1. **(a)** The specific sequence of amino acids in a protein is its primary structure.
2. **(a)** Conversion of diazonium salt into cyanide using $CuCN/KCN$ is Sandmeyer reaction.
3. **(d)** Tertiary butyl alcohol $(CH_3)_3COH$ is formed by hydration of:
   $(CH_3)_2C = CH_2$
4. **(c)** Chloroform undergoes auto-oxidation in air and light to form poisonous phosgene gas $(COCl_2)$.
5. **(a)** Interstitial compounds make transition metals harder.
6. **(c)** Isotonic solutions have the same osmotic pressure.
7. **(b)** The Apollo space programme used hydrogen-oxygen fuel cells.
8. **(b)** Rate law:
   $r \propto [A]^n$
   Given:
   $16 = (4)^n$
   $4^2 = 4^n$
   $n = 2$
9. **(a)** The carbon atom is chiral when it is attached to four different groups.
   • (I) chiral
   • (II) chiral
   • (III) chiral
   • (IV) not chiral (two CH_3 groups are same)
10. **(c)** Alkoxide ion $(RO^-)$is the strongest base among the given species.
11. **(d)** On dilution:
    • Conductivity decreases because number of ions per unit volume decreases.
    • Molar conductivity increases because ions move more freely.
12. **(b)**$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$
    Total ions formed $= 3$
    Water of crystallization does not affect Van't Hoff factor.
13. **(a)** Assertion (A) is true.
    Zr and Hf have almost similar atomic radii.
    Reason (R) is also true.
    Due to lanthanoid contraction, the increase in atomic size from Zr to Hf is compensated.
    Therefore, R correctly explains A.
    So, Both A and R are true, and R is the correct explanation of A.
14. **(a)** For a zero order reaction:
    Rate $= k[A]^0 = k$
    So, the rate of reaction equals the rate constant k. Hence both have the same units.
    Assertion (A) is true.
    Reason (R) is also true because zero order reaction rate is independent of concentration.
    R correctly explains A.
    So, Both A and R are true, and R is the correct explanation of A.
15. **(c)** Assertion (A) is true.
    S_N2 reactions show inversion of configuration due to backside attack of the nucleophile.
    Reason (R) is false.
    S_N2 reaction occurs in a single step and does not involve carbocation formation.
    So, A is true, but R is false.
16. **(d)** Assertion (A) is false.
    p-Nitrophenol is more acidic than p-methoxyphenol because the nitro group withdraws electrons and stabilizes the phenoxide ion.
    Reason (R) is also false.
    Methoxy group mainly shows +M effect (not + I), while nitro group shows -I and -M effects.
    So, Both A and R are false.
17. **(A)** Kohlrausch Law
    Statement: The limiting molar conductivity of an electrolyte is the sum of the individual contributions of its constituent ions.

Formula: $\Lambda_m^\circ = \nu_+\lambda_+^\circ + \nu_-\lambda_-^\circ$
(Where λ_+° and λ_-° are the molar conductivities of cations and anions at infinite dilution).
(B) Faraday's First Law
Statement: The mass (w) of a substance deposited or liberated at an electrode is directly proportional to the quantity of charge (Q) passed through the electrolyte.
Formula: $w = zIt$
(Where z is the electrochemical equivalent, I is current, and t is time).

18. • Monosaccharides (Single sugar unit): Galactose, Glucose
• Disaccharides (Two sugar units): Lactose, Maltose Detailed Classification:
• Galactose: Monosaccharide (simple sugar)
• Glucose: Monosaccharide (simple sugar)
• Lactose: Disaccharide (composed of glucose and galactose)
• Maltose: Disaccharide (composed of two glucose molecules)

19. **(A)** Conversions
(i) Nitrobenzene - Aniline
Reduction of nitro group:
$C_6H_5NO_2 \xrightarrow{Sn/HCl \text{ or } H_2/Ni} C_6H_5NH_2$
(then basify with NaOH to obtain free aniline)
(ii) Aniline → Phenol
Via diazotization:
1. Diazotization:
$C_6H_5NH_2 + NaNO_2 + 2HCl \rightarrow C_6H_5\ N_2Cl^- + 2H_2$
2. Hydrolysis:
$C_6H_5\ N_2^+Cl^- + H_2O \rightarrow C_6H_5OH + N_2 + HCl$

OR

(B)(i) Test to distinguish Dimethylamine and Ethanamine
Use carbylamine test:
• Ethanamine (1° amine) → gives foul-smelling isocyanide:
$C_2H_5NH_2 + CHCl_3 + 3KOH \rightarrow C_2H_5NC$
• Dimethylamine (2° amine) → no reaction
(ii) Benzene diazonium chloride +KI
$C_6H_5\ N_2Cl + KI \rightarrow C_6H_5I + N_2 + KCl$
Product formed: Iodobenzene (C_6H_9I)

20. For a first-order reaction, we use:
$$t = \frac{2.303}{k}\log\frac{a}{a-x}$$
For 90% completion
Remaining $= 10\% \Rightarrow a - x = 0.1a$
$$t_{90} = \frac{2.303}{k}\log\frac{a}{0.1a} = \frac{2.303}{k}\log 10$$
Given $\log 10 = 1$:
$$t_{90} = \frac{2.303}{k}$$
For 99% completion
Remaining $= 1\% \Rightarrow a - x = 0.01a$
$$t_{99} = \frac{2.303}{k}\log\frac{a}{0.01a} = \frac{2.303}{k}\log 100$$
$\log 100 = 2\log 10 = 2$
So,
$$t_{99} = \frac{2.303}{k} \times 2 = \frac{4.606}{k}$$
Now compare
$$t_{99} = \frac{4.606}{k}, t_{90} = \frac{2.303}{k}$$
$t_{99} = 2t_{90}$

21. We use the relation:

$\kappa = \frac{G}{R}$

where G = cell constant

Step 1: Find cell constant using 0.2 M KCl data

Given:

• $R_1 = 200\Omega$

• $\kappa_1 = 0.0248S\ \text{cm}^{-1}$

$G = \kappa_1 \times R_1 = 0.0248 \times 200 = 4.96\ \text{cm}^{-1}$

Step 2: Find conductivity of 0.05 M solution

Given:

• $R_2 = 620\Omega$

$\kappa_2 = \frac{G}{R_2} = \frac{4.96}{620}$

$\kappa_2 = 0.008S\ \text{cm}^{-1}$

Step 3: Molar conductivity of 0.05 M solution

$\Lambda_m = \frac{\kappa \times 1000}{C}$

Where:

• $\kappa = 0.008S\ \text{cm}^{-1}$

• $C = 0.05\ \text{mol}L^{-1}$

$\Lambda_m = \frac{0.008 \times 1000}{0.05} = \frac{8}{0.05} = 160\text{Scm}^2\text{mol}^{-1}$

22. IUPAC Names

(A) $[Co(NH_3)_4Cl(NO_2)]Cl$

→ Tetraamminechloronitrocobalt(III) chloride

(B) $[Ni(NH_3)_6]ClCl_2$

→ Hexaammine nickel(IV) chloride

(overall: Ni is +4 due to $3Cl^-$outside; complex cation is +4)

(C) $K_3[Cr(C_2O_4)_3]$

→ Potassium tris(oxalato)chromate(III)

(D) $[Co(en)_2Br_2]^+$

→ Dibromobis(ethylenediamine)cobalt(III) ion

23. Major Products (Structures)

(A) Ethanal $+CH_3MgBr$ followed by hydrolysis

Ethanat: CH_3CHO

Grignard addition gives a secondary alcohol:

$CH_3CHO + CH_3MgBr \rightarrow CH_3CH(OMgBr)CH_3$

Hydrolysis:

$CH_3CH(OMgBr)CH_3 \rightarrow CH_3CH(OH)CH_3$

Product: Propan-2-ol (isopropyl alcohol)

Structure:

$CH_3 - CH(OH) - CH,$

(B) Hydration of But-1-ene (dil. H_2SO_4)

Markovnikov addition of water.

