00727	1.00867
Actual charge	-1.602×10^{-19}	$+1.602 \times 10^{-19}$	0

Atomic Models

Thomson Model of Atom
J.J. Thomson proposed that, positive charge is spread over a sphere of radius $\approx 10^{-8}$ cm and electrons are embedded in it. This model explains the electrical neutrality of atom but not the other observations like spectra and α-scattering experiment.

Rutherford's Model of Atom
Rutherford proposed that, the nucleus of atom is hard dense core and consists of protons while electrons revolve around the nucleus. It could not explain the line spectra of elements.

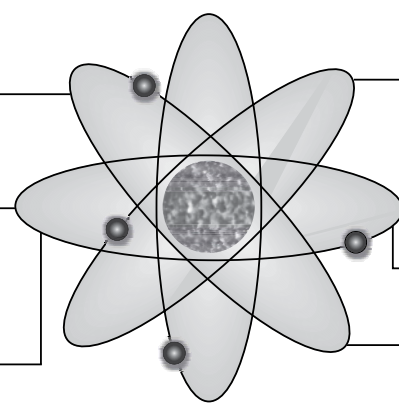
Atomic Models

Bohr's Model of Atom
- Atom consists of a small, heavy and positively charged nucleus in centre, and electrons revolve around the nucleus in fixed paths called orbits.
- The electron can revolve only in those orbits whose angular momentum is an integral multiple of $h/2\pi$ *i.e.*,
  $mvr = \frac{nh}{2\pi}$, $n = 1, 2, 3, ...$
- Energy of an electron in the orbit does not change with time.
- When electron jumps from one level to another, energy is either emitted or absorbed.
  - The energy difference between two states is given by $\Delta E = E_2 - E_1$
  - As the distance of the orbits increases from the nucleus, the energy gap goes on decreasing, *i.e.*,
    $E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > .....$

Drawbacks of Bohr's Model
- Fails to explain electronic repulsions in multielectronic atoms.
- Does not support to the assumption,
  $mvr = \frac{nh}{2\pi}$
- Does not explain Stark effect and Zeeman effect.
- Does not explain the distribution of electrons in orbits.
- Against de-Broglie and Heisenberg's uncertainty principles.

Some Important Terms

Isotopes have same atomic number (Z) but different mass numbers (A).
e.g.; $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$; $^{235}_{92}U$, $^{238}_{92}U$.



Isobars have same mass numbers (A) but different atomic numbers (Z).
e.g.; $^{228}_{88}Ra$, $^{228}_{89}Ac$, $^{228}_{90}Th$.

Isoelectronic species have same number of electrons, *e.g.*, N^{3-}, O^{2-}, F^{-}, Ne, Na^{+} and Mg^{2+}, all have 10 electrons.

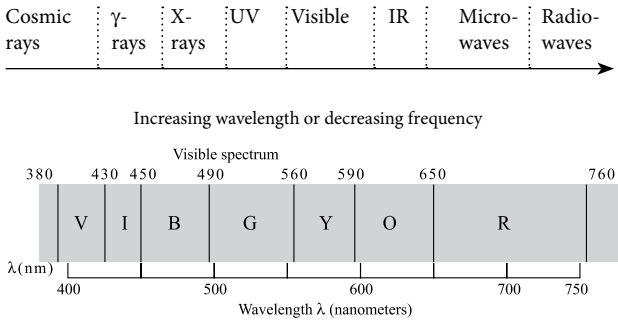
Isotones have different mass numbers (A) as well as different atomic numbers (Z) but have same number of neutrons.
e.g.; $^{39}_{18}Ar$, $^{40}_{19}K$.

Isosters have same number of atoms and electrons, *e.g.*, CO_2, N_2O.

Isodiaphers have same isotopic number.
Isotopic excess mass ($n-p$) = same.
e.g.; $^{235}_{92}U$, $^{231}_{90}Th$.

Electromagnetic Spectrum

- It is the arrangement of components of different types of electromagnetic radiations in increasing order of wavelength or decreasing order of frequency.



Characteristic Properties of Electromagnetic Waves

(i) Wavelength (λ): It is distance between two consecutive crests or troughs. It is expressed in centimetres (cm), nanometres (nm) or angstrom (Å).

1 nm = 10^{-9} m = 10^{-7} cm; 1 Å = 10^{-10} m = 10^{-8} cm

(ii) Frequency (υ): It is the number of waves passing through a given point in one second. It is expressed as cycles per second or hertz (Hz).

1 Hz = 1 cps

Frequency is inversely proportional to wavelength of the wave *i.e.*, $\upsilon \propto \frac{1}{\lambda}$ or $\boxed{\upsilon = \frac{c}{\lambda}}$

where, c is velocity of the wave.

(iii) Velocity (c) : It is defined as the distance travelled by a wave in one second.

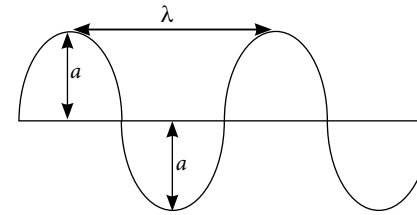
$\boxed{c = \upsilon\lambda}$

Electromagnetic radiations travel with velocity of light *i.e.* $c = 3 \times 10^8$ m/s.

(iv) Wave Number ($\bar{\upsilon}$): It is the number of waves present in one cm length. *i.e.*, $\bar{\upsilon} = \frac{1}{\lambda}$

As we know, $\upsilon = \frac{c}{\lambda}$. Thus, $\boxed{\bar{\upsilon} = \frac{\upsilon}{c}}$

(v) Amplitude (a): It is defined as the height of crest or depth of trough. It gives the intensity or brightness of the beam of light.



Planck's Quantum Theory

- A body can emit or absorb energy not continuously but discontinuously in the form of small packets of energy called **quanta**. A quantum of light is called a **photon**. It explains photoelectric effect and black body radiations.
- The energy of each quantum is directly proportional to the frequency of the radiation, *i.e.*, $E \propto \upsilon$ or $E = h\upsilon$; where h is a proportionality constant, called **Planck's constant**. $h = 6.626 \times 10^{-34}$ joule sec.
- The total amount of energy emitted or absorbed by a body will be some whole number quanta. Hence, $E = nh\upsilon$, where n is any integer.
- The energy possessed by one mole of quanta (or photons), *i.e.*, Avogadro's number (N_0) of quanta is called **one Einstein** of energy. *i.e.*,

  1 Einstein of energy $(E) = N_0 h\upsilon = N_0 h\frac{c}{\lambda}$

Photoelectric Effect

- No. of electrons ejected ∝ Intensity of incident radiations
- Photons having energy equal to or greater than threshold energy can only eject electrons
- *K.E.* of electrons ∝ Frequency of incident radiations
- Photoelectric effect can be mathematically expressed on the basis of quantum theory as :

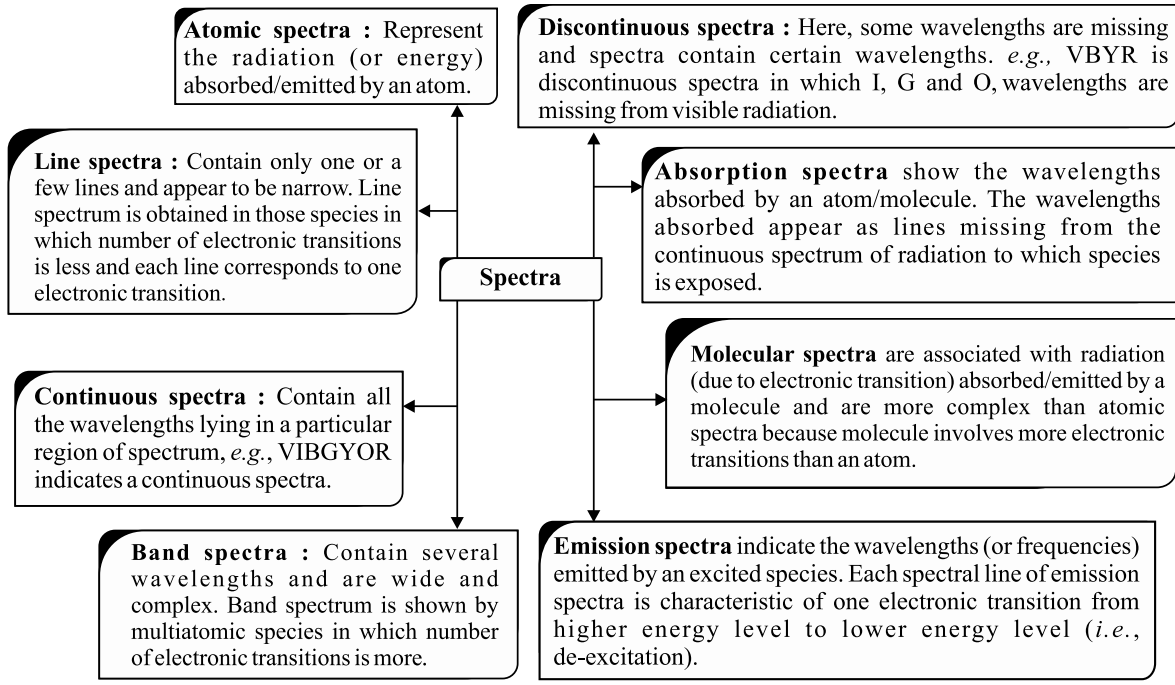
  $\frac{1}{2}mv^2 = h(\upsilon - \upsilon_0)$

  where, $\frac{1}{2}mv^2$ = kinetic energy of ejected electrons

  υ = frequency of incident light

  υ_0 = threshold frequency

Types of Spectra



Spectral Lines for Atomic Hydrogen

Series	n_1	n_2	Spectral Region
Lyman	1	2, 3...	Ultraviolet
Balmer	2	3, 4...	Visible
Paschen	3	4, 5...	Infrared
Brackett	4	5, 6...	Infrared
Pfund	5	6, 7...	Infrared
Humphrey	6	7, 8...	Far Infrared

Rydberg formula

$$\Delta E = R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) = 2.18\times10^{-18}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) \text{J}$$

Where R_H = Rydberg constant = 2.18×10^{-18} J/atom

$$\nu = \frac{\Delta E}{h} = \frac{R_H}{h}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) = 3.29\times10^{15}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) \text{ Hz}$$

and in terms of wave number (υ)

$$\bar{\upsilon} = \frac{\upsilon}{c} = \frac{R_H}{hc}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) = \frac{3.29\times10^{15}}{3\times10^{8}}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

$$= 1.09677 \times 10^{7}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right) \text{ m}^{-1}$$

For hydrogen and hydrogen like particles,

$$\frac{1}{\lambda} = \bar{\upsilon} = R_H\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]Z^2$$

where, $R_H = 109677 \text{ cm}^{-1}$ and Z is the atomic number.

- In case of absorption spectrum, $n_2 > n_1$ and ΔE is positive therefore, energy is absorbed.
- In case of emission spectrum, $n_1 > n_2$ and ΔE is negative therefore, energy is released.

Towards Quantum Mechanical Model of the Atom

Dual Behaviour of Matter

- In 1924, de Broglie proposed that an electron, like light, behaves both as a material and as a wave. This proposal gave birth to wave mechanical theory which states that electrons, protons and even atoms when in motion possess wave properties.
- The de Broglie wavelength of a particle is given by

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

where, h = Planck's constant, m = mass of particle, v = velocity, p = momentum

- Let kinetic energy of the particle of mass 'm' is E.

$$E = \frac{1}{2}mv^2 \;\; ; \;\; \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$$

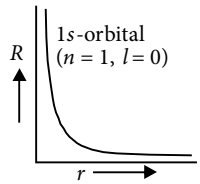
Heisenberg's Uncertainty Principle

It implies that it is impossible to know simultaneously the position and velocity (or momentum) of a microscopic moving particle like electron, proton, etc.

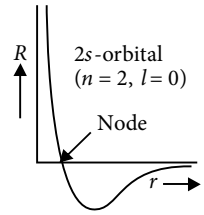
$$\Delta x \cdot \Delta v \geq \frac{h}{4\pi m}$$

where, Δx is the uncertainty in the position and Δv is uncertainty in the velocity.

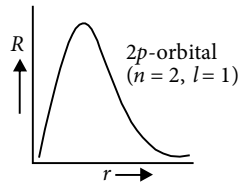
- **Plots of $R_{n,\,l}$ vs r :**



(a) 1s-orbital

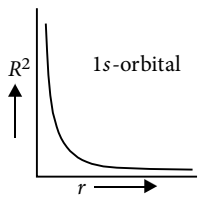


(b) 2s-orbital

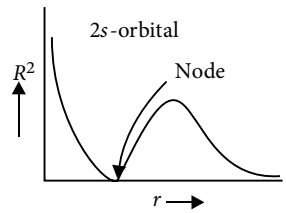


(c) 2p-orbital

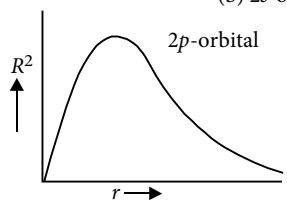
- **Plots of $R^2_{n,\,l}$ vs r :**



(a) 1s-orbital



(b) 2s-orbital



(c) 2p-orbital

Nodes of Different Orbitals

- For a hydrogen atom of principal quantum number n, there are :

(i) $(n - l - 1)$ radial nodes,
(ii) l angular nodes,
(iii) $(n - 1)$ total nodes.

Quantum Number

- A set of four numbers which gives complete information about an electron in an atom.
  - **Principal Quantum Number (n) :** It shows the size and energy of orbital. For single electron atom, $E \propto n$. For multielectron atom $E \propto (n + l)$
  - **Azimuthal Quantum Number (l) :** It shows the shape of orbital. If l = 0, 1 or 2, the orbital is s, p or d.

$$\mu = \sqrt{l(l+1)}\,\frac{h}{2\pi}$$

  - **Magnetic Quantum Number (m) :** It shows orientation of orbital and varies from $-l$ to $+l$ including zero.
  - **Spin Quantum Number (s) :** It shows spinning of electrons and have value $+\frac{1}{2}$ or $-\frac{1}{2}$

Rules for Filling of Orbitals

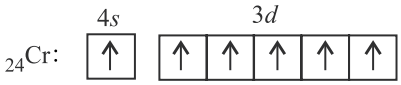
- **Aufbau Principle :** According to this rule, "orbitals are filled in the increasing order of their energies starting with the orbital of lowest energy".
- Energy of various orbitals are compared with $(n + l)$ rule.
- The orbital having lower value of $(n + l)$, has lower energy.
  $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < ...$
- If two orbitals have same $(n + l)$ value, the orbital having lower value of n will have the lower energy.
- **Pauli's Exclusion Principle :** The principle states that, "no two electrons in an atom can have same set of four quantum numbers".
- **Hund's Rule :** According to this rule, "pairing of electrons in an orbital cannot take place until each orbital of the given subshell is occupied by a single electron with parallel spin".

Electronic Configuration

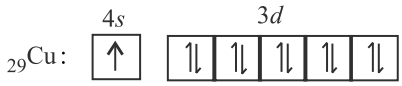
- Electronic configuration is the method of listing the locations of all the electrons on a specific atom. The system locates each electron by energy level and orbital type. The number of electrons in each orbital type is indicated with a superscript. For instance, the electronic configuration of sodium is $1s^2 2s^2 2p^6 3s^1$.

Stability of Completely-filled and Half-filled Configuration

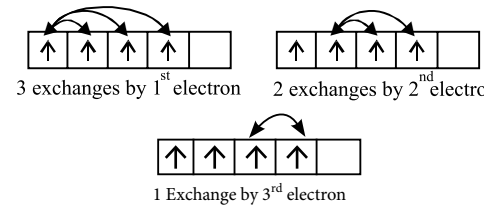
- Elements with atomic number 24(Cr) and 42(Mo) have $ns^1(n-1)d^5$ configuration and not $ns^2(n-1)d^4$, due to extra stability of half-filled orbitals.



- Elements with atomic number ^{29}Cu, ^{47}Ag and ^{79}Au have $ns^1(n-1)d^{10}$ configuration and not $ns^2(n-1)d^9$ due to extra stability of fully-filled orbitals.



- This is because of
  - **Symmetry :** The half-filled and completely filled configurations are more symmetrical and symmetry leads to greater stability.
  - **Exchange energy :** The electrons present in the different orbitals of the same subshell can exchange their positions. Each such exchange results in release of energy (called exchange energy), which leads to a greater stability.



Total number of exchanges = 3 + 2 + 1 = 6

WRAP it up!

MULTIPLE CHOICE QUESTIONS

1. When alpha particles are sent through a thin metal foil most of them go straight through the foil because
(a) alpha particles are much heavier than electron
(b) alpha particles are positively charged
(c) alpha particles move with high velocity
(d) most part of the atom is empty.

2. Match the list-I with list-II and select the correct answer using the codes given below in the list. (n, l and m are respectively the principal, azimuthal and magnetic quantum number)

List-I		List-II	
P.	Number of value of l for an energy level (n)	1.	0, 1, 2, ... ($n-1$)
Q.	Value of l for a particular type of orbit	2.	$+l$ to $-l$ including zero
R.	Number of value of m for $l = 2$	3.	5
S.	Value of 'm' for a particular type of orbital	4.	n

	P	Q	R	S
(a)	4	1	2	3
(b)	4	1	3	2
(c)	1	4	2	3
(d)	1	4	3	2

3. Select the correct statements from the following:
A. Atoms of all elements are composed of two fundamental particles.
B. The mass of electron is 9.10939×10^{-31} kg.
C. All the isotopes of a given element show same chemical properties.
D. Protons and electrons are collectively known as nucleons.
E. Dalton's atomic theory, regarded the atom as an ultimate particle of matter.
Choose the correct answer from the options given below :
(a) A and E only (b) B, C and E only
(c) A, B and C only (d) C, D and E only

4. The energy required to break one mole of hydrogen-hydrogen bonds in H_2 is 436 kJ. What is the longest wavelength of light required to break a single hydrogen-hydrogen bond?
(a) 68.5 nm (b) 137 nm
(c) 274 nm (d) 548 nm

5. According to Bohr's theory, which of the following correctly represents the variation of energy and radius of an electron in n^{th} orbit of H-atom?
(a) $E_n \propto \frac{1}{n^2}, r \propto \frac{1}{n^2}$ (b) $E_n \propto \frac{1}{n^2}, r \propto n^2$
(c) $E_n \propto n^2, r \propto n^2$ (d) $E_n \propto n, r \propto \frac{1}{n}$

6. 1 L of N_2 combines with 3 L of H_2 to form 2 L of NH_3 under the same conditions. This illustrates the
(a) law of constant composition
(b) law of multiple proportions
(c) law of conservation of mass
(d) Gay Lussac's law of gaseous volumes.

7. 0.30 g of an organic compound containing C, H and O on combustion yields 0.44 g CO_2 and 0.18 g H_2O. If one mol of compound weighs 60, then molecular formula of the compound is
(a) C_3H_8O (b) $C_2H_4O_2$
(c) CH_2O (d) C_4H_6O

8. The right option for the mass of CO_2 produced by heating 20 g of 20% pure limestone is (Atomic mass of Ca = 40)
$[CaCO_3 \xrightarrow{1200\ K} CaO + CO_2]$
(a) 2.64 g (b) 1.32 g
(c) 1.12 g (d) 1.76 g

9. Rearrange the following (I to IV) in the order of increasing masses.
I. 1 molecule of oxygen
II. 1 atom of nitrogen
III. 1×10^{-10} g molecular weight of oxygen
IV. 1×10^{-8} g atomic weight of copper
(a) II < I < III < IV (b) IV < III < II < I
(c) II < III < I < IV (d) III < IV < I < II

10. **Statement-I :** If 30 mL of H_2 and 20 mL of O_2 react to form water, 5 mL of H_2 is left at the end of the reaction.
Statement-II : H_2 is the limiting reagent.
(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

11. How much amount of $CuSO_4 \cdot 5H_2O$ is required for liberation of 2.54 g of I_2 when titrated with KI?
(a) 2.5 g (b) 4.99 g
(c) 2.4 g (d) 1.2 g

12. The third line of the Balmer series, in the emission spectrum of the hydrogen atom, is due to the transition from the
(a) fourth Bohr orbit to the first Bohr orbit
(b) fifth Bohr orbit to the second Bohr orbit
(c) sixth Bohr orbit to the third Bohr orbit
(d) seventh Bohr orbit to the third Bohr orbit.

13. In an experiment, 4 g of M_2O_x oxide was reduced to 2.8 g of the metal. If the atomic mass of the metal is 56 g mol^{-1}, the number of O atoms in the oxide is
(a) 1 (b) 2 (c) 3 (d) 4

14. **Statement-I :** de Broglie equation has significance for any microscopic or sub-microscopic particles.
Statement-II : de Broglie wavelength is inversely proportional to the mass of the object.
(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

15. SO_2Cl_2 on reaction with excess of water results into acidic mixture
$SO_2Cl_2 + 2H_2O \longrightarrow H_2SO_4 + 2HCl$
16 moles of NaOH is required for the complete neutralisation of the resultant acidic mixture. The number of moles of SO_2Cl_2 used is
(a) 16 (b) 8 (c) 4 (d) 2

16. A mixture of $CaCl_2$ and NaCl weighing 4.44 g is treated with sodium carbonate solution to precipitate all the calcium ions as calcium carbonate. The calcium carbonate so obtained is heated strongly to get 0.56 g of CaO. The percentage of NaCl in the mixture is
[Atomic mass of Ca = 40]
(a) 31.5 (b) 75
(c) 25 (d) 40.2

17. Which of the following correctly represents 180 g of water?
(i) 5 moles of water (ii) 10 moles of water
(iii) 6.022×10^{23} molecules of water
(iv) 6.022×10^{24} molecules of water
(a) (i) and (ii) (b) (i) and (iv)
(c) (ii) and (iv) (d) (ii) and (iii)

18. For Balmer series in the spectrum of atomic hydrogen, the wave number of each line is given by $\bar{\upsilon} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R_H is a constant and n_1 and n_2 are integers. Which of the following statement(s) is (are) correct?
1. As wavelength decreases, the lines in the series converge.
2. The integer n_1 is equal to 2.

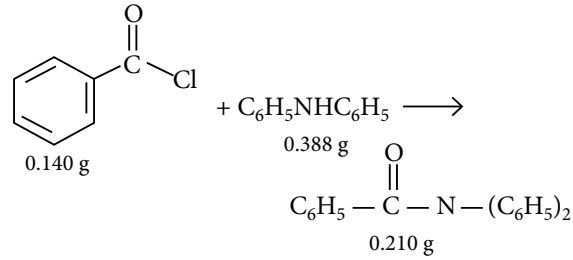
3. The ionization energy of hydrogen can be calculated from the wave number of these lines.
4. The line of longest wavelength corresponds to $n_2 = 3$.

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 2 and 4 (d) 2 only

19. The electrons identified by quantum numbers
(i) $n = 4, l = 1$ (ii) $n = 4, l = 0$
(iii) $n = 3, l = 2$ (iv) $n = 2, l = 1$
can be placed in order of increasing energy from the lowest to highest as
(a) (iv) < (ii) < (iii) < (i)
(b) (ii) < (iv) < (i) < (iii)
(c) (i) < (iii) < (ii) < (iv)
(d) (iii) < (i) < (iv) < (ii).

20. If the threshold frequency of a metal for photoelectric effect is υ_0, then which of the following will not happen?
(a) If frequency of the incident radiation is υ_0, then kinetic energy of the electrons ejected is zero.
(b) If frequency of incident radiation is υ, the kinetic energy of the electrons ejected will be $h\upsilon - h\upsilon_0$.
(c) If frequency is kept same at υ, but intensity is increased, the number of electrons ejected will increase.
(d) If frequency of incident radiation is further increased, the number of photoelectrons ejected will increase.

NUMERICAL VALUE TYPE QUESTIONS

21. 

Consider the above reaction. The percentage yield of amide product is _____. (Round off to the Nearest Integer)
(Given : Atomic mass : C : 12.0 u, H : 1.0 u, N : 14.0 u, O : 16.0 u, Cl : 35.5 u]

22. The mole fraction of glucose ($C_6H_{12}O_6$) in an aqueous binary solution is 0.1. The mass percentage of water in it, to the nearest integer, is _____.

23. The work function of sodium metal is 4.41×10^{-19} J. If photons of wavelength 300 nm are incident on the metal, the kinetic energy of the ejected electrons will be _____ $\times 10^{-21}$ J. ($h = 6.63 \times 10^{-34}$ J s; $c = 3 \times 10^8$ m/s)

24. If the uncertainty in velocity and position of a minute particle in space are, 2.4×10^{-26} (m s^{-1}) and 10^{-7} (m) respectively, the mass of the particle in g is _____. (Nearest integer)
(Given : $h = 6.626 \times 10^{-34}$ J s)

25. The number of correct statements from the following is _____ .
A. For 1*s* orbital, the probability density is maximum at the nucleus.
B. For 2*s* orbital, the probability density first increases to maximum and then decreases sharply to zero.
C. Boundary surface diagrams of the orbitals encloses a region of 100% probability of finding the electron.
D. *p* and *d*-orbitals have 1 and 2 angular nodes respectively.
E. Probability density of *p*-orbital is zero at the nucleus.

SOLUTIONS

1. (d) : Most of the part of atom is empty.

2. (b)

3. (b) : Atoms of all elements are composed of three fundamental particles : electrons, protons and neutrons.
Protons and neutrons are collectively known as nucleons.
Hence, B, C and E are correct statements.

4. (c) : Amount of energy required to break one H—H bond is

$$\frac{436\times10^3}{6.022\times10^{23}} = \frac{436}{6.022\times10^{20}}\ \text{J mol}^{-1}$$

Now, $E = \frac{hc}{\lambda}$

$$\therefore\ \lambda = \frac{6.626\times10^{-34}\times3\times10^8}{436}\times6.022\times10^{20}\ \text{m}$$

$$= \frac{6.626\times6.022\times3}{436}\times10^{-6} \simeq 274\ \text{nm}$$

5. (b) : According to Bohr's theory,

$$r = \frac{n^2h^2}{4\pi^2mZe^2k} \text{ and } E_n = \frac{-k^2 2\pi^2 mZ^2e^4}{n^2h^2}$$

6. (d)

7. (b): Percentage of $C = \frac{12}{44} \times \frac{0.44}{0.30} \times 100 = 40\%$

Percentage of $H = \frac{2}{18} \times \frac{0.18}{0.30} \times 100 = 6.6\%$

Percentage of O = 100 – (40 + 6.6) = 53.4%

Element	%	Molar ratio	Simplest ratio
C	40	$\frac{40}{12} = 3.3$	$\frac{3.3}{3.3} = 1$
H	6.6	$\frac{6.6}{1} = 6.6$	$\frac{6.6}{3.3} = 2$
O	53.4	$\frac{53.4}{16} = 3.3$	$\frac{3.3}{3.3} = 1$

Hence, empirical formula = CH_2O

$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}} = \frac{60}{30} = 2$

∴ Molecular formula of the compound
$= (CH_2O)_2 = C_2H_4O_2$

8. (d): $\underset{40+12+16\times3=100\text{ g}}{CaCO_3} \xrightarrow{1200\text{ K}} \underset{40+16=56\text{ g}}{CaO} + \underset{44\text{ g}}{CO_2}$

100 g $CaCO_3$ produced = 44 g CO_2 gas

20 g $CaCO_3$ will produce $\frac{44}{100} \times 20 = 8.8$ g CO_2 gas

If sample is 100% pure, CO_2 produced = 8.8 g
If sample is 20% pure, CO_2 produced

$= \frac{8.8}{100} \times 20 = 1.76$ g

9. (a): (I) Mass of 1 molecule of oxygen

$= \frac{32}{6.023 \times 10^{23}} = 5.31 \times 10^{-23}$ g

(II) Mass of 1 atom of nitrogen

$= \frac{14}{6.023 \times 10^{23}} = 2.32 \times 10^{-23}$ g

(III) Mass of 1 g molecule of oxygen = 32 g
∴ Mass of 10^{-10} gram molecule $= 32 \times 10^{-10}$
$= 3.2 \times 10^{-9}$ g

(IV) Mass of 10^{-8} g atom of copper $= 63 \times 10^{-8}$
$= 6.3 \times 10^{-7}$ g

Hence, increasing order of mass is II < I < III < IV.

10. (d): $\underset{30\text{ mL}}{H_2} + \underset{\substack{15\text{ mL}\\\text{reacted}}}{\frac{1}{2}O_2} \longrightarrow H_2O$

Volume of O_2 left = 20 – 15 = 5 mL

Statement-II is correct, since H_2 is completely consumed, and hence, H_2 is the limiting reagent.

11. (b): $2CuSO_4 \cdot 5H_2O + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + \underset{254\text{ g}}{I_2} + 10H_2O$

Molecular weight of $2CuSO_4 \cdot 5H_2O$
$= [2(63.5 + 32 + 64) + 10(18)]$ g = 499 g

254 g of I_2 is liberated by 499 g of $CuSO_4 \cdot 5H_2O$

2.54 g of I_2 will be liberated by $\frac{499}{254} \times 2.54 = 4.99$ g of $CuSO_4 \cdot 5H_2O$

12. (b): For Balmer series, $n_1 = 2$
For n^{th} line in any series, $n_2 = n_1 + n$
∴ For 3rd line in Balmer series, $n_2 = 2 + 3 = 5$

13. (c): $M_2O_x \xrightarrow{\text{Reduction}} M$

Eq. of M_2O_x = eq. of Metal

$\frac{\text{Wt. of } M_2O_x}{\text{Eq. wt. of } M_2O_x} = \frac{\text{Wt. of Metal}}{\text{Eq. wt. of Metal}}$

$\frac{4}{\frac{2\times56+x\times16}{2x}} = \frac{2.8}{\frac{56}{x}}$

On solving we get,

$\frac{4}{56+8x} = \frac{2.8}{56}$

$\frac{1}{14+2x} = \frac{1}{20}$

$2x = 6 \Rightarrow x = 3$

Hence, the oxide is M_2O_3.

14. (a): According to de Broglie equation,
λ (wavelength) = h/mv
Because of inverse relation of wavelength and mass, the wavelengths associated with ordinary objects (macroscopic objects) are so short (because of their large mass), that their wave properties cannot be detected.

15. (c): $\underset{x\text{ mole}}{SO_2Cl_2} + 2H_2O \rightarrow \underset{x\text{ mole}}{H_2SO_4} + \underset{2x\text{ mole}}{2HCl}$

(i) $\underset{x\text{ mole}}{H_2SO_4} + \underset{2x\text{ mole}}{2NaOH} \rightarrow Na_2SO_4 + 2H_2O$

(ii) $\underset{2x\text{ mole}}{HCl} + \underset{2x\text{ mole}}{NaOH} \rightarrow NaCl + H_2O$

Total number of moles of NaOH required = $4x = 16$
$\Rightarrow x = 4$.

16. (b): Given that all the calcium present in the mixture will convert into its carbonates and again on heating it gives its oxide CaO of weight 0.56 g.

$$\underbrace{\underset{y}{NaCl} + \underset{x}{CaCl_2}}_{4.44\text{ g}} \xrightarrow{Na_2CO_3} CaCO_3 \xrightarrow{\Delta} \underset{0.56\text{ g}}{CaO}$$

Moles of Ca in $CaCl_2$ = moles of Ca in $CaCO_3$

Moles of Ca in $CaCO_3$ = moles of Ca in CaO

$$\Rightarrow \frac{x}{111} = \frac{0.56}{56} \Rightarrow x = \frac{0.56}{56} \times 111 = 1.11 \text{ g}$$

[mol. wt. of $CaCl_2$ = 111, mol. wt. of CaO = 56]

We know that NaCl + $CaCl_2$ = 4.44 g

$y + 1.11 = 4.44 \Rightarrow y = 3.33$ g

$$\text{Percentage of NaCl} = 3.33 \times \frac{100}{4.44} = 75\%$$

17. (c) : 18 g of H_2O = 1 mol

180 g of H_2O = 10 mol

18 g of H_2O = 6.022×10^{23} molecules of H_2O

$$180 \text{ g of } H_2O = \frac{6.022 \times 10^{23}}{18} \times 180$$

$= 6.022 \times 10^{24}$ molecules of H_2O

18. (c) : (1) Beyond a certain wavelength the line spectrum becomes band spectrum.

(2) For Balmer series $n_1 = 2$

(4) The line of longest wavelength in this series, $n_2 = 3$.

19. (a) : (i) $n = 4, l = 1 \rightarrow 4p$

(ii) $n = 4, l = 0 \rightarrow 4s$ (iii) $n = 3, l = 2 \rightarrow 3d$

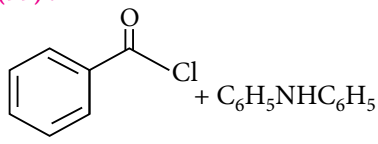
(iv) $n = 2, l = 1 \rightarrow 2p$

$2p < 4s < 3d < 4p$

(iv) < (ii) < (iii) < (i)

20. (d): Increase in intensity (and not frequency) increases the number of photoelectrons ejected.

21. (77) :



$+ C_6H_5NHC_6H_5$

0.140 g $= \frac{0.14}{140.5} = 10^{-3}$ mol

0.388 g $= \frac{0.388}{169} = 2.29 \times 10^{-3}$ mol

$\rightarrow C_6H_5-\underset{\underset{0.210\text{ g}}{}}{\overset{\overset{O}{\|}}{C}}-N(C_6H_5)(C_6H_5)$

Here, benzoyl chloride is limiting reagent.

140.5 g of benzoyl chloride gives 273 g of amide

$$0.140 \text{ g of benzoyl chloride gives } \frac{273}{140.5} \times 0.140 \text{ g}$$

= 0.272 g of amide

Theoretical yield = 0.272 g

Experimental yield = 0.210 g

$$\%\text{yield} = \frac{\text{Experimental yield}}{\text{Theoretical yield}} \times 100$$

$$= \frac{0.210}{0.273} \times 100 = 76.92 \approx 77\%$$

22. (47) : Given, mole fraction of glucose = 0.1

Let total moles of the solution = 1

Hence, mole fraction of water = 0.9

Mass percentage of water

$$= \frac{\text{Mass of water}}{\text{Mass of solution}} \times 100$$

$$= \frac{0.9 \times 18}{0.1 \times 180 + 0.9 \times 18} \times 100$$

$$= \frac{16.2}{18 + 16.2} \times 100 = 47.37\% \approx 47\%$$

23. (222) : Given : $w_0 = 4.41 \times 10^{-19}$ J,

$\lambda = 300$ nm, $K.E.$ = ?, $h = 6.63 \times 10^{-34}$ Js,

$c = 3 \times 10^8$ m s^{-1}

$w_0 = h\upsilon - K.E.$

$$4.41 \times 10^{-19} \text{ J} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}} - K.E.$$

$$4.41 \times 10^{-19} \text{ J} = \frac{19.89 \times 10^{-26}}{300 \times 10^{-9}} - K.E.$$

4.41×10^{-19} J = 6.63×10^{-19} J – $K.E.$

$K.E. = 6.63 \times 10^{-19} - 4.41 \times 10^{-19}$

$= 2.22 \times 10^{-19}$ J = 222×10^{-21} J

24. (22): Given, $\Delta v = 2.4 \times 10^{-26}$ m/s, $\Delta x = 10^{-7}$ m

According to Heisenberg's uncertainty principle,

$$\Delta x \times m\Delta v \geq \frac{h}{4\pi} \Rightarrow m \geq \frac{h}{4\pi \Delta v \Delta x}$$

$$\therefore \quad m \geq \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 2.4 \times 10^{-26} \times 10^{-7}}$$

$$m \geq 0.02198 \text{ kg} \quad \text{or} \quad m \approx 22 \text{ g}$$

25. (3) : Statements A, D and E are correct.

