

# PART – A

## I. Multiple Choice Questions

1. **Number of significant figures in 0.523**  
**Answer:** (a) 3
2. **Molarity is defined as number of moles of solute present in**  
**Answer:** (a) One litre of solution
3. **Rutherford's  $\alpha$ -scattering experiment is related to size of**  
**Answer:** (a) Nucleus
4. **Mendeleev's periodic table is based on**  
**Answer:** (a) Atomic weight
5. **In  $\text{XeF}_4$ , number of lone pairs and shared pairs respectively**  
**Answer:** (b) 2, 4
6. **True for ionic compounds**  
**Answer:** (c) Soluble in polar solvents
7. **Second law of thermodynamics introduced concept of**  
**Answer:** (c) Entropy
8.  **$\Delta H$  (constant pressure) –  $\Delta E$  (constant volume) > RT when**  
**Answer:** (b)  $\Delta n_g > 1$
9. **If catalyst is used in reversible reaction**  
**Answer:** (d) Equilibrium is attained more quickly
10. **Lewis acids are**  
**Answer:** (b) Electron pair acceptors
11. **During reduction, oxidation number**  
**Answer:** (b) Decreases
12. **Catenation property is more marked in**  
**Answer:** (b) Carbon

13. **Methoxy methane and ethyl alcohol are**

**Answer:** (c) Functional isomers

14. **According to Markovnikov's rule, hydrogen attaches to**

**Answer:** (d) Carbon with maximum number of hydrogen atoms

15. **Hydrocarbon that damages DNA and causes cancer**

**Answer:** (d) All of these

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## II. Fill in the blanks

16. Outer shell of most stable atoms contains **8 electrons**

17. Standard enthalpy of formation of element is taken as **zero**

18. When pH decreases, hydrogen ion concentration **increases**

19. Successive members differ by **-CH<sub>2</sub>-** group

20. Process of converting n-hexane to benzene is called **aromatisation**

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## PART – B

### III. Answer any five (2 Marks Each)

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**21. Define Entropy. What happens when liquid changes into vapour?**

**Entropy (S)** is the measure of randomness or disorder of a system.

When a liquid changes into vapour, randomness increases.

Therefore, **entropy increases**.

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**22. Define Heterogeneous Equilibrium. Give Example.**

A heterogeneous equilibrium is one in which reactants and products are present in different physical states.

**Example:**



## 23. Isoelectronic Species

Isoelectronic species are atoms or ions having the same number of electrons.

Check electrons:

- $\text{Na}^+ \rightarrow 10$  electrons
- $\text{Cl}^- \rightarrow 18$  electrons
- $\text{F}^- \rightarrow 10$  electrons
- $\text{Li}^+ \rightarrow 2$  electrons

**Isoelectronic pair:**  $\text{Na}^+$  and  $\text{F}^-$

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## 24. Limitations of Octet Rule (Any Two)

1. It fails to explain molecules with incomplete octet (e.g.,  $\text{BF}_3$ ).
  2. It fails for expanded octet molecules (e.g.,  $\text{PCl}_5$ ).
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## 25. Define Hydrogen Bond. Example of Intramolecular H-bond.

A hydrogen bond is the attractive force between hydrogen attached to a highly electronegative atom (F, O, N) and another electronegative atom.

**Example (Intramolecular H-bond):** o-Nitrophenol

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## 26. Why is Helium Monoatomic? (MOT Explanation)

Helium has electronic configuration:



Bond order formula:

$$\text{Bond order} = (\text{Nb} - \text{Na}) / 2$$

For  $\text{He}_2$ :

$$\text{Bond order} = (2 - 2)/2 = 0$$

Since bond order is zero,  $\text{He}_2$  molecule does not exist.

Therefore, helium is monoatomic.

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## 27. Stock Notation

i)  $\text{HAuCl}_4 \rightarrow$  Gold(III) chloride

ii)  $\text{Fe}_2\text{O}_3 \rightarrow$  Iron(III) oxide

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## 28. $\text{CH}\equiv\text{C}-\text{CH}=\text{CH}-\text{CH}_3$

i) Bond-line formula:

Five carbon chain with triple bond at C1 and double bond at C3.

ii) The compound is **unsaturated** (contains double and triple bonds).