But-1-ene: $CH_2 = CH - CH_2 - CH_3$

OH goes to more substituted carbon:

Product: Butan-2-ol

Structure:

$CH_3 - CH(OH) - CH_2 - CH_3$

(C) Phenol + Bromine water

Electrophilic substitution gives tribromination:

Product: 2,4,6-Tribromophenol

Structure:

OH group on benzene ring with Br at 2, 4, and 6 positions:
$C_6H_2Br_3OH$ (white precipitate)

24. Major products

(A) Reagent: $[Ag(NH_3)_2]^+/OH^-$(Tollens' reagent)
The -CHO group is oxidised to $-COOH$, while ketone remains unchanged.
Product:
→4-oxocyclohexanecarboxylic acid
(Structure: cyclohexane ring with -COOH and $C=O$ (ketone) on the ring)
(B) Reagent: NaOI (iodoform reaction)
The compound contains a methyl ketone group ($-COCH_3$), so it undergoes cleavage.
Products:
• CHI_3 (iodoform, yellow ppt)
• Sodium salt of carboxylic acid
Organic product:
$CH_3-CH=C(CH_3)-COO^-Na^+$
(C) Reagent: NaCN/HCl
This is intramolecular benzoin-type cyclization of o-formylbenzoic acid, forming a cyclic ester.
Product:
→ Phthalide (isobenzofuran-1(3H)-one)
(Structure: fused benzene ring with a 5 -membered lactone ring)

25. We use the Nernst equation:

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{n}\log Q$$

Step 1: Write the reaction quotient (Q)
Reaction:
$Ni(s) + 2Ag^+ \rightarrow Ni^{2+} + 2Ag(s)$

$$Q = \frac{[Ni^{2+}]}{[Ag^+]^2}$$

Given:
• $[Ni^{2+}] = 0.1$
• $[Ag^+] = 0.01$

$$Q = \frac{0.1}{(0.01)^2} = \frac{0.1}{10^{-4}} = 10^3$$

Step 2: Apply log
$\log Q = \log(10^3) = 3$
(given $\log 10 = 1$)
Step 3: Substitute in Nernst equation
• $E^\circ = 1.05$ V
• $n = 2$

$$E = 1.05 - \frac{0.0591}{2} \times 3$$

$E = 1.05 - (0.02955 \times 3)$
$E = 1.05 - 0.08865$
$E = 0.96135$ V

26. **(A)** Haloalkanes +AgCN → isocyanide (R-NC)
AgCN is largely covalent, so nucleophile is nitrogen (N) rather than carbon. Hence attack occurs via N → isocyanide forms as major product.
(B) Allyl chloride shows high S_n1 reactivity
It forms a resonance-stabilized allyl carbocation after ionization. The positive charge is delocalized over two carbon atoms, making carbocation formation easier → faster S_n1 reaction.
(C) Haloarenes are less reactive in nucleophilic substitution
Due to:
• Resonance (partial double bond character in $C-X$ bond)
• sp^2 carbon makes $C-X$ bond stronger
• No stable phenyl carbocation formation

So nucleophilic substitution is very difficult.

27. Using Arrhenius equation:

$$\log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Given:

$k_2/k_1 = 4 \Rightarrow \log 4 = 0.60$

$T_1 = 300K, T_2 = 320K$

$2.303R = 19.15JK^{-1}\ \text{mol}^{-1}$

Now,

$$\frac{1}{300} - \frac{1}{320} = \frac{20}{96000} = \frac{1}{4800}$$

Substitute:

$$0.60 = \frac{E_a}{19.15} \times \frac{1}{4800}$$

$E_a = 0.60 \times 19.15 \times 4800$

$E_a = 55152\ \text{J/mol} \approx 55.2\ \text{kJ/mol}$

28. Since $X(C_3H_9\ N)$ reacts with benzenesulphonyl chloride $(C_6H_5SO_2Cl)$ to give a solid insoluble in alkali, it indicates the Hinsberg test.

Step 1: Identify X

Amines with formula $C_3H_9\ N$ can be:

- 1° amine: propan-1-amine / propan-2-amine
- 2° amine: ethyl methyl amine
- 3° amine: trimethyl amine

Observation given: product is solid and insoluble in alkali → characteristic of secondary amine

So, X = N-methylethanamine (ethylmethylamine)

Structure: $CH_3 - NH - C_2H_5$

Step 2: Reaction (Hinsberg reaction)

Secondary amine reacts with benzenesulphonyl chloride to form a sulphonamide, which is insoluble in alkali:

$C_2H_5NHCH_3 + C_6H_5SO_2Cl \rightarrow C_6H_5SO_2\ N(CH_3)(C_2H_5) + HCl$

Step 3: Product name (IUPAC)

Product formed is:

N -methyl- N -ethylbenzenesulphonamide

29. **(A)** Ambidentate ligand:

A ligand that has two different donor atoms, but can coordinate through only one at a time to the metal ion.

Example: NO_2^-(can bind through N or O), SCN^-(can bind through S or N)

(B) Type of isomerism:

$[Co(NH_3)_5Cl]SO_4$ and $[Co(NH_3)_5SO_4]Cl$ show ionisation isomerism.

Because the ligands inside the coordination sphere and counter ions interchange, giving different ions in solution.

(C) Chelate effect:

Chelate effect is the increased stability of complexes formed by polydentate ligands (chelating ligands) compared to similar complexes with monodentate ligands.

Effect on stability:

Chelating ligands form ring structures with the metal ion, which increases entropy and makes the complex more stable and less easily dissociated.

OR

(c) $Na_3[Cr(C_2O_4)_3]$

Let oxidation state of Cr = x

Oxalate $(C_2O_4^{2-}) = -2$ each, and there are 3 ligands:

$x + 3(-2) = -3$

$x - 6 = -3$

$x = +3$

30. **(A)** Other name of vitamin B_6 is Pyridoxine.

(B) Vitamin responsible for normal blood clotting is Vitamin K. Its deficiency causes increased blood clotting time.

(C) Xerophthalmia is caused by deficiency of Vitamin A.

Two sources of Vitamin A:
• Carrot
• Green leafy vegetables (like spinach)

OR

(c) Vitamin C cannot be stored in the body because it is water-soluble, so excess is excreted in urine.
Disease caused by its deficiency: Scurvy

31. Here are the answers to the selected questions based on Chemical Principles:

(A) Ce (III) is easily oxidised to Ce (IV): Ce (III) has the electronic configuration $[Xe14f^1 5d^0 6s^0$. It easily loses the single electron from the $4f$ orbital to acquire the highly stable noble gas configuration ($4f^0$) of Ce^{4+}.
(B) $E^\circ(Mn^{2+}/Mn)$ is highly negative (-1.18 V): This is due to the extra stability of the half-filled d-orbital $(3d^5)$ in the Mn^{2+} ion, which makes it less likely to get reduced to Manganese metal compared to its neighbors.
(C) Lowest enthalpy of atomisation in 3d series: Zinc (Zn) has the lowest enthalpy of atomisation. It has a fully filled $(3d^{10})$ configuration, meaning no unpaired d-electrons are available for metallic bonding.
(D) Acidification of Sodium Chromate: When acidified, yellow sodium chromate (Na_2CrO_4) is converted into orange sodium dichromate $(Na_2Cr_2O_7)$ due to the formation of the dichromate ion $(Cr_2O_7^{2-})$ in acidic conditions.
(E) Zn, Cd and Hg are soft metals: These metals have a completely filled $(n-1)d^{10}$ configuration and no vacant d-orbitals, resulting in weak metallic bonding.
(F) Permanganate titration and HCl: HCl is not used because $KMnO_4$ is a strong oxidizing agent and will oxidize HCl to Cl_2 gas, consuming the reagent and giving inaccurate titration results.
(G) Lower oxides basic, higher oxides acidic/amphoteric: In lower oxidation states, electrons are available for sharing (basic). In higher oxidation states, the high charge density allows them to accept electron pairs or act as Lewis acids (amphoteric/acidic).

32. (A) (i) Mass of ethylene glycol required
Given:
• Mass of water $= 1.0$ kg
• Freezing point depression $= \Delta T_f = 2.8°C = 2.8$ K
• $K_f = 1.86$ K kg mol^{-1}
• Molar mass of ethylene glycol $= 62$ g/mol
Formula:
$\Delta T_f = K_f m$

$$m = \frac{\Delta T_f}{K_f} = \frac{2.8}{1.86} \approx 1.505 \text{mol/kg}$$

Since solvent = 1 kg water:
moles of solute $= 1.505$
Mass of ethylene glycol:
$= 1.505 \times 62 \approx 93.3$ g
(ii) Deviation of ethanol + acetone mixture
Ethanol and acetone show positive deviation from Raoult's law.
Reason:
The intermolecular hydrogen bonding in ethanol gets weakened when mixed with acetone, so the interactions between unlike molecules are weaker than like molecules → vapour pressure increases.