For 2*s* orbitals, the probability density first decreases sharply to zero and again starts increasing. Boundary surface diagram of the orbitals encloses a region or volume in which the probability of finding the electron is very high, say 90%, but not 100%. ◈◈

GET SET GO for NEET



with exclusive and brainstorming questions

Practicing these questions helps to strengthen your concepts and give you extra edge in your NEET preparation

1. An organic compound of molecular formula $C_6H_6Br_2$ has six carbon atoms in a ring system, two non-conjugate double bonds and two bromo groups at 1,4-positions. Then the compound is

(a) aromatic but non-homo-cyclic

(b) aromatic and hetero-cyclic

(c) homo-cyclic but not aromatic

(d) neither homo-cyclic not hetero-cyclic.

2. A list of species having the formula XZ_4 is given below. XeF_4, SF_4, SiF_4, BF_4^- and BrF_4^-

Defining shape on the basis of the location of X and Z atoms, the total number of species having a square planar shape is

(a) 0 (b) 4 (c) 2 (d) 3

3. A balanced equation for combustion of methane is given below:

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

Which of the following statements is not correct on the basis of the above chemical equation?

(a) One mole of CH_4 reacts with 2 moles of oxygen to give one mole of CO_2 and 2 moles of water.

(b) One molecule of CH_4 reacts with 2 molecules of oxygen to give one molecule of CO_2 and 2 molecules of water.

(c) 22.4 L of methane reacts with 44.8 L of oxygen to give 44.8 L of CO_2 and 22.4 L of water.

(d) 16 g of methane reacts with 64 g of O_2 to give 44 g of CO_2 and 36 g of water.

4. Which of the following is not a correct statement regarding the energies of orbitals?

(a) The lower the value of $(n + l)$ for an orbital, lower is its energy.

(b) Energies of the orbitals in the same subshell decreases with increase in atomic number.

(c) Energy of *s*-orbital is lower than the *p*-orbital and that of *p*-orbital is lower than the *d*-orbital.

(d) If two orbitals have same value for $(n + l)$, the orbital with higher value of n will have lower energy.

5. Match the column-I with column-II and select the appropriate option.

Column-I (Parameters)			Column-II (Description)	
	ΔH	ΔS		
(A)	–	+	(P)	Non-spontaneous at all temperatures
(B)	+	–	(Q)	Spontaneous at low temperature
(C)	–	–	(R)	Non-spontaneous at low temperature
(D)	+	+	(S)	Spontaneous at all temperatures

(a) (A) → P, (B) → Q, (C) → R, (D) → S
(b) (A) → S, (B) → R, (C) → Q, (D) → P
(c) (A) → S, (B) → P, (C) → R, (D) → Q
(d) (A) → S, (B) → P, (C) → Q, (D) → R

6. Consider the following reaction occurring in an automobile.

$2C_8H_{18(g)} + 25O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O_{(g)}$

The sign of ΔH, ΔS and ΔG would be

(a) +, –, + (b) –, +, – (c) –, +, + (d) +, +, –

7. What is the correct sequence, to complete the paragraph? According to Le Chatelier's, if pressure is increased,

(1) if pressure is decreased, the system will try to increase the pressure
(2) the system will try to reduce the pressure
(3) by favouring that reaction which is accompanied by a decrease in the number of moles
(4) by favouring that reaction which is accompanied by an increase in the number of moles.

(a) 2 3 1 4 (b) 1 2 3 4
(c) 1 4 3 2 (d) 1 3 2 4

8. For the change, $C_{diamond} \longrightarrow C_{graphite}$;

ΔH = –1.89 kJ, if 6 g of diamond and 6 g of graphite are separately burnt to yield CO_2, the heat liberated in first case is

(a) less than in the second case by 1.89 kJ
(b) less than in the second case by 11.34 kJ
(c) less than in the second case by 14.34 kJ
(d) more than in the second case by 0.945 kJ

9. If ν_0 is the threshold frequency of a metal X, the correct relation between de Broglie wavelength (λ) associated with photoelectron and frequency (ν) of the incident radiation is

(a) $\lambda \propto \frac{1}{\sqrt{\nu - \nu_0}}$ (b) $\lambda \propto \frac{1}{(\nu - \nu_0)^{1/4}}$

(c) $\lambda \propto \frac{1}{(\nu - \nu_0)^{3/4}}$ (d) $\lambda \propto \sqrt{\nu - \nu_0}$

10. Match the following:

Reaction		Nature of reaction	
A.	$RBr \xrightarrow{Na}$	i.	Partial reduction
B.	$RCOO^-Na^+ \xrightarrow[CaO, \Delta]{NaOH}$	ii.	Electrophilic addition
C.	$R-C\equiv C-R' \xrightarrow[(H_2)]{\text{Lindlar's catalyst}}$	iii.	Wurtz reaction
D.	$H_2C=CH_2 \xrightarrow{Br_2/CCl_4}$	iv.	Decarboxylation
		v.	Decarboxylation dimerization

(a) (A - iii), (B - v), (C - i), (D - ii)
(b) (A - iii), (B - iv), (C - i), (D - ii)
(c) (A - ii), (B - iii), (C - i), (D - ii)
(d) (A - v), (B - i), (C - iii), (D - ii)

11. The solubility of barium phosphate of molar mass 'M' g mol^{-1} in water is x g per 100 mL at 298 K. Its solubility product is $1.08 \times \left(\frac{x}{M}\right)^a \times (10)^b$. The value of a and b respectively are

(a) 7, 5 (b) 5, 7 (c) 5, 5 (d) 7, 7

12. The acidic, basic and amphoteric oxides, respectively, are

(a) Cl_2O, CaO, P_4O_{10}
(b) N_2O_3, Li_2O, Al_2O_3
(c) Na_2O, SO_3, Al_2O_3
(d) MgO, Cl_2O, Al_2O_3

13. The correct statements for the given reaction $xCu_3P + yCr_2O_7^{2-} + H^+ \longrightarrow Cu^{2+} + H_3PO_4 + Cr^{3+}$ are

I. Cu in Cu_3P is oxidised to Cu^{2+} and P in Cu_3P is also oxidised to PO_4^{3-}.
II. The value of y is 12.
III. Eleven electrons are involved in the conversion of Cu_3P to Cu^{2+} and H_3PO_4.

IV. The value of x is 6.

(a) I, III and IV (b) II and IV

(c) I, II, and III (d) I and II

14. **Statement-I :** If there is a covalent bond between two same atoms then the oxidation number of these two atoms will be zero.

Statement-II : The oxidation number of alkali metals is not fixed.

(a) Both statement-I and statement-II are correct.

(b) Statement-I is correct but statement-II is incorrect.

(c) Both statement-I and statement-II are incorrect.

(d) Statement-I is incorrect but statement-II is correct.

15. **Statement-I :** In Lassaigne's test, when both nitrogen and sulphur are present in an organic compound, sodium thiocyanate is formed.

Statement-II : If both nitrogen and sulphur are present in an organic compound, then the excess of sodium used in sodium fusion will decompose the sodium thiocyanate formed to give NaCN and Na_2S.

(a) Both statement-I and statement-II are correct.

(b) Statement-I is correct but statement-II is incorrect.

(c) Both statement-I and statement-II are incorrect.

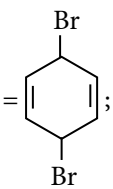
(d) Statement-I is incorrect but statement-II is correct.

SOLUTIONS

1. **(c) :** Organic compound such as $C_6H_6Br_2$ has 6 carbon in a ring, two non-conjugated double bond, two Br group at 1,4-position.

– 2 double bonds or 4π electrons *i.e.*, non-aromatic

– Ring is made up of only C-atom *i.e.*, homocyclic

Compound *i.e.*, = 

;

($C_6H_6Br_2$) - homocyclic and not aromatic.

2. **(c) :** XeF_4 – Square planar

SF_4 – See-saw, SiF_4 – Tetrahedral

BF_4^- – Tetrahedral, BrF_4^- – Square planar

3. **(c) :** 22.4 L of methane reacts with 44.8 L of oxygen to give 22.4 L of CO_2 and 44.8 L of water.

4. **(d) :** If two orbitals have same value for $(n + l)$, the orbital with lower value of n will have lower energy.

5. **(d)**

6. **(b) :** For combustion, ΔH = –ve. As $n_p > n_r$, ΔS = +ve.

$\Delta G = \Delta H - T\Delta S$ as ΔH = –ve and ΔS = +ve

Thus, ΔG = –ve at all temperature.

7. **(a)**

Chemistry bulletin

Skeletal Transformation to Chiral Nanocarbon Molecules

Three-dimensional nanocarbon molecules are crucial building blocks for advanced carbon materials. However, the dependence of current synthetic methods on stepwise bond-forming approaches limits the available chemical space in this field. Here, we demonstrate that a skeletal-transformation approach solves two challenges in nanocarbon synthesis. Firstly, the inner-bond cleavage of π-conjugated hydrocarbons provides access to a ten-membered ring that exclusively contains sp^2-hybridized carbons. The subsequent ring-expansion affords three gigantic decagon-containing chiral nanocarbon molecules with figure-eight or bathtub conformations consisting of up to 170 sp^2-hybridized carbons. Secondly, the subsequent reformation of an internal double bond in the structure is applicable to two of three obtained nanocarbon molecules, which enables the regio- and enantio-selective synthesis of a helically twisted nanographene containing up to 26 six-membered rings. The crystal-packing structure of this chiral nanographene is characterized by a homochiral porous framework consisting of π-stacked double-helical assemblies. These results demonstrate that the skeletal-transformation approach, which has so far targeted bioactive molecules, can be applied to nanocarbon synthesis.

8. **(d):** $C_{diamond} \longrightarrow C_{graphite}$; $\Delta H = -1.89$ kJ

$C_{diamond} + O_2 \longrightarrow CO_2$; $\Delta H = -q_1$

$C_{graphite} + O_2 \longrightarrow CO_2$; $\Delta H = -q_2$

$-\quad\quad -\quad\quad -\quad\quad +$

$C_{diamond} \longrightarrow C_{graphite}$; $\Delta H = -q_1 + q_2 = -1.89$

or $q_2 - q_1 = -1.89$ for 12 g $C_{diamond} \longrightarrow C_{graphite}$

Thus for 6 g $C_{diamond} \longrightarrow C_{graphite}$

$$q_2 - q_1 = \frac{-1.89}{2} = -0.945 \text{ kJ}$$

or $q_1 = q_2 + 0.945$ kJ

So the combustion enthalpy of diamond is more than the combustion enthalpy of graphite.

9. **(a):** Kinetic energy of electron can be given as $K.E. = h\nu - h\nu_0$

$$h(\nu - \nu_0) = \frac{1}{2}m\nu^2$$

$$m\nu^2 = 2h(\nu - \nu_0)$$

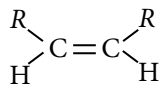
$$\nu = \sqrt{\frac{2h(\nu - \nu_0)}{m}}$$

According to de Broglie equation:

$$\lambda = \frac{h}{m\nu} = \frac{h}{m\left(\frac{2h(\nu-\nu_0)}{m}\right)^{\frac{1}{2}}} = \sqrt{\frac{h}{2m(\nu-\nu_0)}}$$

$$\lambda \propto \frac{1}{\sqrt{\nu - \nu_0}}$$

10. **(b):**

Reaction		Nature of reaction	
A.	$RBr \xrightarrow{Na} R-R + 2NaBr$	iii.	Wurtz reaction
B.	$RCOO^-Na^+ \xrightarrow[CaO,\,\Delta]{NaOH} R-H + Na_2CO_3$	iv.	Decarboxylation
C.	$R-C\equiv C-R' \xrightarrow[\text{catalyst } (H_2)]{\text{Lindlar's}}$ 	i.	Partial reduction
D.	$H_2C=CH_2 \xrightarrow{Br_2/CCl_4} CH_2(Br)-CH_2(Br)$	ii.	Electrophilic addition

11. **(b):** Given, solubility = x g/100 mL or $10x$ g/1 L

$$Ba_3(PO_4)_2 \rightleftharpoons \underset{S}{3Ba^{2+}} + \underset{S}{2PO_4^{3-}}$$

$$K_{sp} = (3S)^3(2S)^2 = 108S^5 \quad \ldots(1)$$

Now, Molar solubility $S = \frac{x \times 10}{M}$

Put the value of K_{sp} and S in equation (1)

$$1.08 \times \left(\frac{x}{M}\right)^a \times (10)^b = 108 \times \left(\frac{x}{M}\right)^5 \times (10)^5$$

Hence $\left(\frac{x}{M}\right)^a \times (10)^b = \left(\frac{x}{M}\right)^5 \times (10^7)$

$\therefore \; a = 5$

$b = 7$

12. **(b) :** Non-metal oxides are acidic *e.g.*, N_2O_3, alkali metals oxides are basic *e.g.*, Li_2O and Al_2O_3 are amphoteric oxide.

13. **(a) :** $4H_2O + \overset{+1\ -3}{Cu_3P} \longrightarrow 3Cu^{2+} + \overset{+5}{H_3PO_4} + 11e^- + 5H^+] \times 6$

$6e^- + 14H^+ + \overset{+6}{Cr_2O_7^{2-}} \longrightarrow 2Cr^{3+} + 7H_2O] \times 11$

$6Cu_3P + 124H^+ + 11Cr_2O_7^{2-} \longrightarrow 18Cu^{2+} + 6H_3PO_4 + 22Cr^{3+} + 53H_2O$

14. **(b):** The oxidation number of alkali metals is always +1.

15. **(a):** In case, nitrogen and sulphur both are present in an organic compound, they may combine during fusion to form sodium thiocyanate.

$$Na + C + N + S \xrightarrow{\Delta} \underset{\text{Sodium thiocyanate}}{NaSCN}$$

If Na is taken in excess, it decomposes NaSCN and forms Na_2S and NaCN.

$$2Na + NaSCN \xrightarrow{\Delta} Na_2S + NaCN$$



CBSE Warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exams as per the latest pattern and syllabus by CBSE for the academic session 2026-27.

Series-4 Chemical Bonding and Molecular Structure

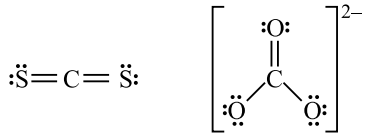
General Instructions : Read the following instructions carefully and follow them :

(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into five sections – Section A, B, C, D and E.
(iii) Section A – questions number 1 to 16 are multiple choice type questions. Each question carries 1 mark.
(iv) Section B – questions number 17 to 21 are very short answer type questions. Each question carries 2 marks.
(v) Section C – questions number 22 to 28 are short answer type questions. Each question carries 3 marks.
(vi) Section D – questions number 29 and 30 are case-based questions. Each question carries 4 marks.
(vii) Section E – questions number 31 to 33 are long answer type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the sections except section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is not allowed.

Time Allowed : 3 hours **Maximum Marks :** 70

SECTION-A

1. What is the formal charge on carbon atom in the following two structures?

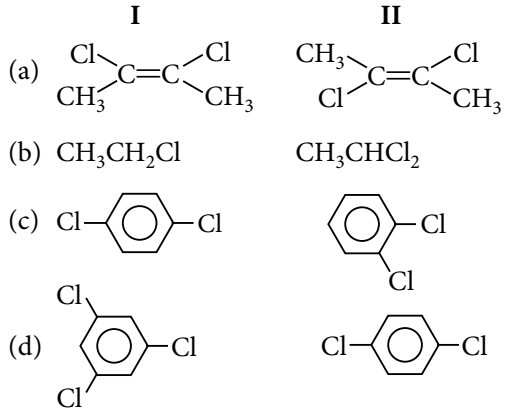


(a) 0, – 2 (b) 0, 0 (c) +2, – 2 (d) +1, – 1

2. Which of the following facts regarding bond order is not valid?

(a) Bond order is given by the number of covalent bonds between the two atoms in a molecule.
(b) With increase in bond order, bond enthalpy of the molecule decreases.
(c) Isoelectronic molecules and ions have identical bond orders.
(d) With increase in bond order, bond length decreases.

3. In which pair the permanent dipole in molecule I greater than that in molecule II?



4. According to VSEPR theory,

(a) the shape of the molecule depends only upon the bonded electron pairs
(b) pair of electrons attract each other in valence shells

(c) the pairs of electrons tend to occupy such positions that minimise repulsions
(d) the pairs of electrons tend to occupy such positions that minimise distances from each other.

5. Which of the following shows the Lewis dot structure for CO_2?

(a) :Ö::C::Ö: (b) :Ö:C::Ö:
(c) :Ö::C:Ö: (d) :Ö:C:Ö:

6. Arrange the following in order of increasing dipole moment : H_2O, H_2S, BF_3.

(a) $BF_3 < H_2S < H_2O$ (b) $H_2S < BF_3 < H_2O$
(c) $H_2O < H_2S < BF_3$ (d) $BF_3 < H_2O < H_2S$

7. Bond order of N_2^+, N_2^- and N_2 will be

(a) 2.5, 2.5 and 3 respectively
(b) 2, 2.5 and 3 respectively
(c) 3, 2.5 and 3 respectively
(d) 2.5, 2.5 and 2.5 respectively.

8. Match the column-I with column-II and mark the appropriate choice.

Column-I		Column-II	
(A)	C_2H_2	(i)	sp^3d^2 hybridisation
(B)	SF_6	(ii)	sp^3d^3 hybridisation
(C)	SO_2	(iii)	sp hybridisation
(D)	IF_7	(iv)	sp^2 hybridisation

(a) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(b) (A) → (iii), (B) → (i), (C) → (iv), (D) → (ii)
(c) (A) → (ii), (B) → (iii), (C) → (i), (D) → (iv)
(d) (A) → (iv), (B) → (i), (C) → (iii), (D) → (ii)

9. Which of the following molecules shows intramolecular hydrogen bonding?

(a) *o*-Nitrophenol (b) *p*-Nitrophenol
(c) Benzoic acid (d) Ethanol

10. Which of the following statement is not correct from the molecular orbital theory?

(a) Be_2 is not a stable molecule.
(b) He_2 is not stable but He_2^+ is expected to exist.
(c) Bond strength of N_2 is maximum amongst the homonuclear diatomic molecules belonging to the second period.
(d) The order of energies of molecular orbitals in N_2 molecule is, $\sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$

11. Which of the following order is correct?

(a) $AlCl_3 < MgCl_2 < NaCl$: Polarising power
(b) $CO > CO_2 > > HCO_2^- > CO_3^{2-}$: Bond length
(c) $BeCl_2 < NF_3 < NH_3$: Dipole moment
(d) $H_2S > NH_3 > SiH_4 > BF_3$: Bond angle

12. Few examples of the compounds formed by chemical bonding are given below. Mark the incorrect example.

(a) A molecule with central atom devoid of octet – BF_3
(b) A molecule with linear shape – CO_2
(c) A non-polar covalent compound between two different atoms – CH_4
(d) A molecule which is V-shaped with a bond angle 104.5° – NH_3

For question number 13 to 16, two statements are given- one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(c) Assertion (A) is true, but Reason (R) is false.
(d) Assertion (A) is false, but Reason (R) is true.

13. **Assertion (A) :** In NH_3, N is sp^3 hybridised, but bond angle is found to be 107°.
Reason (R) : The decrease in bond angle is due to repulsion between the lone pair on nitrogen and bond pair between N and H.

14. **Assertion (A) :** PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.
Reason (R) : P in PCl_5 is sp^3d^2 hybridised whereas I in IF_5 is sp^3d hybridised.

15. **Assertion (A) :** In the bonding molecular orbital (MO) of H_2, electron density is increased between the nuclei.
Reason (R) : The bonding MO is $\psi_A + \psi_B$, which shows destructive interference of the combining electron waves.

16. **Assertion (A) :** He_2 molecule is unstable and does not exist.
Reason (R) : Bond order for He_2 molecule is 0.5.

SECTION-B

17. **(a)** Write two factors responsible for formation of ionic bond.

(b) Which has higher dipole moment CCl_4 or CH_3Cl?

18. Explain why CO_2 molecules have zero dipole moment although C—O bonds are polar?

19. What is the formal charge on various atoms in nitrite ion?

20. Given electronic configuration for four elements as (I) $1s^2$, (II) $1s^2 2s^2 2p^2$, (III) $1s^2 2s^2 2p^5$, and (IV) $1s^2 2s^2 2p^6$. Select the one species which is capable of forming ionic as well as covalent bonds?

21. **(A)** How is lattice energy related with stability of an ionic compound?

OR

(B) Using VSEPR, draw the molecular structures of OSF_4 and XeF_4 indicating the position of lone pairs and hybridization of central atoms.

SECTION-C

22. Give the Lewis representation of

(a) sulphuric acid

(b) nitrogen dioxide

(c) ozone molecule.

23. The dipole moment of KCl is 3.336×10^{-29} coulomb metre which indicates that it is a highly polar molecule. The inter atomic distance between K^+ and Cl^- in this molecule is 2.6×10^{-10} m. Calculate the dipole moment of KCl molecule if there were opposite charges of one fundamental unit located at each nucleus. Calculate percentage ionic character of KCl.

24. **(a)** Discuss the shape of NF_3 according to VSEPR model.

(b) Using VSEPR theory, draw the shape of PCl_5 and BrF_5.

25. Draw the molecular orbital diagram for oxygen molecule (O_2) and write its electronic configuration also.

26. **(a)** How many σ- and π-bonds are present in the following molecules?

(i) *m*-xylene **(ii)** $HCONHCH_3$

(b) Give reason :

HF is polar though it has covalent bond.

27. Write important conditions essential for the linear combination of atomic orbitals.

28. **(A)** Arrange N_2, O_2, F_2, Cl_2 in increasing order of bond dissociation energy.

OR

(B) What are polar and non-polar molecules? BF_3 and NF_3 both are covalent, but BF_3 is non-polar while NF_3 is polar.

SECTION-D

The following questions are case based questions. Each question has an internal choice and carries 4(2 + 1 + 1) marks each . Read the passage carefully and answer the questions that follow :

29. The approximate shape of a molecule can often be predicted by using what is called the valence shell electron pair repulsion (VSEPR) model. Electron in bonds and in lone pairs can be thought as charge cloud that repel one another and stay as far apart as possible thus causing molecules to acquire specific shapes.

The repulsive interactions of electron pairs decrease in order :

Lone pair – Lone pair > Lone pair – Bond pair > Bond pair – Bond pair

These repulsion effect results in deviations from idealised shapes and alteration in bonds and molecules.

(a) How many bond pairs and lone pairs are present in ClF_3 molecule.

(b) Draw the shape of XeF_4 molecule using VSEPR theory.

(c) Predict the geometry of XeF_2 molecule.

OR

(c) What is the shape of $[SnCl_3]^-$ ion?

30. The electrons in an atom occupy atomic orbitals which are represented as the regions around the nuclei where there is a high probability of finding the electrons. Molecular orbital theory is based on the linear combination of atomic orbitals (LCAO) of the atoms constituting the molecule or ion and hence is also called LCAO-MO theory. In this theory, atomic orbitals of the combining atoms get mixed and rearrange themselves to form molecular orbitals. Two atomic orbitals can overlap to form two molecular orbitals – one of which lies at a lower energy level, called bonding molecular orbital

(BMO) than the other at a higher energy level, called antibonding molecular orbital (ABMO). The sequence of the rearrangement of molecular orbitals is determined by the two nuclei and the filling of electron in them follow the Aufbau principle. Each molecular orbital can hold one or two electrons in accordance with Pauli's exclusion principle. The bond order of a molecule or ion is half the number of bonding electrons minus the number of antibonding electrons. Molecular orbital theory can explain the bond length, bond dissociation energy, bond stability and paramagnetism/diamagnetism of molecules.

(a) Out of B_2, O_2 and N_2 which is/are diamagnetic?

(b) Explain why N_2 has greater bond dissociation energy than N_2^+?

OR

(b) What is the bond order of Li_2?

(c) N_2^+ is not a diamagnetic molecule. Why?

SECTION-E

31. (A) (a) Give reasons for the following **(any 2)**:

(i) BF_3 has a zero dipole moment although the B—F bonds are polar.

(ii) All carbon to oxygen bond lengths in CO_3^{2-} are equivalent.

(iii) Water molecule has a bent structure whereas $BeCl_2$ has a linear structure.

(b) Arrange the following bonds in order of increasing ionic character. Give reason also.
N — H, F — H, C — H, O — H

(c) Give two examples of ionic compounds.

OR

(B) Write the molecular orbital configuration of the following species :
O_2 , O_2^+, O_2^-, O_2^{2-}. Arrange them in order of their decreasing stabilities.

32. (A) (a) (i) What is the decreasing order of repulsion of various electron pairs?
lp–lp, bp–bp, lp–bp

(ii) BrF_3 is a T-shape molecule while NF_3 has a pyramidal shape. Explain.

(b) Why is it that in the SF_4 molecule, the lone pair of electrons occupies an equatorial position in the overall trigonal bipyramidal arrangement in preference to the axial position?

OR

(B) (a) What is the total number of sigma and pi-bonds in the following molecule?

(i) $CH_3-CH=CH-C\equiv CH$

(ii) $CH\equiv C-\overset{\overset{O}{\|}}{C}-CH_2COOH$

(b) Why is sigma bond stronger than π-bond? Explain.

33. (A) (a) Write Lewis structures for the following molecules/ions :

(i) Urea, NH_2CONH_2

(ii) Nitrogen trichloride, NCl_3

(iii) Tetrafluoroborate ion, BF_4^-

(iv) Carbonate ion, CO_3^{2-}

(v) Hydrogen peroxide, H_2O_2

OR

(B) Answer the following :

(a) Define bond order and bond enthalpy. What is their correlation?

(b) What are the important consequences of lattice enthalpy?

(c) Explain formation of NaCl with Lewis structure.

SOLUTIONS

1. (b) : $:\ddot{S}=C=\ddot{S}:$

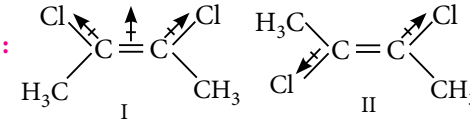
Formal charge on C atom = Valence electrons – Total number of lone pair of electrons – $\frac{1}{2}$ × Total number of bonding electrons

$= 4 - 0 - \frac{1}{2} \times 8 = 0$

Similarly, formal charge on C atom in other structure = 0

2. (b) : Higher the bond order, higher is the bond enthalpy.

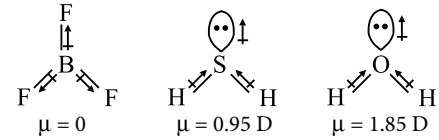
3. (a) :



The molecule I has higher dipole moment than II.

4. (c) **5. (a)**

6. (a) : In BF_3, dipole moment is zero due to its symmetrical structure.



In H_2S and H_2O due to unsymmetrical structure net +ve dipole is there. H_2O has higher dipole due to higher electronegativity of oxygen than sulphur.

7. (a) **8. (b)**

9. (a)

10. (d) : The correct order of energies of molecular orbitals in N_2 molecule is

$\sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < \pi^* 2p_x = \pi^* 2p_y < \sigma^* 2p_z$

11. (c) : (a) Polarising power of cations increases with the increasing charge.

$\underset{(+1)}{NaCl} < \underset{(+2)}{MgCl_2} < \underset{(+3)}{AlCl_3}$

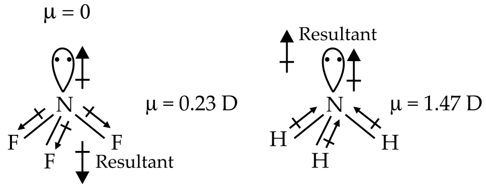
(b) Bond order $\propto \frac{1}{\text{Bond length}}$

Molecule/Ion	Bond order
CO	3
CO_2	2
HCO_2^-	1.5
CO_3^{2-}	1.33

Hence, the decreasing order of bond length is

$CO_3^{2-} > HCO_2^- > CO_2 > CO.$

(c) $\underset{\mu = 0}{Cl \leftrightarrow Be \leftrightarrow Cl}$,



Correct order of dipole moment : $BeCl_2 < NF_3 < NH_3$

(d) Correct order of bond angle :

$\underset{120°}{BF_3} > \underset{109°28'}{SiH_4} > \underset{107°}{NH_3} > \underset{92°}{H_2S}$

12. (d) : The correct example is H_2O. NH_3 is pyramidal and its bond angle is 107°.

13. (a) : Lone pair - lone pair repulsion > lone pair - bond pair repulsion > bond pair - bond pair repulsion. In NH_3, there are three bond pairs and one lone pair. The three N – H bond pairs are pushed closer because of the lone pair - bond pair repulsion, and HNH bond angle gets reduced from 109°28' (the tetrahedral angle) to 107°.

14. (c) : P in PCl_5 is sp^3d hybridised and I in IF_5 is sp^3d^2 hybridised.

15. (c) : Bonding molecular orbital involves constructive interference.

16. (c) : $He_2 : \sigma 1s^2\ \sigma^* 1s^2$

$$B.O. = \frac{1}{2}(2-2) = 0$$

Thus He_2 molecule is unstable and does not exist.

17. (a) Low ionisation energy and high electron affinity.

(b) CH_3Cl has higher dipole moment.

18. Carbon dioxide (CO_2) has a linear and symmetrical structure (O=C=O). Its net dipole moment is zero, as the moments of the two C—O bonds, having opposite directions, cancels each other.

19. The Lewis structure of nitrite ion is $\left[\overset{1}{\ddot{\underset{\cdot\cdot}{O}}} = \ddot{N} - \overset{2}{\ddot{\underset{\cdot\cdot}{O}}}:\right]^-$

Formal charge on nitrogen atom $= 5 - 2 - \frac{1}{2} \times 6 = 0$

Formal charge on O atom marked 1 $= 6 - 4 - \frac{1}{2} \times 4 = 0$

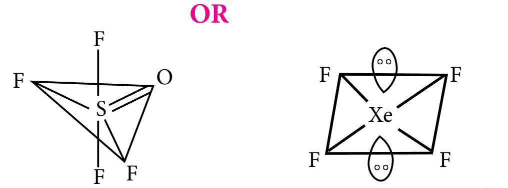
Formal charge on O atom marked 2 $= 6 - 6 - \frac{1}{2} \times 2 = -1$

20. Element (III) with electronic configuration $1s^2 2s^2 2p^5$ *i.e.*, fluorine can form bond either by accepting one electron or by sharing one electron. For example : Na – F is ionic but F – F is covalent.

21. (A) Stability of an ionic compounds depends directly on the magnitude of lattice energy. High negative value of lattice energy gives more stability to an ionic compound.

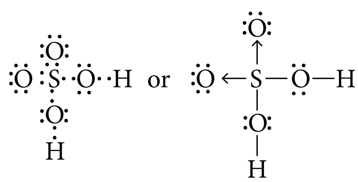
OR

(B)



Trigonal bipyramidal sp^3d Square planar shape sp^3d^2

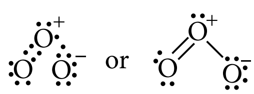
22. (a)



(b) NO_2 is an odd electron molecule.

$\ddot{O}=\dot{N}-\ddot{O}:$

(c)



23. For one unit charge, $q = 1.602 \times 10^{-19}$ C

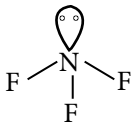
Dipole moment $\mu = q \times d$

$\therefore\ \mu = 1.602 \times 10^{-19} \times 2.6 \times 10^{-10}$

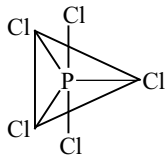
$= 4.1652 \times 10^{-29}$ coulomb meter

% ionic character $= \dfrac{\mu_{observed}}{\mu_{ionic}} \times 100$

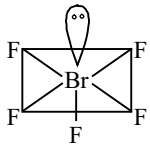
$= \dfrac{3.336 \times 10^{-29}}{4.1652 \times 10^{-29}} \times 100 = 80.09\,\%$

24. (a) 

Geometry : Tetrahedral
Shape : Trigonal pyramidal

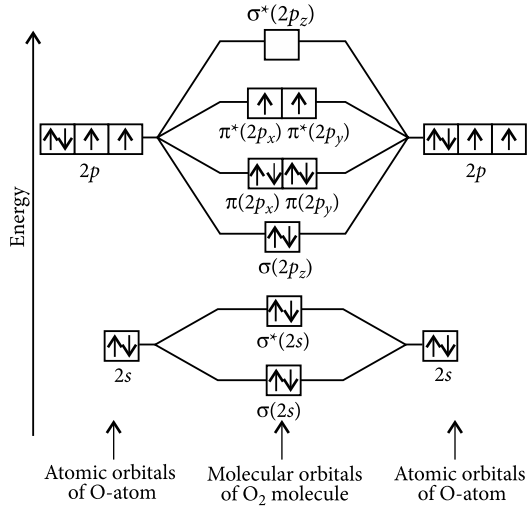
(b) 

Geometry : Trigonal bipyramidal

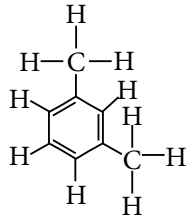


Geometry: Octahedral
Shape : Square pyramidal

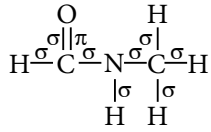
25.



$\sigma 1s^2 \sigma^* 2s^2\, \sigma 2s^2\, \sigma^* 2s^2\, \sigma 2p_z^2 (\pi 2p_x^2 = \pi 2p_y^2)\, (\pi^* 2p_x^1 = \pi^* 2p_y^1)$

26. (a) (i) 

σ-bonds = 18,
π-bonds = 3

(ii) 

σ-bonds = 8,
π-bonds = 1

(b) HF is a polar covalent compound due to greater difference in electronegativities of H and F.

27. Necessary conditions for linear combination of atomic orbitals :

(i) The symmetry and relative energies of combining atomic orbitals *A* and *B* must be close to each other.
(ii) The extent of overlap between the charge clouds of *A* and *B* should be large.
(iii) Atomic orbitals of the same sign should overlap.

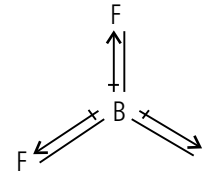
28. (A) Increasing order of bond dissociation energy :

$F_2 < Cl_2 < O_2 < N_2$

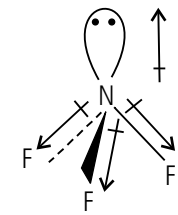
Oxygen having two pairs of unused electrons on each atom exert less repulsion than that of chlorine or fluorine each having three pairs of unused electrons. Nitrogen having only one pair of unused electrons exert minimum repulsion, hence it is the most stable.
Fluorine - fluorine bond energy is less than the Cl – Cl because of larger repulsion between the non-bonded electrons of the two smaller fluorine atoms.

OR

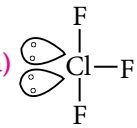
(B) The molecules having $\mu = 0$ are called non-polar molecules and molecules having $\mu > 0$ are called polar molecules. The resultant dipole moment in BF_3 is zero as BF_3 is a symmetrical molecule whereas, it is non-zero in NF_3 due to its pyramidal shape.



$\mu = 0$
BF_3

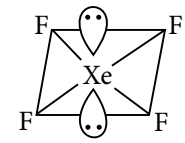


$\mu = 0.23$ D
NF_3

29. (a) 

ClF_3 has 3 bond pairs and 2 lone pairs of electrons.

(b) XeF_4 has square planar shape.



(Square planar)

(c) $XeF_2 \Rightarrow 2\ bp + 3\ lp$
$\Rightarrow$ Trigonal bipyramidal geometry

OR

(c) Shape of $[SnCl_3]^-$ is trigonal pyramidal.

30. (a) $B_2 = (KK)\, \sigma 2s^2\, \sigma^* 2s^2\, (\pi 2p_x^1 = \pi 2p_y^1)$
Two unpaired electrons $\Rightarrow$ Paramagnetic

$O_2 = (KK)\,\sigma2s^2\,\sigma^*2s^2\,\sigma2p_z^2\,(\pi2p_x^2 = \pi2p_y^2)(\pi^*2p_x^1 = \pi^*2p_y^1)$
Two unpaired electrons ⇒ Paramagnetic
$N_2 = (KK)\,\sigma2s^2\,\sigma^*2s^2\,(\pi2p_x^2 = \pi2p_y^2)\sigma2p_z^2$
No unpaired electrons ⇒ Diamagnetic

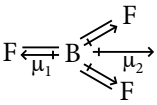
(b) The bond order of N_2 is 3 while that of N_2^+ is 2.5. Thus, the bond dissociation energy of N_2 is higher than that of N_2^+.