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## 29. Geometrical Isomers of But-2-ene

1. **Cis-but-2-ene**

2. **Trans-but-2-ene**

## PART – C

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## IV. Answer any three (3 Marks Each)

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### 30. Electronegativity

**Definition:**

Electronegativity is the tendency of an atom in a molecule to attract the shared pair of electrons towards itself.

**Trend in Periodic Table:**

- Across a period (left → right):  
Electronegativity increases  
(Due to increase in nuclear charge and decrease in atomic size)
  - Down a group (top → bottom):  
Electronegativity decreases  
(Due to increase in atomic size and shielding effect)
- 

### 31. Shape of Ammonia (NH<sub>3</sub>) – VSEPR Theory

**In NH<sub>3</sub>:**

- Nitrogen has 5 valence electrons
- It forms 3 bond pairs with hydrogen
- 1 lone pair remains

**Total electron pairs = 4**

**According to VSEPR theory:**

- Electron pair geometry = Tetrahedral
- Due to one lone pair, the molecular shape becomes Trigonal Pyramidal
- Bond angle  $\approx 107^\circ$

**Lone pair–bond pair repulsion > bond pair–bond pair repulsion**  
**Hence bond angle decreases from  $109.5^\circ$  to  $107^\circ$ .**

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### 32. (a) Dipole Moment

Definition:

Dipole moment is the product of magnitude of charge and distance between the charges.

Dipole moment ( $\mu$ ) =  $q \times d$

Unit: Debye (D)

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### 32. (b) Why Sigma Bond is Stronger than Pi Bond?

- Sigma bond is formed by head-on overlap of orbitals.
- Pi bond is formed by sidewise overlap.

Head-on overlap is more effective than sidewise overlap.  
Therefore, sigma bond is stronger than pi bond.

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### 33. Lewis Structure of $\text{NO}_2^-$

Total valence electrons:

N = 5

O =  $6 \times 2 = 12$

Extra electron (negative charge) = 1

Total = 18 electrons

Structure:

One N atom in centre bonded to two O atoms.

One double bond and one single bond (resonance structure exists).

Formal charge calculation:

Formal charge = Valence electrons – (Lone pair electrons +  $\frac{1}{2}$  bonding electrons)

For double bonded oxygen:

Formal charge =  $6 - (4 + 2) = 0$

For single bonded oxygen:

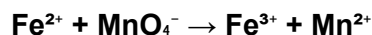
Formal charge =  $6 - (6 + 1) = -1$

Hence, negative charge is on one oxygen (delocalised due to resonance).

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### 34. Balance the Reaction (Oxidation Number Method)

Reaction:

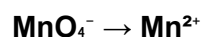


In acidic medium:

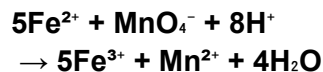
Oxidation:



Reduction:



Balanced equation:



## V. Answer any three (3 Marks Each)

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### 35. Dalton's Atomic Theory (Any Three)

1. Matter is made up of indivisible atoms.
  2. Atoms of same element have identical mass and properties.
  3. Atoms combine in simple whole number ratios to form compounds.
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### 36. Limitations of Bohr's Model

1. Applicable only to hydrogen-like atoms.

2. Cannot explain Zeeman effect.
3. Cannot explain Stark effect.

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### 37. Element with Atomic Number 24

Atomic number 24 → Chromium (Cr)

i) Electronic configuration:



ii) Number of unpaired electrons:

6 unpaired electrons

iii) Belongs to:

d-block element

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### 38. Relationship Between $C_p$ and $C_v$

For ideal gas:

$$C_p - C_v = R$$

Derivation (final result):

$$C_p = C_v + R$$

Where:

$C_p$  = Heat capacity at constant pressure

$C_v$  = Heat capacity at constant volume

$R$  = Gas constant

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### 39. Le Chatelier's Principle

If a system at equilibrium is disturbed by change in temperature, pressure or concentration, the system shifts in such a way as to oppose the disturbance.

For exothermic reaction:



Heat is released.

If temperature increases → equilibrium shifts in backward direction.

If temperature decreases → equilibrium shifts in forward direction.