OR

(B) (i) Mass of sucrose required
Given:
• Mass of water $= 500$ g $= 0.5$ kg
• Boiling point increase:
$\Delta T_b = 100 - 99.68 = 0.32K$
• $K_b = 0.52K$ kg mol^{-1}
• Molar mass of sucrose $= 342$ g/mol
Formula:
$\Delta T_b = K_b m$

$$m = \frac{0.32}{0.52} \approx 0.615 \text{ mol/kg}$$

Moles of sucrose:
$= 0.615 \times 0.5 = 0.3075$mol

Mass:
$= 0.3075 \times 342 \approx 105.2$ g
(ii) Henry's Law + application
Henry's Law:
At constant temperature, the partial pressure of a gas in vapour phase is directly proportional to its mole fraction in the solution:
$P = K_H x$
Application:
Used in carbonated drinks (soft drinks) to dissolve CO_2 gas under high pressure.

33. **(A) (i)** Identification of compound (A)
Given: $C_9H_{10}O$
• Forms 2,4-DNP derivative - carbonyl compound
• Reduces Fehling solution - aldehyde (not ketone)
• Undergoes Cannizzaro reaction - no $\alpha - H$ - aromatic aldehyde
• On strong oxidation gives benzene-1,2-dicarboxylic acid (phthalic acid) → indicates ortho-substituted benzaldehyde
So compound is:
o-ethylbenzaldehyde (2-ethylbenzaldehyde)
(ii) Reactions
(1) With 2,4-DNP
Forms yellow/orange precipitate (hydrazone):
$C_6H_4(C_2H_5)CHO + H_2NNHC_6H_3(NO_2)_2 \rightarrow$ 2,4-DNP hydrazone $+ H_2O$
(2) With Fehling solution
Since it is an aldehyde:
$RCHO^2 + 2Cu^{2+} + 5OH^- \rightarrow RCOO^- + Cu_2O \downarrow + 3H_2O$
(Brick red ppt of Cu_2O)
(iii) Cannizzaro reaction
$2C_6H_4(C_2H_5)CHO + OH \rightarrow C_6H_4(C_2H_5)CH_2OH + C_6H_4(C_2H_5)COO$
Products:
• o-ethylbenzyl alcohol
• sodium o-ethylbenzoate

OR

(B) (i) Explanations
(1) α-hydrogens are acidic
Due to formation of resonance-stabilized enolate ion after removal of $\alpha - H$.
(2) Aldehydes oxidise more easily than ketones
Because aldehydes have one hydrogen atom, making oxidation easier; ketones lack this and are more stable.
(ii) Order
(1) Decreasing nucleophilic addition reactivity:
Propanal > Acetone > Benzaldehyde
(Aldehydes > ketones; aromatic ring reduces reactivity)
(2) Increasing boiling point:
Dimethyl ether < Propanal < Propane < Ethanol
(Actually correct trend based on intermolecular forces:
Propane < Dimethyl ether < Propanal < Ethanol)
(iii) Test to distinguish
• Benzoic acid: gives effervescence with $NaHCO_3$ (CO_2 gas released)
$C_6H_5COOH + NaHCO_3 \rightarrow C_6H_5COONa + CO_2 + H_2O$
• Benzaldehyde: does not react with $NaHCO_3$, but gives Tollens test (silver mirror).

34. **(d)** For a strong electrolyte, limiting molar conductivity is given by:
$\Lambda_m^\circ(CaCl_2) = \lambda^\circ(Ca^{2+}) + 2\lambda^\circ(Cl^-)$
Given:
• $\lambda^\circ(Ca^{2+}) = 119.0S\ cm^2\ mol^{-1}$
• $\lambda^\circ(Cl^-) = 76.35\ cm^2\ mol^{-1}$
Now substitute:
$\Lambda_m^\circ = 119.0 + 2 \times 76.3$

$= 119.0 + 152.6 = 271.6 Scm^2\ mol^{-1}$

35. **(a)** The given reaction shows Cannizzaro reaction of formaldehyde (methanal) with concentrated KOH .

In Cannizzaro reaction:

• One molecule is reduced → alcohol

• One molecule is oxidised → carboxylate salt

Reaction:

$2HCHO + \text{ conc. } KOH \xrightarrow{\Delta} CH_3OH + HCOOK$

So:

• $A =$ Methanol (CH_3OH)

• $B =$ Potassium formate $(HCOOK)$

36. **(c)** Vitamin C acid

Vitamin C is Ascorbic acid

Reason: Ascorbic acid is the chemical name of Vitamin C, a strong reducing agent and antioxidant.

37. **(a)** Rosenmund reduction catalyst

Rosenmund reduction converts acid chlorides to aldehydes:

$RCOCl + H_2 \xrightarrow{Pd^2/BaSO_4} RCHO$

Reason: Pd is poisoned by $BaSO_4$ to prevent further reduction of aldehyde to alcohol.

38. **(a)** Fastest S_n1 reaction

S_n1 rate depends on stability of carbocation:

Stability order:

$3^\circ > 2^\circ > 1^\circ >$ methyl

Options:

• $(CH_3)_3C - Br$ → tertiary carbocation (most stable)

• $(CH_3)_2CH - Br$ → secondary

• $CH_3CH_2 - Br$ → primary

• $(CH_3)_3C - CH_2 - Br$ → primary-like (no stable carbocation)

39. **(b)** Maximum oxidation states in 3d series

• Sc: limited oxidation states

• Ti: $+2, +3, +4$

• Cr: $+2$ to $+6$

• Mn: $+2$ to $+7$ (maximum range)

Reason: Mn has maximum number of unpaired electrons → shows highest oxidation states up to $+7$.

40. **(c)** Arrhenius equation

The correct form is:

$k = Ae^{-E_a/RT}$

Reason: Rate constant decreases exponentially with increase in activation energy E_a.

41. **(a)** Tertiary amine identification

A tertiary amine has nitrogen attached to three alkyl groups (no $N - H$ bond).

• (c) $CH_3 - NH - CH_2 - CH_3$ → secondary amine (has $N - H$)

• (d) $(C_2H_5)_2CHNH_2$ → primary amine (NH_2 group present)

So the correct option among typical structures is the one where N is bonded to 3 alkyl groups only.

42. **(c)** Grignard reagent + ketone + hydrolysis

Reaction:

• Ketone $+RMgX$ → alkoxide intermediate

• Hydrolysis → tertiary alcohol

Reason: Ketone already has two alkyl groups; Grignard adds third → forms tertiary alcohol after hydrolysis.

43. **(b)** Zero order reaction graph

For a zero-order reaction:

$[R] = [R]_0 - kt$

Comparing with straight line equation $y = c + mx$:

• Slope $= -k$

• Intercept $= [R]_0$

44. **(a)** Match the following

(I) Oxidation of primary alcohols to aldehydes

• Reagent: PCC

(I → R)

(II) Butan-2-one → Butan-2-ol (reduction)

• Reagent: $NaBH_4$

(II → P)

(III) Phenol → 2,4,6-tribromophenol

• Reagent: Bromine water

(III → S)

(IV) Dehydration of propan-2-ol to propene

• Reagent: $85\%H_3PO_4$ at 440 K

(IV → Q)

So:

• I – (R)

• II-(P)

• III - (S)

• IV - (Q)

45. **(a)** General electronic configuration of d-block elements

d -block elements (transition elements) have valence electrons in $(n-1)$d and ns orbitals.

General configuration:

$(n-1)d^{1-10}ns^{1-2}$

Reason:

• d-block elements have partially filled or fully filled $(n-1)$d subshell

• ns subshell has 1 or 2 electrons in most cases

• This allows variable oxidation states and transition properties

46. **(d)** Assertion (A) : p-Nitrophenol is actually more acidic than phenol because the $-NO_2$ group is strongly electronwithdrawing and stabilizes the p-nitrophenoxide ion by resonance and -1 effect.

Reason (R) : So, the reason correctly explains the increased acidity, but the assertion is incorrect.

So, Assertion (A) is false and Reason (R) is true.

47. **(a)**• A is true: Benzoic acid does not undergo Friedel-Crafts reaction.

• R is true: The -COOH group is strongly electron-withdrawing (deactivating), and it also forms a complex with the Lewis acid catalyst $AlCl_3$, further reducing the reactivity of the benzene ring.

So, Assertion (A) is true and Reason (R) is true, and R is the correct explanation of A.

48. **(c)**• Assertion (A): True - Fructose is a reducing sugar (it can tautomerize in alkaline medium to aldoses and reduce Fehling's and Tollen's reagents).