OR

(b) $Li_2 : \sigma1s^2\sigma^*1s^2\,\sigma2s^2$

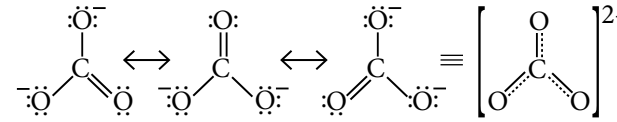
$$\text{Bond order} = \frac{1}{2}(N_b - N_a) = \frac{4-2}{2} = 1$$

(c) The electronic configuration of $N_2^+ = \sigma1s^2\sigma^*1s^2\,\sigma2s^2\,\sigma^*2s^2\,(\pi2px^2 = \pi2py^2)\,\sigma2pz^1$
As one unpaired electron is present in $\sigma2p_z$ molecular orbital, N_2^+ cannot be diamagnetic, it is paramagnetic in nature.

31. (A) (a) (i) In case of BF_3 molecule, 

μ_1 and μ_2 cancel each other, hence dipole moment becomes zero.

(ii) Due to resonance, all the C—O bond lengths are equivalent in carbonate ion (CO_3^{2-}) as shown :



(iii) Presence of two bond pairs and lack of lone pairs around the central Be atom give $BeCl_2$ a linear shape. While in H_2O, two lone pairs are also present along with two bond pairs around the central oxygen(O) atom so, the shape of the molecule is bent.

(b) Greater the difference in electronegativity of bonded atoms, more is the ionic character of covalent bond. Hence, the increasing order of ionic character is :

C — H < N — H < O — H < F — H

(c) NaCl and MgO are examples of ionic compounds.

OR

(B)

Species	Total electrons	Electronic Configuration	Bond order	Magnetic character
O_2	16	$KK\sigma2s^2\,\sigma^*2s^2\,\sigma2p_z^2\,\pi2p_x^2 = \pi2p_y^2\;\;\pi^*2p_x^1 = \pi^*2p_y^1$	$\frac{(8-4)}{2} = 2.0$	Paramagnetic
O_2^+	15	$KK\sigma2s^2\,\sigma^*2s^2\,\sigma2p_z^2\,\pi2p_x^2 = \pi2p_y^2\;\pi^*2p_x^1 = \pi^*2p_y^0$	$\frac{(8-3)}{2} = 2.5$	Paramagnetic
O_2^-	17	$KK\sigma2s^2\,\sigma^*2s^2\,\sigma2p_z^2\,\pi2p_x^2 = \pi2p_y^2\;\pi^*2p_x^2 = \pi^*2p_y^1$	$\frac{(8-5)}{2} = 1.5$	Paramagnetic
O_2^{2-}	18	$KK\sigma2s^2\,\sigma^*2s^2\,\sigma2p_z^2\,\pi2p_x^2 = \pi2p_y^2\;\pi^*2p_x^2 = \pi^*2p_y^2$	$\frac{(8-6)}{2} = 1.0$	Diamagnetic

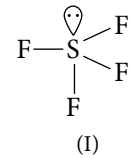
Therefore, relative order of stability is

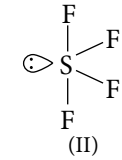
$O_2^+ > O_2 > O_2^- > O_2^{2-}$.

32. (A) (a) (i) The decreasing order of repulsion is :
lone pair-lone pair (*lp-lp*) > lone pair-bond pair (*lp-bp*) > bond pair-bond pair (*bp-bp*)

(ii) In BrF_3, Br is the central atom that have five electron pairs (three bond pairs and two lone pairs). It is a AX_3L_2 type molecule. It is sp^3d hybridised molecule, so it is T-shaped molecule. NF_3 is AX_3L type molecule and sp^3 hybridised so it has pyramidal shape.

(b) In SF_4, the central S atom has five electron pairs (four bond pairs and one lone pair) whose arrangement should be trigonal bipyramidal. However, one of the electron pairs is lone pair. SF_4 can, therefore, have structure (I) or structure (II).


(I)
l.p. in the axial position


(II)
l.p. in the equatorial position

In structure (I), there are three *lp*—*bp* repulsions at 90°. In structure (II), there are only two *lp*—*bp* repulsions at 90°. Hence, structure (II) is favoured one. The structure (II) is known as see-saw shape.

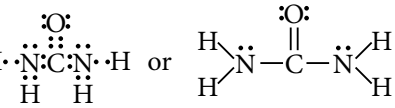
OR

(B) (a) (i) No. of σ - bonds = 10, No. of π - bonds = 3

(ii) No. of σ - bonds = 11, No. of π - bonds = 4

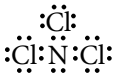
(b) The strength of a bond depends upon the extent of overlapping. Since formation of σ-bond involves overlapping along the internuclear axis, therefore there is considerable overlapping. Hence, the σ-bond forms a strong bond. On the other hand, in case of the formation of a π-bond, sideways overlapping takes place which is only to a small extent. Hence, π-bond form weak bond.

33. (A) (a) (i)

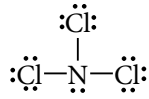


or

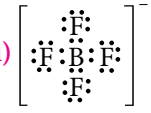
(ii)



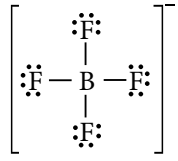
or



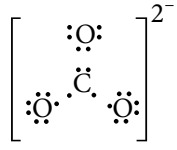
(iii)



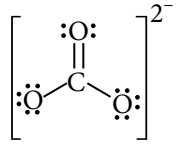
or



(iv)



or



(v)

or

OR

(B) (a) Bond order of a molecule or an ion is a measure of the strength or stability of the bond. Numerically, it is half of the difference between number of electrons in bonding (N_b) and in anti-bonding (N_a) molecular orbitals.

$$\text{Bond order} = \frac{1}{2}(N_b - N_a)$$

The amount of energy required to break one mole of bonds of a particular type and separate the bonded atoms in the gaseous state is called bond enthalpy or bond dissociation energy. Higher the bond order, higher is the bond dissociation enthalpy.

(b) The important consequences of lattice enthalpy are:

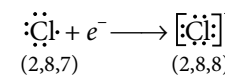
(i) Greater the lattice enthalpy, more the stability of ionic compound.

(ii) The lattice enthalpies affect the solubilities of ionic compounds.

(c) Sodium by losing one electron from its outermost shell, it acquires the inert gas configuration of neon and changes into sodium ion.

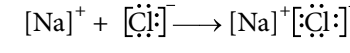
$$\underset{(2,8,1)}{Na} \longrightarrow \underset{(2,8)}{Na^+} + e^-$$

Chlorine accepts one electron released by sodium to complete its octet and acquire stable configuration of argon. In this process, chlorine is converted into chloride ion.



(2,8,7) (2,8,8)

As they approach each other, they are held together by strong electrostatic forces of attraction. Thus, formation of sodium chloride takes place.



Winners : *Rajesh, Arun*

SOLUTIONS TO AUGUST 2026 WORD GRID

A	C	L	P	W	Z	U	S	T	L	A	I	X	M	V
T	L	A	I	Y	G	K	L	N	P	Q	S	T	W	V
A	I	X	M	A	E	R	E	P	L	K	U	H	B	J
W	N	I	T	R	O	G	L	Y	C	E	R	I	N	L
T	L	A	I	X	T	J	K	L	A	M	U	G	R	Y
O	F	O	R	N	R	T	L	A	L	P	Q	S	T	W
Q	T	B	E	X	U	D	G	K	C	A	I	X	M	Z
W	U	O	N	I	Q	S	T	W	I	T	L	A	I	Y
R	R	Q	C	H	L	O	R	O	F	O	R	M	L	B
F	Y	M	U	I	R	E	T	U	E	D	T	R	E	W
T	L	A	I	C	R	U	S	T	R	P	Q	S	T	W
A	I	X	M	X	A	O	F	O	O	G	K	L	N	P
Q	T	B	L	Z	D	T	L	A	L	A	I	X	M	D
W	U	V	P	S	A	U	V	P	G	P	Q	S	T	W
R	I	X	I	D	S	O	F	O	R	T	L	A	I	Y
E	N	O	N	I	U	Q	O	L	L	Y	H	P	L	T
T	O	S	T	Q	A	C	L	U	D	G	K	L	N	P
O	P	A	E	W	N	C	Y	T	D	P	Q	S	T	W

1. Roentgen
2. Xray
3. Phylloquinone
4. Calciferol
5. Nitroglycerin
6. Nausadar
7. Chloroform
8. Deuterium

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CLASS XI

SYLLABUS*

Following the protocol of NEP (2020), NCF (2023), NCERT and CBSE guidelines, National and various State Boards for the convenience of schools and students, any change/reduction in the syllabi will be reflected in actual question papers.

Total Questions : 50 Time : 1 hr.

PATTERN & MARKING SCHEME			
Section	**(1) Physics & Chemistry**	**(2) Achievers Section**	**(3) Mathematics or Biology**
No. of Questions	**25**	**5**	**20**
Marks per Ques.	**1**	**3**	**1**

Section – 1 : *Physics* : Units and Measurements, Mechanics, Properties of Matter, Heat and Thermodynamics, Oscillations, Waves.

Chemistry : Some Basic Concepts of Chemistry, Structure of Atom, Classification of Elements and Periodicity in Properties, Chemical Bonding and Molecular Structure, Thermodynamics, Equilibrium, Redox Reactions, Organic Chemistry - Some Basic Principles and Techniques, Hydrocarbons.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section – 1.

Section – 3 : Sets, Relations and Functions, Logarithms, Complex Numbers & Quadratic Equations, Linear Inequalities, Sequences and Series, Trigonometry, Straight Lines, Conic Sections, Permutations and Combinations, Binomial Theorem, Statistics, Limits and Derivatives, Probability, Introduction to 3-D Geometry.

OR

Section – 3 : Diversity in the Living World, Structural Organisation in Plants and Animals, Cell : Structure and Functions, Plant Physiology, Human Physiology.

Practice Questions

1. Molecular shapes of SF_4, CF_4 and XeF_4 are

A. the same, with 2, 0 and 1 lone pairs of electrons respectively

B. the same, with 1, 1 and 2 lone pairs of electrons respectively

C. different, with 0, 1 and 2 lone pairs of electrons respectively

D. different, with 1, 0 and 2 lone pairs of electrons respectively.

2. The linear combination of atomic orbitals to form molecular orbitals takes place only when the combining atomic orbitals

I. have the same energy

II. have the minimum overlap

III. have same symmetry about the molecular axis

IV. have different symmetry about the molecular axis

Choose the most appropriate from the options given below :

A. I, II and III only

B. II, III and IV only

C. I and III only

D. II and IV only

3. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffered solution of HA in which 50% of the acid is ionized is

A. 7.0 B. 4.5 C. 2.5 D. 9.5

4. Read the following statements regarding spontaneity of a process and choose the correct statement

(i) When enthalpy factor is absent then randomness factor decides spontaneity of a process.

(ii) When randomness factor is absent then enthalpy factor decides spontaneity of a process.

(iii) When both the factors take place simultaneously, the magnitude of both the factors decide spontaneity of a process.

A. (i) and (ii) only B. (i) and (iii) only

C. (i), (ii) and (iii) D. (ii) and (iii) only.

5. Match column-I with column-II and select the correct option.

Column-I		Column-II	
(A)	Mass of $(NH_4)_2CO_3$ (M = 96 g mol^{-1}) which contains 0.4 mol NH_4^+	(p)	1.92 g

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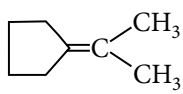
(B)	Mass of $(NH_4)_2CO_3$ which contains 6.02×10^{23} hydrogen atoms	(q)	19.2 g
(C)	Mass of $(NH_4)_2CO_3$ which will produce 3.0 mL of CO_2 when treated with hydrochloric acid.	(r)	12.0 g
(D)	Mass of $(NH_4)_2CO_3$ which is required to prepare 100 mL of 0.2 M $(NH_4)_2CO_3$ solution	(s)	288.0 g

A. (A) – (p), (B) – (q), (C) – (r), (D) – (s)
B. (A) – (s), (B) – (r), (C) – (q), (D) – (p)
C. (A) – (r), (B) – (q), (C) – (p), (D) – (s)
D. (A) – (q), (B) – (r), (C) – (s), (D) – (p)

6. Which of the following alkenes on ozonolysis gives a mixture of ketones only?

(i) $CH_3CH{=}CHCH_3$

(ii) $CH_3{-}\underset{\displaystyle CH_3}{\underset{|}{CH}}{-}CH{-}CH_2$

(iii) 

(iv) $(CH_3)_2C{=}C\begin{matrix}CH_3\\CH_3\end{matrix}$

A. (iii) and (iv) only B. (iii) and (i) only
C. (ii) and (iv) only D. (i) and (iii) only

7. What are the oxidation states of phosphorus in the following compounds?

H_3PO_2, H_3PO_4, $Mg_2P_2O_7$, PH_3, HPO_3

A. +1, +3, +3, +3, +5 B. +3, +3, +5, +5, +5
C. +1, +2, +3, +5, +5 D. +1, +5, +5, –3, +5

8. Match list-I with list-II and select the correct option.

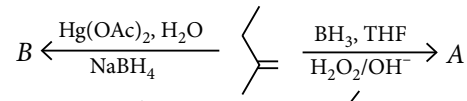
List-I (Successive ionisation energies)				**List-II (Elements) (kJ mol^{-1})**	
	IE_1	IE_2	IE_3		
1.	2080	3963	6130	A.	H
2.	520	7297	11810	B.	Li
3.	900	1758	14810	C.	Be
4.	800	2428	3660	D.	B
				E.	Ne

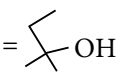
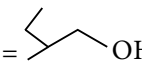
A. 1-C, 2-B, 3-D, 4-E B. 1-C, 2-E, 3-B, 4-D
C. 1-D, 2-A, 3-B, 4-D D. 1-E, 2-B, 3-C, 4-D

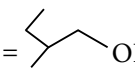
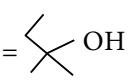
9. An alkane with a molecular formula C_6H_{14} reacts with chlorine in the presence of light and heat to give two constitutionally isomeric monochlorides of molecular formula $C_6H_{13}Cl$. What is the most reasonable starting alkane?

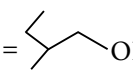
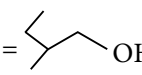
A. *n*-Hexane B. 2,2-Dimethylbutane
C. 2,3-Dimethylbutane D. 3-Methylpentane

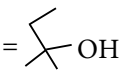
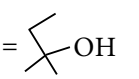
10. Find out the major products from the following reactions.



A. $A =$  , $B =$ 

B. $A =$  , $B =$ 

C. $A =$  , $B =$ 

D. $A =$  , $B =$ 

11. For a reaction, $2K_{(g)} + L_{(g)} \rightarrow 2M_{(g)}$; $\Delta U° = -10.5$ kJ and $\Delta S° = -44.1$ J K^{-1}. Calculate $\Delta G°$ at 298 K for the reaction and predict whether the reaction will be spontaneous or non-spontaneous.

A. $\Delta G = +0.16$ kJ, non-spontaneous
B. $\Delta G = -0.16$ kJ, spontaneous
C. $\Delta G = +26.12$ kJ, non-spontaneous
D. $\Delta G = -26.12$ kJ, spontaneous.

12. For the Balmer series in the spectrum of H-atom, $\bar{\nu} = R_H\left\{\frac{1}{n_1^2} - \frac{1}{n_2^2}\right\}$, the correct statements among (I) to (IV) are

(I) as wavelength decreases, the lines in the series converge
(II) the integer n_1 is equal to 2
(III) the lines of longest wavelength corresponds to $n_2 = 3$
(IV) the ionization energy of hydrogen can be calculated from wave number of these lines.

A. (II), (III) and (IV) B. (I), (III) and (IV)
C. (I), (II) and (III) D. (I), (II) and (IV)

13. 0.5 g of an organic substance containing phosphorous was heated with conc. HNO_3 in the Carius tube. The phosphoric acid thus formed was precipitated

with magnesia mixture ($MgNH_4PO_4$) which on ignition gave a residue of 1.0 g of magnesium pyrophosphate ($Mg_2P_2O_7$). The percentage of phosphorous in the organic compound is

A. 55.85% B. 15.72% C. 17.18% D. 50.5%

14. **Statement-I :** Oxidation of *tert*-butyl benzene with $KMnO_4$ gives benzoic acid.

Statement-II : Controlled oxidation of benzene with air in presence of V_2O_5 gives maleic anhydride.

A. Both statement-I and statement-II are correct.
B. Statement-I is correct but statement-II is incorrect.
C. Both statement-I and statement-II are incorrect.
D. Statement-I is incorrect but statement-II is correct.

15. Which of the following reactions are disproportionation reactions?

(i) $2Cu^+ \longrightarrow Cu^{2+} + Cu^0$

(ii) $3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(iii) $2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$

(iv) $2MnO_4^- + 3Mn^{2+} + 2H_2O \longrightarrow 5MnO_2 + 4H^+$

Select the correct option from the following.

A. (i) and (iv) only B. (i) and (ii) only
C. (i), (ii) and (iii) D. (i), (iii) and (iv)

ACHIEVERS SECTION

16. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals?

(i) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbital of lower angular momentum.
(ii) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.
(iii) According to wave mechanics, the ground state angular momentum is equal to $h/2\pi$.
(iv) The plot of ψ *vs* r for various azimuthal quantum numbers, shows peak shifting towards higher r value.

A. (i) and (iv) only B. (i) and (iii) only
C. (i) and (ii) only D. (ii) and (iii) only

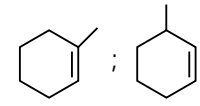
17. Consider the following statements,

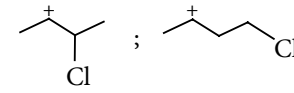
(i) The pH of a mixture containing 400 mL of 0.1 M H_2SO_4 and 400 mL of 0.1 M NaOH will be approximately 1.3.
(ii) Ionic product of water is temperature dependent.
(iii) A monobasic acid with $K_a = 10^{-5}$ has a pH = 5. The degree of dissociation of this acid is 50%.
(iv) The Le Chatelier's principle is not applicable to common-ion effect.

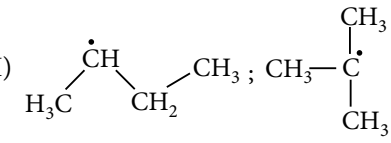
The correct statements are

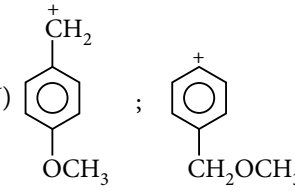
A. (i) and (ii) only
B. (ii) and (iii) only
C. (i), (ii) and (iv) only
D. (i), (ii) and (iii) only

18. In which of the following pairs, the second member is more stable than first?

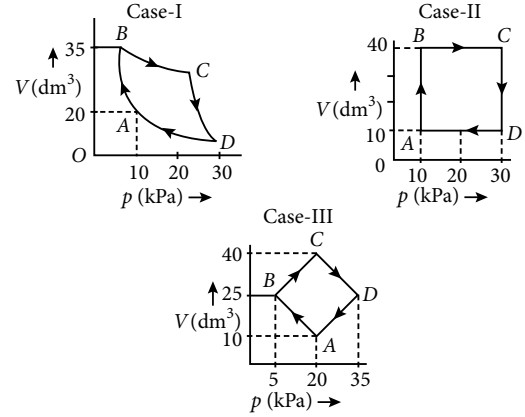
(I) 

(II) 

(III) 

(IV) 

A. I and II only B. II only
C. II and III only D. I and IV only

19. 

An ideal gas undergoes a cyclic transformation starting from the point A and coming back to the same point by tracing the path $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$ as shown in the three cases above.

Choose the correct option regarding ΔU :

A. ΔU (Case-III) > ΔU(Case-II) > ΔU(Case-I)

B. ΔU (Case-I) = ΔU(Case-II) = ΔU(Case-III)

C. ΔU (Case-I) > ΔU(Case-II) > ΔU(Case-III)

D. ΔU (Case-I) > ΔU(Case-III) > ΔU(Case-II)

20. Using the given figure, the ratio of R_f values of sample *A* and sample *C* is $x \times 10^{-2}$. Value of x is _____.

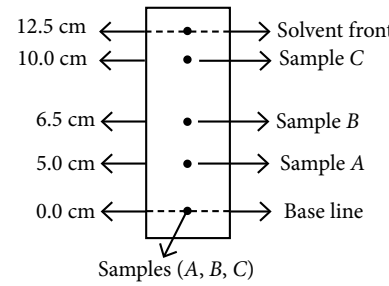


Fig.: Paper chromatography of samples

A. 50 B. 100 C. 20 D. 15

Darken your choice with HB Pencil

1.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**5.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**9.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**13.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**17.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**6.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**10.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**14.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**18.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**7.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**11.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**15.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**19.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**8.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**12.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**16.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ	**20.**	Ⓐ	Ⓑ	Ⓒ	Ⓓ

SOLUTIONS

1. (D) : Hybridisation, $H = 1/2(V + M - C + A)$

SF_4 : $H = 1/2(6 + 4 - 0 + 0) = 5$ *i.e.* sp^3d

CF_4 : $H = 1/2\ (4 + 4 - 0 + 0) = 4$ *i.e.* sp^3

XeF_4 : $H = 1/2\ (8 + 4 + 0 - 0) = 6$ *i.e.* sp^3d^2

i.e. they have different shapes.

In SF_4 we have five hybrid orbitals but only four are used by F atoms so it has one lone pair. In CF_4, C has four hybrid orbitals and all of these are used by F so it has no or zero lone pair of electron. In XeF_4, there are six hybrid orbitals and only four are used by F atoms. Thus there are two lone pairs around Xe.

2. (C) : Conditions for the combination of atomic orbitals are as follows :

(I) The combining atomic orbitals must have the same or nearly the same energy.

(II) The combining atomic orbitals must overlap to the maximum extent.

(III) The combining atomic orbitals must have the same symmetry about the molecular axis.

3. (D) : For acidic buffer, $pH = pK_a + \log \dfrac{[A^-]}{[HA]}$

When the acid is 50% ionised, $[A^-] = [HA]$

$pH = pK_a + \log 1 \implies pH = pK_a$

Given $pK_a = 4.5$; $pH = 4.5$

$\therefore$ $pOH = 14 - 4.5 = 9.5$

4. (C) : All the statements regarding spontaneity of a reaction are correct

5. (D) : (A $\rightarrow$ q) 2 mol $NH_4^+ \equiv$ 1 mol of $(NH_4)_2CO_3$ = 96 g

0.4 mol $NH_4^+ = \dfrac{96 \times 0.4}{2} = 19.2$ g

(B $\rightarrow$ r) 8 mol H atoms $\equiv$ 1 mol $(NH_4)_2CO_3$ = 96 g

1 mol H atoms (6.02×10^{23} H atoms) $= \dfrac{96}{8} = 12.0$ g

(C $\rightarrow$ s) $(NH_4)_2CO_3 + 2HCl \rightarrow 2NH_4Cl + CO_2 + H_2O$

1 mol 1 mol

1 mol of $CO_2 \equiv$ 1 mol of $(NH_4)_2CO_3$ = 96 g

3 mol of $CO_2 \equiv 96 \times 3 = 288.0$ g

(D $\rightarrow$ p) 100 mL $\times$ 0.2 M = 20 mmol $(NH_4)_2CO_3$

$= 20 \times 10^{-3} \times 96 = 1.92$ g

6. (A) : Alkenes which have two substituents on each carbon atom of the double bond give mixture of ketones on ozonolysis.

7. (D) : H_3PO_2 : $+ 3 + x - 4 = 0 \implies x = +1$

H_3PO_4 : $+ 3 + x - 8 = 0 \implies x = +5$

$Mg_2P_2O_7$: $+ 4 + 2x - 14 = 0 \implies x = +5$

PH_3 : $x + 3 = 0 \implies x = -3$

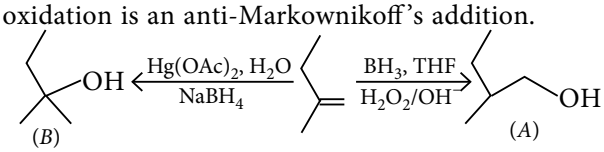
HPO_3 : $+ 1 + x - 6 = 0 \implies x = +5$

8. (D)

9. (C) : $CH_3-\underset{\underset{CH_3}{|}}{CH}-\underset{\underset{CH_3}{|}}{CH}-CH_3 \xrightarrow{Cl_2}$ (C_6H_{14})

$CH_3CH(CH_2Cl)-CH(CH_3)-CH_3 + CH_3-CH(CH_3)-C(Cl)(CH_3)-CH_3$

10. (B) : Mercuration-demercuration is a Markownikoff's addition while hydroboration-oxidation is an anti-Markownikoff's addition.



11. (A) : $2K_{(g)} + L_{(g)} \rightarrow 2M_{(g)}$

$\Delta n_g = 2 - 3 = -1$

$\Delta H° = \Delta U° + \Delta n_g RT = -10.5 \times 10^3 + (-1 \times 8.314 \times 298)$

$= -10500 + (-2477.572) = -12977.57\ J = -12.98\ kJ$

$\Delta G° = \Delta H° - T\Delta S° = -12.98 - 298\ (-44.1 \times 10^{-3})$

$= -12.98 + 13.14 = 0.16\ kJ$

Since $\Delta G°$ is +ve hence it is non-spontaneous.

12. (C)

13. (A) : $P + HNO_3 \longrightarrow H_3PO_4 \xrightarrow{(NH_4Cl + MgCl_2)} MgNH_4(PO_4) \xrightarrow{\Delta} Mg_2P_2O_7$ (Magnesium pyrophosphate)

Molecular weight of $Mg_2P_2O_7$

$= 24 \times 2 + 31 \times 2 + 16 \times 7 = 222\ g\ mol^{-1}$

$$\text{Percentage of P} = \frac{62}{222} \times \frac{\text{Mass of } Mg_2P_2O_7}{\text{Mass of compound}} \times 100$$

$$= \frac{62}{222} \times \frac{1.0}{0.5} \times 100 = 55.85\%$$

14. (D) : Due to absence of benzylic hydrogens, *tert*-butyl benzene does not undergo oxidation.

15. (B) : Disproportionation reactions are those in which the same element/ compound gets oxidized and reduced simultaneously.

$2Cu^+ \rightarrow Cu^{2+} + Cu^0$

$3\overset{+6}{Mn}O_4^{2-} + 4H^+ \longrightarrow 2\overset{+7}{Mn}O_4^- + \overset{+4}{Mn}O_2 + 2H_2O$

16. (A)

17. (D) : (i) For an acid-base mixture :

$N_3V_3 = N_1V_1 - N_2V_2$

Normality = Molarity × basicity

For H_2SO_4 ; $N_1 = 0.1 \times 2$, $V_1 = 400$

For NaOH ; $N_2 = 0.1 \times 1$, $V_2 = 400$

$N_3V_3 = 0.2 \times 400 - 0.1 \times 400 = 40$

$$N_3 \times 800 = 40 \Rightarrow N_3 = \frac{40}{800} = 0.05$$

$pH = -\log[H^+] = -\log(0.05) = 1.3$

(ii) Ionic product of water is the product of molar concentration of H^+ ions and OH^- ions. Ionic product of water is temperature dependent.

(iii) $K_a = 10^{-5}$

pH = 5, $[H^+] = 10^{-5}$

$$K_a = \frac{C\alpha^2}{1-\alpha} \Rightarrow K_a = \frac{[H^+]\alpha}{(1-\alpha)}$$

$$\Rightarrow 10^{-5} = \frac{10^{-5}\alpha}{1-\alpha} \Rightarrow 1 - \alpha = \alpha$$

$$\alpha = \frac{1}{2} = 50\%$$

(iv) Le-Chatelier's principle is applicable for common-ion effect.

18. (C) : –Cl shows electron withdrawing effect (*–I*) and destabilises the carbocation.

19. (B) : Change in internal energy, ΔU is a state function *i.e.* it does not depend on the path taken but depends only on initial and final state.

Thus, it is zero for cyclic processes.

As all the given processes are cyclic so,

ΔU (Case-I) = ΔU (Case-II)

= ΔU (Case-III) = 0

20. (A) : $R_f(A) = \frac{5}{12.5}$, $R_f(C) = \frac{10}{12.5}$

$$\therefore \quad \frac{R_f(A)}{R_f(C)} = \frac{5/12.5}{10/12.5} = \frac{5}{10} = 0.5 = 50 \times 10^{-2}$$

For other sections/subjects please refer to Physics For You and Biology Today



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CLASS XII

SYLLABUS*

Following the protocol of NEP (2020), NCF (2023), NCERT and CBSE guidelines, National and various State Boards for the convenience of schools and students, any change/reduction in the syllabi will be reflected in actual question papers.

Section – 1 : *Physics* : Electricity and Magnetism, Electromagnetic Induction, Alternating current, Electromagnetic waves, Optics, Modern Physics, Semiconductor Electronics.

Chemistry : Solutions, Electrochemistry, Chemical Kinetics, The *d*- and *f*-Block Elements, Coordination Compounds, Haloalkanes and Haloarenes, Alcohols, Phenols and Ethers, Aldehydes, Ketones and Carboxylic Acids, Amines, Biomolecules.

Section – 2 : Higher Order Thinking Questions - Syllabus as per Section-1.

Section – 3 : Relations and Functions, Inverse Trigonometric Functions, Matrices and Determinants, Continuity and Differentiability, Application of Derivatives, Integrals, Application of Integrals, Differential Equations, Vector Algebra, Three Dimensional Geometry, Probability, Linear Programming.

OR

Section – 3 : Reproduction, Genetics and Evolution, Biology in Human Welfare, Biotechnology, Ecology.

Total Questions : 50 Time : 1 hr.

PATTERN & MARKING SCHEME			
Section	**(1) Physics & Chemistry**	**(2) Achievers Section**	**(3) Mathematics or Biology**
No. of Questions	**25**	**5**	**20**
Marks per Ques.	**1**	**3**	**1**

Practice Questions

1. The correct IUPAC name of the following compound is $[Cr(NH_3)_5(NCS)]\ [ZnCl_4]$

A. pentaammineisothiocyanatochromium(III) tetrachlorozincate(II)

B. pentammineisothiocyanatezinc chloridechromate(III)

C. pentaammineisothiocyanatochromate(II)

D. isothiocyanatopentaamminechromium(II) zinc chloride(IV).

2. For the reaction, $2A + B \rightarrow$ products, when the concentrations of *A* and *B* both were doubled, the rate of the reaction increased from 0.3 mol L^{-1} s^{-1} to 2.4 mol L^{-1} s^{-1}. When the concentration of *A* alone is doubled, the rate increased from 0.3 mol L^{-1} s^{-1} to 0.6 mol L^{-1} s^{-1}. Which one of the following statements is correct?

A. Order of the reaction with respect to *B* is 2.

B. Order of the reaction with respect to *B* is 1.

C. Order of the reaction with respect to *A* is 2.

D. Total order of the reaction is 4.

3. Highest oxidation state of Mn is exhibited in Mn_2O_7. The correct statements about Mn_2O_7 are

I. Mn is tetrahedrally surrounded by oxygen atoms.

II. Mn is octahedrally surrounded by oxygen atoms.

III. Contains Mn—O—Mn bridge.

IV. Contains Mn—Mn bond.

Choose the correct answer from the options given below:

A. I and IV only

B. I and III only

C. II and III only

D. II and IV only

4. Choose the incorrect statement among the following.

(i) The reactivity of aromatic aldehydes and ketones is less than that of aliphatic carbonyl compounds towards nucleophilic addition reactions.

(ii) Benzaldehyde does not give Fehling's test.

(iii) The H-atom in ethanal are acidic in nature.

(iv) "*p*-Nitrobenzaldehyde" is less reactive than "benzaldehyde" towards nucleophilic addition reactions.

A. ii B. iii C. iv D. i

5. Which compounds among the following give positive iodoform test?

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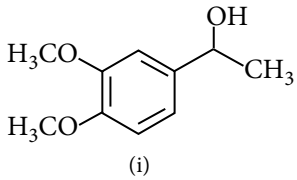
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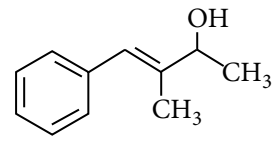
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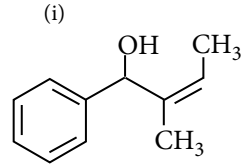
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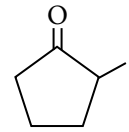
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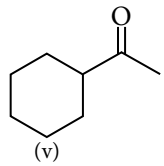
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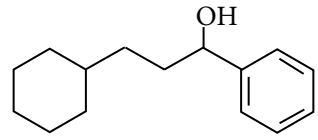

(i)


(ii)


(iii)


(iv)


(v)


(vi)

A. (i), (iii) and (vi) only
B. (iii), (iv) and (v) only
C. (i), (ii) and (v) only
D. (ii), (iv) and (vi) only

6. **Statement-I :** A catalyst provides an alternative path to the reaction in which conversion of reactants into products take place quickly.
Statement-II : The catalyst forms an activated complex of higher potential energy with the reactants by which more number of molecules are able to cross the barrier per unit of time.
A. Both statement-I and statement-II are correct.
B. Statement-I is correct but statement-II is incorrect.
C. Both statement-I and statement-II are incorrect.
D. Statement-I is incorrect but statement-II is correct.

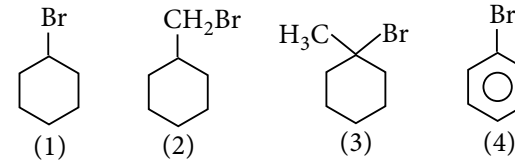
7. Hydrolysis of which of the following nucleic acids does not give equal number of A and T or G and C
(i) *m*-RNA (ii) single strand DNA
(iii) *r*-RNA (iv) double helix DNA
A. (i), (ii) and (iii) only B. (ii), (iii) and (iv) only
C. (ii) only D. (i) only

8. Which of the following statements is true?
1. Tertiary amines react with acid chlorides.
2. *N*-Ethyl benzene sulphonamide is soluble in alkali.
3. *N*, *N*-Diethyl benzene sulphonamide is soluble in alkali.
4. Tertiary amines react with Hinsberg's reagent.
A. 1 B. 2 C. 3 D. 4

9. How long will it take for a uniform current of 6.00 A to deposit 78 g of gold from a solution of $AuCl_4^-$? What mass of chlorine gas will be formed simultaneously at anode of the cell? (Atomic mass of Au = 197)
A. t = 3010 sec, w = 35.50 g
B. t = 20306 sec, w = 45.54 g
C. t = 19500 sec, w = 54.5 g
D. t = 19139.16 sec, w = 42.24 g

10. Which of the following statements is correct for $[Mn(CN)_6]^{3-}$ according to valence bond theory?
A. d^2sp^3, inner orbital complex, paramagnetic, 2.84 B.M.
B. d^2sp^3, inner orbital complex, diamagnetic, zero magnetic moment.
C. d^2sp^3, outer orbital complex, paramagnetic, 2.87 B.M.
D. dsp^2, outer orbital complex, diamagnetic, zero magnetic moment.

11. The correct increasing order of reactivity of following compounds towards S_N2 reaction is


(1) (2) (3) (4)

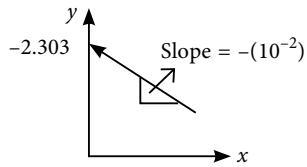
A. 2 > 4 > 1 > 3 B. 3 > 1 > 2 > 4
C. 4 > 2 > 1 > 3 D. 2 > 1 > 3 > 4

12. Match the following.

List–I		List–II	
A.	Beri-beri	I.	Riboflavin
B.	Scurvy	II.	Thiamine
C.	Cheilosis	III.	Pyridoxine
D.	Rickets	IV.	Ascorbic acid
		V.	Vitamin D

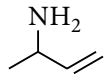
The correct answer is
A. A–III, B–IV, C–III, D–V
B. A–II, B–IV, C–I, D–V
C. A–III, B–V, C–I, D–II
D. A–III, B–V, C–IV, D–II

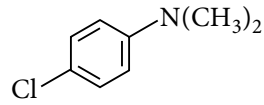
13. At 298 K, for a first order reaction ($A \rightarrow P$) the following graph is obtained. The rate constant (in s^{-1}) and initial concentration (in mol L^{-1}) of 'A' are respectively.
(y-axis = $\ln(a - x)$; x-axis = time in sec)



A. $2.303 ; 10^{-1}$ B. $10^{-2} ; 2.303$
C. $10^{-1} ; 10^{-2}$ D. $10^{-2} ; 10^{-1}$

14. IUPAC names of the following compounds *I* and II are

I. 