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#### 40. Relation Between $K_p$ and $K_c$

$$K_p = K_c (RT)^{\Delta n}$$

Where

$\Delta n$  = moles of gaseous products – moles of gaseous reactants

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(i)  $K_p > K_c$

Example:



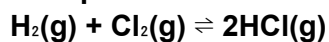
Here  $\Delta n = 1$

So  $K_p > K_c$

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(ii)  $K_p = K_c$

Example:



Here  $\Delta n = 0$

So  $K_p = K_c$

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### PART – D

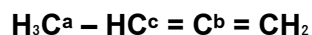
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#### VI. Answer any two (5 Marks Each)

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##### 41. (a) Hybridisation of Marked Carbon Atoms

Given compound:



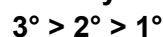
- Carbon a ( $\text{H}_3\text{C}-$ )  $\rightarrow$  single bonds only  $\rightarrow$   $\text{sp}^3$  hybridised
  - Carbon c ( $-\text{HC}=\text{}$ )  $\rightarrow$  involved in one double bond  $\rightarrow$   $\text{sp}^2$  hybridised
  - Carbon b ( $=\text{C}=\text{}$ )  $\rightarrow$  involved in two double bonds  $\rightarrow$   $\text{sp}$  hybridised
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#### 41. (b) Carbocation

A carbocation is a positively charged carbon species having six electrons in its valence shell.

Example:  $\text{CH}_3^+$

Stability order:



(Tertiary > Secondary > Primary)

Reason: Greater alkyl groups give +I effect and hyperconjugation.

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#### 42. (a) Estimation of Carbon (Principle & Calculation)

Principle:

Organic compound is heated with excess  $\text{CuO}$  in presence of oxygen.  
Carbon gets oxidised to  $\text{CO}_2$ .

$\text{CO}_2$  is absorbed in  $\text{KOH}$  solution.

Increase in weight gives amount of  $\text{CO}_2$ .

Calculation:

Mass of carbon =

$$(12 / 44) \times \text{Mass of } \text{CO}_2 \text{ formed}$$

Percentage of carbon =

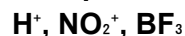
$$(\text{Mass of carbon} / \text{Mass of compound}) \times 100$$

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#### 42. (b) Electrophiles

Electrophiles are electron-deficient species which accept electron pairs.

Examples:



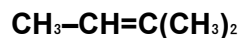
### 43. (a) Ozonolysis Problem

Alkene gives:

Ethanal ( $\text{CH}_3\text{CHO}$ )

Propan-2-one ( $\text{CH}_3\text{COCH}_3$ )

Required alkene:



IUPAC Name: 2-methylbut-2-ene

Reaction:

Alkene +  $\text{O}_3 \rightarrow$  Ozonide  $\rightarrow$

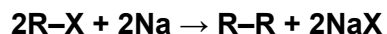
On hydrolysis  $\rightarrow$  Ethanal + Propan-2-one

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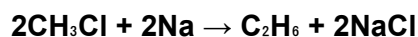
### 43. (b) Wurtz Reaction

When alkyl halides are treated with sodium in dry ether, higher alkane is formed.

General reaction:



Example:



### 44. (a) Nitration of Benzene

Benzene reacts with concentrated  $\text{HNO}_3$  in presence of concentrated  $\text{H}_2\text{SO}_4$ .

Step 1: Formation of electrophile



**Step 2: Electrophilic attack on benzene ring**

**Step 3: Deprotonation to restore aromaticity**

**Product formed: Nitrobenzene**

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#### **44. (b) Staggered Conformation of Ethane**

**In staggered conformation:**

- Hydrogen atoms are maximum apart
- Torsional strain is minimum
- It is most stable conformation

**(Draw Newman projection in exam)**

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## **PART – E**

### **VII. Answer any four (3 Marks Each)**

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#### **45. Molecular Formula Determination**

**Given:**

**C = 26.66%**

**H = 2.22%**

**O = 71.12%**

**Step 1: Convert to moles**

**C =  $26.66 / 12 = 2.22$**

**H =  $2.22 / 1 = 2.22$**

**O =  $71.12 / 16 = 4.445$**

**Step 2: Divide by smallest value (2.22)**

$$\text{C} = 1$$

$$\text{H} = 1$$

$$\text{O} = 2$$

Empirical formula =  $\text{CHO}_2$

Empirical mass = 45

Given molecular mass = 90

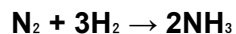
$$\text{Multiplier} = 90 / 45 = 2$$

Molecular formula =  $\text{C}_2\text{H}_2\text{O}_4$

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## 46. Mass of Ammonia Formed

Reaction:



Given:

Mass  $\text{N}_2$  = 2000 g

Mass  $\text{H}_2$  = 1000 g

Moles:

$$\text{N}_2 = 2000 / 28 = 71.4 \text{ mol}$$

$$\text{H}_2 = 1000 / 2 = 500 \text{ mol}$$

Required ratio = 1 : 3

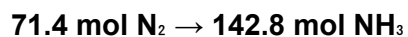
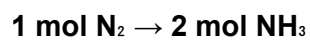
For 71.4 mol  $\text{N}_2 \rightarrow$

$\text{H}_2$  required = 214.2 mol

Available  $\text{H}_2$  = 500 mol

So  $\text{N}_2$  is limiting reagent

From reaction:



$$\text{Mass } \text{NH}_3 = 142.8 \times 17$$

$$= 2427.6 \text{ g}$$

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#### 47. First Line of Balmer Series

Formula:

$$1/\lambda = R \left[ (1/2^2) - (1/3^2) \right]$$

$$1/\lambda = 1.09677 \times 10^7 \times (1/4 - 1/9)$$

$$= 1.09677 \times 10^7 \times (5/36)$$

$$= 1.52 \times 10^6 \text{ m}^{-1}$$

$$\text{Wave number} = 1.52 \times 10^6 \text{ m}^{-1}$$

$$\text{Wavelength} = 1 / (1.52 \times 10^6)$$

$$= 6.58 \times 10^{-7} \text{ m}$$

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#### 48. Energy of One Mole of Photons

Given:

$$\nu = 5 \times 10^{14} \text{ Hz}$$

Formula:

$$E = h\nu$$

$$h = 6.626 \times 10^{-34} \text{ J s}$$

Energy of one photon:

$$= 6.626 \times 10^{-34} \times 5 \times 10^{14}$$

$$= 3.313 \times 10^{-19} \text{ J}$$

For one mole:

$$E = 3.313 \times 10^{-19} \times 6.022 \times 10^{23}$$

$$= 1.996 \times 10^5 \text{ J}$$

$$= 199.6 \text{ kJ}$$

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## 49. Enthalpy of Formation of Benzene

Given:

$$\Delta H_c(\text{C}) = -393.5 \text{ kJ/mol}$$

$$\Delta H_c(\text{H}_2) = -285.83 \text{ kJ/mol}$$

$$\Delta H_c(\text{C}_6\text{H}_6) = -3267 \text{ kJ/mol}$$

Using Hess law:

$$\Delta H_f(\text{C}_6\text{H}_6) = [6(-393.5) + 3(-285.83)] - (-3267)$$

$$= -2361 - 857.49 + 3267$$

$$= +48.51 \text{ kJ/mol}$$

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## 50. Work Done in Isothermal Expansion

Formula:

$$W = -nRT \ln(V_2/V_1)$$

Given:

$$n = 1 \text{ mol}$$

$$R = 8.314 \text{ J/mol K}$$

$$T = 298 \text{ K}$$

$$V_2/V_1 = 20/10 = 2$$

$$W = -(1)(8.314)(298) \ln 2$$

$$= -(2477.5)(0.693)$$

$$= -1717 \text{ J}$$

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## 51. $\Delta G^\circ$ of Hydrolysis

Formula:

$$\Delta G^\circ = -RT \ln K$$

**Given:**

$$K = 2 \times 10^{-3}$$

$$T = 300 \text{ K}$$

$$\Delta G^\circ = -(8.314)(300) \ln(2 \times 10^{-3})$$

$$\ln(2 \times 10^{-3}) = -6.214$$

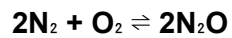
$$\Delta G^\circ = 15500 \text{ J}$$

$$= 15.5 \text{ kJ}$$

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## **52. Equilibrium Composition**

**Reaction:**



**Given:**

$$\text{N}_2 = 0.482 \text{ mol}$$

$$\text{O}_2 = 0.933 \text{ mol}$$

$$\text{Volume} = 10 \text{ L}$$

$$K_c = 2 \times 10^{-37} \text{ (very small)}$$

Since  $K_c$  is extremely small  $\rightarrow$  reaction hardly proceeds.

**Therefore:**

**Equilibrium amounts approximately:**

$$\text{N}_2 \approx 0.482 \text{ mol}$$

$$\text{O}_2 \approx 0.933 \text{ mol}$$

$$\text{N}_2\text{O} \approx 0$$