• Reason (R): False - Fructose does reduce Fehling's solution and Tollen's reagent.

49. **(c)**• Assertion (A): True - If external opposing potential is greater than 1.1 V , the cell reaction reverses and electrons flow from Cu to Zn .

• Reason (R): False - Under such conditions, the cell does not act as a galvanic cell; it behaves like an electrolytic cell.

50. **(A)** Order of a reaction:

It is the sum of the powers of the concentration terms of the reactants in the rate law of a chemical reaction.

(B) Activation energy:

It is the minimum energy that reactant molecules must possess in order to undergo effective collision and form products.

51. (1) Given Data

• w_2 (Solute): 18 g

• w_1 (Solvent): 200 g

• ΔT_f: $273.15\ K - 272.07\ K = 1.08\ K$

• K_f: $1.86\ K\ kg\ mol^{-1}$

(2) Calculation

Using the formula:

$$M_2 = \frac{1000 \times K_f \times w_2}{\Delta T_f \times w_1}$$

$$M_2 = \frac{1000 \times 1.86 \times 18}{1.08 \times 200}$$

$$M_2 = \frac{33480}{216} = 155 \text{ g/mol}$$

Molecular mass of solute $= 155$ g/mol

52. **(A)** Faster S_N2 reaction: $CH_3 - CH_2 - I$

Reason:

S_N2 reaction rate depends on leaving group ability.

I^- is a better leaving group than Br^- because:

• Larger size → weaker C-I bond

• More stable ion after leaving

So, ethyl iodide reacts faster than ethyl bromide in SN2 reaction.

(B) Increasing order of boiling points:

Butane < 1-Chlorobutane < 1-Bromobutane < 1-Iodobutane

Reason:

Boiling point increases with:

• Increasing molecular mass

• Increasing van der Waals forces

• Increasing polarizability of halogen (I > Br > Cl)

So, iodide derivative has the highest boiling point.

53. **(A)** Nucleophilic Addition Mechanism

(1) Step 1: Nucleophilic Attack - The nucleophile (Nu^-) attacks the carbonyl carbon, shifting the π-electrons to oxygen. Carbon changes from sp^2 to sp^3 to form a tetrahedral intermediate.

(2) Step 2: Protonation - The intermediate oxygen (O^-) picks up a proton (H^+) from the medium to form the final neutral product.

OR

(B) Conversions

(i) Toluene to Benzoic Acid

Oxidize with alkaline $KMnO_4$ followed by acidification:

$$C_6H_5CH_3 \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } KMnO_4, KOH, \Delta} C_6H_5COOH$$

(ii) Ethanol to 3-Hydroxybutanal

(1) Oxidation: Convert ethanol to ethanal using PCC.

$$CH_3CH_2OH \xrightarrow{PCC} CH_3CHO$$

(2) Aldol Reaction: Treat ethanal with dilute NaOH .

$$2CH_3CHO \xrightarrow{\text{dil. NaOH}} CH_3CH(OH)CH_2CHO$$

54. **(A)** Reaction of Glucose with Bromine Water

When glucose ($C_6H_{12}O_6$) reacts with bromine water-a mild oxidizing agent-the aldehyde group (-CHO) is oxidized to a carboxylic acid group (-COOH), forming gluconic acid ($C_6H_{12}O_7$). The brown color of the bromine water is decolourised during the reaction.

Chemical Equation:

$$CHO(CHOH)_4CH_2OH + Br_2 + H_2O \rightarrow COOH(CHOH)_4CH_2OH + 2HBr$$

(Glucose → Gluconic Acid)

(B) Identification of Bases

(i) Thymine (T): Present in DNA.

(ii) Uracil (U): Present in RNA.

55. **(A)** Geometrical isomers of $[Pt(en)_2Cl_2]^{2+}$

This complex shows octahedral geometry and exhibits cis-trans isomerism.

• cis-isomer: both Cl^- ligands are adjacent (90° apart)

• trans-isomer: Cl^- ligands are opposite (180° apart)

Representation:

• cis-$[Pt(en)_2Cl_2]^{2+}$:
Cl and Cl next to each other
• trans-$[Pt(en)_2Cl_2]^{2+}$:
Cl opposite to Cl

(B) Electronic configuration of d^4 ion when $\Delta_0 < P$
Since $\Delta_0 < P$ (weak field ligands) → high spin complex
For octahedral field:
$t_{2g}^3 e_g^1$
So arrangement is:
• 3 electrons in t_{2g}
• 1 electron in e_g

(C) Unidentate ligand
A unidentate ligand is a ligand that binds to the central metal atom through only one donor atom.
Example:
• NH_3 (ammine)
• Cl^-(chloride)
• H_2O (aqua)
Example: NH_3 is a unidentate ligand because it donates one lone pair through nitrogen only.

56. $E^\circ_{cell} = 0 - (-0.14) = 0.14V$

$$Q = \frac{[Sn^{2+}]}{[H^+]^2} = \frac{10^{-3}}{10^{-4}} = 10$$

$$E = 0.14 - \frac{0.0591}{2}\log 10$$

$$E = 0.14 - 0.02955 = 0.11V$$

57. Here are the chemical equations for the requested organic reactions:

(A) Hydroboration-Oxidation Reaction
This reaction converts alkenes into alcohols (anti-Markovnikov addition of water).

$$3CH_3 - CH = CH_2 \xrightarrow[THF]{(i)BH_3} (CH_3CH_2CH_2)_3\,B \xrightarrow[OH^-]{(t)H_2O_2} 3CH_3CH_2CH_2OH$$

Result: Propene is converted to Propan-1-ol.

(B) Williamson Synthesis
This is an S_N2 reaction used to prepare ethers from an alkyl halide and a sodium alkoxide.
$R - X + R' - ONa \rightarrow R - O - R' + NaX$
• Example: $CH_3Br + CH_3CH_2ONa \longrightarrow CH_3 - O - CH_2CH_3 + NaBr$ (Methoxyethane)

(C) Friedel-Crafts Alkylation of Anisole
Anisole reacts with an alkyl halide in the presence of anhydrous aluminium chloride ($AlCl_3$). The methoxy group ($-OCH_3$) is ortho-para directing.

$$C_6H_5OCH_3 + CH_3Cl \xrightarrow{\text{Anhyd. } AlCl_3} CH_3OC_6H_4CH_3$$
(Ortho and Para isomers) + HCl

• Major product: 4 -Methoxytoluene (para-isomer).

(D) Reimer-Tiemann Reaction
Phenol reacts with chloroform in the presence of sodium hydroxide to introduce an aldehyde group (-CHO) at the ortho position.

$$C_6H_5OH \xrightarrow[\text{aq. NaOH}]{(4)CHCl_3} \text{Intermediate} \Big| \xrightarrow{(4)H^+} C_6H_4(OH)(CHO)$$

58. **(A)** Chemical tests
(i) Phenol vs Benzoic acid
Test: $NaHCO_3$ (sodium bicarbonate) test
• Benzoic acid: gives brisk effervescence (CO_2 gas evolved)
$C_6H_5COOH + NaHCO_3 \rightarrow C_6H_5COONa + CO_2 + H_2O$
• Phenol: does not react (no CO_2 evolution)
(ii) Propanal vs Propanone
Test: Tollens' reagent

• Propanal (aldehyde): gives silver mirror
• Propanone (ketone): no reaction
$CH_3CH_2CHO \rightarrow$ Ag mirror (positive test)
(B) Stronger acid
Stronger acid:
$CH_2FCH_2CH_2COOH$
Reason:
• Fluorine has a strong -I (electron withdrawing) effect
• In $CH_2FCH_2CH_2COOH$, F is closer to -COOH , so it stabilizes the carboxylate ion more effectively
• In CH_3CHFCH_2COOH, F is slightly farther / less effectively withdrawing

59. Explanation of terms
(A) Essential amino acids
These are amino acids that cannot be synthesized by the human body and must be obtained through diet.
Example: valine, leucine, lysine, etc.
(B) Peptide bond
It is the amide linkage $(-CO-NH-)$ formed between the carboxyl group $(-COOH)$ of one amino acid and the amino group ($-NH_2$) of another, with elimination of a water molecule.
(C) Denaturation
It is the process in which a protein loses its natural structure and biological activity due to changes in temperature, pH , or chemicals, without breaking peptide bonds.