II. 

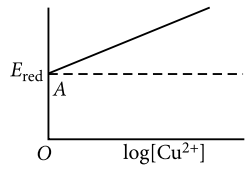
A. I = But-3-en-2-amine;
II = 4-*N*,*N*-dimethylaminochlorobenzene
B. I = But-1-en-3-amine;
II = 4-*N*,*N*-dimethylaminochlorobenzene
C. I = But-1-en-3-amine;
II = 4-Chloro-*N*,*N*-dimethylbenzenamine
D. I = But-3-en-2-amine;
II = 4-Chloro-*N*,*N*-dimethylbenzenamine.

15. Two elements *R* and *S* form compounds having molecular formula RS_2 and RS_4. When dissolved in 20.0 g of benzene (C_6H_6), 1.0 g RS_2 lowers the freezing point by 2.3 °C whereas 1.0 g of RS_4 lowers the freezing point by 1.3 °C. The molal depression constant for benzene is 5.1 K kg mol^{-1}. Calculate the atomic mass of *R* and *S* respectively.

A. *R* = 25.57 and *S* = 42.64
B. *R* = 57.25 and *S* = 64.42
C. *R* = 15.25 and *S* = 5.40
D. *R* = 75.25 and *S* = 25.75

ACHIEVERS SECTION

16. For the reaction, $Cu^{2+} + 2e^- \rightarrow Cu$; $\log[Cu^{2+}]$ *vs E* graph is of type as shown in figure where *OA* = 0.34 V, the electrode potential of the half-cell of $Cu|Cu^{2+}(0.1\ M)$ will be



A. $-0.34+\frac{0.0591}{2}$ V B. 0.34 + 0.0591 V
C. 0.34 V D. none of these.

17. Which of the following statements are correct?

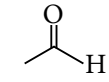
I. The M^{3+}/M^{2+} reduction potential for iron is greater than manganese.
II. The higher oxidation states of first row *d*-block elements get stabilized by oxide ion.
III. Aqueous solution of Cr^{2+} can liberate hydrogen from dilute acid.
IV. Magnetic moment of V^{2+} is observed between 4.4 – 5.2 B.M.

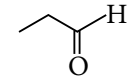
Choose the correct answer from the options given below :

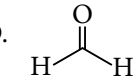
A. I, II and IV only B. III and IV only
C. I and II only D. II and III only

18. Treatment of 2-bromobutane with hot alcoholic KOH gives a mixture of three isomeric butenes (*P*), (*Q*) and (*R*). Ozonolysis of the minor product (*P*) gives HCHO and another aldehyde in equimolar amounts. Both (*Q*) and (*R*) gave the same single product (*S*) on ozonolysis. Find structural formula of (*S*).

A. 

B. 

C. 

D. 

19. Which of the following statements is true?

1. 200 mL of 0.2 M NaOH has same number of moles of solute as 1000 mL of 1 M NaOH.



2. 200 mL of 1 M NaOH has same number of moles as 1000 mL of 0.2 M NaOH.
3. 100 mL of 0.2 M NaOH has same number of moles as 1000 mL of 1 M NaOH.
4. 2000 mL of 0.2 M NaOH has same number of moles as 1000 mL of 1 M NaOH.

A. 3 B. 2
C. 4 D. 1

20. Which of the following statements are correct?

I. P is having least negative electron gain enthalpy among P, S, Cl and F.
II. In Zr and Hf, lanthanoid contraction is observed.
III. $La(OH)_3$ is most basic among lanthanoid hydroxides.
IV. The radii of Na and Na^+ are 95 pm, 186 pm respectively.

A. I, III and IV only B. II and IV only
C. I and III only D. I, II and III only

Darken your choice with HB Pencil

1.	Ⓐ Ⓑ Ⓒ Ⓓ	5.	Ⓐ Ⓑ Ⓒ Ⓓ	9.	Ⓐ Ⓑ Ⓒ Ⓓ	13.	Ⓐ Ⓑ Ⓒ Ⓓ	17.	Ⓐ Ⓑ Ⓒ Ⓓ
2.	Ⓐ Ⓑ Ⓒ Ⓓ	6.	Ⓐ Ⓑ Ⓒ Ⓓ	10.	Ⓐ Ⓑ Ⓒ Ⓓ	14.	Ⓐ Ⓑ Ⓒ Ⓓ	18.	Ⓐ Ⓑ Ⓒ Ⓓ
3.	Ⓐ Ⓑ Ⓒ Ⓓ	7.	Ⓐ Ⓑ Ⓒ Ⓓ	11.	Ⓐ Ⓑ Ⓒ Ⓓ	15.	Ⓐ Ⓑ Ⓒ Ⓓ	19.	Ⓐ Ⓑ Ⓒ Ⓓ
4.	Ⓐ Ⓑ Ⓒ Ⓓ	8.	Ⓐ Ⓑ Ⓒ Ⓓ	12.	Ⓐ Ⓑ Ⓒ Ⓓ	16.	Ⓐ Ⓑ Ⓒ Ⓓ	20.	Ⓐ Ⓑ Ⓒ Ⓓ

SOLUTIONS

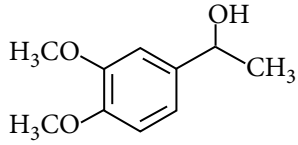
1. (A): Pentaammineisothiocyanatochromium(III) tetrachlorozincate(II).

2. (A): If concentration of [*A*] is doubled, rate will be doubled, so order of *A* is 1.
Again if concentration of *A* and *B* both were doubled, the rate will increase 8 times.
Rate = $[2A]\ [2B]^2 = 8[A][B]^2$
It means order of *B* is 2.
Hence, overall order is 3.

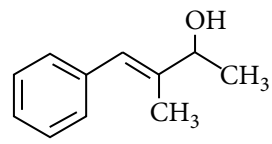
3. (B)

4. (C): Presence of electron withdrawing group (–*I* effect) in carbonyl compounds increases the reactivity towards nucleophilic addition.

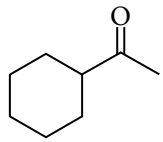
5. (C): Iodoform reaction with sodium hypoiodite is used to detect CH_3CO– group or $CH_3CH(OH)$– group. Thus, following compounds give positive iodoform test.



(i)



(ii)



(v)

6. (B)

7. (A): Hydrolysis of the following nucleic acids does not give equal number of A and T or G and C.
m-RNA - single stranded,
Single stranded DNA,
r-RNA - single stranded

8. (B): *N*-ethylbenzene sulphonamide is soluble in alkali due to presence of acidic hydrogen.

9. (D): Reactions take place at electrodes are :
At cathode : $AuCl_4^- + 3e^- \longrightarrow Au + 4Cl^-$
At anode : $Cl^- \longrightarrow 1/2Cl_2 + e^-$
For the deposition of 197 g (1 mole) of Au = 3F of charge is required thus, for the deposition of 78 g of

Au, charge required $= \frac{3F}{197} \times 78 = 1.19\ F$

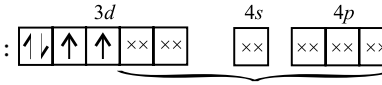
= 1.19 × 96500 coulombs
As $Q = I \times t$

$$t = \frac{Q}{I} = \frac{1.19 \times 96500}{6} = 19139.16 \text{ sec}$$

By 1 F charge, 35.5 g of Cl_2 gas is formed, thus from 1.19 F, mass of chlorine gas formed = 35.5 × 1.19 = 42.24 g

10. (A): In $[Mn(CN)_6]^{3-}$, oxidation state of Mn = +3,
$Mn^{3+} = [Ar]3d^4$

$[Mn(CN)_6]^{3-}$:

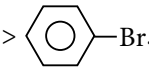


d^2sp^3, inner orbital complex

It has two unpaired electrons. Therefore it is paramagnetic.

$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} = 2.84$ B.M.

11. (D): Nucleophilic substitution through S_N2 mechanism is governed by steric hindrance. Thus, reactivity of

1° $R-X$ > 2° $R-X$ > 3° $R-X$ > 

$\therefore$ Thus, the order is 2 > 1 > 3 > 4.

12. (B):

Beri-beri	- Thiamine	(A - II)
Scurvy	- Ascorbic acid	(B - IV)
Cheilosis	- Riboflavin	(C - I)
Rickets	- Vitamin D	(D - V)

13. (D): According to Arrhenius equation

$A = A_0 e^{-kt}$ ...(i)

Taking log on both sides of (i) $\ln A = \ln A_0 - kt$

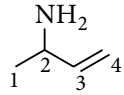
We know that $y = mx + c$

Hence, $-k$ = slope = $-(10^{-2})$ or $k = 10^{-2}$ s^{-1}

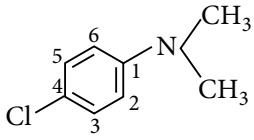
$\ln A_0 = c = -2.303$ or $\log A_0 \times 2.303 = -2.303$.

Log $A_0 = -1.0$

Taking antilog on both sides $A_0 = 10^{-1}$

14. (D): (I) 

But-3-en-2-amine

II. 

4-Chloro-*N*, *N*-dimethylbenzenamine

15. (A): For RS_2, $\Delta T_f = K_f \times \dfrac{W_2 \times 1000}{M_2 \times W_1}$

or, $2.3 = 5.1 \times \dfrac{1 \times 1000}{M_2 \times 20}$

$\therefore$ $M_2 = \dfrac{50 \times 5.1}{2.3} = 110.86$ g moL^{-1}

Similarly for RS_4, $1.3 = 5.1 \times \dfrac{1 \times 1000}{M_2 \times 20}$

$\therefore$ $M_2 = \dfrac{50 \times 5.1}{1.3} = 196.15$ g moL^{-1}

Molecular mass of $RS_2 = 110.86$ g mol^{-1} and molecular mass of $RS_4 = 196.15$ g mol^{-1}

For RS_4, $R + 4S = 196.15$ ... (i)

For RS_2, $R + 2S = 110.86$ ... (ii)

By subtracting (ii) from (i), $2S = 85.29$

$\therefore$ $S = 42.645$

Putting the value of S in equation (ii),

$R + 2 \times 42.645 = 110.86$

or, $R = 110.86 - 85.29 = 25.57$

16. (A): $E_{Cu/Cu^{2+}} = E^{\circ}_{Cu/Cu^{2+}} - \dfrac{0.059}{2}\log[Cu^{2+}]$

$OA = 0.34\ V = E^{\circ}_{Cu^{2+}/Cu} = -E^{\circ}_{Cu/Cu^{2+}}$

$\Rightarrow$ $E^{\circ}_{Cu/Cu^{2+}} = -0.34$ V

Now, $E_{Cu/Cu^{2+}} = -0.34 - \dfrac{0.059}{2}\log(0.1) = -0.34 + \dfrac{0.0591}{2}$ V

17. (D)

18. (B): $CH_3-\underset{\underset{Br}{|}}{CH}-CH_2-CH_3 + \text{Alc. KOH} \longrightarrow$

$\underset{\substack{\text{(Minor)}\\(P)}}{CH_2=CH-CH_2-CH_3} + \underset{\substack{\text{(Major)}\\(cis \text{ and } trans)\\(Q \text{ and } R)}}{CH_3-CH=CH-CH_3}$

$CH_2=CH-CH_2-CH_3 + O_3 \xrightarrow{Zn/H_2O} HCHO + CH_3CH_2CHO$

$CH_3-CH=CH-CH_3 + O_3 \xrightarrow{Zn/H_2O} \underset{(S)}{2CH_3CHO}$

19. (B): 200 mL of 1 M NaOH has same number of moles as 1000 mL of 0.2 M NaOH.

For 200 mL of 1 M NaOH,

$M = \dfrac{n}{V}$ or $n = M \times V = 200 \times 1 = 200$ millimoles

Similarly, For 1000 mL of 0.2 M NaOH.

$n = 1000 \times 0.2 = 200$ millimoles

20. (D): The size of Na^+ ion is smaller than Na because of increased effective nuclear charge in Na^+ ion.

For other sections/subjects please refer to Physics For You and Biology Today

Quotable Quote

"Great spirits have always encountered violent opposition from mediocre minds."

– Albert Einstein

Quiz CLUB

Unlock Your Knowledge!



1. _____ is an alkaline earth metal element that gives explosive firework star shells an incredibly bright, apple-green colour profile when ignited at high temperatures.
2. _____ is a light-sensitive lanthanoid inside paper currency that glows with fluorescent ink under ultraviolet light to reveal counterfeit banknotes.
3. Luxury smartphones utilize a thin, transparent touchscreen coating that relies heavily on the post-transition metal called _____ to conduct electrical touches.
4. Pure _____ is a highly toxic, corrosive halogen gas, but it is added to commercial window glass to block solar ultraviolet rays.
5. The striking surface on the side of a modern safety matchbox contains a friction-sensitive layer of _____ phosphorus that ignites when a match head is rubbed against it.
6. If you charge your phone too quickly or at freezing temperatures, lithium ions can fail to enter the battery's anode, which is typically made of _____.
7. The only two non-silvery metals on the periodic table are gold and _____.
8. Soda fizzes because carbon dioxide gas is dissolved in the liquid under high pressure, forming weak _____ acid.
9. Packaged potato chip bags are inflated with pure _____ gas instead of regular air to displace oxygen and prevent the oils from oxidizing.
10. Honeybee venom contains a high concentration of _____ acid, giving the sting a low, acidic pH of around 5.0 to 5.5.
11. In forensic homicide investigations, the Marsh test is a classic chemical method used to detect trace amounts of _____ in human tissue.
12. Forensic scientists measure the decay of the radioactive isotope _____ to date organic materials up to 50,000 years old.
13. The chemical process where amino acids flip into their mirror-image configurations after death is called _____.
14. Forensic scientists use _____ on soil samples to detect the presence of amino acids, which turn a distinct purple colour when a hidden grave is nearby.
15. Modern sunscreens use nano-sized particles of zinc oxide or _____ dioxide to block harmful UV rays without leaving a visible white residue on the skin.
16. The chemical weapon Agent _____, used extensively during the Vietnam War as a defoliant, caused severe long-term health crisis due to contamination by a toxic dioxin byproduct.
17. Napoleon's hair was analyzed using a nuclear technique called Neutron Activation Analysis (NAA), which detects trace elements by measuring _____ray emissions.
18. All actinoids are completely radioactive, and those beyond _____ do not exist naturally on Earth, requiring creation inside particle accelerators.
19. The "Little Boy" bomb dropped on Hiroshima was a gun-type weapon powered by enriched _____.
20. The "Fat Man" bomb dropped on Nagasaki relied on an implosion core of _____.

◈ ◈

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

CHEMISTRY IN FOCUS

CLASS 12

TOPIC

Electrochemistry

Detailed theory with High Definition images of the given topic is covered under this heading.

Electrochemistry is the study of production of electricity from energy released during spontaneous chemical reactions and the use of electrical energy to bring about non-spontaneous chemical transformations.

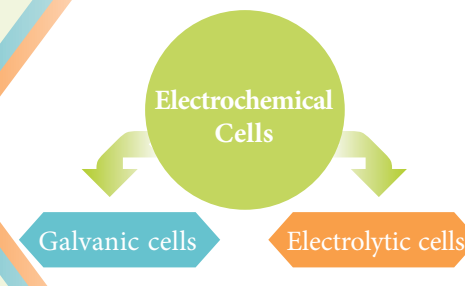
Electrochemical Cell

- Electrochemical cell is a system or arrangement in which two electrodes are dipped in the same electrolyte or in two different electrolytes which are joined by a salt bridge.
- The reactions that occur in electrochemical cells are called the *electrochemical reactions*.

Types of Electrochemical Cells

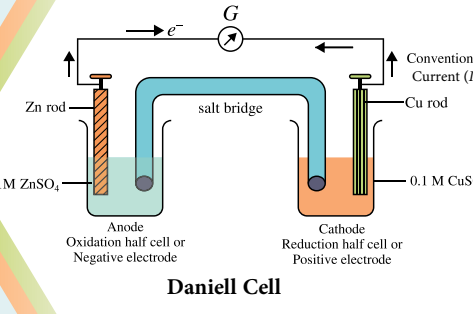
Electrolytic Cells : An electrochemical cell in which non-spontaneous reaction is forced to occur by passing a direct current from an external source into the solution is called an *electrolytic cell*. In such cells electrical energy is converted into chemical energy.

Voltaic or Galvanic Cells : An electrochemical cell in which a spontaneous chemical reaction produces electricity is called *voltaic cell* or *galvanic cell*.



Daniell cell : In the Daniell cell, a zinc rod is dipped in a solution of $ZnSO_4$ solution taken in a beaker. Similarly, copper rod is dipped in a solution of $CuSO_4$ taken in a beaker. The two electrodes are connected by conducting metallic wire through a voltmeter and a switch externally. The two solutions are connected internally *via* a salt bridge.

- **Reaction in a Daniell cell :**
  $Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$
- The dry cell, nickel-cadmium cell, lead storage cell, fuel cells are some other examples of galvanic cells.



Daniell Cell

Salt Bridge

- In galvanic cell, the solutions are connected by a salt bridge. It is a U-shaped glass tube containing a saturated solution of an inert electrolyte such as KCl or NH_4NO_3 and gelatin or agar-agar solution. KCl is preferred because the transport numbers of K^+ and Cl^- are almost same *i.e.* have same cationic and anionic mobility.
- **Function of Salt Bridge**
  - It completes the circuit and allows the flow of current.
  - It maintains the electrical neutrality of the solutions in the two half cells.

Representation of an Galvanic Cell

An galvanic cell can be represented as :

Metal | metal ion (conc.) || metal ion (conc.) | Metal

Anode Salt bridge Cathode

For Daniell cell : Zn | Zn^{2+} (C_1) || Cu^{2+} (C_2)|Cu

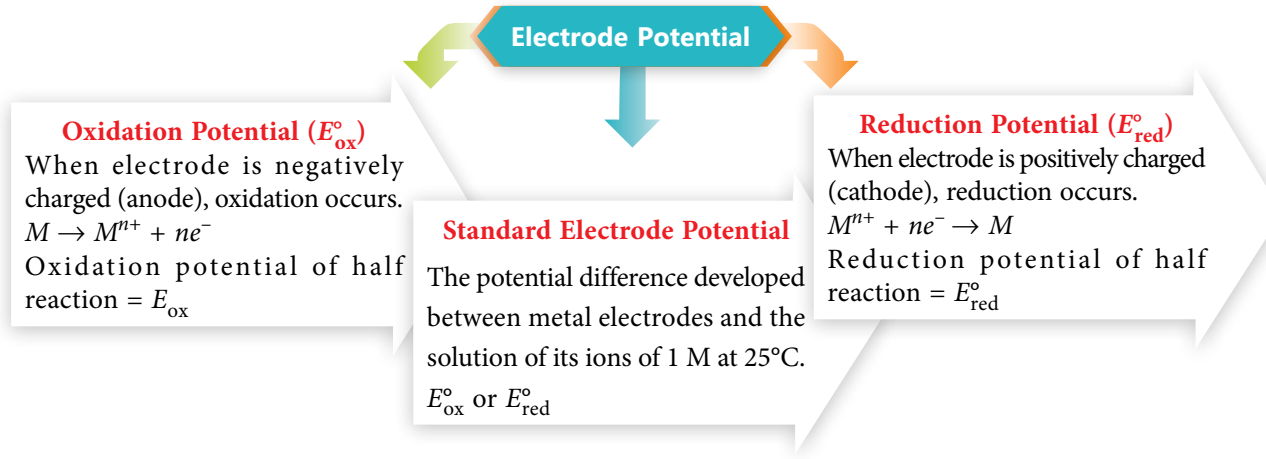
When a salt bridge is used it is represented by two vertical lines (||) as shown above.

A Summary on Cell Construction and Convention

Cell type	Reaction type	ΔG	E	Reduction	Oxidation	Direction of e^- flow	Sign at cathode	Sign at anode
Electrolysis (Electrolytic cell)	non-spontaneous	+	–	cathode	anode	e^- flow from anode to cathode	–	+
Electrochemical cell [Galvanic/Voltaic cell (battery)]	spontaneous	–	+	cathode	anode	e^- flow from anode to cathode	+	–

Electrode Potential

It is the potential difference set up between the metal electrode and its ions in the solution or it is the tendency of an electrode to get oxidised or reduced.



Electrochemical Series

When various electrodes are arranged in order of increasing values of their standard reduction potentials we get a series called *electrochemical series*.

Standard reduction potentials at 298 K (Electrochemical Series)

Reduction half reaction			Standard reduction potential E° (in volt)
$Li^+ + e^-$	$\rightarrow$	Li	–3.05
$K^+ + e^-$	$\rightarrow$	K	–2.93
$Ba^{2+} + 2e^-$	$\rightarrow$	Ba	–2.90
$Ca^{2+} + 2e^-$	$\rightarrow$	Ca	–2.87
$Na^+ + e^-$	$\rightarrow$	Na	–2.71
$Mg^{2+} + 2e^-$	$\rightarrow$	Mg	–2.36
$Al^{3+} + 3e^-$	$\rightarrow$	Al	–1.66
$Mn^{2+} + 2e^-$	$\rightarrow$	Mn	–1.18
$2H_2O_{(l)} + 2e^-$	$\rightarrow$	$H_{2(g)} + 2OH^-_{(aq)}$	–0.83
$Zn^{2+} + 2e^-$	$\rightarrow$	Zn	–0.76
$Cr^{3+} + 3e^-$	$\rightarrow$	Cr	–0.74
$Fe^{2+} + 2e^-$	$\rightarrow$	Fe	–0.44
$Cd^{2+} + 2e^-$	$\rightarrow$	Cd	–0.40
$Co^{2+} + 2e^-$	$\rightarrow$	Co	–0.28
$Ni^{2+} + 2e^-$	$\rightarrow$	Ni	–0.25
$Sn^{2+} + 2e^-$	$\rightarrow$	Sn	–0.14
$Pb^{2+} + 2e^-$	$\rightarrow$	Pb	–0.13
$2H^+ + 2e^-$	$\rightarrow$	H_2	0.00
$Sn^{4+} + 2e^-$	$\rightarrow$	Sn^{2+}	+ 0.15
$Cu^{2+} + e^-$	$\rightarrow$	Cu^+	+ 0.34
$Cu^+ + e^-$	$\rightarrow$	Cu	+ 0.52
$I_2 + 2e^-$	$\rightarrow$	$2I^-$	+ 0.54
$Fe^{3+} + e^-$	$\rightarrow$	Fe^{2+}	+ 0.77
$Ag^+ + e^-$	$\rightarrow$	Ag	+ 0.80
$Br_2 + 2e^-$	$\rightarrow$	$2Br^-$	+ 1.08
$O_{2(g)} + 4H^+_{(aq)} + 4e^-$	$\rightarrow$	$2H_2O$	+ 1.23
$Cl_2 + 2e^-$	$\rightarrow$	$2Cl^-$	+ 1.36
$Au^{3+} + 3e^-$	$\rightarrow$	Au	+ 1.40
$Co^{3+} + e^-$	$\rightarrow$	Co^{2+}	+ 1.81
$F_2 + 2e^-$	$\rightarrow$	$2F^-$	+ 2.87

← Increasing strength of oxidising agent

Increasing strength of reducing agent →

CONCEPT MAP

BATTERIES AND CORROSION

BATTERIES

A battery is a device that stores chemical energy and makes it available in an electrical form. In an accumulator or a battery by passing current, chemical reactions are produced and after these reactions are completed (*i.e.*, when batteries are fully charged), these can be used to get electricity by connecting them to circuits.

Batteries are usually divided into two broad classes :

(i) Primary Batteries (ii) Secondary Batteries

Primary Batteries

Primary batteries irreversibly transform chemical energy to electrical energy. Once the capacity of the initial supply of reactants is exhausted, energy cannot be readily restored to the battery by electrical means. We can also say that, primary cells are those in which the reaction occurs only once and it cannot be used after the electrolyte is exhausted, *i.e.*, cannot be recharged, *e.g.*, dry cell, mercury cell.

Dry Cell or Leclanche Cell

Dry Cell

Anode	Cathode	Electrolyte
(Negative electrode) Cylindrical zinc container	(Positive electrode) Graphite rod	Mixture of MnO_2 + C (around cathode) Paste of NH_4Cl and $ZnCl_2$ (around anode)

- **Cell reactions :**

  At anode : $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

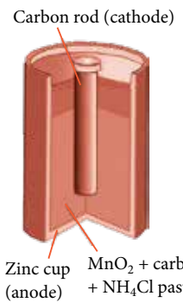
  At cathode : $2MnO_{2(s)} + 2NH^+_{4(aq)} + 2e^- \longrightarrow 2MnO(OH) + 2NH_{3(g)}$

- **Overall reaction :**

  $Zn_{(s)} + 2NH^+_{4(aq)} + 2MnO_{2(s)} \longrightarrow Zn^{2+}_{(aq)} + 2MnO(OH) + 2NH_{3(g)}$

Voltage range 1.25 V to 1.5 V.

Used in transistors, clocks, torches, toys, flash lights, etc.



Dry cell

Mercury Cell

Mercury Cell

Cathode	Anode	Electrolyte
Paste of HgO + C	Zinc-mercury amalgam,	Paste of KOH and ZnO

- **Cell reactions :**

  At anode : $Zn(Hg) + 2OH^-_{(aq)} \longrightarrow ZnO_{(s)} + H_2O + 2e^-$ (Amalgam)

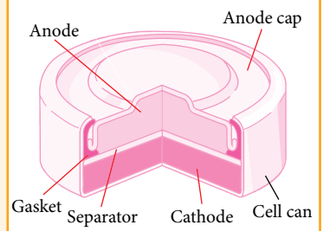
  At cathode : $HgO_{(s)} + H_2O_{(l)} + 2e^- \rightarrow Hg_{(l)} + 2OH^-_{(aq)}$

- **Overall reaction :**

  $Zn(Hg) + HgO_{(s)} \rightarrow ZnO_{(s)} + Hg_{(l)}$

  Voltage =1.35V

Used for low current devices like hearing aids, watches, etc.



Mercury cell

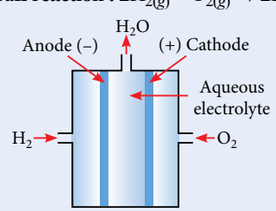
Fuel Cell

Fuel cells are the devices which can convert the energy of combustion of fuels directly into electrical energy e.g., $H_2 - O_2$ fuel cell.

Anode : $2H_{2(g)} + 4OH^-_{(aq)} \rightarrow 4H_2O_{(l)} + 4e^-$

Cathode : $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$

Overall reaction : $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$



H_2-O_2 Fuel cell

Secondary Batteries

Secondary batteries can have the chemical reactions reversed by supplying electrical energy to the cell, restoring their original composition. We can also say that, secondary cells are those which can be recharged by reversing the reaction, e.g., lead storage battery and Ni-Cd cell.

Lead Storage Battery

Lead accumulator

Cathode	Anode	Electrolyte
Lead oxide	Lead plates	Dil. H_2SO_4 solution (38% by mass, density 1.30 g cm^{-3})

Reactions during discharge :

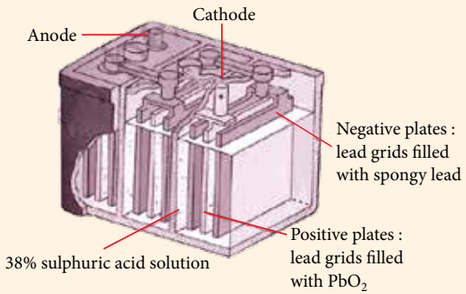
At anode : $Pb_{(s)} + SO^{2-}_{4(aq)} \longrightarrow PbSO_{4(s)} + 2e^-$

At cathode : $PbO_{2(s)} + SO^{2-}_{4(aq)} + 4H^+_{(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$

Overall reaction :

$$Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \underset{\text{Recharging}}{\overset{\text{Discharging}}{\rightleftharpoons}} 2PbSO_{4(s)} + 2H_2O_{(l)}$$

- Voltage : 6 V to 12 V
- On charging the battery, the reaction is reversed and $PbSO_{4(s)}$ act as anode and cathode is converted into Pb and PbO_2 respectively.
- When density of H_2SO_4 decreases from 1.30 g cm^{-3} to 1.20 g cm^{-3}, battery needs charging.
- These cells are mainly used in automobiles and invertors.



Lead Storage battery

Nickel-Cadmium Storage Cell (NiCad Cell)

Nickel-cadmium storage cell

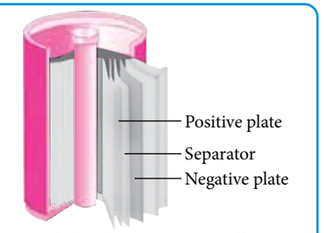
Cathode	Anode	Electrolyte
NiO_2	Cd	KOH solution

Cell reactions : At anode : $Cd_{(s)} + 2OH^-_{(aq)} \rightarrow Cd(OH)_{2(s)} + 2e^-$

At cathode : $NiO_{2(s)} + 2H_2O_{(l)} + 2e^- \rightarrow Ni(OH)_{2(s)} + 2OH^-_{(aq)}$

Overall reaction : $Cd_{(s)} + NiO_{2(s)} + 2H_2O_{(l)} \underset{\text{Recharging}}{\overset{\text{Discharging}}{\rightleftharpoons}} Cd(OH)_{2(s)} + Ni(OH)_{2(s)}$

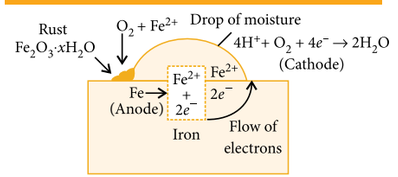
Voltage =1.4V



Nickel-cadmium storage cell

CORROSION

Mechanism or Theory of Corrosion



Overall reaction : $2Fe_{(s)} + O_{2(g)} + 4H^+_{(aq)} \longrightarrow 2Fe^{2+}_{(aq)} + 2H_2O_{(l)}$; $E^\circ_{cell} = 1.67$ V

$4Fe^{2+}_{(aq)} + O_{2(g)} + 4H_2O \longrightarrow 2Fe_2O_3 + 8H^+_{(aq)}$

$Fe_2O_3 + xH_2O \longrightarrow Fe_2O_3 \cdot xH_2O$ (Rust)

- The slow eating away of metals when exposed to the atmosphere is called *corrosion*.
- Weakening of iron, due to oxidation of iron atoms, is a well known example of electrochemical corrosion. This is commonly known as *rust i.e.*, $Fe_2O_3 . xH_2O$.

Factors which Promote Corrosion

- **Reactivity of metal :** More active metals are readily corroded.
- **Presence of air and moisture :** Air, moisture and gases like SO_2, CO_2 catalyse the process of corrosion.
- **Presence of impurities :** Pure metals do not corrode.
- **Presence of electrolytes :** Electrolytes in water increase the rate of corrosion.
- **Strains in metals :** Corrosion takes place rapidly at bends, scratches, nicks and cuts in the metal.

Applications of Electrochemical Series

- **To calculate the emf of an electrochemical cell :**
  $E^\circ_{cell} = E^\circ_{right\ (cathode)} - E^\circ_{left\ (anode)}$
  e.g., $Zn \mid Zn^{++} \parallel Ag^+ \mid Ag$
  $E^\circ_{cell} = E^\circ_R - E^\circ_L = 0.80 - (-0.76) = 1.56$ V
- **To compare the relative strengths of oxidising and reducing agents :** The more positive is the value of E°, the better will be the oxidising agent. The more negative is the value of E°, the better will be the reducing agent.
- **To predict the feasibility of reaction :** The feasibility of reaction can be predicted by knowing the net emf of the cell reaction. In general, if E°_{cell} = + ve, the reaction is feasible whereas if E°_{cell} = –ve, the reaction is not feasible as $\Delta G^\circ = -nFE^\circ_{cell}$.
- **To predict whether a metal will react with acid to give H_2 gas :** Any metal placed above the hydrogen is a strong reducing agent and will displace H_2 from a dilute acid, whereas the metals placed below the hydrogen are strong oxidising agent; thus cannot displace H_2 from a dilute acid *e.g.*,
  $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
- **To predict whether a metal will displace another metal from its salt solution or not :** A metal which is placed higher up in the series will displace all metals which are kept below it from solutions of their salts.

Nernst Equation

For a general reaction,

$M^{n+}_{(aq)} + ne^- \longrightarrow M_{(s)}$

Nernst equation can be written as

$$E = E^\circ - \frac{RT}{nF}\ln\frac{[M]}{[M^{n+}]}$$

or $$E = E^\circ - \frac{2.303RT}{nF}\log\frac{[M]}{[M^{n+}]}$$

where E = Reduction potential of electrode

E° = Standard reduction potential of electrode

R = Gas constant (8.314 J K^{-1} mol^{-1})

T = Temperature in Kelvin

F = Faraday (96500 coulombs)

Since concentrations of pure solids and liquids are taken as unity, then

$$E = E^\circ - \frac{2.303RT}{nF}\log\frac{1}{[M^{n+}_{(aq)}]}$$

$$E = E^\circ - \frac{0.0591}{n}\log\frac{1}{[M^{n+}_{(aq)}]}$$

Applications of Nernst Equation

- **To calculate electrode potential of a cell :**
  $aA + bB \xrightarrow{ne^-} xX + yY$
  $$E_{cell} = E^\circ_{cell} - \frac{RT}{nF}\ln\frac{[X]^x[Y]^y}{[A]^a[B]^b}$$
  At 25°C or 298 K,
  $$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n}\log\frac{[X]^x[Y]^y}{[A]^a[B]^b}$$
- **To calculate equilibrium constant**
  At equilibrium, $E_{cell} = 0$
  $$E^\circ_{cell} = \frac{0.0591}{n}\log K_c \text{ at 298 K}$$
- **To calculate Gibb's free energy of reaction**
  $\Delta_r G^\circ = -n\,FE^\circ_{cell}$
  or $\Delta_r G^\circ = -RT\ln K_c = -2.303\,RT\log K_c$

Electrode Potential of a Half-Cell Reaction from Two or More Half-Cell Reactions

Suppose ΔG_1, ΔG_2 are the free energy changes of two half-cell reaction and ΔG_3 is the free energy change of half-cell reaction obtained by adding first two half-cell reaction.

$$\therefore \quad \Delta G_3 = \Delta G_1 + \Delta G_2\,;\ -n_3FE_3 = -n_1FE_1 + (-n_2FE_2)\,;\ E_3 = \frac{n_1E_1 + n_2E_2}{n_3}$$

E_{cell} is an intensive property but $\Delta_r G$ is an extensive thermodynamic property and the value depends on n.

Conductance of Electrolytic Solutions

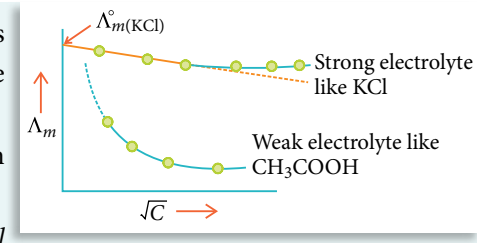
The phenomenon of flow of current due to movement of ions through the solution of an electrolyte is known as electrolytic conduction. It is accompanied with decomposition of the electrolyte.

Property	Formula	Units	Effect of dilution
Conductance (G)	$\frac{1}{R} = \frac{A}{\rho l} = \frac{\kappa A}{l}$	Ohm^{-1} (Ω^{-1})/Siemens (S)	Increases as large number of ions are produced.
Specific conductance (κ) or conductivity	$\frac{1}{\rho}$ or $G\frac{l}{A}$	$Ohm^{-1}\ cm^{-1}$/S cm^{-1}	Decreases as number of ions per cm^3 decreases.
Equivalent conductivity (Λ_{eq})	$\kappa \times V_{eq}$ or $\kappa \times \frac{1000}{N}$	$\Omega^{-1}\ cm^2\ eq^{-1}$/S $m^2\ eq^{-1}$	Increases with dilution due to large increase in V.
Molar conductivity (Λ_m)	$\kappa \times V_m$ or $\kappa \times \frac{1000}{M}$	$\Omega^{-1}\ cm^2\ mol^{-1}$/S $cm^2\ mol^{-1}$	Increases with dilution due to large increase in V.

Variation of Molar Conductivity with Concentration

Molar conductivity increases with decrease in concentration. This is because the total volume of solution containing one mole of electrolyte also increases.

When concentration approaches zero, the molar conductivity is known as *limiting molar conductivity* and is represented by the symbol Λ_m°.



For a strong electrolyte molar conductivity is shown by *Debye-Huckel Onsager* equation as follows :

$$\Lambda_m = \Lambda_m^\circ - A\sqrt{C}$$

Here, Λ_m° = Molar conductivity at infinite dilution (Limiting molar conductivity)

A = Constant which depends upon nature of solvent and temperature

c = Concentration

Plot of Λ_m against $C^{1/2}$ is a straight line with intercept equal to Λ_m° and slope equal to '$-A$'.

Thus, Λ_m decreases linearly with $\sqrt{C}$, when $C \approx 0$, $\Lambda_m^c = \Lambda_m^\circ$ and Λ_m° can be determined experimentally.

For weak electrolytes

There is a very large increase in conductance with dilution especially near infinite dilution as no. of ions increases. Λ_m increases as C decreases but does not reach a constant value even at infinite dilution. Hence, their Λ_m° cannot be determined experimentally.

For strong electrolytes

There is only a small increase in conductance with dilution. This is because a strong electrolyte is completely dissociated in solution and so, the number of ions remain constant and on dilution, inter-ionic attractions decreases as ions move far apart.

Kohlrausch's Law of Independent Migration of Ions

It states that limiting molar conductivity of an electrolyte can be represented as the sum of the individual contributions of the anion and cation of the electrolyte.

$\Lambda^\circ_m = \upsilon_+\lambda^\circ_+ + \upsilon_-\lambda^\circ_-$

Where, λ°_+ and λ°_- are the limiting molar conductivities of the cation and anion respectively and υ_+ and υ_- are stoichiometric no. of cations and anions respectively in one formula unit of the electrolyte.

Applications of Kohlrausch's Law

- **Calculation of molar conductivity of weak electrolytes:**

$$\Lambda^\circ_{m\,(CH_3COOH)} = \lambda^\circ_{CH_3COO^-} + \lambda^\circ_{H^+}$$
$$= \left(\lambda^\circ_{H^+} + \lambda^\circ_{Cl^-}\right) + \left(\lambda^\circ_{CH_3COO^-} + \lambda^\circ_{Na^+}\right) - \left(\lambda^\circ_{Na^+} + \lambda^\circ_{Cl^-}\right)$$
$$= \Lambda^\circ_{m\,(HCl)} + \Lambda^\circ_{m\,(CH_3COONa)} - \Lambda^\circ_{m\,(NaCl)}$$

- **Calculation of degree of dissociation :**

$$\text{Degree of dissociation } (\alpha) = \frac{\Lambda^c_m}{\Lambda^\circ_m}$$
$$= \frac{\text{Molar conductivity at concentration } C}{\text{Molar conductivity at infinite dilution}}$$

- **Calculation of dissociation constant (K_c) of a weak electrolyte :**

	AB	$\rightleftharpoons$	A^+	B^-
Initial conc.	c		0	0
Conc. at eqm.	$(c - c\alpha)$		$c\alpha$	$c\alpha$

$$K_c = \frac{C\alpha \times C\alpha}{(C - C\alpha)} = \frac{C\alpha^2}{(1-\alpha)}$$

- **Calculation of solubility of sparingly soluble salt :**

Solutions are considered saturated at infinite dilution, So that, $\Lambda_m = \Lambda^\circ_m$ and molarity = solubility

$$\text{Thus, } \Lambda^\circ_m = \frac{\kappa \times 1000}{\text{molarity}} = \frac{\kappa \times 1000}{\text{solubility}} \text{ or Solubility} = \frac{\kappa \times 1000}{\Lambda^\circ_m}$$

Electrolysis

It is the process of chemical decomposition of an electrolyte by passage of electric current through its solution.

Faraday's Law of Electrolysis

First Law

The amount of substance deposited during chemical reaction which occurs at any electrode during electrolysis by a current is proportional to the quantity of electricity passed through the electrolyte.

$W \propto Q$ or $W = ZQ = Z \times I \times t$

where, Z is electrochemical equivalent of the substance deposited and unit of Z = kg C^{-1}.

$$\left(Z = \frac{\text{Eq. wt. of substance}}{96500}\right)$$

Second Law

The amount of different substances liberated by the same quantity of electricity passing through the electrolytic solution are proportional to their equivalent weights.

$$W \propto E \quad \text{or,} \quad \frac{W_1}{W_2} = \frac{E_1}{E_2}$$

where, E is the equivalent weight.

Products of Electrolysis

Electrolyte	Products		Reactions involved	
	At cathode	At anode	At cathode	At anode
Molten NaCl	Na metal	Cl_2 gas	$Na^+_{(l)} + e^- \rightarrow Na_{(l)}$	$Cl^-_{(l)} \rightarrow \frac{1}{2}Cl_{2(g)} + e^-$
Aqueous NaCl	H_2 gas	Cl_2 gas	$H_2O_{(l)} + e^- \rightarrow \frac{1}{2}H_{2(g)} + OH^-_{(aq)}$	$Cl^-_{(aq)} \rightarrow \frac{1}{2}Cl_{2(g)} + e^-$
Dil. H_2SO_4	H_2 gas	O_2 gas	$H^+_{(aq)} + e^- \rightarrow \frac{1}{2}H_{2(g)}$	$2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$
Conc. H_2SO_4	H_2 gas	$S_2O^{2-}_{8(aq)}$	$H^+_{(aq)} + e^- \rightarrow \frac{1}{2}H_{2(g)}$	$2SO^{2-}_{4(aq)} \rightarrow S_2O^{2-}_{8(aq)} + 2e^-$

Class XI

Monthly test drive

This specially designed column enables students to self analyse their extent of understanding of all chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Chemical Bonding and Molecular Structure | Hydrogen

Total Marks : 120 **Time taken :** 60 Min.

NEET

Only One Option Correct Type

1. Which of the following statements are correct with respect to molecular orbital theory?
1. Be_2 is not a stable molecule.
2. He_2 is not stable but He_2^+ is expected to exist.
3. Bond strength of N_2 is maximum amongst the homonuclear diatomic molecules, belonging to the second period.
4. The order of energies of molecular orbitals in N_2 molecule is: $\sigma 1s^2 < \sigma 1s^2 < \sigma 2s^2 < \sigma 2s^2 < \sigma 2p_z^2 < \pi 2p_x^2 = \pi 2p_y^2$.

(a) 1, 3 and 4 (b) 2, 3 and 4
(c) 1, 2 and 4 (d) 1, 2 and 3

2. Which theory of inorganic chemistry relates geometry of a molecule with lone pair of electrons on central atom?
(a) Molecular orbital theory
(b) Valence bond theory
(c) VSEPR theory
(d) Werner's theory

3. The outer orbitals of C in ethene molecule can be considered to be hybridized to give three equivalent sp^2 orbitals. The total number of sigma (σ) and pi (π) bonds in ethene molecule is
(a) 3 sigma (σ) and 2 pi (π) bonds
(b) 4 sigma (σ) and 1 pi (π) bonds
(c) 5 sigma (σ) and 1 pi (π) bonds
(d) 1 sigma (σ) and 2 pi (π) bonds.

4. Which of the following order is correct?
(a) $AlCl_3 < MgCl_2 < NaCl$: Polarising power.
(b) $CO > CO_2 > > HCO_2^- > CO_3^{2-}$: Bond length.
(c) $BeCl_2 < NF_3 < NH_3$: Dipole moment.
(d) $H_2S > NH_3 > SiH_4 > BF_3$: Bond angle.

5. Which of the following conditions are correct for resonating structures?
A. The contributing structures must have the same number of unpaired electrons.
B. The contributing structures should have similar energies.
C. The contributing structures should be so written that unlike charges reside on atoms that are far apart.
D. The positive charge should be present on the electropositive element and the negative charge on the electronegative element.
(a) A and B only (b) B and C only
(c) A, B and D only (d) B, C and D only

6. The number of lone pair of electrons on the central atoms of H_2O, $SnCl_2$, PCl_3 and XeF_2, respectively, are
(a) 2, 1, 1, 3 (b) 2, 2, 1, 3
(c) 3, 1, 1, 2 (d) 2, 1, 2, 3.

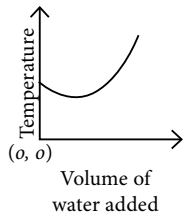
7. Which of the following statements are correct?
A. Ionic bonds are easily formed between elements having comparatively high ionisation enthalpy and low negative values of electron gain enthalpy.
B. Most ionic compounds have cations derived from metals and anions derived from non-metals.
C. In NaCl, the sum of ionisation enthalpy for formation of $Na^+_{(g)}$ and electron gain enthalpy for formation of $Cl^-_{(g)}$ is more than that compensated for the lattice enthalpy of NaCl.

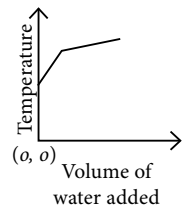
D. Ionic compounds in their molten state consists of orderly three dimensional arrangements of cations and anions held together by coulombic interaction energies.

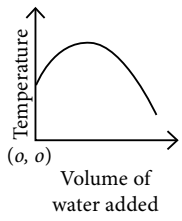
(a) A and B only (b) A, B and C only
(c) B and C only (d) C and D only

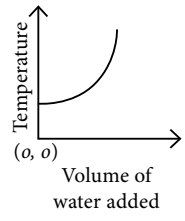
8. Which of the following will have largest bond angle?
(a) H_2O (b) H_2S (c) H_2Se (d) H_2Te

9. When water is stirred with glucose, strong hydrogen bonds are initially formed between glucose molecules and water molecules, but as more water is added, these hydrogen bonds are broken. Which graph represents the observed temperature changes?

(a) 

(b) 

(c) 

(d) 

10. Shapes of ClF_3 and ICl_2^-, respectively are
(a) trigonal pyramidal and irregular tetrahedral
(b) linear and T-shape
(c) T-shape and linear
(d) trigonal planar and linear.

11. The correct order of increasing bond angles in the following triatomic species is
(a) $NO_2^+ < NO_2 < NO_2^-$ (b) $NO_2^+ < NO_2^- < NO_2$
(c) $NO_2^- < NO_2^+ < NO_2$ (d) $NO_2^- < NO_2 < NO_2^+$.

12. The ground state magnetic property of B_2 and C_2 molecules will be
(a) B_2 paramagnetic and C_2 diamagnetic
(b) B_2 diamagnetic and C_2 paramagnetic
(c) both are diamagnetic
(d) both are paramagnetic.

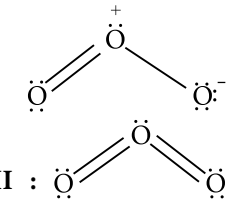
Statement Type

Directions : Each of the given questions contains two statements, statement-I and statement-II. In the light of the given statements, select the correct answer from the options given below.

(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

13. **Statement-I :** All F — S — F angles in SF_4 are greater than 90° but less than 180°.
Statement-II : The lone pair-lone pair repulsion is weaker than bond pair-bond pair repulsion.

14. **Statement-I :** The electronic structure of O_3 is



Statement-II : structure is not allowed because octet around O cannot be expanded.

15. **Statement-I :** The HF_2^- ions exist in the solid and liquid state.
Statement-II : HF shows strong H-bonding in both solid and liquid state.

JEE (Main & Advanced)

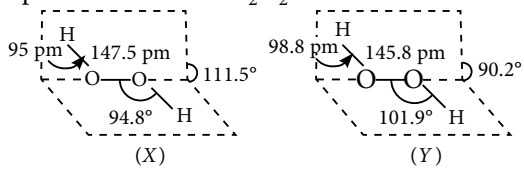
Only One Option Correct Type

16. Which of the following are isostructural pairs?
A. SO_4^{2-} and CrO_4^{2-} B. $SiCl_4$ and $TiCl_4$
C. NH_3 and NO_3^- D. BCl_3 and $BrCl_3$
(a) C and D only (b) B and C only
(c) A and C only (d) A and B only

17. The correct statements among (I) to (IV) are :
I. saline hydrides produce H_2 gas when reacted with H_2O.
II. reaction of $LiAlH_4$ with BF_3 leads to B_2H_6.
III. PH_3 and CH_4 are electron-rich and electron-precise hydrides, respectively.
IV. HF and CH_4 are called as molecular hydrides.
(a) I, II, III and IV (b) III and IV only
(c) I, III and IV only (d) I, II and III only

18. For OF_2 molecule, consider the following :
A. Number of lone pairs on oxygen is 2.
B. FOF angle is less than 104.5°.
C. Oxidation state of O is –2.
D. Molecule is bent or 'V' shaped.
Correct options are
(a) A and C only (b) C and D only
(c) B only (d) A, B and D only

19. Two structures of H_2O_2 are drawn below. Identify the phases *X* and *Y* of H_2O_2.



(a) (*X*) is the structure of H_2O_2 in gas phase and (*Y*) in solid phase.
(b) (*X*) is structure of H_2O_2 in solid phase and (*Y*) in gas phase.
(c) (*X*) and (*Y*) are structures of H_2O_2 in gas phase.
(d) (*X*) and (*Y*) are structures of H_2O_2 in solid phase.

More than One Option Correct Type

20. Amongst the following, the correct statement(s) is/are

(a) NO has one unpaired electron in the antibonding molecular orbital
(b) NO^+ is more stable than O_2^+
(c) Both OF^+ and Ne_2^+ are paramagnetic.
(d) In a π-bond, the electron density is concentrated along the bond axis.

21. Select the incorrect statement(s).

(a) H_2O_2 can be prepared commercially by partial oxidation of 2-propanol.
(b) Old lead paintings regain their original colour by washing with hydrogen peroxide solution.
(c) H_2O_2 has basic properties and behaves as a weak base.
(d) Auto decomposition of H_2O_2 into water and oxygen is accelerated by alcohol.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I		Column II
1. LRUOIFEN	(a)	It halts chemotherapy-targeted cell replication as a square planar platinum(II) coordination complex that forms intrastrand cross-links with DNA purine bases.
2. RDSGERVII	(b)	It is a material that defies gravity through quantum levitation when cooled below its critical temperature to trap magnetic flux lines.
3. ITIALSCPN	(c)	It is a light noble gas that makes up about a quarter of our sun, created through a nuclear fusion process.
4. IOMAMAN	(d)	It is a sweet-tasting, highly viscous liquid used to keep cosmetics moist, but when mixed with nitric acid, it transforms into a volatile dynamite explosive.
5. YEITRP	(e)	It is a volatile, flammable liquid that alchemists called spirit of wine.
6. NHALEOT	(f)	It is a highly corrosive, pale yellow elemental halogen gas used to manufacture the compounds that etch patterns onto glass.
7. RCORNDTCOUSEPU	(g)	It is a molecular cage structure composed of sixty carbon atoms shaped like a soccer ball.
8. MHIULE	(h)	It is a lethal, cyan-coloured crystalline copper salt used by ancient Egyptians as an eyeshadow pigment.
9. EFLETKCNNLRRBISMUUEE	(i)	It is a shimmering crystal made of iron and sulfur that looks so much like real gold that miners historically nicknamed it fools gold.
10. EYLRNIGCE	(j)	It is a pungent, alkaline gas synthesis process developed by Fritz Haber in 1909.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

22. Identify correct statement(s).
(a) Ionic compounds has high melting and boiling points.
(b) CO_2 is less polar than N_2O.
(c) *Ortho*-nitrophenol is more volatile than *para*-nitrophenol.
(d) Ethyl alcohol is more soluble in water than dimethyl ether.

23. Which of the following statements is/are not correct for D_2O?
(a) Its boiling point is higher than H_2O.
(b) The solubility of NaCl in D_2O is more than H_2O.
(c) D_2O reacts faster than H_2O.
(d) The viscosity of D_2O is higher than H_2O at 25°C.

Integer / Numerical Value Type

24. The hybridisation of P exhibited in PF_5 is sp^xd^y. The value of y is _____.

25. Sodium stearate presents in soap react with hard water to form $(C_xH_yCOO)_2M$ (here, M = Ca, Mg). The value of $y - x$ is _____.

26. The difference between bond orders of CO and NO^+ is $x/2$ where x = _____. (Round off to the nearest integer)

Comprehension Type

Hybridisation is defined as the phenomenon of mixing of orbitals of nearly the same energy so as to redistribute their energies and to give rise to new orbitals of equivalent energy. It is the valence shell atomic orbitals of the central atom which get hybridised. One of the electrons from an orbital in the ground state electronic configuration of the atom gets promoted to the next available orbital of higher energy resulting in an excited state electronic configuration with the appropriate number of half filled orbitals. The orbitals in the excited state undergo hybridisation giving hybrid orbitals of equivalent energy. Hybrid orbitals, generally, form either bonds or lone pair of electrons. They do not form π bonds. Hybridised orbitals can overlap in a greater extent due to their greater extension in space. Bonds formed by the overlap of hybrid orbitals gives a particular shape to a molecule. Depending on the type of orbitals used, the hybridisation may be categorised as sp (linear), sp^2 (trigonal planar), sp^3(tetrahedral), sp^3d(trigonal bipyramidal, sp^3d^2(octahedral), sp^3d^3(pentagonal bipyramidal), etc.

27. The state of hybridisation of the central atom and the number of lone pairs over the central atom in $POCl_3$ are
(a) sp, 0 (b) sp^2, 0 (c) sp^3, 0 (d) dsp^2, 1.

28. The strength of bonds formed by s–s, p–p and s–p overlap is in the order of
(a) s–s < s–p < p–p (b) s–s > p–p > s–p
(c) s–p > s–s > p–p (d) p–p > s–s > s–p

Matching Type

29. Match list-I with list-II.

List-I (Species)		List-II (Hybrid Orbitals)	
(A)	SF_4	(i)	sp^3d^2
(B)	IF_5	(ii)	d^2sp^3
(C)	NO_2^+	(iii)	sp^3d
(D)	NH_4^+	(iv)	sp^3
		(v)	sp

Choose the correct answer from the options given below :
(a) (A) – (iii), (B) – (i), (C) – (v) and (D) – (iv)
(b) (A) – (ii), (B) – (i), (C) – (iv) and (D) – (v)
(c) (A) – (iv), (B) – (iii), (C) – (ii) and (D) – (v)
(d) (A) – (i), (B) – (ii), (C) – (v) and (D) – (iii)

30. Match the column-I with column-II and select the correct option.

Column-I (Volume Strength)		Column-II (Normality)	
(A)	10 vol. H_2O_2	1.	17.857 N
(B)	20 vol. H_2O_2	2.	5.357 N
(C)	30 vol. H_2O_2	3.	1.785 N
(D)	100 vol.H_2O_2	4.	3.57 N

(a) A – 1, B – 3, C – 2, D – 4
(b) A – 4, B – 2, C – 3, D – 1
(c) A – 4, B – 3, C – 2, D – 1
(d) A – 3, B – 4, C – 2, D – 1



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SELF CHECK

No. of questions attempted .....
No. of questions correct .....
Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

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Class XII

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Unit 4 The Solid State | Solutions

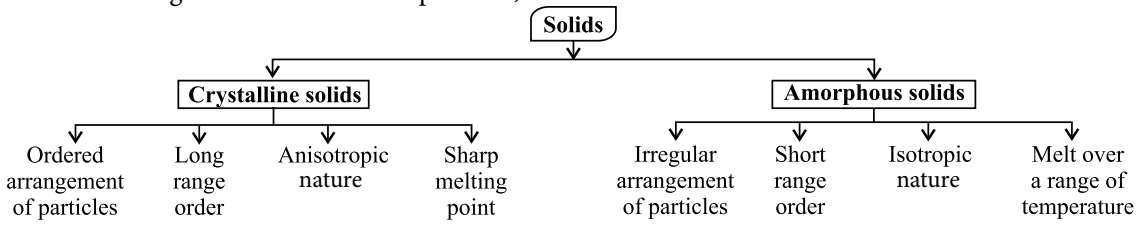
THE SOLID STATE

Introduction

- The solid state represents the physical state of matter in which constituents have no translatory motion, although vibratory or rotational motions are possible about their position in solid lattice.

Types of Solids

On the basis of arrangement of constituent particles, solids are classified as :



Characteristics of Various Types of Crystalline Solids

S.No.	Characteristics	Molecular solids	Ionic solids	Metallic solids	Covalent solids
1.	Constituent particles present in lattice sites	Molecules (Polar or non-polar)	Positive and negative ions	Positive ions in a sea of delocalised electrons	Atoms
2.	Bonding forces	Weak van der Waals forces, or hydrogen bonding	Electrostatic attraction between ions	Electrostatic attraction between cations and sea of electrons (metallic bonds)	Strong covalent bonds
3.	Hardness	Very soft (Only H bonded solids are hard, *i.e.*, H_2O)	Hard	Variable (hard or soft)	Very hard, except graphite which is soft
4.	Brittleness	Low	Brittle	Very low	Medium

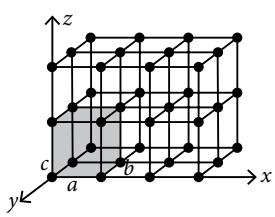
5.	Melting point	Low	High	Fairly high	Very high
6.	Electrical conductivity	Bad conductors	Bad conductors (conductors in molten state or in aqueous solutions)	Good conductors	Bad conductors except graphite
7.	Solubility	Some are soluble and some are insoluble in both polar as well as non-polar solvents	Soluble in polar and insoluble in non-polar solvents	Insoluble in polar as well as non-polar solvents	Insoluble in polar and usually soluble in non-polar solvents
8.	Examples	CH_4, H_2, CO_2, H_2O, sugar, etc.	NaCl, ZnS, KNO_3, CaO, $BaCl_2$, etc.	All metals and alloys	Diamond, graphite, etc.

Crystal Lattice

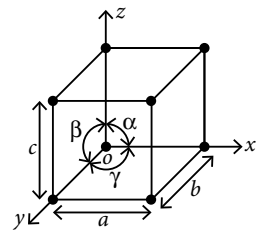
The regular arrangement of an infinite set of points which describes the three-dimensional arrangement of constituent particles (atoms, ions or molecules) in space is called a *crystal lattice* or *space lattice*.

Unit Cell

- The smallest repeating units of space lattice which when repeated over and over again in three-dimension, result into the whole of the space lattice of the crystal is called the *unit cell*.



Representation of space lattice and unit cell (Shaded portion)



Representation of dimensions of unit cell

Crystallographic axes : *ox*, *oy*, *oz*
Interfacial angles : α, β, γ
Primitives : *a*, *b*, *c*

- **Calculation of number of particles per unit cell :**
  Contribution of each atom present at the corner = 1/8
  Contribution of each atom present on the face = 1/2
  Contribution of each atom present on the edge centre = 1/4
  Contribution of each atom present at the body centre = 1

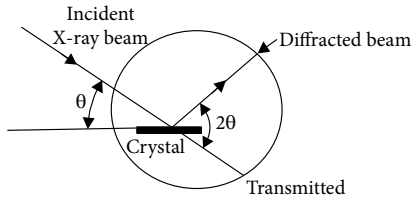
Seven Types of Crystal System

Crystal System	Relative Axial Length	Angles	Examples
Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90°$	NaCl, CsCl, CaF_2, CaO
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	SnO_2, TiO_2, $CaSO_4$
Ortho-rhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	K_2SO_3, KNO_3, $BaSO_4$, $CaCO_3$ (aragonite)
Rhombo-hedral (trigonal)	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$	$CaCO_3$ (calcite), HgS
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°$, $\gamma = 120°$	SiC, CdS, ZnO.
Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90° \neq \beta$	$CaSO_4 \cdot 2H_2O$, $KClO_3$, mono-clinic sulphur
Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$CuSO_4 \cdot 5H_2O$, $K_2Cr_2O_7$

X-Ray Study of Crystals

Bragg's equation

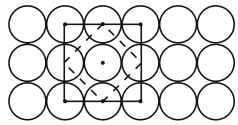
$n\lambda = 2d \sin\theta$, this relation is known as Bragg's equation.
Here; n = An integer (1, 2, 3.....) which represents the serial order of diffracted beam
λ = Wavelength of X-ray used
d = Distance between planes of the constituent particles.
θ = Angle between incident X-rays and plane of the crystal.



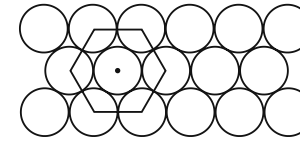
A simple representation of X-ray diffraction

Packing of Constituents in Crystals

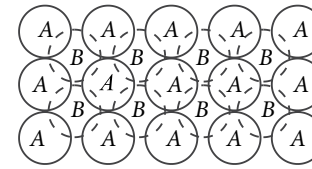
- Constituents of a crystal have tendency to pack as closely as possible to have maximum density and stability.
- Square close packing system has spheres of adjacent rows one over the other, showing a vertical as well as horizontal alignment to form a square.



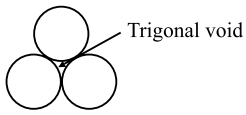
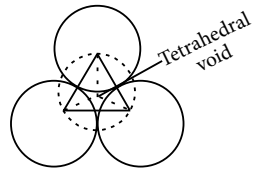
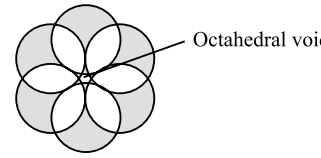
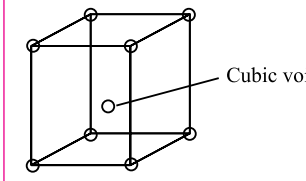
- Hexagonal close packing system has spheres of every second row placed in the depression between spheres of the first row. Subsequently, spheres of third row are vertically aligned with those of the first row.



- Body centred cubic arrangement (*bcc*) is not the closest system, it is obtained when the spheres of the first row (layer) are slightly open and not in contact with each other.



Interstitial Sites in Closed Packed Structure

Trigonal Void	Tetrahedral Void	Octahedral Void	Cubic Void
 Trigonal void is formed at the centre of three spheres.	 Tetrahedral void is formed by covering trigonal voids by spheres of lower layer	 Octahedral void is formed at the centre of six spheres.	 Cubic void is formed at the centre of eight spheres.
$r = 0.155\ R$	$r = 0.225\ R$	$r = 0.414\ R$	$r = 0.732\ R$
where r = radius of void, R = Radius of closely packed spheres			

Characteristics of Voids

- If the no. of closely packed spheres is N, then the no. of octahedral voids is N and the no. of tetrahedral voids is $2N$.
- Decreasing order of the size of the various voids is : Cubic > Octahedral > Tetrahedral > Trigonal

Radius Ratio

$$\text{Radius ratio} = \frac{r_+}{r_-} = \frac{\text{Radius of the cation}}{\text{Radius of the anion}}$$

Relationship between Radius Ratio, Coordination Number and Geometrical Shapes

Radius Ratio	Coordination No.	Structural Arrangement	Structure Type	Examples
0.155 – 0.225	3	Planar triangular	—	B_2O_3
0.225 – 0.414	4	Tetrahedral	Sphalerite, ZnS	CuCl, CuBr, CuI, BaS, HgS

0.414 – 0.732	6	Octahedral	Sodium chloride (Rock salt)	NaBr, KBr, MgO, MnO, CaO, CaS
0.732 – 1.000	8	Body-centred cubic	Caesium chloride	CsI, CsBr, TlBr, NH_4Br

- **Relationship between nearest neighbours distance (d), edge length of unit cell (a) and radius of atom (r) :**

Simple	Face-centred	Body-centred
$d = a$	$d = \frac{\sqrt{2}}{2}a = 0.707a$	$d = \frac{\sqrt{3}}{2}a = 0.866a$
$r = \frac{a}{2}$	$r = \frac{\sqrt{2}}{4}a = 0.3535a$	$r = \frac{\sqrt{3}}{4}a = 0.433a$

Packing Fraction

$$f = \frac{\text{Number of lattice points } (Z) \times \text{ Volume of one sphere in the unit cell}}{\text{Volume of the unit cell } (V)} = \frac{Z \times \frac{4}{3}\pi r^3}{a^3}$$

- **Characteristics of different types of unit cells :**

Type of Unit Cell	Simple or Primitive	Face Centred	Body Centred
Position of particles	Only at the corners	At the corners as well as centre of six faces	At the corners and the body centre
No. of atoms per unit cell	1	4	2
Coordination number	6	12	8
Packing efficiency	52%	74%	68%

Relation between Density and Edge of Cubic Crystals

$$\rho = \frac{Z \times M}{a^3 \times N_A}$$

- **For elements :** Z = No. of atoms/unit cell (1 for simple, 2 for *bcc* and 4 for *fcc*)
where, M = Atomic mass of the element; a = Edge length of the unit cell; N_A = Avogadro's number.
- **For ionic compounds :** Z = No. of formula units in one unit cell *e.g.*, 4 for NaCl and ZnS, 1 for CsCl etc.,
M = Formula mass (molecular mass) of the compound,
a = Edge length = 2 × distance between Na^+ and Cl^- in case of NaCl.

Characteristic Properties of Various Types of Ionic Solids

Type	Crystal	Ions Forming the Close Packed Structure	Ions Present in Voids	Coordination Number	No. of Formula Unit	Examples
AB	ZnS type	S^{2-} ions form *ccp* structure	Zn^{2+} ions in alternate tetrahedral voids	$Zn^{2+} = 4$ $S^{2-} = 4$	4	ZnS, AgI, CuCl, HgS, CuBr, CuI, BeS
AB	NaCl type	Cl^- ions form *ccp* structure	Na^+ ions in all octahedral holes	$Na^+ = 6$ $Cl^- = 6$	4	NaCl, LiCl, KBr, AgBr, MgO, CsI, CaO
AB	CsCl type	*bcc* structure, Cl^- ions are at the corners of a cube	Cs^+ ions at the centre of the cube	$Cs^+ = 8$ $Cl^- = 8$	1	CsBr, CsCl, CsCN, CsI, TlCl, TlBr, TiI, TiCN

AB_2	CaF_2 type (Fluorite)	Ca^{2+} ions form *ccp* structure	F^- ions in all tetrahedral holes	$Ca^{2+} = 8$ $F^- = 4$	4	CaF_2, BaF_2, SrF_2, CdF_2, ThO_2, ZrO_2
A_2B	Na_2O type (Antifluorite structure)	O^{2-} ions form *ccp* structure	Na^+ ions are in all tetrahedral holes	$Na^+ = 4$ $O^{2-} = 8$	4	Na_2O, K_2O, Li_2O, Na_2S

Imperfections in Solids

At absolute zero, crystals tend to have a perfectly ordered arrangement. This arrangement correspond to states of lowest energy. As the temperature increases, the crystals start deviating from the perfectly ordered arrangement. Any deviation from the perfectly ordered arrangement constitutes a defect or imperfection. These defects are sometimes called thermodynamic defects because these defects depends on the temperature.

Types of Imperfections

- **Line defects** — Irregularities from ideal arrangements in entire rows of lattice points.
- **Point defects** — Irregularities from ideal arrangement around a point or an atom in a crystalline substance.
  - Stoichiometric defects
    (1) Vacancy defects
    (2) Interstitial defects
    (a) Frenkel defects
    (b) Schottky defects
  - Non-Stoichiometric defects
    (1) Metal excess defects
    (a) due to anionic vacancy
    (b) due to extra cation
    (2) Metal deficiency defects
  - Impurity defects Pressure of foreign atom in the crystal. Example, introduction of $SrCl_2$, in molten NaCl is the example of impurity defects

Stoichiometric Defects

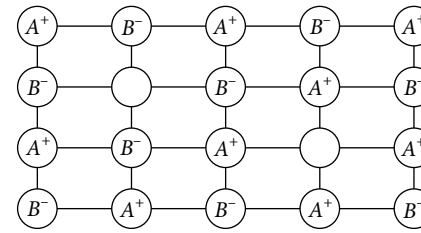
These are the point defects that do not disturb the stoichiometry of the solid. They are also called **intrinsic or thermodynamic defects**. These are of two types: vacancy defects and interstitial defects.

1. **Vacancy defect :** When some of the lattice sites are vacant, the crystal is said to have vacancy defect. This results in decrease in density of the substance. This defect can also develop when a substance is heated.
2. **Interstitial defect :** When some constituent particles (atoms or molecules) occupy an interstitial site, the crystal is said to have interstitial defect. This defect increases the density of the substance.

Vacancy and interstitial defects can be shown by non-ionic solids. Ionic solids must always maintain electrical neutrality. Rather than simple vacancy or interstitial defects, they show these defects as Frenkel defects and Schottky defects.

(i) Schottky Defect

This type of defect is characterised by missing of equal number of cations and anions from their lattice sites so that the electrical neutrality of the system is maintained. This type of defect is shown by 'ionic compounds' with
(a) high coordination number and
(b) small difference in size of positive and negative ions.
Example : NaCl, CsCl, KBr, KCl, AgBr etc.



Consequences of Schottky Defect

(a) Since crystal lattices have lesser number of ions, density of the crystal decreases.
(b) The presence of a number of ionic vacancies lowers lattice energy or the stability of the crystal.

(ii) Frenkel Defect

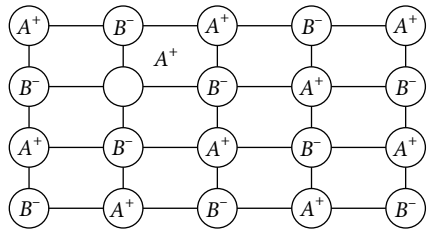
In this type of defect, an ion shifts from its original lattice site to interstitial site, so that electrical neutrality as well as stoichiometry of the compound is maintained. Since cations are smaller in size, so it is generally cations that shift from lattice to interstitial site.

This type of defect is shown by ionic compounds having

(a) large difference in size of cations and anions

(b) highly polarising cations and easily polarisable anions.

Example : ZnS, AgBr, AgI, AgCl, etc.



Consequences of Frenkel Defect

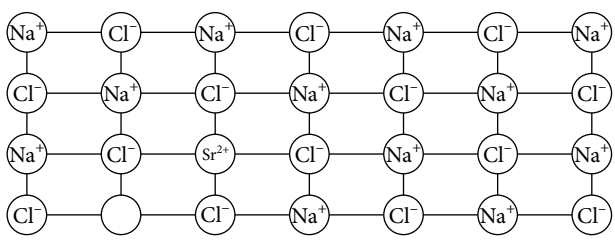
(a) Since no ions are lost from the crystal as a whole, therefore density of the crystal is not affected.

(b) The crystal shows electrical conductivity to a small extent by ionic mechanism.

Impurity Defects

When some foreign atom is present in crystal, the defect is called impurity defect. If the foreign atom is present at lattice site (in place of host atom), the solid is called **substitutional solid solution**, whereas if the impurity is present at vacant interstitial site, the solid is called **interstitial solid solution**.

If molten NaCl containing a little amount of $SrCl_2$ is crystallised, some of the sites of Na^+ ions are occupied by Sr^{2+}. Each Sr^{2+} replaces two Na^+ ions. It occupies the site of one ion and the other site remains vacant. The cationic vacancies thus produced are equal in number to that of Sr^{2+} ions. Another similar example is the solid solution of $CdCl_2$ and AgCl.