60. **(A)** IUPAC name of the compound
From the structure (cyclohexene ring with Cl and Br substituents):
• Parent: cyclohex-1-ene
• Substituents:
• Cl at C -1 (on double bond carbon)
• Br at C-4
IUPAC name:
1-chloro-4-bromocyclohex-1-ene
(B) Reason
The $-NO_2$ group (at ortho or para position) increases nucleophilic substitution in haloarenes because:
• It is a **strong electron
(C) When ethyl chloride (C_2H_5Cl) is treated with alcoholic potassium hydroxide (alc. KOH), it undergoes dehydrohalogenation (elimination reaction) to form ethene (C_2H_4).
Reaction:
$C_2H_5Cl + KOH(\text{ alc. }) \rightarrow C_2H_4 + KCl + H_2O$
Explanation:
•Alcoholic KOH favors elimination rather than substitution.
•A hydrogen atom and the chlorine atom are removed from adjacent carbon atoms.
•This results in the formation of a double bond.
Product
•Ethene (ethylene) is formed.

61. For a first order reaction,
$$t = \frac{2.303}{k}\log\frac{a}{a-x}$$
For 99.9% completion:
$$\frac{a-x}{a} = 0.1\% = \frac{0.1}{100} = 10^{-3}$$
So, $\frac{a}{a-x} = 10^3$
Hence,
$$t = \frac{2.303}{k}\log 10^3$$
$$t = \frac{2.303}{k} \times 3 = \frac{6.909}{k}$$
Now,

$t_{1/2} = \frac{0.693}{k}$

Therefore,

$\frac{t}{t_{1/2}} = \frac{6.909/k}{0.693/k} \approx 10$

$t = 10t_{1/2}$

Hence proved.

62. Based on the principles of Valence Bond Theory, here are the answers to the questions regarding the coordination compounds:

(A) $[CoF_6]^{3-}$ is paramagnetic.

• Reasoning: The cobalt ion in $[CoF_6]^{3-}$ is $Co^{3+}(d^6)$ · $\mathbf{F^-}$is a weak field ligand and cannot pair the electrons in the 3d orbital. Therefore, the hybridization is sp^3d^2 (outer orbital), leaving four unpaired electrons in the 3d subshell.

(B) Coordination Number: The coordination number of Co in $[Co(en)_2Cl_2]^+$is 6 .

• Reasoning: Ethylenediamine (en) is a bidentate ligand $(2 \times 2 = 4)$ and chloride (Cl^-) is a monodentate ligand ($2 \times 1 = 2$), total $= 4 + 2 = 6$.

(C) (i) IUPAC Name: Diamminedichloridoplatinum(IV) ion.

(ii) $[Co(NH_3)_6]^{3+}$ is an Inner Orbital Complex.

• Reasoning: NH_3 is a strong field ligand, forcing the 3d electrons of $Co^{3+}(d^6)$ to pair up. This leaves two 3d orbitals empty, allowing d^2sp^3 hybridization.

OR

(c) $[Ni(NH_3)_6]^{2+}$:

• Hybridization: The Nickel ion is $Ni^{2+}(d^8)$. Since NH_3 is a strong ligand, it enables d^2sp^3 hybridization.

• Shape: Octahedral. The coordination number is 6 .

63. **(A)** Function of salt bridge:

• It completes the electrical circuit.

• It maintains electrical neutrality in both half-cells by migration of ions.

• It prevents direct mixing of the two solutions.

(B) A galvanic cell behaves like an electrolytic cell when an external opposing potential greater than the cell emf is applied.

(C) No, copper sulphate solution cannot be stored in a zinc pot.

$E^\circ_{cxll} = E^\circ_{cathode} - E^\circ_{anode}$

$= 0.34 - (-0.76) = 1.10\ V$

Since E^0_{ecll} is positive, the reaction is spontaneous:

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

So zinc dissolves and copper gets deposited.

OR

(C) (i) $MnO_4^- \rightarrow Mn^{2+}$

Change in oxidation number:

$+7 \rightarrow +2$

Electrons gained $= 5$

Hence charge required:

$= 5F$

(ii) $2H_2O \rightarrow O_2 + 4H^+ + 4e$

For 1 $molO_2$, electrons involved $= 4$

Hence charge required:

$= 4F$

64. **(A)** Zinc is not regarded as a transition element because it has completely filled $3d^{10}$ orbitals in both Zn and Zn^{2+}.

(B) Lanthanoid contraction is the gradual decrease in atomic and ionic radii of lanthanoids from La to Lu.

(C) Chromium loses one electron easily to attain stable half-filled $3d^5$ configuration, so its first ionization enthalpy is lower than Zn .

(D) Transition elements are good catalysts due to variable oxidation states and formation of intermediate complexes.

(E) Transition metal compounds are coloured due to d − d electronic transitions.

(F) K_2MnO_4

is paramagnetic because Mn is in +6 oxidation state $(3d^1)$ having unpaired electron.

$KMnO_4$ has $Mn^{7+}(3d^0)$, so it is diamagnetic.

(G) $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

65. (A) (i) Reverse osmosis

The process in which solvent molecules move from solution to pure solvent through a semipermeable membrane by applying pressure greater than osmotic pressure is called reverse osmosis.

(ii) Aquatic species are more comfortable in cold water because the solubility of oxygen is higher in cold water than in warm water.

(iii) Vapour pressure of solution

Given:

• Mass of glucose $= 2$ g

• Molar mass $= 180\ g\ mol^{-1}$

• Mass of water $= 100$ g

• Vapour pressure of pure water $P° = 32.8mmHg$

Moles of glucose:

$$n_B = \frac{2}{180} = 0.0111$$

Moles of water:

$$n_A = \frac{100}{18} = 5.56$$

Mole fraction of water:

$$X_A = \frac{5.56}{5.56 + 0.0111} \approx 0.998$$

Using Raoult's law:

$P = X_A P°$

$P = 0.998 \times 32.8$

$P \approx 32.73mmHg$

OR

(B)(i) Van't Hoff factor will be less than 1 because ethanoic acid associates (dimerises) in benzene.

(ii) Ideal solution

A solution which obeys Raoult's law over the entire range of concentration is called an ideal solution.

(iii) Given:

$\Delta T_f = 2K, K_f = 1.86$

For $CaCl_2$:

$i = 3$

$\Delta T_f = iK_f m$

$2 = 3 \times 1.86 \times m$

$$m = \frac{2}{5.58} = 0.358\ mol\ kg^{-1}$$

Mass of water:

$500\ g = 0.5\ kg$

Moles of $CaCl_2$:

$n = 0.358 \times 0.5 = 0.179$

Mass:

$= 0.179 \times 111$

19.9 g

66. (A) Identification of compounds

The identity of the compounds in the sequence are as follows:

• A: Benzamide $(C_6H_5CONH_2)$

• B: Aniline $(C_6H_5NH_2)$

• C: Benzene diazonium chloride ($C_6H_5\ N_2Cl$)

• D: Phenyl isocyanide (C_6H_5NC)

• E: Benzene (C_6H_6)

Step-by-Step Reaction Sequence

(1) Hoffmann Bromamide Degradation

Benzamide (A) reacts with bromine and aqueous or ethanolic potassium hydroxide to lose the carbonyl carbon, forming Aniline (B).

$C_6H_5CONH_2 + Br_2 + 4KOH \rightarrow C_6H_5NH_2 + K_2CO_3 + 2KBr + 2H_2O$

(2) Diazotization Reaction

Aniline (B) reacts with nitrous acid (generated in situ from $NaNO_2$ and HCl) at 273 -278 K to form Benzene diazonium chloride (C).

$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278\ K} C_6H_5\ N_2Cl + NaCl + 2H_2O$

(3) Carbylamine Reaction

Aniline (B) on treatment with chloroform and ethanolic potassium hydroxide forms Phenyl isocyanide (D), characterized by its foul smell.

$C_6H_5NH_2 + CHCl_3 + 3KOH(\text{ alc. }) \rightarrow C_6H_5NC + 3KCl + 3H_2O$

(4) Deamination with Ethanol

Benzene diazonium chloride (C) reacts with ethanol (E) to undergo reduction, yielding Benzene and byproduct ethanal.

$C_6H_5\ N_2Cl + CH_3CH_2OH \rightarrow C_6H_6 + CH_3CHO + N_2 + HCl$

OR

(B) Amines and Basicity

(i) Hinsberg's Reagent and Basicity Order

(1) Hinsberg's Reagent: It is Benzenesulfonyl chloride ($C_6H_5SO_2Cl$), used to distinguish between primary, secondary, and tertiary amines.