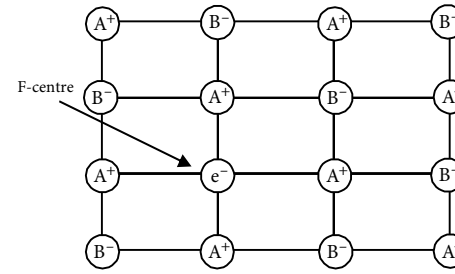
Cation vacancy created by presence of impurity cation

Non-stoichiometric Defects

When the ratio of the cations to the anions becomes different from that indicated by the ideal chemical formula, the defects are called non-stoichiometric defects.

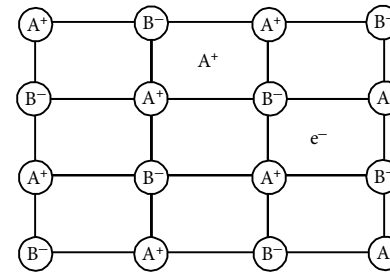
I. Metal excess defect :

- **Due to anionic vacancies** *e.g.*, on heating crystals of NaCl in presence of Na vapour, some anions (Cl^-) leave lattice sites which are occupied by electrons called **F-centres** giving **colour to crystals**.



Metal excess defect due to anion vacancy

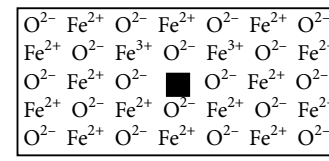
- **Due to presence of extra cations at interstitial sites** *e.g.*, on heating, white ZnO turns yellow as it loses oxygen and Zn^{2+} ions and the electrons occupy interstitial sites.



Metal excess defect due to presence of interstitial cation

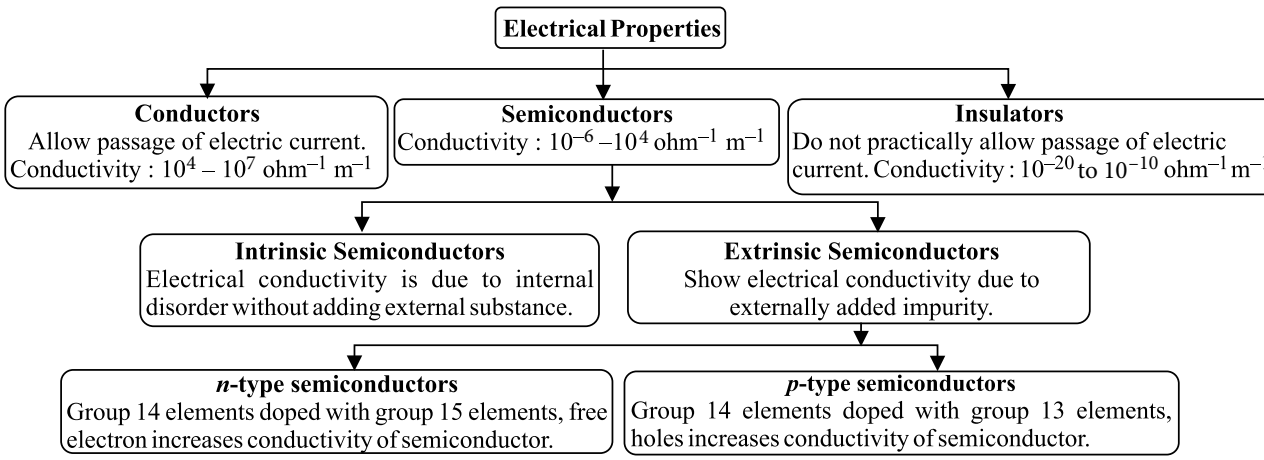
II. Metal deficiency defect :

(i) Cation vacancy: It usually occurs due to missing of a cation from its lattice site and the presence of a cation having higher charge in the adjacent lattice site *e.g.*, in crystals of FeO (which is mostly found with a composition ranging from $Fe_{0.93}O$ to $Fe_{0.96}O$). Some Fe^{2+} cations are missing and the loss of positive charge is made up by the presence of required number of Fe^{3+} ions.



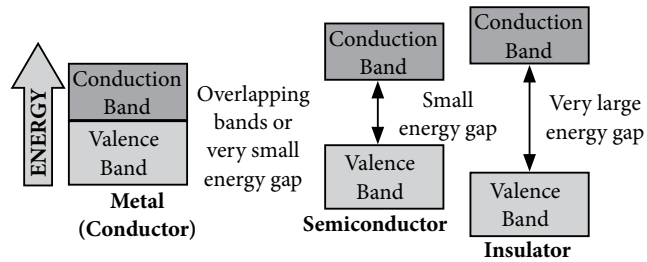
(ii) **Extra Anions Occupying Interstitial Sites:** In such a case the extra negative charge is balanced by extra charges (oxidation of equal number of cations to higher oxidation states) on the adjacent metal ions.

Electrical Properties



Band Theory

In case of semiconductors, the gap between valence band and conduction band is small. Conductivity of semiconductors increases with rise in temperature.



Magnetic and Dielectric Properties

Magnetic Properties	Dielectric Properties
Diamagnetic substances : Substances which are weakly repelled by external magnetic field. *e.g.*, N_2, NaCl, Zn, TiO_2, etc.	**Piezoelectricity or Pressure Electricity :** Electricity produced due to the displacement of ions from their orderly arrangement by the application of mechanical stress. *e.g.*, $PbZrO_3$, $NH_4H_2PO_4$, quartz, etc.
Paramagnetic substances : Substances which are weakly attracted by external magnetic field. *e.g.*, O_2, Cu^{2+}, Fe^{3+}, Cr^{3+}, etc.	**Pyroelectricity :** Some piezoelectric crystals when heated produce a small electric current.
Ferromagnetic substances : Substances which show permanent magnetism even in the absence of external magnetic field. *e.g.*, Ni, Fe, Co, etc.	**Ferroelectricity :** Certain piezoelectric crystals show permanent alignment of dipoles even in the absence of electric field. *e.g.*, Rochelle salt, $BaTiO_3$.
Antiferromagnetic substances : Substances which have zero net dipole moment even though they are having large number of unpaired electrons. *e.g.*, MnO.	**Antiferroelectricity :** In some crystals, equal number of dipoles are oriented in opposite directions so that the crystal does not possess net dipole moment. *e.g.*, lead zirconate ($PbZrO_3$).
Ferrimagnetic substances : These are the substances which possess very small net magnetic moment even though they are having a large number of unpaired electrons. *e.g.*, Fe_3O_4.	

SOLUTIONS

Introduction

A solution is a homogeneous mixture of two or more substances whose composition varies within certain limits.

Components of Solutions

The substances that make up a homogeneous solution are called the components of solution. A binary solution has two components. A ternary solution has three components. A quaternary solution has four components.

- **Solute:** The component present in smaller amount in a solution is known as solute.
- **Solvent:** The component present in larger amount in a solution is known as solvent.

Types of Solutions

Types of solutions on the basis of physical states of solute and solvent

Solute	Solvent	Example
Gas	Gas	Mixture of gases (air)
Liquid	Gas	Water vapour in air (humidity)
Solid	Gas	Sublimation of a solid (*e.g.*, camphor) into a gas, dust or smoke particles in air
Gas	Liquid	CO_2 gas dissolved in water
Liquid	Liquid	Mixture of miscible liquids (*i.e.* alcohol in water)
Solid	Liquid	Salt in water, sugar in water
Gas	Solid	Phenomenon of adsorption of gases over metals (*i.e.*, hydrogen over palladium)
Liquid	Solid	Mercury in copper, mercury in gold
Solid	Solid	Homogeneous mixture of two or more metals *i.e.*, alloys (*e.g.*, copper in gold, zinc in copper), coloured stones, gems, etc.

Depending upon the amount of solute dissolved in a solvent, we have the following types of solutions :

1. The point at which a liquid cannot dissolve more of the solute at a constant temperature is called saturation point and such a solution is called **saturated solution**.
2. A solution may sometimes contains more solute than would be necessary to saturate it at a given temperature. Such a solution is called **supersaturated solution**.
3. A solution in which more of the solute can be dissolved at a given temperature is called **unsaturated solution**.

On the basis of concentration of solutions

The concentration of a solution is defined as the relative amount of solute present in a solution. On the basis of concentration of solution, there are two types of solutions:

(i) Dilute Solution: Solution containing relatively very small quantity of solute.

(ii) Concentrated solution: Solution containing relatively very large quantity of solute.

Methods of Expressing the Concentration of a Solution

The concentration of a solution can be expressed in a number of ways. The important methods are:

Mass percentage, $\left(\frac{w}{W}\right)\% = \frac{w_2}{(w_1 + w_2)} \times 100$

Volume percentage, $\left(\frac{v}{V}\right)\% = \frac{V_2}{(V_1 + V_2)} \times 100$

Mass by volume percentage, $\left(\frac{w}{V}\right)\% = \frac{w_2}{V_{\text{solution}}\,(\text{in mL})} \times 100$

Strength (g L^{-1}) $= \frac{w_2\,(\text{in g})}{V_{\text{solution}}\,(\text{in mL})} \times 1000$

Mass fraction, $\left(\frac{w}{W_{\text{total}}}\right) \Rightarrow x_1 = \frac{w_1}{w_1 + w_2}$ or $x_2 = \frac{w_2}{w_1 + w_2}$

Parts per million (ppm) $= \frac{w_2}{(w_1 + w_2)} \times 10^6$

Molarity, (M) (mol L^{-1}) $= \frac{w_2 \times 1000}{M_2 \times V_{\text{solution}}\,(\text{in mL})}$

Molality, (m) (mol kg^{-1}) $= \frac{w_2 \times 1000}{M_2 \times w_1\,(\text{in g})}$

Normality, (N) (g-eq L^{-1}) $= \frac{w_2 \times 1000}{E_2 \times V_{\text{solution}}\,(\text{in mL})}$

Mole fraction, (x) $\Rightarrow x_1 = \frac{n_1}{n_1 + n_2}$ or $x_2 = \frac{n_2}{n_1 + n_2}$, and $x_1 + x_2 = 1$

Solubility

Solubility of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.

Solubility of a Solid in a Liquid

Solubility of a solid in a liquid can be defined as the maximum amount of solid (solute) in grams dissolved in 100 g of the liquid (solvent) to form a saturated solution at a given temperature.

Factors affecting the solubility of a solid in a liquid

- **Nature of solute and solvent :** There is a general rule 'like dissolves like' which explains that ionic solids (*e.g.,* NaCl) dissolve in polar solvents like water and are less soluble or insoluble in non-polar solvents like benzene, CCl_4, etc. Similarly, non-ionic or covalent compounds (*e.g.,* I_2) dissolve readily in non-polar solvents but are less soluble or insoluble in polar solvents.
- **Temperature :** If the dissolution process is endothermic**,** the solubility increases continuously with increase in temperature, *e.g.,* $NaNO_3$, KNO_3, NaCl, KCl, etc.
  If the dissolution process is exothermic then solubility decreases continuously with increase of temperature, *e.g,* cerium sulphate, Li_2CO_3, $Na_2CO_3{\cdot}H_2O$
  This is in accordance with Le-Chatelier's principle.
- **Pressure :** Pressure has very little effect on the solubility of a solid in a liquid because solids and liquids are highly incompressible.

Solubility of a Gas in a Liquid

Gases are generally soluble in liquid. Oxygen is sufficiently soluble in water to support aquatic life. Similarly CO_2 and NH_3 are highly soluble

Factors affecting solubility of a gas in a liquid

- **Nature of the gas :** The gases which can be easily liquefied are more soluble in aqueous solvents.
- **Nature of the liquid (solvent) :** The gases which are capable of forming ions in aqueous solutions are much more soluble in water than in other solvents.
- **Temperature of the solution :** It has been found that under constant pressure, the solubility of a gas decreases with rise in temperature. However, some gases are more soluble at higher temperature than at lower temperature..
- **Pressure of the gas over the solution :** Solubilities of gases in liquids vary considerably with pressure which can be explained by Henry's law.

Henry's law

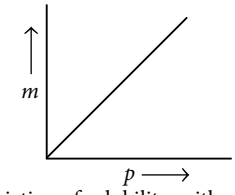
Henry was the first who gave a quantitative relation between pressure and solubility of a gas in a solvent. This law states that "the mass of gas dissolved per unit volume of the solvent at a given temperature is proportional to the pressure of the gas in equilibrium with the solution."

i.e., $m \propto p$; $m = K_H{\cdot}p$

where, K_H = Proportionality constant which is called Henry's constant.

K_H depends on the nature of the gas, nature of the solvent, temperature and unit of pressure.

The plot of *m vs p* is a straight line passing through the origin.



Variation of solubility with pressure

- Greater the value of K_H, lower is the solubility of the gas at the same partial pressure at a particular temperature.
- The value of K_H increases with increase of temperature implying that the solubility decreases with increase in temperature at the same pressure.

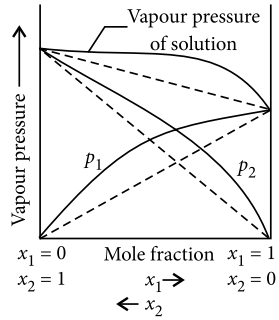
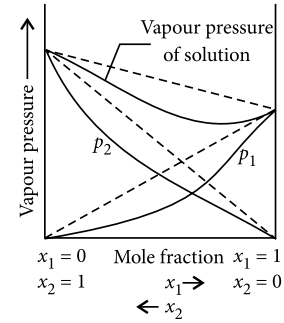
Vapour Pressure of Solutions and Raoult's Law

- **Vapour pressure of liquid-liquid solutions :** Raoult's Law states that for a solution of volatile liquids, the partial vapour pressure of each component of the solution is directly proportional to its mole fraction present in solution.
  $P_{total} = p_1 + p_2 = x_1p_1^\circ + x_2p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ)x_2$
- **Vapour pressure of solutions of solids in liquids :** Vapour pressure of the solution at a given temperature is lower than the vapour pressure of the pure solvent at the same temperature.

Ideal and Non-ideal Solutions

Ideal Solutions	Non-ideal Solutions
Obey Raoult's law at all temperatures and concentrations.	Do not obey Raoult's law at all temperatures and concentrations.
$p_1 = x_1 p_1^\circ$; $p_2 = x_2 p_2^\circ$	$p_1 \neq x_1 p_1^\circ$; $p_2 \neq x_2 p_2^\circ$
$\Delta H_{mix} = 0$, $\Delta V_{mix} = 0$	$\Delta H_{mix} \neq 0$, $\Delta V_{mix} \neq 0$
$A - B$ interactions $\approx$ $A - A$ and $B - B$ interactions.	$A - B$ interactions $\neq$ $A - A$ and $B - B$ interactions.
Do not form azeotropes (constant boiling mixtures).	Form azeotropes.

Non-ideal Solutions showing Positive and Negative Deviations from Raoult's Law

Solutions showing Positive Deviation	Solutions showing Negative Deviation
$A - B << A - A$ or $B - B$ interactions	$A - B >> A - A$ or $B - B$ interactions
$\Delta H_{mix} > 0$, $\Delta V_{mix} > 0$	$\Delta H_{mix} < 0$, $\Delta V_{mix} < 0$
$p_i > p_i^\circ x_i$	$p_i < p_i^\circ x_i$
form minimum boiling azeotropes	form maximum boiling azeotropes
Examples : Ethanol and acetone, carbon disulphide and acetone, methanol and water, cyclohexanol and cyclohexane. 	Examples : Phenol and aniline, chloroform and acetone, chloroform and diethyl ether, chloroform and benzene, water and HNO_3 or HCl. 

Azeotropes

The mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of components in liquid as well as vapour phase are called **constant boiling mixtures** or **azeotropic mixtures**.

I. **Minimum boiling azeotropes :** They formed by those liquid pairs which show positive deviations from ideal behaviour *e.g.*, ethanol-water mixture.

II. **Maximum boiling azeotropes :** They are formed by those liquid pairs which show negative deviations from ideal behaviour *e.g.*, nitric acid-water mixture.

Colligative Properties

Colligative properties are the properties which depend only on the number of solute particles dissolved in a definite amount of the solvent and do not depend on the nature of the solute. These are :

I. Relative Lowering of Vapour Pressure :

When a non-volatile solute is dissolved in a solvent, vapour pressure of the solution is lower than that of the pure solvent which is known as lowering of vapour pressure. Relative lowering of vapour pressure is equal to the mole fraction of the solute in the solution.

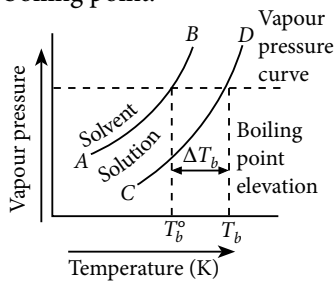
By Raoult's law,

$$\frac{p_1^\circ - p_1}{p_1^\circ} = x_2 = \frac{n_2}{n_1 + n_2} \text{ or } \frac{p_1^\circ - p_1}{p_1^\circ} = \frac{n_2}{n_1} = \frac{w_2 \times M_1}{M_2 \times w_1}$$

($\because$ for dilute solutions, $n_2 << n_1$)

II. Elevation in Boiling Point

The boiling point of a solution containing a non-volatile solute is always higher than the boiling point of the pure solvent. This increase in boiling point is termed as elevation in boiling point.



$\Delta T_b = T_b - T_b^\circ$

$\Delta T_b \propto m$ or $\Delta T_b = K_b m$

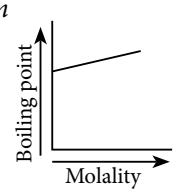
$$\Delta T_b = K_b \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right) \text{ or } M_2 = \frac{K_b \times w_2 \times 1000}{\Delta T_b \times w_1 (\text{in g})}$$

K_b is called boiling point elevation constant or molal elevation constant or Ebullioscopic constant, having unit K kg mol^{-1}.

$\Delta T_b = K_b\, m$

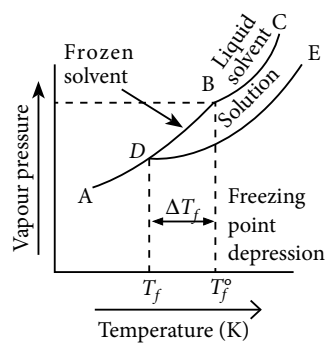
or, $T_b - T_b^\circ = K_b m \implies T_b = T_b^\circ + K_b m$

Thus plot T_b *vs.* molality (m) will be linear with positive slope (= K_b), showing that boiling point of solution increases linearly with molality.



III. Depression in Freezing Point

The freezing point of a solution containing a non-volatile solute is always less than the freezing point of the pure solvent. This decrease in freezing point is termed as depression in freezing point.



$\Delta T_f = T_f^\circ - T_f$

$\Delta T_f \propto m$ or $\Delta T_f = K_f m$

$$\Delta T_f = K_f \left(\frac{w_2 \times 1000}{M_2 \times w_1 (\text{in g})} \right)$$

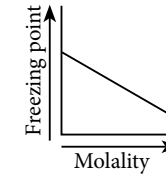
or $M_2 = \dfrac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1 (\text{in g})}$

K_f is known as freezing point depression constant or molal depression constant or cryoscopic constant, having unit K kg mol^{-1}.

$\Delta T_f = K_f m$

or, $T_f^\circ - T_f = K_f m \implies T_f = T_f^\circ - K_f m$

Thus plot of T_f *vs.* molality (m) will be linear with negative slope (= $-K_f$), showing that freezing point of solution decreases linearly with molality.



Calculation of Molal Elevation Constant (K_b) and Molar Depression Constant (K_f) :

$$K_b = \frac{MRT_b^2}{\Delta H_{vap} \times 1000}; \; K_f = \frac{MRT_f^2}{\Delta H_{fus} \times 1000}$$

where, ΔH_{vap} = Enthalpy of vaporisation

ΔH_{fus} = Enthalpy of fusion,

R = Gas constant,

M = Molar mass of solvent

IV. Osmotic Pressure

The net spontaneous flow of the solvent molecules from the solvent to the solution or from a less concentrated solution to a more concentrated solution through a semipermeable membrane is called **osmosis**.

The minimum excess pressure that has to be applied on the solution to prevent the entry of the solvent into the solution through the semipermeable membrane is called the osmotic pressure.

$$\pi = CRT = \left(\frac{n_2}{V} \right) RT \,, \; \pi V = \frac{w_2 RT}{M_2}$$

or $M_2 = \dfrac{w_2 RT}{\pi V}$

Based upon the osmotic pressure, solutions can be divided into following three categories –

Isotonic solutions
If two solutions of different substances have same osmotic pressure at same temperature.

Hypertonic solutions
If a solution has higher osmotic pressure than the other solution.

Hypotonic solutions
If a solution has lower osmotic pressure than the other solution.

Exosmosis and endosmosis : When the semipermeable membrane permits the solvent molecules to come out through the membrane, it is called exosmosis. When the membrane permits the solvent molecules to enter inside, it is called endosmosis.

Reverse osmosis : If a pressure higher than the osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semipermeable membrane and the process is called **reverse osmosis**. It is used in **desalination of sea water**.

VAN'T HOFF FACTOR

- It is defined as the ratio of the experimental value of the colligative property to the calculated value of the colligative property.

$$i = \frac{\text{Observed value of the colligative property}}{\text{Calculated value of the colligative property}}$$

$$i = \frac{\text{Calculated molecular mass}}{\text{Observed molecular mass}}$$

$$i = \frac{\text{Total number of moles of particles after association/dissociation}}{\text{Number of moles of particles before association/dissociation}}$$

For association, $i < 1$; For dissociation, $i > 1$

- **Relation between van't Hoff factor and degree of dissociation :** $\alpha = \frac{i-1}{n-1}$
- **Relation between van't Hoff factor and degree of association :** $\alpha = \frac{i-1}{\frac{1}{n}-1}$
- **Modified equations for colligative properties :**

$$\frac{p_A^\circ - p_A}{p_A^\circ} = i \cdot \frac{n_B}{n_A},$$

$$\Delta T_b = iK_b\, m,\ \Delta T_f = iK_f m,\ \pi = i\, n_B RT/V$$

Significance of van't Hoff factor (*i*)

With the help of value of (i), we can determine the value of degree of dissociation or association (α) for an electrolyte.

WRAP it up!

MULTIPLE CHOICE QUESTIONS

1. A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm of Hg at 300 K. The vapour pressure of propyl alcohol is 200 mm of Hg. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm Hg) at the same temperature will be

(a) 360 (b) 350
(c) 300 (d) 700

2. Select the correct statements.

(I) Crystalline solids have long range order.
(II) Crystalline solids are isotropic.
(III) Amorphous solids are sometimes called pseudo solids.
(IV) Amorphous solids soften over a range of temperatures.
(V) Amorphous solids have a definite heat of fusion.

Choose the most appropriate answer from the options given below.

(a) (III), (IV) only
(b) (I), (II), (V) only
(c) (I), (III) and (IV) only
(d) (II) and (IV) only

3. The density of 10.0% by mass KCl solution in water is 1.06 g cm^{-3}. Its molarity is

(a) 1.489 M (b) 1.420 M
(c) 1.420 mol kg^{-1} (d) 1.489 mol kg^{-1}

4. Match the column-I (type of crystalline solid) with the column-II (example for each type) :

Column-I		Column-II	
P.	Molecular solid	(i)	SiC
Q.	Ionic solid	(ii)	Mg
R.	Metallic solid	(iii)	H_2O
S.	Network solid	(iv)	MgO

(a) P-(iii), Q-(i), R-(ii), S-(iv)
(b) P-(iv), Q-(iii), R-(ii), S-(i)
(c) P-(ii), Q-(iv), R-(iii), S-(i)
(d) P-(iii), Q-(iv), R-(ii), S-(i)

5. Which among the following statements is not true about covalent or network solid?
   (a) The atoms in this solid are linked by covalent bonds.
   (b) In this solid, the constituent particles are atoms.
   (c) These are soft in nature.
   (d) Covalent solids have high melting points.

6. Which of the following statements is correct?
   (a) Lowering of vapour pressure takes place only in ideal solutions.
   (b) Lowering of vapour pressure does not depend upon the solvent at a given concentration of the solute.
   (c) Solvents with higher boiling points have higher vapour pressure.
   (d) Relative lowering of vapour pressure does not depend upon the solvent at a given concentration of the solute.

7. If a, b, c are the lengths of three edges of unit cell, α is the angle between side b and c, β is the angle between side a and c and γ is the angle between side a and b, what is the Bravais Lattice dimensions of a tetragonal crystal?
   (a) $a = b = c$ and $\alpha = \beta = \gamma = 90°$
   (b) $a = b \neq c$ and $\alpha = \beta = \gamma = 90°$
   (c) $a = b = c$ and $\alpha = \beta = \gamma \neq 90°$
   (d) $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$

8. Match the list-I with list-II and select the correct answer using the codes given below the lists.

List-I		List-II	
(A)	10.6 g Na_2CO_3 dissolved in 100 mL solution (density = 1.06 g mL^{-1})	(p)	0.1 M
(B)	34.2 g L^{-1} sucrose solution (density = 1.0342 g mL^{-1})	(q)	1 M
(C)	9.8% H_2SO_4 solution (density = 1.25 g mL^{-1})	(r)	1.25 M
(D)	20% aqueous ethanol solution by volume (density = 0.938 g mL^{-1})	(s)	3.0 M

   (a) A-p; B-q; C-r; D-s (b) A-q; B-p; C-s; D-r
   (c) A-q; B-r; C-p; D-s (d) A-q; B-p; C-r; D-s

9. A binary liquid solution is prepared by mixing n-heptane and ethanol. Which one of the following statements is correct regarding the behaviour of the solution?
   (a) The solution formed is an ideal solution.
   (b) The solution is non-ideal, showing +ve deviation from Raoult's law.
   (c) The solution is non-ideal, showing –ve deviation from Raoult's law.
   (d) n-heptane shows +ve deviation while ethanol shows –ve deviation from Raoult's law.

10. How many number of atoms are there in a cube based unit cell, having one atom on each corner and 2 atoms on each body diagonal of cube?
   (a) 4 (b) 9 (c) 8 (d) 6

11. Which of the following has been arranged in the increasing order of freezing point?
   (a) 0.025 M KNO_3 < 0.1 M NH_2CSNH_2 < 0.05 M $BaCl_2$ < 0.1M NaCl
   (b) 0.1 M NaCl < 0.05 M $BaCl_2$ < 0.1 M NH_2CSNH_2 < 0.025 M KNO_3
   (c) 0.1 M NH_2CSNH_2 < 0.1 M NaCl < 0.05 M $BaCl_2$ < 0.025 M KNO_3
   (d) 0.025 M KNO_3 < 0.05 M $BaCl_2$ < 0.1 M NaCl < 0.1 M NH_2CSNH_2

12. van't Hoff factors of equimolal solutions of sodium chloride, barium chloride and glucose in water are
   (a) 2, 3, 0 respectively (b) 2, 3, 6 respectively
   (c) 2, 3, 4 respectively (d) 2, 3, 1 respectively.

13. **Statement-I :** Iodine is more soluble in CCl_4 than in water.
   Statement-II : Non-polar solutes are more soluble in non-polar solvents.
   (a) Both statement-I and statement-II are correct.
   (b) Statement-I is correct but statement-II is incorrect.
   (c) Both statement-I and statement-II are incorrect.
   (d) Statement-I is incorrect but statement-II is correct.

14. What are the coordination numbers (C.N.) of Ca^{2+} and F^- ion in calcium fluoride (CaF_2) crystal structure?
   (a) C.N. of Ca^{2+} = 4 and F^- = 8
   (b) C.N. of Ca^{2+} = 6 and F^- = 6
   (c) C.N. of Ca^{2+} = 8 and F^- = 8
   (d) C.N. of Ca^{2+} = 8 and F^- = 4

15. A gaseous mixture contains 70.6 g O_2 and 167.5 g neon. If pressure of the mixture in the cylinder is 25 bar, what is partial pressure of O_2 and Ne in the mixture? (At. wt. of Ne = 20)
   (a) 5.2 bar, 19.79 bar
   (b) 19.75 bar, 5.25 bar
   (c) 52.5 bar, 19.75 bar
   (d) 5.25 bar, 197.5 bar

16. The following solutions were prepared by dissolving 10 g of glucose ($C_6H_{12}O_6$) in 250 mL of water (P_1). 10 g of urea (CH_4N_2O) in 250 mL of water (P_2) and 10 g of sucrose ($C_{12}H_{22}O_{11}$) in 250 mL of water (P_3). The right option for the decreasing order of osmotic pressure of these solutions is

(a) $P_3 > P_1 > P_2$ (b) $P_2 > P_1 > P_3$

(c) $P_1 > P_2 > P_3$ (d) $P_2 > P_3 > P_1$

17. **Statement-I :** In the body-centred cubic structure of CsCl the arrangement of Cl^- is primitive.

Statement-II : In the CsCl, the Cs^+ ion remains at body-centered position and Cl^- at corners.

(a) Both statement-I and statement-II are correct.

(b) Statement-I is correct but statement-II is incorrect.

(c) Both statement-I and statement-II are incorrect.

(d) Statement-I is incorrect but statement-II is correct.

18. The correct statement regarding defect in solids is

(a) Schottky defect has no effect on the physical properties of solids

(b) Frenkel defect is a dislocation defect

(c) Frenkel defect is usually favoured by a very small difference in the sizes of cations and anions

(d) trapping of proton in the lattice leads to the formation of F-centers.

19. The freezing point depression constant for water is 1.86 °C m^{-1}. If 5.00 g Na_2SO_4 is dissolved in 45.0 g H_2O, the freezing point is changed by –3.82°C. Calculate the van't Hoff factor for Na_2SO_4.

(a) 2.05 (b) 2.63 (c) 3.11 (d) 0.381

20. Addition of a non-volatile solute in a volatile ideal solvent

(a) increases the vapour pressure of the solvent

(b) decreases the vapour pressure of the solvent

(c) decreases the boiling point of the solvent

(d) increases the freezing point of the solvent.

NUMERICAL VALUE TYPE QUESTIONS

21. Molality of an aqueous solution of urea is 4.44 m. Mole fraction of urea in solution is $x \times 10^{-3}$. Value of x is _____. (Integer answer)

22. At 20 °C, the vapour pressure of benzene is 70 torr and that of methyl benzene is 20 torr. The mole fraction of benzene in the vapour phase at 20 °C above an equimolar mixture of benzene and methyl benzene is _____ $\times 10^{-2}$. (Nearest Integer)

23. Ionic radii of cation A^+ and anion B^- are 102 and 181 pm respectively. These ions are allowed to crystallize into an ionic solid. This crystal has cubic close packing for B^-. A^+ is present in all octahedral voids. The edge length of the unit cell of the crystal AB is _____ pm. (Nearest Integer)

24. The osmotic pressure of a solution of NaCl is 0.10 atm and that of a glucose solution is 0.20 atm. The osmotic pressure of a solution formed by mixing 1 L of the sodium chloride solution with 2 L of the glucose solution is $x \times 10^{-3}$ atm. x is _____. (nearest integer)

25. The unit cell of copper corresponds to a face centered cube of edge length 3.596 Å with one copper atom at each lattice point. The calculated density of copper in kg/m^3 is _____. [Molar mass of Cu : 63.54 g ; Avogadro Number = 6.022×10^{23}]

SOLUTIONS

1. **(b) :** According to Raoult's law,

$$P = p_A + p_B = p_A^\circ x_A + p_A^\circ x_B$$

or $290 = p_A^\circ \times (0.6) + 200 \times (1 - 0.6)$

or $290 = 0.6 \times p_A^\circ + 0.4 \times 200 \Rightarrow p_A^\circ = 350$ mm Hg

2. **(c)**

3. **(b) :** Mass of 1 litre solution = 1000 × 1.06 = 1060 g

Amount of KCl in solution = $1060 \times \frac{10}{100} = 106$ g

Molarity $= \frac{106}{74.5} \times \frac{1000}{1000} = 1.42$ M or 1.42 mol L^{-1}

4. **(d) :**

Column-I		Column-II	
P.	Molecular solid	(iii)	H_2O
Q.	Ionic solid	(iv)	MgO
R.	Metallic solid	(ii)	Mg
S.	Network solid	(i)	SiC

5. **(c) :** Covalent network solids are very hard in nature.

6. **(d)** 7. **(b)** 8. **(d)**

9. **(b) :** The solution containing *n*-heptane and ethanol shows non-ideal behaviour with positive

deviation from Raoult's law. This is because the ethanol molecules are held together by strong H-bonds, however the forces between *n*-heptane and ethanol are not very strong, as a result they easily vapourise showing higher vapour pressure than expected.

10. (b)

11. (b): Greater is the effective molarity ($i \times C$), higher the ΔT_f value and lower the freezing point.

12. (d): $NaCl_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$, $i = 2$

$BaCl_{2(aq)} \longrightarrow Ba^{2+}_{(aq)} + 2Cl^-_{(aq)}$, $i = 3$

Glucose does not undergo dissociation or association hence, $i = 1$.

13. (a)

14. (d): Each Ca^{2+} ion is surrounded by 8 F^- ions and each F^- ion by 4 Ca^{2+} ions. Thus, coordination number of Ca^{2+} is 8 and F^- is 4.

15. (a): $n_{O_2} = \frac{70.6}{32} = 2.2$; $n_{Ne} = \frac{167.5}{20} = 8.375$

Mole fraction of O_2 in vapour phase,

$$x_{O_2} = \frac{n_{O_2}}{n_{O_2} + n_{Ne}} = \frac{2.2}{2.2 + 8.375} = 0.2080$$

Mole fraction of Ne in vapour phase,

$$x_{Ne} = \frac{n_{Ne}}{n_{O_2} + n_{Ne}} = \frac{8.375}{2.2 + 8.375} = 0.7919$$

Given, total pressure, $P = 25$ bar;

$$x_{O_2} = \frac{p_{O_2}}{P} \quad \therefore \ 0.2080 = \frac{p_{O_2}}{25} \Rightarrow p_{O_2} = 5.2 \text{ bar}$$

$$x_{Ne} = \frac{p_{Ne}}{P} \quad \therefore \ 0.7919 = \frac{p_{Ne}}{25} \Rightarrow p_{Ne} = 19.79 \text{ bar}$$

16. (b): Osmotic pressure (π) = CRT

$\therefore \quad \pi \propto C$

For glucose solution, $C_1 = \frac{10}{180} \times \frac{1000}{250} = 0.22$ M

For urea solution, $C_2 = \frac{10}{60} \times \frac{1000}{250} = 0.66$ M

For sucrose solution, $C_3 = \frac{10}{342} \times \frac{1000}{250} = 0.117$ M

Hence, order of osmotic pressure is $P_2 > P_1 > P_3$.

17. (a) **18. (b)**

19. (b): We know that $\Delta T_f = i \times K_f \times \frac{w_B \times 1000}{M_B \times w_A}$

Given : $\Delta T_f = 3.82$, $K_f = 1.86$

$w_B = 5$, $M_B = 142$, $w_A = 45$

$$i = \frac{\Delta T_f \times M_B \times w_A}{K_f \times w_B \times 1000} = \frac{3.82 \times 142 \times 45}{1.86 \times 5 \times 1000} = 2.63$$

20. (b)

21. (74) : Molality = 4.44 m, means 4.44 moles of urea is present in 1 kg of solvent (*i.e.*, water).