(2) Gaseous Phase Basicity Order: The increasing order of basic strength in the gaseous phase is:

$C_2H_5NH_2 < (C_2H_5)_2NH < (C_2H_5)_3\ N$

• Reason: In the gaseous phase, only the inductive effect $(+1)$ matters. As the number of electron-releasing ethyl groups increases, electron density on the nitrogen increases, making the lone pair more available for donation.

(ii) Reasoning

(1) Methyl Amine vs. Aniline: Methyl amine is more basic because its lone pair is fully available on the nitrogen. In aniline, the lone pair is delocalized into the benzene ring due to resonance, making it less available for protonation.

(2) Aniline and Bromine Water: The $-NH_2$ group is a very strong activating group that increases electron density at the ortho and para positions via resonance. This high reactivity leads to immediate trisubstitution at all available positions (2,4 , and 6).

(3) Boiling Points (Primary vs. Tertiary): Primary amines have two hydrogen atoms attached to nitrogen, allowing for extensive intermolecular hydrogen bonding. Tertiary amines have no hydrogens on nitrogen and cannot form these bonds, resulting in lower boiling points.

67. (d) Scandium generally shows only +3 oxidation state.

68. (b) $[CoCl_2(en)_2]^+$can exist in cis and trans forms.

69. (a) Co^{3+}, octahedral complex with strong field ligand

$Co^{3+} = 3d^6$

Strong field ligand in octahedral complex causes pairing:

$t_{2g}^6 e_g^0$ → all electrons paired → diamagnetic.

70. (c) The major product of this reaction is (C).

• The reaction involves a nucleophilic substitution where the cyanide ion (CN^-) acts as the nucleophile. The starting material has two chlorine atoms, but they react very differently:

(1) Benzylic Chlorine $(-CH_2Cl)$: This is highly reactive. The carbon-chlorine bond is relatively weak, and the resulting transition state (or carbocation) is stabilized by the benzene ring. It undergoes S_N2 substitution easily with KCN to form the $-CH_2CN$ group.

(2) Aryl Chlorine ($-Cl$ on the ring): This bond is much stronger because of resonance (the lone pairs on chlorine interact with the ring, giving the bond partial double-bond character). Nucleophilic substitution on an aromatic ring usually requires extreme conditions or strong electron-withdrawing groups (like $-NO_2$) to proceed. Under these standard conditions, it remains unreacted.

Therefore, only the chlorine in the side chain is replaced by the cyanide group.

71. (d) More nitro groups increase acidity strongly, so it has the lowest pK_a.

72. **(b)** Ethers with HI undergo cleavage; iodide attacks the less hindered methyl group.

73. **(d)** Primary amines form sulphonamides having acidic H , soluble in alkali.

74. **(a)** In aqueous medium:

$C_6H_5NH_2 < (CH_3)_3\ N < CH_3NH_2 < (CH_3)_2NH$

75. **(d)** Vitamin K is essential for blood clotting.

76. **(c)** A catalyst lowers activation energy, hence increases the rate constant k.

77. **(b)** For isotonic solutions:

$$\frac{1}{M_X} = \frac{6}{342}$$

$$M_X = \frac{342}{6} = 57\ \text{g mol}^{-1}$$

78. **(d)** At cathode in aqueous NaCl :

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

79. **(c)** Assertion (A) is true.

Reason (R) is false.

Ethylene glycol is soluble in water because it forms hydrogen bonds with water molecules. Its addition lowers the freezing point due to depression in freezing point (a colligative property).

80. **(d)** Assertion (A) is false.

Reason (R) is true.

For complex reactions, order and molecularity are generally not the same. Molecularity is defined only for elementary reactions, while order is determined experimentally.

81. **(a)** Assertion (A) is true.

Reason (R) is true and Reason correctly explains Assertion (A).

Ethanol forms intermolecular hydrogen bonding, giving it a higher boiling point than dimethyl ether.

82. **(b)** Assertion (A) is true.

Reason (R) is true but Reason does not correctly explain Assertion (A).

Aniline does not undergo Friedel-Crafts reaction because the amino group forms a complex with $AlCl_3$, deactivating the benzene ring.

83. **(A)** Molal depression constant

Molal depression constant (K_f) is defined as the decrease in freezing point produced when 1 mole of a non-volatile solute is dissolved in 1 kg of solvent.

Relation with enthalpy of fusion:

$$K_f = \frac{RT_f^2M}{1000\Delta H_{fus}}$$

where

R = gas constant

T_f = freezing point of pure solvent

M = molar mass of solvent

ΔH_{fus} = enthalpy of fusion of solvent

OR

(B) Ethanol and acetone mixture shows positive deviation from Raoult's law.

Reason:

The intermolecular attraction between ethanol and acetone molecules is weaker than that between ethanolethanol molecules, so vapour pressure increases.

This forms a minimum boiling azeotrope.

84. **(A)** Let the rate law be:

Rate $\propto [X]^n$

Given:

$27 = 3^n$

$n = 3$

Hence, the order of the reaction is 3 .

(B) A bimolecular reaction becomes kinetically first order when one reactant is taken in large excess, so its concentration remains practically constant during the reaction.

Example:
Hydrolysis of ethyl acetate in excess water:
$CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$
Since water is in excess, the reaction shows pseudo-first-order kinetics.

85. **(A)** $2MnO_4^- + 5SO_3^{2-} + 6H^+ \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$
(B) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

86. **(A)** CH_3CH_2I reacts faster in S_N2 reaction than CH_3CH_2Br.
Reason:
I^- is a better leaving group than Br^- because the $C-I$ bond is weaker than the $C-Br$ bond.
(B) Chloroform is stored in closed dark coloured bottles because in presence of air and sunlight it gets oxidised to poisonous phosgene gas ($COCl_2$).

87. Reactions of glucose:
(A) With HCN
Glucose undergoes nucleophilic addition with HCN to form glucose cyanohydrin.
$C_6H_{12}O_6 + HCN \rightarrow C_6H_{11}O_6CN + H_2O$
(B) With conc. HNO_3
Both aldehyde group and primary alcohol group of glucose are oxidised to give saccharic acid.
$CHO(CHOH)_4CH_2OH \xrightarrow{\text{conc. } HNO_3} COOH(CHOH)_4COOH$
(Product: saccharic acid)

88. Given :
- Mass of solute $= 5$ g
- Mass of water $= 200$ g
- Vapour pressure of pure water $P^0 = 32$ mmHg
- Vapour pressure of solution, $P = 31.84$ mmHg

Using Raoult's law:
$$\frac{P^0 - P}{P^0} = X_{\text{solute}}$$
$$\frac{32 - 31.84}{32} = \frac{0.16}{32} = 0.005$$
So, mole fraction of solute $= 0.005$
Let molar mass of solute $= M$.
Moles of solute :
$$n_2 = \frac{5}{M}$$
Moles of water:
$$n_1 = \frac{200}{18} = 11.11$$
Now,
$$X_{\text{solute}} = \frac{n_2}{n_1 + n_2}$$
$$0.005 = \frac{5/M}{11.11 + 5/M}$$
Since solute amount is very small,
$$0.005 \approx \frac{5/M}{11.11}$$
$$\frac{5}{M} = 0.005 \times 11.11$$
$$\frac{5}{M} = 0.05555$$
$$M = \frac{5}{0.05555} \approx 90$$
90 g mol^{-1}

89. Given :
- Conductivity, $\kappa = 2.48 \times 10^{-2}$ S cm^{-1}

• Concentration, $C = 0.2\text{M}$

Molar conductivity :

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

$$\Lambda_m = \frac{2.48 \times 10^{-2} \times 1000}{0.2}$$

$$\Lambda_m = \frac{24.8}{0.2} = 124 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\Lambda_m = 124 \text{ S cm}^2 \text{ mol}^{-1}$$

Limiting molar conductivity :

$$\Lambda_m^\circ = \lambda_{K^+}^\circ + \lambda_{Cl}^\circ$$

$$= 73.5 + 76.5 = 150 \text{ S cm}^2 \text{ mol}^{-1}$$

Degree of dissociation :

$$\alpha = \frac{\Lambda_m}{\Lambda_m^\circ}$$

$$\alpha = \frac{124}{150} = 0.827$$

$$\alpha \approx 0.83$$

90. $k = \frac{2.303}{t} \log \frac{a}{a-x}$

25% complete in 40 min :

$$\frac{a}{a-x} = \frac{100}{75} = \frac{4}{3}$$

$$k = \frac{2.303}{40} \log \frac{4}{3}$$

$$= \frac{2.303}{40}(0.60 - 0.48)$$

$$= 6.9 \times 10^{-3} \text{ min}^{-1}$$

$$k = 6.9 \times 10^{-3} \text{ min}^{-1}$$

For 80% completion :

$$\frac{a}{a-x} = \frac{100}{20} = 5$$

$$t = \frac{2.303}{k} \log 5$$

$$= \frac{2.303 \times 0.69}{6.9 \times 10^{-3}}$$

$$t = 230 \text{ min}$$

91. **(A)** Hydrolysis of 2-bromobutane to form $(\pm)$-butan-2-ol occurs by S_N1 mechanism.

Reason : A planar carbocation intermediate is formed, so nucleophile attacks from both sides giving racemic mixture $(\pm)$-butan-2-ol.

(B) Chlorobenzene and methyl chloride react with sodium metal in dry ether to give toluene.

Reaction :

$$C_6H_5Cl + CH_3Cl + 2Na \xrightarrow{\text{dry ether}} C_6H_5CH_3 + 2NaCl$$

This reaction is called Wurtz-Fittig reaction.

92. **(A) (i)** Reimer-Tiemann reaction

$$C_6H_5OH + CHCl_3 + 3NaOH \rightarrow o - HOC_6H_4CHO + 3NaCl + 2H_2O$$

(Phenol gives salicylaldehyde)

(ii) Kolbe's reaction

$$C_6H_5ONa + CO_2 \xrightarrow[4-7 \text{ atm}]{373 \text{ K}} o - HOC_6H_4COONa$$

On acidification :

$$o - HOC_6H_4COONa + HCl \rightarrow o - HOC_6H_4COOH + NaCl$$

(Salicylic acid is formed)

(B) Reagent used :

Bromine water (Br_2/H_2O)

Reaction :

$C_6H_5OH + 3Br_2 \rightarrow$ 2,4,6-tribromophenol $+ 3HBr$

93. **(A)** Benzoic acid to Benzaldehyde

$$C_6H_5COOH \xrightarrow{SOCl_2} C_6H_5COCl \xrightarrow[\text{Rosenmund}]{H_2/Pd-BaSO_4} C_6H_5CHO$$

(B) Ethanal to Propanone

$$CH_3CHO + CH_3MgBr \xrightarrow{\text{dry ether}} CH_3CH(OMgBr)CH_3 \xrightarrow{H_3O^+} CH_3CH(OH)CH_3$$

$$CH_3CH(OH)CH_3 \xrightarrow{[O]} CH_3COCH_3$$

(C) Acetophenone to Benzoic acid

$$C_6H_5COCH_3 \xrightarrow{I_2/NaOH} C_6H_5COONa \xrightarrow{H^+} C_6H_5COOH$$

(Haloform reaction)

(D) Bromobenzene to 1-Phenylethanol

$$C_6H_5Br \xrightarrow{Mg/\text{ dry ether}} C_6H_5MgBr$$

$$C_6H_5MgBr + CH_3CHO \longrightarrow C_6H_5CH(OMgBr)CH_3 \xrightarrow{H_3O^+} C_6H_5CH(OH)CH_3$$

94. Here are the step-by-step transformations for both reaction sequences:

Reaction (A)

(1) Step 1 $\left(CH_3CH_2Cl \xrightarrow{KCN} A\right)$:

The cyanide ion (CN^-) replaces the chlorine via S_N2 substitution.

• $A = CH_3CH_2CN$ (Propanenitrile / Ethyl cyanide)

(2) Step 2 $\left(A \xrightarrow{LiAlH_4} B\right)$:

$LiAlH_4$ is a strong reducing agent that reduces the nitrile group (-CN) to a primary amine $(-CH_2NH_2)$.

• $B = CH_3CH_2CH_2NH_2$ (Propan-1-amine)

(3) Step 3 $\left(B \xrightarrow{HNO_2,0°C} \mathbf{C}\right)$:

Aliphatic primary amines react with nitrous acid to form highly unstable diazonium salts, which immediately decompose in water to form alcohols and release nitrogen gas.

• $C = CH_3CH_2CH_2OH$ (Propan-1-ol)

Reaction (B)

(1) Step 1(Nitrobenzene $\xrightarrow{Fe/HCl} A$) :

This is a classic reduction of a nitro group ($-NO_2$) to an amino group ($-NH_2$).

• $A = C_6H_5NH_2$ (Aniline)

(2) Step 2 $\left(A \xrightarrow{NaNO_2+HCl,273\ K} B\right)$:

At low temperatures, aniline reacts with nitrous acid (formed in situ) to produce a stable diazonium salt.

• $B = C_6H_5\ N_2^+Cl^-$(Benzene diazonium chloride)

(3) Step 3 $\left(B \xrightarrow{C_6H_5OH} C\right)$:

This is a coupling reaction. The diazonium salt acts as an electrophile and attacks the phenol at the para-position to form an azo dye.

• C = p-Hydroxyazobenzene (An orange-colored dye)

• Structure: $HO - C_6H_4 - N = N - C_6H_5$

95. **(A)** Transition metals and their compounds act as good catalysts because :

• they exhibit variable oxidation states.

• they provide a suitable surface for adsorption of reactants.

• they form unstable intermediate complexes during reactions.

(B) The contraction in atomic size of lanthanoids is due to the poor shielding effect of 4 f-electrons. As atomic number increases, nuclear charge increases but 4 f-electrons do not shield effectively, causing greater attraction between nucleus and outer electrons.

(C) Lanthanoid contraction is the regular decrease in the atomic and ionic radii of lanthanoids with increase in atomic number from La to Lu.

Effect : Due to lanthanoid contraction, the atomic radii of elements of the third transition series are almost equal to those of the corresponding elements of the second transition series.

OR

(C) In aqueous medium, Cr^{2+} is a stronger reducing agent than Fe^{2+}.
Reason :
$Cr^{2+} \rightarrow Cr^{3+}$
occurs readily because Cr^{3+} has stable $3d^3$ configuration. Hence, Cr^{2+} easily loses an electron and acts as a stronger reducing agent.

96. (A) Essential Amino Acids
Essential amino acids are those that cannot be synthesized by the human body and therefore must be obtained through our diet. Examples include valine, leucine, and lysine.
(B) Zwitter Ionic Form
In a zwitterionic form, an amino acid exists as a dipolar ion where the carboxyl group (-COOH) loses a proton and the amino group ($-NH_2$) accepts one. This results in a molecule with both a negative and a positive charge ($H_3\ N^+ - CHR - COO^-$), making it electrically neutral and amphoteric.
(C) Protein Structure and Linkages
(i) Examples:
• Fibrous protein: Keratin (found in hair/nails) or Collagen.
• Globular protein: Insulin or Albumin (found in egg white).
(ii) Linkages: Monomers (amino acids) are held together by peptide bonds (-CO NH - linkages).

OR

(C) Sugars and Nucleic Acids
(i) Reducing Sugar: The defining structural feature is the presence of a free aldehydic or ketonic group (specifically a hemiacetal or hemiketal group). This allows the sugar to reduce Tollen's reagent or Fehling's solution.
(ii) Nucleoside vs. Nucleotide:
• Nucleoside: Contains only a nitrogenous base and a pentose sugar.
• Nucleotide: Contains a nitrogenous base, a pentose sugar, and a phosphoric acid group (it is essentially a nucleoside with a phosphate attached).

97. (A) (i) Cell :
$Zn(s)|Zn^{2+}(0.001M)|Cd^{2+}(0.1M)\ |\ Cd(s)$
$E^\circ_{\text{cell}} = E^\circ_{\text{enthodc}} - E^\circ_{\text{anode}}$
$= (-0.40) - (-0.76) = 0.36\ \text{V}$
Cell reaction :
$Zn + Cd^{2+} \rightarrow Zn^{2+} + Cd$
$$Q = \frac{[Zn^{2+}]}{[Cd^{2+}]} = \frac{0.001}{0.1} = 10^{-2}$$
Using Nernst equation :
$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{2}\log Q$$
$$= 0.36 - \frac{0.0591}{2}\log 10^{-2}$$
$$= 0.36 - \frac{0.0591}{2}(-2)$$
$$= 0.36 + 0.0591$$
$E_{\text{coll}} \approx 0.42\ \text{V}$
(ii) Faraday's second law :
When the same quantity of electricity is passed through different electrolytes, the masses of substances liberated are proportional to their equivalent masses.
During electrolysis of aqueous NaCl solution, OH^- ions are produced, hence pH increases and solution becomes alkaline.