No. of moles of water = $\frac{1000}{18} = 55.55$ mol

Mole fraction of urea = $\frac{4.44}{55.55 + 4.44}$

$= 0.074 = 74 \times 10^{-3}$

Value of $x = 74$

22. (78) : $p_{Total} = p^\circ_{Benzene} x_{Benzene} + p^\circ_{Toluene} x_{Toluene}$

$= (70)\frac{1}{2} + (20)\frac{1}{2} = 35 + 10 = 45$

$p_{Benzene} = p_{Total} y_{Benzene}$

$$y_{Benzene} = \frac{70 \times \frac{1}{2}}{45} = \frac{35}{45} = 0.777 \approx 0.78 = 78 \times 10^{-2}$$

23. (566) : For *ccp* lattice, $r^+ + r^- = \frac{a}{2}$

$a = 2(r^+ + r^-)$

$a = 2(102 + 181)$

$a = 2 \times 283 = 566$ pm

24. (167) : On mixing two solutions,

$$\pi_{final} = \frac{\pi_1 V_1 + \pi_2 V_2}{V_1 + V_2} = \frac{0.1 \times 1 + 0.2 \times 2}{3}$$

$= 0.1667$ or 167×10^{-3}

Thus, $x = 167$

25. (9076) : For *fcc*, $Z = 4$

$$d = \frac{Z \times M}{N_A \times a^3} = \frac{4 \times 63.54}{6.022 \times 10^{23} \times (3.596 \times 10^{-10})^3 \times 1000}$$

$= 9076.2 \approx 9076$ kg/m^3

◈◈

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

1. (d)	**2.** (a)	**3.** (b)	**4.** (b)	**5.** (c)
6. (d)	**7.** (b)	**8.** (a)	**9.** (b)	**10.** (c)
11. (d)	**12.** (c)	**13.** (c)	**14.** (d)	**15.** (c)
16. (c)	**17.** (c)	**18.** (c)	**19.** (d)	**20.** (b,d)
21. (a,b)	**22.** (a,b,c)	**23.** (a,b,c,d)		**24.** (3)
25. (10)	**26.** (4)	**27.** (c)	**28.** (d)	**29.** (b)
30. (a)				

GET SET GO for JEE



with exclusive and brainstorming questions

Practicing these questions helps to strengthen your concepts and give you extra edge in your JEE preparation

1. The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because

(a) the 5*f* orbitals extend further from the nucleus than the 4*f* orbitals

(b) the 5*f* orbitals are more buried than the 4*f* orbitals

(c) there is a similarity between 4*f* and 5*f* orbitals in their angular part of the wave function

(d) the actinoids are more reactive than the lanthanoids

2. For the reaction $A + B \rightarrow C$, we have the following data :

Initial concentration of *A* (in molarity)	Initial concentration of *B* (in molarity)	Rate (initial) (Relevant unit)
1	10	100
1	1	1
10	1	10

The order of the reaction with respect to *A* and *B* are

(a) not possible to tell with the given data

(b) first order with respect to both *A* and *B*

(c) first order with respect to *A* and second order with respect to *B*

(d) second order with respect to *A* and first order with respect to *B*.

3.

Electrolyte	KCl	KNO_3	HCl	NaOAc	NaCl
$\Lambda°$**(S cm^2 mol^{-1})**	149.9	145.0	426.2	91.0	126.5

Calculate $\Lambda°_{HOAc}$ using appropriate molar conductance of the electrolytes listed above at infinite dilution of H_2O at 25°C.

(a) 517.2 (b) 552.7 (c) 390.7 (d) 476.5

4. Match each coordination compound in list-I with an appropriate pair of characteristics from list-II and select the correct answer using the code given below the lists.

{*en* = $H_2NCH_2CH_2NH_2$;

Atomic nos.: Ti = 22; Cr = 24; Co = 27; Pt = 78}

List-I		List-II	
(P)	$[Cr(NH_3)_4Cl_2]Cl$	1.	Paramagnetic and exhibits ionisation isomerism
(Q)	$[Ti(H_2O)_5Cl](NO_3)_2$	2.	Diamagnetic and exhibits *cis-trans* isomerism

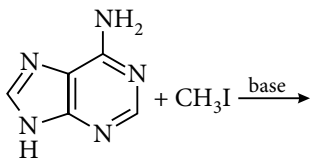
(R)	$[Pt(en)(NH_3)Cl]NO_3$	3.	Paramagnetic and exhibits *cis-trans* isomerism
(S)	$[Co(NH_3)_4(NO_3)_2]NO_3$	4.	Diamagnetic and exhibits ionisation isomerism

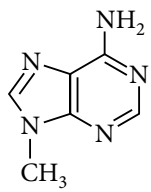
	P	Q	R	S
(a)	4	2	3	1
(b)	3	1	4	2
(c)	2	1	3	4
(d)	1	3	4	2

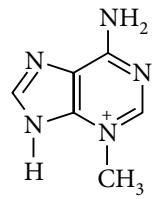
5. **Statement-I :** In phenols, the –OH group is attached to sp^2 hybridised carbon of an aromatic ring.
Statement-II : The carbon-oxygen bond length (136 pm) in phenol is slightly more than that in methanol.
(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

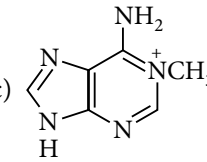
6. In the depression of freezing point experiment
A. vapour pressure of the solution is less than that of pure solvent
B. vapour pressure of the solution is more than that of pure solvent
C. only solute molecules solidify at the freezing point
D. only solvent molecules solidify at the freezing point.
Choose the most appropriate answer from the options given below.
(a) A only (b) B and C only
(c) A and C only (d) A and D only

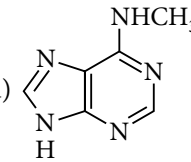
7. The major product in the following reaction is



(a) 

(b) 

(c) 

(d) 

8. Match the column-I with column-II and mark the appropriate choice.

Column-I		Column-II	
(A)	$RCOCH_3 \xrightarrow[HCl]{Zn-Hg} RCH_2CH_3$	(i)	Kolbe's reaction
(B)	$2C_6H_5CHO \xrightarrow{NaOH} C_6H_5COONa + C_6H_5CH_2OH$	(ii)	Clemmensen reduction
(C)	$C_6H_6 + CH_3COCl \xrightarrow[AlCl_3]{Anh.} C_6H_5COCH_3$	(iii)	Friedel–Crafts reaction
(D)	$C_6H_5OH + CO_2 + NaOH \rightarrow HOC_6H_4COONa$	(iv)	Cannizzaro reaction

(a) (A) → (ii), (B) → (iv), (C) → (iii), (D) → (i)
(b) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)
(c) (A) → (iii), (B) → (ii), (C) → (i), (D) → (iv)
(d) (A) → (iv), (B) → (i), (C) → (ii), (D) → (iii)

9. **Statement-I :** According to Saytzeff rule, less substituted alkene is the major product of dehydrohalogenation.
Statement-II : During elimination reaction, hydrogen atom is lost from β-carbon.
(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

10. Consider the following first order reactions occurring at 298 K with same initial concentration of *A*:
(1) $A \rightarrow B$; rate constant, $k = 0.693\ min^{-1}$
(2) $A \rightarrow C$; half-life, $t_{1/2} = 0.693$ min
Choose the correct option.
(a) Reaction (1) is faster than reaction (2).
(b) Reaction (1) is slower than reaction (2).
(c) Both reactions proceed at the same rate.
(d) Since two different products are formed, rates cannot be compared.

11. Identify correct statements from below.

(A) The chromate ion is square planar.

(B) Dichromates are generally prepared from chromates.

(C) The green manganate ion is diamagnetic.

(D) Dark green coloured K_2MnO_4 disproportionates in a neutral or acidic medium to give permanganate.

(E) With increasing oxidation number of transition metal, ionic character of the oxides decreases.

Choose the correct answer from the options given below :

(a) A, D and E only (b) B, D and E only

(c) B, C and D only (d) A, B and C only

12. In the following sequence of reactions,

$$C_3H_6 \xrightarrow[H_3O^+]{H^+/H_2O} A \xrightarrow[\text{dil KOH}]{\text{KIO}} B + C$$

The compounds *B* and *C* respectively are

(a) CI_3COOK, CH_3I

(b) CH_3I, HCOOK

(c) CI_3COOK, HCOOH

(d) CHI_3, CH_3COOK

INTEGER / NUMERICAL VALUE TYPE

13. Liquids *A* and *B* form ideal solution over the entire range of composition. At temperature *T*, equimolar binary solution of liquids *A* and *B* has vapour pressure 45 Torr. At the same temperature, a new solution of *A* and *B* having mole fractions x_A and x_B, respectively, has vapour pressure of 22.5 Torr. The value of x_A/x_B in the new solution is _____. (Given that the vapour pressure of pure liquid *A* is 20 Torr at temperature *T*.)

14. How many compounds from the following have central atom with oxidation number +3?

ClF_3, ICl_3, IO_3^-, ClF_5, BrF_3

15. A short peptide on complete hydrolysis produces 3 moles of glycine (G), two moles of leucine (L) and two moles of valine (V) per mole of peptide. The number of peptide linkages in it are _____.

SOLUTIONS

1. **(a) :** As the distance between the nucleus and 5*f* orbitals (actinides) is more than the distance between the nucleus and 4*f* orbitals (lanthanides) hence the hold of nucleus on valence electron decreases in actinides or we can say that 4*f* orbitals are buried deep inside the nucleus and 5f orbitals are more diffused. Thus, for this reason the actinoids exhibit more number of oxidation states in general.

2. **(c) :** Rate $= k[A]^x [B]^y$; Order $= x + y$

1st case: $(\text{Rate})_1 = k(1)^x (10)^y$

$\Rightarrow 100 = k(1)^x (10)^y$ ...(i)

2nd case: $(\text{Rate})_2 = k(1)^x (1)^y$

$\Rightarrow 1 = k(1)^x (1)^y$ ...(ii)

3rd case: $(\text{Rate})_3 = k(10)^x (1)^y$

$\Rightarrow 10 = k(10)^x (1)^y$ ...(iii)

Dividing (i) by (ii), we get

$$\frac{100}{1} = (10)^y, (10)^2 = (10)^y \Rightarrow y = 2$$

Dividing (ii) by (iii), we get

$$\frac{1}{10} = \left(\frac{1}{10}\right)^x, x = 1$$

$\therefore$ Rate $= k[A]^1[B]^2$

3. **(c) :** $\Lambda^\circ_{HOAc} = \Lambda^\circ_{NaOAc} + \Lambda^\circ_{HCl} - \Lambda^\circ_{NaCl}$

$= 91.0 + 426.2 - 126.5 = 390.7 \text{ S cm}^2 \text{ mol}^{-1}$

4. **(b) :** P : Cr^{3+} has $3d^3$ configuration, with 3 unpaired electrons. Hence, it shows paramagnetic behaviour. Complex of the type Ma_4b_2 shows *cis-trans* isomerism.

Q : Ti^{3+} has $3d^1$ configuration, hence shows paramagnetic behaviour. Complex gives Cl^- and NO_3^- ions in solution hence, shows ionisation isomerism.

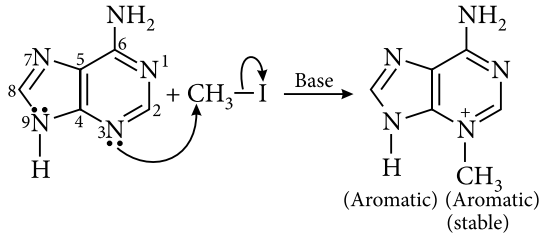
R : Pt^{2+} has $3d^8$ configuration but ligands are strong field ligands hence, it forms square planar complex. Thus, all electrons are paired and show diamagnetic behaviour and it also exhibits ionisation isomerism.

S : Co^{3+} has $3d^6$ configuration. But, ligands present are strong enough to cause electron pairing, hence, it shows diamagnetic behaviour and exhibits *cis-trans* isomerism as it is Ma_4b_2 type complex.

5. **(b) :** The C—O bond length (136 pm) in phenol is slightly less than that in methanol (142 pm).

6. **(d):** In the depression of freezing point experiment only solvent molecules solidify and vapour pressure of solution decreases as some of the surface area is occupied by solute molecules, so less number of molecules will go in vapour form.

7. **(b):** Methylation takes place most frequently at N–3 in adenine.



8. **(a)**

9. **(d):** Highly substituted alkene is the major product of dehydrohalogenation according to Saytzeff rule

10. **(b):** For reaction (1) : $A \rightarrow B$,
rate constant $(k_1) = 0.693\ \text{min}^{-1}$
For reaction (2), $A \rightarrow C$,

$$\text{rate constant } (k_2) = \frac{0.693}{t_{1/2}} \Rightarrow \frac{0.693}{0.693} = 1\ \text{min}^{-1}$$

So, $k_1 < k_2$

Hence, reaction (1) is slower than reaction (2).

11. **(b):** Chromate ion (CrO_4^{2-}) has tetrahedral structure.
Dichromates $(Cr_2O_7^{2-})$ are generally prepared from chromates (CrO_4^{2-}), *e.g.*,

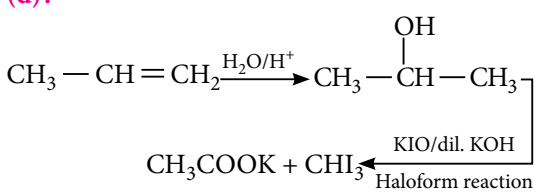
$$2Na_2CrO_4 + 2H^+ \longrightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$$

The green manganate ion is paramagnetic because of one unpaired electron. Dark green coloured K_2MnO_4 disproportionates in a neutral or acidic medium to give permanganate.

$$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O.$$

As the oxidation number of a transition metal increases, ionic character decreases.

12. **(d):**



13. **(19):** $p_A^\circ = 20$ Torr
For equimolar binary solution : $x_A = x_B = 1/2$

$$\therefore \quad \frac{p_A^\circ + p_B^\circ}{2} = 45 \Rightarrow p_B^\circ = 70 \text{ Torr}$$

If mole fractions are x_A and x_B then according to Dalton's law of partial pressures,

$$p_B^\circ + (p_A^\circ - p_B^\circ)x_A = 22.5$$
$$\Rightarrow 70 + (20 - 70)x_A = 22.5$$
$$\Rightarrow x_A = \frac{47.5}{50} \text{ and } x_B = \frac{2.5}{50}$$
$$\frac{x_A}{x_B} = \frac{47.5}{2.5} = 19$$

14. **(3):** Compounds with Oxidation state +3 are ClF_3, BrF_3, ICl_3.
Compounds with Oxidation state +5 = ClF_5, IO_3^-

15. **(6):** On complete hydrolysis, we will obtain total seven moles of amino acids. Combination of n amino acids gives a polypeptide with $(n - 1)$ peptide linkage. Similarly combination of seven amino acids gives a heptapeptides with six peptide linkages.

◈◈



Here are the nine shuffled words containing 3 sets of trio. The three letters of trio can be arranged in any sequence. Complete these words by finding 3 sets of trio.

CYA– – –E
– – –PTION
– – – HOBORIC
DYSP– – –IUM
NOVES– – –L
PEN– – –E
P– – –EIN
PRECU– – –R
EN– – –IOMER

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month.
Winners' names will be published in next issue.



CBSE Warm-up!

CLASS-XII

Chapterwise practice questions for CBSE Exams as per the latest pattern and syllabus by CBSE for the academic session 2026-27.

Series-4 The *d*– and *f*– Block Elements | Coordination Compounds

General Instructions : Read the following instructions carefully and follow them :

(i) This question paper contains 33 questions. All questions are compulsory.

(ii) Question paper is divided into five sections – Section A, B, C, D and E.

(iii) Section A – questions number 1 to 16 are multiple choice type questions. Each question carries 1 mark.

(iv) Section B – questions number 17 to 21 are very short answer type questions. Each question carries 2 marks.

(v) Section C – questions number 22 to 28 are short answer type questions. Each question carries 3 marks.

(vi) Section D – questions number 29 and 30 are case-based questions. Each question carries 4 marks.

(vii) Section E – questions number 31 to 33 are long answer type questions. Each question carries 5 marks.

(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the sections except section A.

(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.

(x) Use of calculators is not allowed.

Time Allowed : 3 hours **Maximum Marks :** 70

SECTION-A

1. $E^{\circ}_{Mn^{3+}/Mn^{2+}}$ is highly positive than that of $E^{\circ}_{Cr^{3+}/Cr^{2+}}$ or $E^{\circ}_{Fe^{3+}/Fe^{2+}}$ because

(a) Mn^{2+} (d^5) can be easily oxidised to Mn^{3+}(d^4) due to low ionisation enthalpy

(b) third ionisation enthalpy of Mn is much larger due to stable half filled d^5 electronic configuration of Mn^{2+}

(c) Mn^{3+} is more stable than Mn^{2+} due to higher oxidation state.

(d) second ionisation enthalpy of Mn is higher than third ionisation enthalpy.

2. Which of the following catalysts is not correctly matched with the reaction?

(a) Vanadium(V) oxide in contact process for oxidation of SO_2 to SO_3.

(b) Finely divided iron in Haber's process in conversion of N_2 and H_2 to NH_3.

(c) $PtCl_2$ catalyses the oxidation of ethyne to ethanal in the Wacker process.

(d) Ni in presence of hydrogen for conversion of vegetable oil to ghee.

3. The correct IUPAC name of the coordination compound $K_3[Fe(CN)_5NO]$ is

(a) potassium pentacyanonitrosylferrate(II)

(b) potassium pentacyanonitroferrate(III)

(c) potassium nitritopentacyanoferrate(IV)

(d) potassium nitritepentacyanoiron(II).

4. Match the following columns :

Column-I (Ions)		Column-II (Magnetic moment B.M.)	
(A)	Ni^{2+}	(p)	0
(B)	Zn^{2+}	(q)	5.92
(C)	Mn^{2+}	(r)	2.83
(D)	Cr^{2+}	(s)	4.90

(a) (A) – s, (B) – p, (C) – q, (D) – r
(b) (A) – r, (B) – p, (C) – q, (D) – s
(c) (A) – p, (B) – r, (C) – q, (D) – s
(d) (A) – p, (B) – s, (C) – q, (D) – r

5. $CuSO_4$ is paramagnetic while $ZnSO_4$ is diamagnetic because
(a) Cu^{2+} ion has $3d^9$ configuration while Zn^{2+} ion has $3d^{10}$ configuration
(b) Cu^{2+} ion has $3d^5$ configuration while Zn^{2+} ion has $3d^6$ configuration
(c) Cu^{2+} has half filled orbitals while Zn^{2+} has fully filled orbitals
(d) Cu^{2+} ion has $3d^9$ configuration while Zn^{2+} ion has $3d^8$ configuration.

6. $[CoF_6]^{3-}$ is
(a) paramagnetic and undergoes sp^3d^2 hybridisation
(b) diamagnetic and undergoes d^2sp^3 hybridisation
(c) paramagnetic and undergoes sp^3d hybridisation
(d) diamagnetic and undergoes sp^3 hybridisation.

7. Arrange the following complexes in increasing order of conductivity of their solutions.
(i) $[Co(NH_3)_3Cl_3]$ (ii) $[Co(NH_3)_4Cl_2]Cl$
(iii) $[Co(NH_3)_6]Cl_3$ (iv) $[Co(NH_3)_5Cl]Cl_2$
(a) (i) < (ii) < (iv) < (iii)
(b) (ii) < (i) < (iii) < (iv)
(c) (i) < (iii) < (ii) < (iv)
(d) (iv) < (i) < (ii) < (iii)

8. Match the complexes given in column-I with the oxidation states of central metal atoms in column-II and mark the appropriate choice.

Column-I (Complex)		Column-II (Oxidation state of central atom)	
(A)	$K_3[Co(C_2O_4)_2Cl_2]$	(i)	0
(B)	$[Pt(C_2H_4)Cl_3]^-$	(ii)	+1
(C)	$[Fe(H_2O)_5NO]SO_4$	(iii)	+3
(D)	$[Ni(CO)_4]$	(iv)	+2

(a) (A) → (ii), (B) → (i), (C) → (iv), (D) → (iii)
(b) (A) → (iv), (B) → (ii), (C) → (i), (D) → (iii)
(c) (A) → (iii), (B) → (iv), (C) → (ii), (D) → (i)
(d) (A) → (i), (B) → (ii), (C) → (iii), (D) → (iv)

9. Arrange the oxides of manganese according to increasing acidic strength.
(a) $MnO < Mn_3O_4 < Mn_2O_3 < MnO_2 < Mn_2O_7$
(b) $Mn_2O_7 < MnO_2 < Mn_2O_3 < Mn_3O_4 < MnO$
(c) $MnO_2 < Mn_2O_7 < Mn_3O_4 < Mn_2O_3 < MnO$
(d) $Mn_3O_4 < Mn_2O_3 < Mn_2O_7 < MnO_2 < MnO$

10. Highest oxidation state of manganese in fluoride is +4 (MnF_4) but highest oxidation state in oxides is +7 (Mn_2O_7) because
(a) fluorine is more electronegative than oxygen
(b) fluorine does not possess *d*-orbitals
(c) fluorine stabilises lower oxidation state
(d) in covalent compounds, fluorine can form single bond only while oxygen forms double bonds.

11. Mark the incorrect statement.
(a) Inner orbital (low spin) complexes involve d^2sp^3 hybridisation.
(b) Outer orbital (high spin) complexes involve sp^3d^2 hybridisation.
(c) Tetrahedral complexes generally involve dsp^2 hybridisation.
(d) Stereoisomerism involves geometrical and optical isomerism.

12. Which of the following is not correctly matched with the example given?
(a) An element of first transition series which has highest second ionisation enthalpy – Cu
(b) An element of first transition series with highest third ionisation enthalpy – Zn
(c) An element of first transition series with lowest enthalpy of atomisation – Zn
(d) Last element of third transition series – Cd

For question number 13 to 16, two statements are given- one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:
(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(c) Assertion (A) is true, but Reason (R) is false.
(d) Assertion (A) is false, but Reason (R) is true.

13. **Assertion (A) :** In transition elements, *ns* orbital is filled up first and $(n-1)d$ afterwards, during ionization *ns* electrons are lost prior to $(n-1)d$ electrons.
Reason (R) : The effective nuclear charge experienced by $(n-1)d$ electrons is higher as compared to *ns* electrons.

14. **Assertion (A) :** The geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ are optically inactive.
Reason (R) : Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess plane of symmetry.

15. **Assertion (A) :** Chemical properties of lanthanoids are different from each other.
Reason (R) : The change in the ionic radii in lanthanoids is very small.

16. **Assertion (A) :** Ethylenediamminetetraacetate ion forms an octahedral complex with the metal ion.
Reason (R) : It has six donor atoms which coordinate simultaneously to the metal ion.

SECTION-B

17. Calculate the number of unpaired electrons in the following gaseous ions :
Ti^{3+} and Cr^{3+} (Atomic number of Ti = 22, Cr = 24)
Which one of them is most stable in aqueous solution and why ?

18. Give reasons for the following :
(a) Transition metals form alloys.
(b) MnO is basic whereas Mn_2O_7 is acidic.

19. When a coordination compound $CrCl_3 \cdot 6H_2O$ is mixed with $AgNO_3$, 2 moles of AgCl are precipitated per mole of the compound. Write structural formula of the complex.

20. How many stereoisomers of compound $[CrCl_2(ox)_2]^{3-}$ are possible?

21. **(A)** Write the hybridization and magnetic behaviour of the complex $[Ni(CO)_4]$.
(At. no. of Ni =28)

OR

(B) Ni^{2+} ion is bound to two water molecules and two oxalate ions.
Write the name and magnetic behaviour of the above coordination compound.
(At. nos. Co = 27, Ni = 28)

SECTION-C

22. Following are the transition metal ions of 3*d* series :
Ti^{4+}, V^{2+}, Mn^{3+}, Cr^{3+}
(Atomic numbers : Ti = 22, V = 23, Mn = 25, Cr = 24)
Answer the following :
(a) Which ion is most stable in aqueous solution and why?
(b) Which ion is strong oxidising agent and why?
(c) Which ion is colourless and why?

23. Write down the IUPAC names of the following compounds :
(a) $[Co(NH_3)_5ONO]Cl_2$
(b) $K_3[Cr(CN)_6]$
(c) $[Cr(NH_3)_5CO_3]Cl$

24. Account the following :
(a) Transition metals form large number of complex compounds.
(b) The lowest oxide of transition metal is basic whereas the highest oxide is acidic.
(c) E° value for the Mn^{3+}/Mn^{2+} couple is highly positive (+1.57 V) as compared to Cr^{3+}/Cr^{2+}.

25. For the complex $[NiCl_4]^{2-}$, write
(a) the IUPAC name
(b) the hybridization type
(c) the geometry of the complex.
(Atomic no. of Ni = 28)

26. **(a)** What is *d-d* transition?
(b) Tetrahedral complexes are always of high spin. Explain.

27. The formula $Co(NH_3)_5SO_4Br$ could represent a sulphate or a bromide. Write the two possible structures and name them. What type of isomerism do these exhibit?

28. **(A)** When $FeCr_2O_4$ is fused with Na_2CO_3 in the presence of air it gives a yellow solution of compound (*P*). Compound (*P*) on acidification gives compound (*Q*). Compound (*Q*) on reaction with KCl forms an orange coloured compound (*R*). An acidified solution of compound (*R*) oxidises Na_2SO_3 to (*S*). Identify (*P*), (*Q*), (*R*) and (*S*).

OR

(B) Complete the following reactions.
(a) $MnO_2 + KOH + O_2 \longrightarrow$
(b) $I^- + MnO_4^- + H^+ \longrightarrow$
(c) $Cr_2O_7^{2-} + Sn^{2+} + H^+ \longrightarrow$

SECTION-D

The following questions are case based questions. Each question has an internal choice and carries 4(2 + 1 + 1) marks each. Read the passage carefully and answer the questions that follow :

29. The *f*-block elements are those in which the differentiating electron enters the $(n-2)$ orbital. There are two series of *f*-block elements corresponding to filling of 4*f*- and 5*f*-orbitals called

lanthanoids and actinoids respectively. They show different oxidation states depending upon the stability of f^0, f^7 and f^{14} configurations.

(a) Which is the 2nd last element in the series of the actinoids? Write the electronic configuration of the element.

(b) What is the most common oxidation state of lanthanoids?

(c) What is the general electronic configuration of inner transition elements?

OR

(c) What is the atomic number of thorium?

30. The nature of bonding structure of the coordination compound can be explained to some extent by valence bond theory. The central metal atom/ion makes available a number of vacant orbitals equal to its coordination number. The appropriate atomic orbitals (*s*, *p* and *d*) of the metal hybridise to give a set of equivalent orbitals of definite geometry such as square planar, tetrahedral, octahedral and so on. A strong covalent bond is formed only when the orbitals overlap to the maximum extent. The *d*-orbitals involved in the hybridisation may be either inner *d*-orbitals *i.e.*, $(n-1)\,d$ or outer *d*-orbitals *i.e.*, *nd*. The complexes formed are called inner orbital complex (low spin complex) and outer orbital complex (high spin complex) respectively. Further, the complexes can be paramagnetic or diamagnetic in nature. The drawbacks of this theory are that this involves number of assumptions and also does not explain the colour of the complex.

Answer the following questions:

(a) Explain $[Co(NH_3)_6]^{3+}$ is an inner orbital or outer orbital complex.

(b) Predict whether $[FeF_6]^{3-}$ is diamagnetic or paramagnetic.
[Atomic number : Fe = 26]

OR

(b) What is the coordination number of Co in $[Co(en)_2Cl_2]^+$?

(c) What are the hybridisations of inner and outer orbital complexes?

SECTION-E

31. (A) (a) Account for the following :

(i) Manganese shows maximum number of oxidation states in 3*d*-series.

(ii) Ti^{4+} is colourless whereas V^{4+} is coloured in an aqueous solution.

(b) Write the chemical equations for the preparation of $KMnO_4$ from MnO_2. Why does purple colour of acidified permanganate solution decolourise when it oxidises Fe^{2+} to Fe^{3+} ?

OR

(B) Answer the following questions:

(a) Why is chemistry of actinoids more complicated as compared to lanthanoids?

(b) $E^\circ_{M^{2+}/M}$ values are not regular for first row transition elements (3*d* series). Why?

(c) Identify the following:

(i) Oxoanion of chromium which is stable in acidic medium.

(ii) The lanthanoid element that exhibits +4 oxidation state.

(d) Write the products obtained on heating $KMnO_4$.

32. (A) (a) What is meant by crystal field splitting energy? On the basis of crystal field theory, write the electronic configuration of d^4 in terms of t_{2g} and e_g in an octahedral field when

(i) $\Delta_o > P$ (ii) $\Delta_o < P$

(b) Write two limitations of crystal field theory.

OR

(B) (a) For the complex $[Fe(en)_2Cl_2]Cl$, identify the following :

(i) Oxidation number of iron

(ii) Hybrid orbitals and geometry of the complex

(iii) Magnetic behaviour of the complex

(iv) Name of the complex.

(b) $[Ni(H_2O)_6]^{2+}$ is green and becomes violet when ethane-1, 2-diamine is added to it. Identify the observation.

MONTHLY TEST DRIVE CLASS XI — ANSWER KEY

1. (d)	**2.** (c)	**3.** (c)	**4.** (c)	**5.** (c)
6. (a)	**7.** (c)	**8.** (a)	**9.** (c)	**10.** (c)
11. (d)	**12.** (a)	**13.** (b)	**14.** (a)	**15.** (a)
16. (d)	**17.** (a)	**18.** (d)	**19.** (a)	**20.** (a,b,c)
21. (c,d)	**22.** (a,b,c,d)	**23.** (b,c)	**24.** (1)	**25.** (18)
26. (0)	**27.** (c)	**28.** (a)	**29.** (a)	**30.** (d)

33. (A) (a) Give IUPAC name, geometry and draw the structures of

(i) $Ni(CO)_4$ (ii) $Fe(CO)_5$

(iii) $Cr(CO)_6$

OR

(B) (a) How many ions are produced from the complex, $[Co(NH_3)_6]Cl_2$ in solution?

(b) Why are low spin tetrahedral complexes not formed?

(c) What is the IUPAC name of the complex $[Ni(NH_3)_6]Cl_2$?

(d) Write oxidation state, coordination number, geometry and magnetic moment of $Cs[FeCl_4]$

SOLUTIONS

1. (b) : The third ionisation energy of Mn required to change $Mn^{2+}(d^5)$ to $Mn^{3+}(d^4)$ is much larger due to stable half-filled d^5 electronic configuration.

2. (c) : In the Wacker process, the oxidation of ethyne to ethanal is catalysed by $PdCl_2$.

3. (a)

4. (b) : In Ni^{2+}, no . of unpaired = 2

$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = 2.83$ B.M.

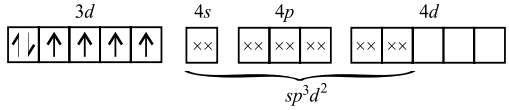
Similarly in Zn^{2+}, $n = 0 \Rightarrow \mu = 0$

In Mn^{2+}, $n = 5 \Rightarrow \mu = 5.92$ B.M.

In Cr^{2+}, $n = 4 \Rightarrow \mu = 4.90$ B.M.

5. (a) : Cu^{2+} has $3d^9$ configuration *i.e.,* one unpaired electron, hence, it is paramagnetic while Zn^{2+} has $3d^{10}$ configuration *i.e.,* all orbitals are filled, hence it is diamagnetic in nature.

6. (a) : $[CoF_6]^{3-}$ is paramagnetic.



7. (a) : Higher the number of ions in the solution, higher is the conductivity.

No. of ions : $[Co(NH_3)_3Cl_3] = 0$; $[Co(NH_3)_4Cl_2]Cl = 2$

$[Co(NH_3)_5Cl]Cl_2 = 3$; $[Co(NH_3)_6]Cl_3 = 4$

8. (c)

9. (a) : Acidic strength of oxides of same transition metals increases with increase in oxidation number.

$\overset{+2}{MnO}, \overset{+8/3}{Mn_3O_4}, \overset{+3}{Mn_2O_3}, \overset{+4}{MnO_2}, \overset{+7}{Mn_2O_7}$

Hence, the order of acidic strength is

$\underset{\text{Basic}}{MnO} < Mn_3O_4 < Mn_2O_3 < MnO_2 < \underset{\text{Acidic}}{Mn_2O_7}$

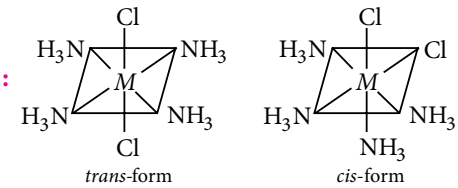
10. (d)

11. (c) : Tetrahedral complexes generally involve sp^3 hybridisation.

12. (d) : Hg is the last element of third transition series.

13. (a)

14. (a) :



Octahedral complexes of the type Ma_4b_2 exhibit geometrical isomerism.

Geometrical isomer of the complex $[M(NH_3)_4Cl_2]$ are optically inactive. Plane of symmetry causes optical inactivity.

15. (d) : The change in the ionic radii of lanthanoids is very small, thus their chemical properties are similar.

16. (a)

17. $Ti^{3+} : 3d^1$

No of unpaired electrons = 1

$Cr^{3+} : 3d^3$

No. of unpaired electrons = 3

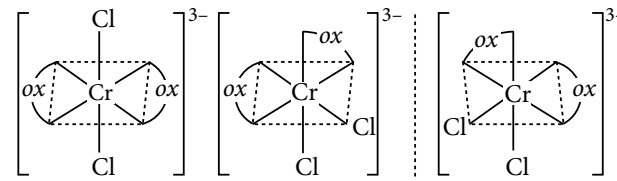
Out of these, Cr^{3+} is most stable in aqueous solution due to half filled t_{2g} level, *i.e.*, t_{2g}^3.

18. (a) Transition metals form alloys because they have similar atomic radii.

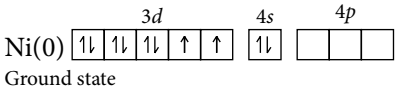
(b) Basic nature of oxides decreases and acidic nature increases with increase in oxidation state of the metal. Oxidation state of Mn in MnO is +2 thus it is basic while in Mn_2O_7 it is +7 thus it is acidic.

19. For one mole of the compound, two moles of AgCl are precipitated which indicates two ionisable chloride ions in the complex. Hence, its structural formula is $[CrCl(H_2O)_5]Cl_2.H_2O$

20. $[CrCl_2(ox)_2]^{3-}$ can exist in *cis* and *trans*-form. *Cis*-form is optically active and thus exists in enantiomeric pair.

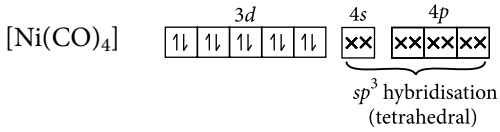


21. (A) $[Ni(CO)_4]$ contains Ni(0) – $3d^8 4s^2$ configuration.



Ground state

CO is a strong field ligand hence, 4*s*-electrons will shift to 3*d*-orbital making 4*s*-orbital vacant.



The complex has all paired electrons hence, it is diamagnetic.

OR

(B) $[Ni(ox)_2(H_2O)_2]^{2-}$: Diaquadioxalatonickelate(II) ion

In the presence of weak *ox* and H_2O ligand, Ni(II) forms high spin complex (sp^3d^2 hybridisation). It is paramagnetic.

22. (a) Cr^{3+} is the most stable, because of stable t_{2g}^3 electronic configuration of Cr^{3+} in aqueous solution.

(b) Mn^{3+} is the strongest oxidising agent. Mn^{3+} on reduction gives Mn^{2+} which is quite stable due to half-filled $3d^5$ electronic configuration.

(c) Electronic configuration of Ti^{4+} = $[Ar]3d^0 4s^0$ Due to absence of electron in its *d*-orbitals, Ti^{4+} is a colourless ion.

23. (a) Pentaamminenitro-O-cobalt(III) chloride

(b) Potassium hexacyanochromate(III)

(c) Pentaamminecarbonatochromium(III) chloride

24. (a) Transition metals form a large number of complex compounds due to following reasons :

- Comparatively smaller size of metal ions.
- High ionic charges.
- Availability of *d*-orbitals for bond formation.

(b) Lowest oxidation compounds of transition metals are basic due to their ability to get oxidised to higher oxidation states. Whereas, the higher oxidation state of metal and compounds gets reduced to lower ones and hence are acidic in nature.

e.g.,CrO is basic whereas CrO_3 is acidic.

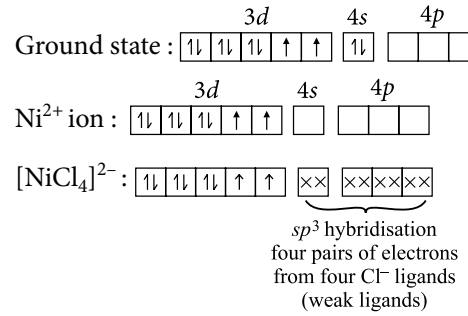
(c) $E°$ value of Mn^{3+}/Mn^{2+} is + 1.57 V.

$Mn^{3+}_{(aq)} + e^- \longrightarrow Mn^{2+}_{(aq)}$; $E° = +1.57$ V

This value is highly positive because Mn^{3+} (d^4) has a very high tendency to get reduced to Mn^{2+} (d^5) which has a stable half - filled electronic configuration.

25. (a) Tetrachloridonickelate(II) ion

(b) Ni atom ($Z = 28$)



The complex has sp^3 hybridisation.

(c) The complex ion has tetrahedral geometry.

26. (a) When ligands approach the central metal, *d*-orbitals of atom or ion of its complex breaks into two parts t_{2g} and e_g levels (for octahedral complex). When light falls on the complex the complex absorbs light of suitable frequency for transfer of electron from lower level to higher level. This jump of electron from one *d*-level to another is called *d*-*d* transition.





ANSWERS AUGUST 2026

The three set of trios are **(DIA, IDA, ADI), (EST, ETS, STE) and (OSM, SMO, MOS)**

A DI A B A T I C
R I C K E T **S**
M O S C O V I U M
P A L L **A D** I U M
S T E R O I D
O S M O S I S
O X I **D A** T I O N
S M O K E
L I M E **S** T O N E

***Winners** : Poorna, Soumili*

(b) For tetrahedral complexes crystal field splitting energy Δ_t is always less than pairing energy. So, tetrahedral complexes are always high spin.

27. $[Co(NH_3)_5SO_4]Br$

pentaamminesulphatocobalt(III) bromide.

$[Co(NH_3)_5Br]SO_4$

pentaamminebromocobalt(III) sulphate.

These are ionisation isomers.

28. (A) $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \longrightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

$2Na_2CrO_4 + H_2SO_4 \longrightarrow \underset{(P)}{Na_2Cr_2O_7} + Na_2SO_4 + H_2O$

$Na_2Cr_2O_7 + 2KCl \longrightarrow \underset{(R)}{K_2Cr_2O_7} + 2NaCl$

$K_2Cr_2O_7 + 4H_2SO_4 + 3Na_2SO_3 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3Na_2SO_4$ (*S*)

OR

(B) (a) $2MnO_2 + 4KOH + O_2 \longrightarrow 2K_2MnO_4 + 2H_2O$

(b) $2MnO_4^- + 10I^- + 16H^+ \longrightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

(c) $Cr_2O_7^{2-} + 3Sn^{2+} + 14H^+ \longrightarrow 2Cr^{3+} + 3Sn^{4+} + 7H_2O$

29. (a) Nobelium with atomic number 102 is the second last element of actinoid series. Its electronic configuration is [Rn] $5f^{14}\,6d^0\,7s^2$.

(b) +3

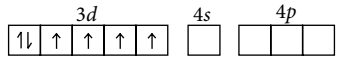
(c) $(n-2)f^{1-14}\,(n-1)d^{0-1}\,ns^2$

OR

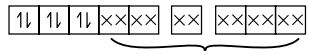
(c) Atomic number of thorium is 90.

30. (a) $[Co(NH_3)_6]^{3+}$ is an inner orbital complex.

Oxidation state of cobalt in $[Co(NH_3)_6]^{3+}$ is +3.

Co^{3+} : 

Ground State

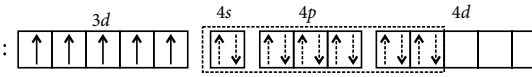
$[Co(NH_3)_6]^{3+}$ ion : 

d^2sp^3 hybridisation
six pairs of electrons
from six NH_3 ligands
(Strong field ligand)

(b) Compound $[FeF_6]^{3-}$ is paramagnetic in nature due to the presence of unpaired electrons.

Fe^{3+} : [Ar] $3d^5$.

F^- being a weak field ligand, cannot cause pairing of electrons.

$[FeF_6]^{3-}$: 

sp^3d^2 hybridisation

OR

(b) Coordination number of Co in $[Co(en)_2Cl_2)^+$ is six as *en* is a bidentate and Cl is a monodentate ligand.

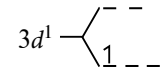
(c) Inner orbital complex and outer orbital complexes involve d^2sp^3 and sp^3d^2 hybridisation respectively.

31. (A) (a) (i) In 3*d* series, Mn shows maximum number of oxidation state because number of unpaired electrons is maximum in Mn.

(ii) Colour of transition metal ions is due to the *d*-*d* transitions. Ions which do not involve in *d*-*d* transitions are colourless.

Ti^{4+} : [Ar]$3d^04s^0$, no *d*-*d* transition, colourless

V^{4+} : [Ar]$3d^1$, *d*-*d* transition occur as shown below :



Hence, V^{4+} ion is coloured.

In other words, generally the ions having empty *d*-orbitals or no unpaired electron in *d*-orbitals of transition element are colourless.

(b) Preparation of potassium permanganate : Potassium permanganate is prepared by the fusion of MnO_2 (pyrolusite) with potassium hydroxide and an oxidising agent like KNO_3 to form potassium manganate which disproportionates in a neutral or acidic solution to form permanganate.

$2MnO_2 + 4KOH + O_2 \longrightarrow 2K_2MnO_4 + 2H_2O$

$3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

$\underset{\text{(Purple colour)}}{5Fe^{2+} + MnO_4^- + 8H^+} \longrightarrow \underset{\text{(Colourless)}}{Mn^{2+} + 4H_2O} + 5Fe^{3+}$

OR

(B) (a) Chemistry of actinoids is more complicated than lanthanoids because

(1) actinoids show greater number of oxidation states due to the comparable energies of 5*f*, 6*d* and 7*s* orbitals.

(2) most of the actinoids are radioactive and the study of their chemistry in the laboratory is difficult.

(b) The $E^{\circ}_{(M^{2+}/M)}$ values are not regular due to the irregular variation of ionisation enthalpies ($\Delta_i H_1 + \Delta_i H_2$) and also the sublimation enthalpies across the period.

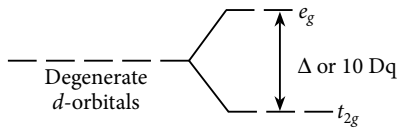
(c) (i) $Cr_2O_7^{2-}$

(ii) Ce exhibits +4 oxidation state. However, Tb also exhibit +4 state

(d) $2KMnO_4 \xrightarrow{\text{heat}} K_2MnO_4 + MnO_2 + O_2$

32. (A)(a) The difference of energy between two splitted levels of *d*-orbitals is called crystal field splitting energy. It is denoted by Δ or 10 D*q*.

For octahedral Δ_o, for tetrahedral it is Δ_t and for square planar Δ_{sp}.



Splitted *d*-orbitals

(i) When $\Delta_o > P$, $t_{2g}^4 e_g^0$

(ii) When $\Delta_o < P$, $t_{2g}^3 e_g^1$

(b) (i) It assumes ligands to be point charges.

(ii) It does not take into account the covalent character of bonding between the ligand and the central metal atom.

OR

(B) (a) (i) $[Fe(en)_2Cl_2]Cl$

$x + 0 \times 2 + (-1) \times 2 + (-1) \times 1 = 0$

$\therefore \quad x = +3$

Oxidation number of iron = +3

(ii) d^2sp^3 hybridisation and octahedral geometry.

(iii) Paramagnetic due to presence of one unpaired electron.

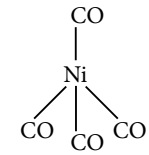
(iv) dichlorido*bis*(ethane-1,2-diamine)iron(III) chloride

(b) Ethane-1,2-diamine is stronger ligand than H_2O. When H_2O molecule is replaced by ethane-1,2-diamine (*en*) the crystal field splitting energy (Δ) increases. Complex absorbs light of higher frequency for *d-d* transition. This is why colour of complex changes from green to violet.

$[Ni(H_2O)_6]^{2+}$ – Green, $[Ni(en)_3]^{2+}$ – violet

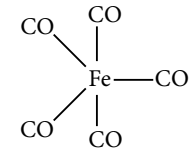
Δ_o small $\qquad$ Δ_o large

33. (A) (a) $Ni(CO)_4$: Tetracarbonylnickel(0)



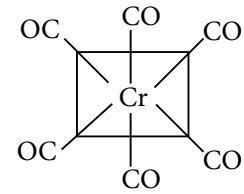
Tetrahedral

(b) $Fe(CO)_5$: Pentacarbonyliron(0)



Trigonal bipyramidal

(c) $Cr(CO)_6$: Hexacarbonylchromium (0)



Octahedral

OR

(B) (a) Three ion, $[Co(NH_3)_6]^{2+}$, $2Cl^-$

(b) Orbital splitting energies are not sufficiently large enough to cause pairing.

(c) Hexaamminenickel(II) chloride

(d) $Cs[FeCl_4]$

Oxidation state of Fe = +3

Coordination number = 4

Geometry -Tetrahedral

Magnetic moment $\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)}$

$= \sqrt{35} = 5.92$ B.M.

UNSCRAMBLED WORDS

AUGUST 2026

1-g-SUDAN	6-j-INSULIN
2-d-HEMLOCK	7-a-DARMSTADTIUM
3-i-ASPARTAME	8-f-FORMALIN
4-e-ANIONIC	9-b-TAUTOMERISM
5-c-THALIDOMIDE	10-h-SALVARSAN

Winners : Soumili, Yogesh

Class XII

Monthly test drive

This specially designed column enables students to self analyse their extent of understanding of all chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Solutions | General Principles and Processes of Isolation of Elements

Total Marks : 120 **Time taken :** 60 Min.

NEET

Only One Option Correct Type

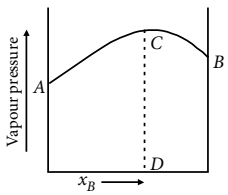
1. An ideal solution was obtained by mixing methanol and ethanol. If the partial vapour pressure of methanol and ethanol are 2.619 kPa and 4.556 kPa respectively; the composition of vapour (in terms of mole fraction) will be
(a) 0.635 MeOH, 0.365 EtOH
(b) 0.173 MeOH, 0.827 EtOH
(c) 0.574 MeOH, 0.326 EtOH
(d) 0.365 MeOH, 0.635 EtOH

2. The degree of dissociation (α) of a weak electrolyte, A_xB_y is related to van't Hoff factor (i) by the expression
(a) $\alpha = \frac{i-1}{(x+y-1)}$ (b) $\alpha = \frac{i-1}{(x+y+1)}$
(c) $\alpha = \frac{(x+y-1)}{i-1}$ (d) $\alpha = \frac{(x+y+1)}{i-1}$

3. Consider the following aqueous solutions and assume 100% ionization in electrolytes.
I. 0.1 m Urea II. 0.04 m $Al_2(SO_4)_3$
III. 0.05 m $CaCl_2$ IV. 0.005 m NaCl
The correct statement regarding the above solutions is
(a) freezing point will be lowest for solution I
(b) freezing point will be highest for solution IV
(c) boiling point will be highest for solution IV
(d) vapour pressure will be highest for solution II

4. 30 g of a saturated solution on evaporation gave a residue of 5 g. Solubility of solute is
(a) 25 (b) 20 (c) 15 (d) 30

5. The diagram given here is a vapour pressure composition diagram for a binary solution of A and B. In the solution, $A - B$ interactions are



(a) similar to $A - A$ and $B - B$ interactions
(b) greater than $A - A$ and $B - B$ interactions
(c) smaller than $A - A$ and $B - B$ interactions
(d) unpredictable.

6. Which one of the following statements is false?
(a) The correct order of osmotic pressure of 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose.
(b) The osmotic pressure (π) of a solution is given by the equation, $\pi = MRT$, where M is the molarity of the solution.
(c) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction.
(d) Two sucrose solutions of same molality prepared in different solvents will have the same depression in freezing point.

7. A 1% solution of KCl (I), NaCl (II), $BaCl_2$ (III) and urea (IV) have their osmotic pressure at the same temperature in the ascending order as (Assume 100% ionisation of the electrolytes at this temperature)
(a) I < III < II < IV (b) III < IV < I < II
(c) I < II < III < IV (d) I < III < IV < II

8. After adding non-volatile solute freezing point of water decreases to –0.186°C. Calculate ΔT_b.
(Given : K_f = 1.86 K kg mol^{-1} and K_b = 0.521 K kg mol^{-1}).
(a) 0.0521 K (b) 0.0186 K
(c) 0.521 K (d) 1.86 K

9. Two liquids *A* and *B* have vapour pressure in the ratio $p_A^\circ : p_B^\circ = 1 : 2$ at a certain temperature. Suppose that we have an ideal solution of *A* and *B* in the mole fraction ratio $A : B = 1 : 2$, the mole fraction of *A* in the vapour in equilibrium with the solution at the given temperature is
(a) 0.25 (b) 0.2 (c) 0.5 (d) 0.33

10. Arrange the following aqueous solutions in the order of their increasing boiling points
(i) 10^{-4} M NaCl (ii) 10^{-4} M Urea
(iii) 10^{-3} M $MgCl_2$ (iv) 10^{-2} M NaCl
(a) (i) < (ii) < (iv) < (iii)
(b) (ii) < (i) = (iii) < (iv)
(c) (ii) < (i) < (iii) < (iv)
(d) (iv) < (iii) < (i) = (ii)

11. The order of increasing freezing point of C_2H_5OH, $Ba_3(PO_4)_2$, Na_2SO_4, KCl and Li_3PO_4 is
(a) $Ba_3(PO_4)_2 < Na_2SO_4 < Li_3PO_4 < C_2H_5OH < KCl$
(b) $Ba_3(PO_4)_2 < C_2H_5OH < Li_3PO_4 < C_2H_5OH < KCl$
(c) $C_2H_5OH < KCl < Na_2SO_4 < Ba_3(PO_4)_2 < Li_3PO_4$
(d) $Ba_3(PO_4)_2 < Li_3PO_4 < Na_2SO_4 < KCl < C_2H_5OH$

12. If molality of the dilute solution is doubled, the value of molal depression constant (K_f) will be
(a) halved (b) tripled
(c) unchanged (d) doubled.

Statement Type

Directions : Each of the given questions contains two statements, statement-I and statement-II. In the light of the given statements, select the correct answer from the options given below.
(a) Both statement-I and statement-II are correct.
(b) Statement-I is correct but statement-II is incorrect.
(c) Both statement-I and statement-II are incorrect.
(d) Statement-I is incorrect but statement-II is correct.

13. **Statement-I :** The strength of 1 molar solution in g L^{-1} is always lower than that of 1 molal solution for same solute and solvent.
Statement-II : Molality depends upon density while molarity does not.

14. **Statement-I :** Azeotropic mixtures are formed only by ideal solutions.
Statement-II : Boiling point of an azeotrope is either higher than both the components or lower than both the components.

15. **Statement-I :** If red blood cells are removed from the body and placed in pure water, pressure inside the cells decreases.
Statement-II : The concentration of the salt content in the cell increases.

JEE (Main & Advanced)

Only One Option Correct Type

16. The freezing point of an aqueous solution of KCN containing 0.1892 mol kg^{-1} of solvent was found to be – 0.704°C. On adding 0.095 mol of $Hg(CN)_2$, the freezing point of the solution was found to be – 0.530 °C. If the complex - formation takes place according to the following equation.
$Hg(CN)_2 + n$KCN $\rightleftharpoons K_n[Hg(CN)_{n+2}]$ ($K_f = 10^{23}$)
What is the formula of the complex?
[$K_f(H_2O)$ is 1.86 kg mol^{-1} K.]
(a) $K_2[Hg(CN)_6]$ (b) $K[Hg(CN)_4]$
(c) $K_2[Hg(CN)_4]$ (d) $K[Hg(CN)_2]$

17. In aluminium extraction by the Baeyer's process, alumina is extracted from bauxite by sodium hydroxide at high temperatures and pressures.
$Al_2O_{3(s)} + 2OH^-_{(aq)} \longrightarrow 2AlO^-_{2(aq)} + H_2O_{(l)}$
Solid impurities such as Fe_2O_3 and SiO_2 are removed and then $Al(OH)^-_4$ is reprecipitated.
$2Al(OH)^-_4 \longrightarrow Al_2O_3{\cdot}3H_2O_{(s)} + 2OH^-_{(aq)}$.

SOLUTIONS TO AUGUST 2026 QUIZ CLUB

1. lodestone
2. nitrate
3. first
4. lime
5. tyrosinase
6. silicone
7. cationic
8. mass
9. lactic
10. chlorine
11. enterotoxins
12. wilkinson
13. nickel
14. dichromate
15. sulphide
16. electronegativity
17. helium
18. catalysts
19. phosphine
20. neon

Winners: Poorna, Anuj

In the industrial world

(a) carbon dioxide is added to precipitate the alumina

(b) temperature and pressure are dropped and the supersaturated solution seeded

(c) both (a) and (b) are practised

(d) the water is evaporated.

18. A solution containing 0.5126 g naphthalene (mol. mass = 128) in 50 g of carbon tetrachloride yields a boiling point elevation 0.402 °C while a solution of 0.6216 g of an unknown solute in the same weight of sample solvent gives a boiling point elevation of 0.647 °C. The molecular mass of unknown solute is

(a) 98.48 g mol^{-1} (b) 46.25 g mol^{-1}

(c) 96.46 g mol^{-1} (d) 46.52 g mol^{-1}

19. Which of the following statements, about the advantage of roasting of sulphide ore before reduction is not true?

(a) The ΔG_f° of the sulphide is greater than those for CS_2 and H_2S.

(b) The ΔG_f° is negative for roasting of sulphide ore to oxide.

(c) Roasting of the sulphide to the oxide is thermodynamically feasible.

(d) Carbon and hydrogen are suitable reducing agents for metal sulphides.

More than One Option Correct Type

20. Henry's constant (in kbar) for four gases α, β, γ and δ in water at 298 K is given below :

Gas	α	β	γ	δ
K_H	50	2	2×10^{-5}	0.5

(density of water = 10^3 kg m^{-3} at 298 K)

This table implies that

(a) α has the highest solubility in water at a given pressure

(b) solubility of γ at 308 K is lower than at 298 K

(c) the pressure of a 55.5 molal solution of γ is 1 bar

(d) the pressure of a 55.5 molal solution of δ is 250 bar.

21. Select the correct statement(s).

(a) Based on reactivity series, occurrence of certain elements takes place in native state.

(b) Cresol and aniline are called froth stabilizers in froth floatation process.

(c) Cryolite is used in the electrolysis of alumina for decreasing electrical conductivity.

(d) Sulphide ores of Cu, Ag, Zn are concentrated by hydraulic washing.

22. Select the correct statement(s).

(a) In the decomposition of an oxide into metal entropy increases.

(b) To make ΔG negative, $T\Delta S > \Delta H$.

(c) Ellingham diagram represents change in free energy with temperature.

(d) Reduction of an oxide with aluminium is called van Arkel process.

23. Which of the following solution are isotonic with respect to 0.5 M NaCl solution having degree of dissociation = 0.8. ?

(a) 153.9 gm of sucrose dissolved in 500 mL of solution.

(b) 0.3 M aq. Na_2SO_4 solution undergoing 100% ionization

(c) 1.8 % *w*/*W* aq. NaOH solution undergoing 100% ionization

(d) 1.2 M solution of benzoic acid in benzene where the acid dimerizes to an extent of 50%.

Integer / Numerical Value Type

24. A certain mass of a substance when dissolved in 100 g C_6H_6 lowers the freezing point by 1.28 °C. The same mass of solute when dissolved in 100 g of water lowers the freezing point by 1.40 °C. If the substance has normal molecular mass in benzene and is completely dissociated in water, the number of ions formed when it dissociates in water is K_f for H_2O and C_6H_6 are 1.86 and 5.12 K mol^{-1} kg respectively is _____.

25. $2Cu_2S + 3O_2 \longrightarrow$ '*P*' + $2SO_2$

'*PQ*' + *C* $\longrightarrow$ '*Q*' + '*R*'

The total valence electrons in compound '*C*' is _____.

26. Silver ore is oxidised by using oxygen from air as follows :

$4Ag + xNaCN + 2H_2O + O_{2(air)} \rightarrow y\text{Na}[Ag(CN)_2] + 4NaOH$

What is the value of $(x - y)$?

Comprehension Type

The electrolyte solutions show abnormal colligative properties. To account for this effect we define a quantity called the van't Hoff factor given by

$$i = \frac{\text{Actual number of particles in solution after dissociation}}{\text{Number of formula units initially dissolved in solution}}$$

$i = 1$ (for non-electrolytes)

$i > 1$ (for electrolytes, undergoing dissociation)

$i < 1$ (for solutes undergoing association)

27. Benzoic acid undergoes dimerisation in benzene solution. The van't Hoff factor (i) is related to the degree of association (α) of the acid as

(a) $i = 2 - \alpha$ (b) $i = 1 + (\alpha/3)$

(c) $i = 1 - (\alpha/2)$ (d) $i = 1 + (\alpha/2)$

28. van't Hoff factors of equimolal solutions of sodium chloride, barium chloride and glucose in water are

(a) 2, 3, 0 respectively (b) 2, 3, 6 respectively

(c) 2, 3, 4 respectively (d) 2, 3, 1 respectively.

Matching Type

29. Match the column-I with column-II and mark the appropriate choice.

Column-I		Column-II	
A.	Ideal solution	P.	HNO_3(68%) + water (32%)
B.	Non-ideal solution showing positive deviation	Q.	Hexane + heptane
C.	Non-ideal solution showing negative deviation	R.	Ethanol (95.5%) + water (4.5%)
D.	Minimum boiling azeotropes	S.	Acetone + ethyl alcohol
E.	Maximum boiling azeotropes	T.	Acetone + chloroform

(a) A → S, B → T, C → Q, D → P, E → R

(b) A → Q, B → S, C → T, D → R, E → P

(c) A → S, B → P, C → R, D → T, E → Q

(d) A → S, B → R, C → P, D → Q, E → T

30. Match the column-I with column-II and select the correct option.

Column-I		Column-II	
(A)	$\underset{\text{(Impure)}}{Ni} + 4CO \xrightarrow{330\ K} Ni(CO)_4 \xrightarrow{450\ K} \underset{\text{(Pure)}}{Ni} + 4CO$	(p)	Hydrometallurgy
(B)	$4M + 8CN^- + 2H_2O + O_2 \rightarrow 4[M(CN)_2]^- + 4OH^-$ $4[M(CN)_2]^- + 2Zn \rightarrow 2[Zn(CN)_4]^{2-} + 4M$	(q)	Auto reduction
(C)	$2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$	(r)	Mond's process
(D)	$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$	(s)	Hall-Heroult Process

(a) (A)-(r); (B)-(p); (C)-(s); (D)-(q)

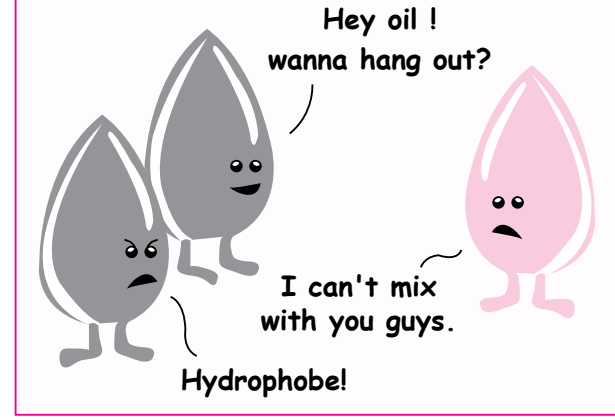
(b) (A)-(s); (B)-(q); (C)-(p); (D)-(r)

(c) (A)-(p); (B)-(r); (C)-(q); (D)-(s)

(d) (A)-(q); (B)-(s); (C)-(r); (D)-(p)

◈ ◈

CHEM CAPSULE



Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted .....

No. of questions correct .....

Marks scored in percentage .....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

GK CORNER



Enhance Your General Knowledge with Current Updates!

GLASGOW 2026 COMMONWEALTH GAMES

- **Mirabai Chanu (Gold-Women's 48 kg Weightlifting):** The queen of Indian weightlifting scripted history by capturing India's first gold medal at the Glasgow 2026 Games. By lifting a record-breaking combined total of 190 kg (85 kg Snatch / 105 kg Clean & Jerk), she completed an iconic golden hat-trick and shattered multiple Commonwealth records.
- **Sharmila Dhankar (Gold-Women's Shot Put F57 Para Athletics):** Creating an absolute milestone, Sharmila secured an emotion-fueled gold medal in the women's shot put F57 final. With a magnificent, season-best throw of 9.81 metres, she became the first-ever Indian para-athlete to win a Commonwealth gold in para-athletics, snapping a 20-year medal drought.
- **Rishikanta Singh Chanambam (Silver - Men's 60 kg Weightlifting):** The weightlifter put up a powerhouse performance to secure a silver medal in the men's 60 kg category. He held the distinct honour of becoming the first able-bodied athlete from India to step onto the podium at Glasgow 2026, registering a brilliant new Commonwealth record in the snatch segment.
- **Sarvesh Anil Kushare (Silver - Men's High Jump):** Delivering a stellar performance at Scotstoun Stadium, high jumper Sarvesh leaped to a silver medal in a highly competitive final. He cleared a phenomenal height of 2.25 metres to bag the second spot, finishing just behind Jamaica's Romaine Beckford who claimed the gold.
- **Gyaneshwari Yadav (Silver-Women's 53 kg Weightlifting):** Making a dream debut on the Commonwealth stage, the young weightlifting prodigy grabbed a silver medal in the women's 53 kg division. She put on a highly composed display of strength to lift a grand total of 199 kg, successfully opening India's medal account on the second day of events.
- **Valluri Ajaya Babu (Silver-Men's 79 kg Weightlifting):** In an absolute nail-biter of a finish, Valluri clinched a well-deserved silver medal in the men's 79kg weightlifting final. Showing incredible grit, he lifted a massive total of 330kg, missing out on the gold medal by a heartbreakingly slim margin of just 1kg behind Malaysia's Erry Hidayat.
- **Raja Muthupandi (Silver-Men's 65 kg Weightlifting) :** Adding significantly to India's early weightlifting masterclass, Raja put up a spectacular show of force to claim silver in the men's 65kg division. His clean execution under immense pressure fortified India's early position in the top ten of the global standings.
- **Jhandu Kumar (Bronze-Men's Heavy weight Para Power lifting):** The para-powerlifter etched his name into history by becoming the athlete who officially opened India's medal account at the Glasgow 2026 Games. Competing fiercely in the heavyweight group, he registered his personal-best lift of 190kg on his second attempt to bag a brilliant bronze.

- **Bindyarani Devi Sorokhaibam (Bronze - Women's 58 kg Weight lifting):** Continuing India's absolute dominance in the weightlifting arena, the elite lifter claimed a bronze medal in a high-octane women's 58kg final. She secured her podium spot by lifting a combined total of 199kg, proving her elite status once again at the international level.
- **Shilpa Kanchugarakoppalu Shyla (Bronze - Women's Shot Put F57 Para Athletics):** Shilpa was successfully awarded a well-deserved bronze medal in the women's shot put F57 final. Showing incredible focus on her major international debut, she launched the iron implement to register a magnificent personal-best throw of 7.26 metres.

TEST Yourself!

1. Sarvesh Kushare won high jump silver at which arena?
   (a) Emirates Arena
   (b) OVO Hydro
   (c) Scotstoun Stadium
   (d) Tollcross Swimming Centre
2. What milestone did Mirabai Chanu achieve at Glasgow 2026?
   (a) India's first silver medal
   (b) India's very first gold medal
   (c) First international debut
   (d) Bronze on the opening day
3. In which weight category did Gyaneshwari Yadav compete to win her silver medal?
   (a) 53 kg (b) 48 kg
   (c) 49 kg (d) 58 kg
4. What total weight did Valluri Ajaya Babu lift to win silver?
   (a) 190 kg (b) 199 kg
   (c) 330 kg (d) 9.81 kg
5. Shilpa Shyla won a bronze medal in which sport?
   (a) Women's High Jump
   (b) Heavyweight Para Powerlifting
   (c) Women's Shot Put F57 Para Athletics
   (d) Women's 58kg Weightlifting
6. Sharmila Dhankar's gold ended a medal drought of how many years?
   (a) 5 years
   (b) 10 years
   (c) 15 years
   (d) 20 years
7. What distinct milestone did para-powerlifter Jhandu Kumar achieve?
   (a) India's first weightlifting gold
   (b) Officially opened India's medal account
   (c) Threw a season-best 9.81 metres
   (d) Completed a golden hat-trick
8. Who was India's first able-bodied podium finisher at these Games?
   (a) Raja Muthupandi
   (b) Valluri Ajaya Babu
   (c) Rishikanta Singh Chanambam
   (d) Jhandu Kumar
9. Bindyarani Devi Sorokhaibam won which medal by lifting 199 kg?
   (a) Gold Medal
   (b) Silver Medal
   (c) Bronze Medal
   (d) Diamond Trophy
10. What did Raja Muthupandi's silver medal execution secure for India?
    (a) First para-athletics gold
    (b) Fortified India's early top-ten global standing
    (c) Upgraded a bronze to a silver
    (d) Set a new high jump record

Answer Key

1.	(c)	2.	(b)	3.	(c)	4.	(c)	5.	(c)
6.	(d)	7.	(b)	8.	(c)	9.	(c)	10.	(b)

WORD GRID

Readers are requested to send their responses of word grid. Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.

A	C	R	X	T	Z	H	Q	H	O	P	I	B	K	L
D	E	B	N	N	M	Q	Z	Y	U	W	Q	X	O	I
B	T	L	M	N	O	C	P	R	S	Q	Z	Y	C	G
J	I	O	P	L	H	H	X	Z	B	G	T	R	E	A
N	L	M	K	O	I	L	V	C	Z	Q	W	P	X	T
T	O	G	H	Y	V	O	Z	M	O	P	R	Q	S	F
H	E	I	T	L	Y	R	B	N	M	Q	X	E	S	A
A	Z	F	O	R	M	A	L	D	E	H	Y	D	E	T
A	C	R	L	R	M	M	Q	O	O	P	R	Q	S	F
T	O	G	U	O	B	I	Q	W	N	Q	W	P	X	T
A	Z	F	E	E	N	N	V	X	W	I	J	H	G	T
G	H	E	N	I	R	E	C	Y	L	G	T	Q	S	F
A	Z	F	E	R	M	A	L	D	E	H	Y	E	G	T
A	Z	F	E	E	N	N	V	X	W	I	J	H	R	W
A	Z	F	O	T	P	A	L	D	E	H	Y	D	N	T
P	O	T	A	S	S	I	U	M	L	M	Y	T	R	X
Z	X	C	V	B	N	M	L	P	O	I	U	Y	T	R

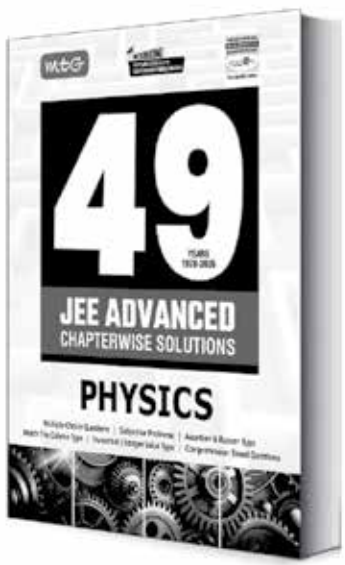
Clues

1. It is a pungent aldehyde gas sprayed onto new cotton shirts and trousers to prevent wrinkling and mildew during overseas shipping.
2. It is a highly volatile aromatic hydrocarbon solvent historically used in correction fluids and permanent markers, breathing in too much of it damages the central nervous system.
3. It is a non-stick synthetic fluoropolymer coating applied to kitchen frying pans.
4. It is a sweet-tasting polyol liquid used in everyday toothpaste to keep the paste moist.
5. It is a microporous mineral used in water softeners to swap out heavy calcium and magnesium ions for harmless ions.
6. It is an organic chemical skin treatment ingredient related to Vitamin A that is heavily restricted during pregnancy.
7. It is a sharp, burning gas released when chlorine bleach is mixed with window cleaners containing ammonia.
8. It is an alkali metal compound that colours a laboratory Bunsen burner flame a soft, beautiful lilac or violet hue.

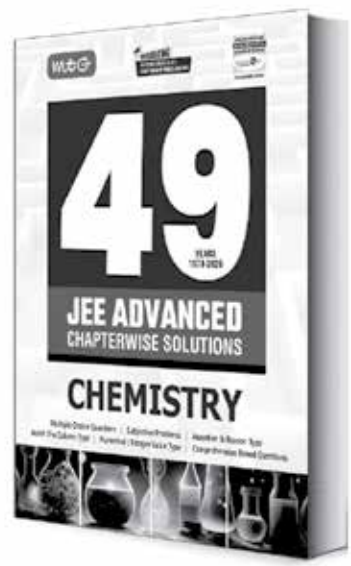
Note :- Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.

mtG

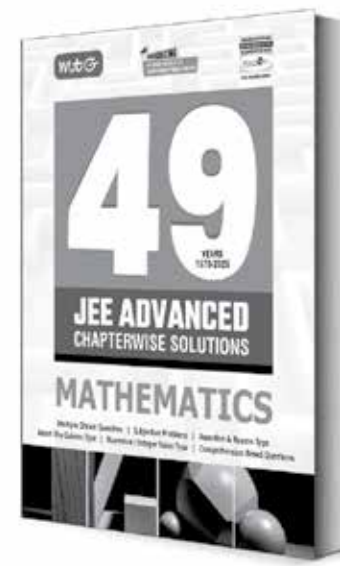
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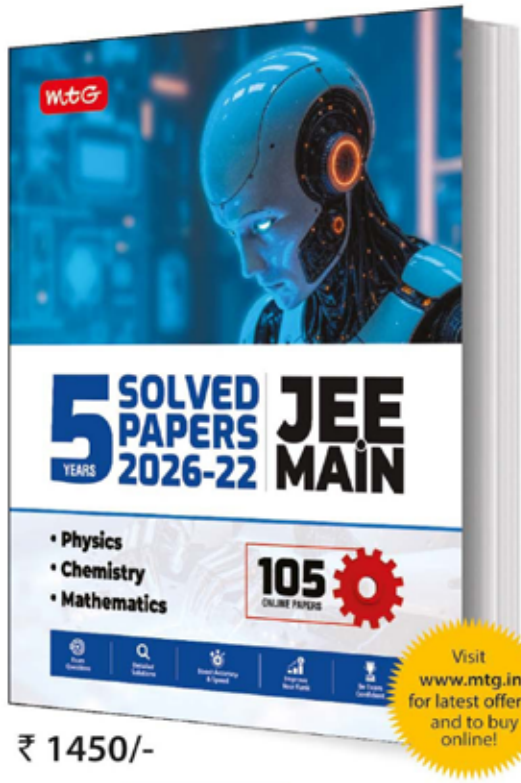
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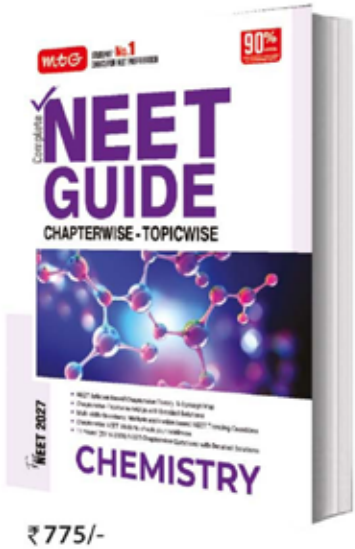
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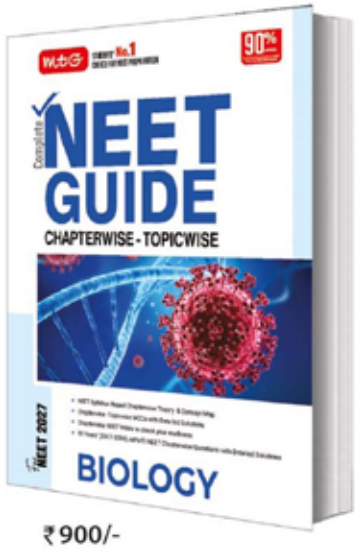
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