OR

(B)(i) $Fe(s) + 2Ag^+(aq) \rightarrow Fe^{2+}(aq) + 2Ag(s)$
$E^\circ_{\text{ecll}} = 0.80 - (-0.44) = 1.24\ \text{V}$
$\Delta_r G^\circ = -nFE^\circ_{\text{ccll}}$
Here $n = 2$
$= -2 \times 96500 \times 1.24$
$= -239320\ \text{J mol}^{-1}$

$\Delta_r G^\circ = -239.3 \text{ kJ mol}^{-1}$

$E^\circ_{\text{cell}} = \frac{0.0591}{n} \log K_e$

$1.24 = \frac{0.0591}{2} \log K_e$

$\log K_e = \frac{2 \times 1.24}{0.0591} \approx 42$

$\log K_c \approx 42$

(ii) Two advantages of fuel cells :

• They have high efficiency.

• They are pollution free.

(iii) $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

For formation of 1 mole O_2, 4 Faradays are required.

$= 4F$

98. (A) (i) Major products

(1) $C_6H_5CH_2CH_3 \xrightarrow[\kappa KOH]{KMnO_4} C_6H_5COOH$

Product : Benzoic acid

(2) $C_6H_5CHO + CH_3COCH_3 \xrightarrow{\text{dil. NaOH}} C_6H_5CH = CHCOCH_3$

Product : Benzalacetone

(3) $C_6H_5COOH \xrightarrow{Br_2/FeBr_3} m$-Bromobenzoic acid

Product : m-Bromobenzoic acid

(ii) Chemical tests

(1) $C_6H_5COCH_3$ and $C_6H_5COCH_2CH_3$

Use Iodoform test:

• $C_6H_5COCH_3$ gives yellow precipitate of iodoform.

• $C_6H_5COCH_2CH_3$ does not give the test.

(2) Pentanal and Pentan-3-one

Use Tollens' reagent :

• Pentanal gives silver mirror.

• Pentan-3-one does not react.

OR

(B)(i) Reasons

(1) In semicarbazide, only one $-NH_2$ group is involved because the other $-NH_2$ group is resonance stabilised with carbonyl group and is less nucleophilic.

(2)Acetaldehyde is more reactive than acetone towards HCN because :

• acetaldehyde has less steric hindrance.

• $+I$ effect of one alkyl group is less than that of two alkyl groups in acetone.

(ii) (1) Increasing acidic strength :

$CH_3COOH < HCOOH < O_2NCH_2COOH$

(2) Reagent :

$CH_3CH = CHCH_2CN \rightarrow CH_3CH = CHCH_2CHO$

Reagent : $SnCl_2/HCl$ followed by hydrolysis

(Stephen reaction)

(iii) Hell-Volhard-Zelinsky reaction

$CH_3COOH \xrightarrow{Br_2/P} CH_2BrCOOH$

(α-bromination of carboxylic acids)

99. (A) IUPAC name of the complex: $[Co(H_2O)(CN)(en)_2]^{2+}$

[Aquacyanobis(ethylenediamine) cobalt(III) ion]

(Note: Co is in +3 oxidation state: $x + O(-1) + (-1) + 2(\theta) = +2 \Longrightarrow x = +3$)

(B) Geometrical isomerism not possible in tetrahedral complexes:

Tetrahedral complexes do not show geometrical isomerism because all four ligand positions are adjacent to each other (all bond angles are equal, $\approx 109.5^\circ$). The relative positions of the ligands are identical in all arrangements,

meaning there are no different "cis" or "trans" positions as found in square planar or octahedral complexes.

(C) Increasing order of crystal field splitting energy (A_0):

Spectrochemical series dictates that the strength of ligands is $F^- < NH_3 < CN^-$. Stronger field ligands cause larger splitting.

$[CoF_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$

(D) Hybridization and magnetic character of $[Ni(CO)_4]$:

• Hybridization: sp^3 (Tetrahedral)

• Magnetic Character: Diamagnetic (all 10 electrons in $3d^{10}$ are paired due to strong CO ligand causing $4s$ electrons to pair into $3d$)

(E) Stability and Spin for $[CoF_6]^{3-}$ and $[Co(C_2O_4)_3]^{3-}$:

(i) More stable: $[Co(C_2O_4)_3]^{3-}$ (It is a chelated complex, whereas $F^-$is a monodentate weak field ligand).

(ii) High spin complex: $[CoF_6]^{3-}$($F^-$is a weak field ligand, resulting in unpaired electrons: $t_{2g}^4 e^{2\ 2}$).

(F) Difference between Ambidentate and Bidentate ligand:

• Ambidentate ligand: A unidentate ligand that can coordinate through two different atoms, but only one at a time (e.g., NO_2^-through N or O, SCN^-through S or N).

• Bidentate ligand: A ligand that coordinates through two donor atoms simultaneously to the same metal ion, forming a chelate ring (e.g., ethylenediamine, oxalate).

(G) Electronic configuration of d^5 in octahedral field:

(i) $\Delta_o > P$ (Strong field/Low spin): $t_{2g}^5 e_g^0$

(ii) $\Delta_o < P$ (Weak field/High spin): $t_{2g}^3 e_g^2$

100. **(b)** When Manganese dioxide is fused with Potassium hydroxide in air, it gives Potassium manganate.

Reaction:

$2MnO_2 + 4KOH + O_2 \rightarrow 2\ K_2MnO_4 + 2H_2O$

101. **(d)** EDTA $^{4-}$ is a polydentate ligand (hexadentate ligand).

102. **(a)** The ligand which forms a chelate complex is Oxalate ion because it is a bidentate ligand.

103. **(c)** The compound containing sp^2 hybridised carbon bonded to X is:

$CH_2 = CH - X$

Here, X is directly attached to a double bonded carbon (sp^2).

104. **(d)** Most acidic compound is p-chlorophenol because Cl shows $-I$ effect and stabilizes phenoxide ion.

105. **(a)** Anisole reacts with Hydrogen iodide to give Phenol and Methyl iodide.

Reaction:

$C_6H_5OCH_3 + HI \rightarrow C_6H_5OH + CH_3I$

106. **(c)** Ethanol on heating with conc. Sulfuric acid at 413 K gives Diethyl ether.

107. **(b)** An azeotropic solution having boiling point lower than either component shows positive devia Raoult's law.

108. **(d)** Relative lowering of vapour pressure = mole fraction of solute.

$$\frac{P^0 - P}{P^0} = X_{\text{solute}} = 0.0225$$

109. **(a)** During electrolysis of aqueous Sodium chloride solution, hydrogen gas is liberated at cathode

110. **(b)** A catalyst changes the activation energy of a reaction.

111. **(a)** For reaction:

Rate $\propto [P]^n$

Doubling concentration increases rate by 8:

$2^n = 8 = 2^3$

So,

$n = 3$

112. **(a)** Assertion (A) is true.

Gabriel phthalimide synthesis is used for the preparation of aliphatic primary amines.

Reason (R) is also true.

The phthalimide anion reacts with alkyl halides through nucleophilic substitution to form N -alkyl phthalimide.

Since the reason correctly explains the assertion, the answer is:

Both A and R are true and R is the correct explanation of A.

113. **(d)** Assertion (A) is false.
DNA contains adenine, guanine, cytosine and thymine; uracil is present in RNA.
Reason (R) is true.
DNA undergoes self-replication.

114. **(c)** Assertion (A) is true.
Diazonium salts of aromatic amines are more stable than those of aliphatic amines.
Reason (R) is false.
Aliphatic diazonium salts are unstable and do not show stabilizing resonance.

115. **(a)** Assertion (A) is true.
p-Nitroaniline is a weaker base than p-Toluidine.
Reason (R) is also true.
The $-NO_2$ group has strong electron withdrawing ($-I$ and -M) effects, reducing electron density on nitrogen and decreasing basic strength.
Therefore:
Both A and R are true and R is the correct explanation of A.

116. For isotonic solutions:

$$\frac{w_1}{M_1} = \frac{w_2}{M_2}$$

Given:

$$w_1 = 6, M_1 = 180, w_2 = 2.5$$

$$\frac{6}{180} = \frac{2.5}{M_2}$$

$$M_2 = \frac{2.5 \times 180}{6} = 75$$

Therefore, molecular mass of unknown substance:
$= 75\ \text{g mol}^{-1}$

117. For a first order reaction:

$$t = \frac{2.303}{k}\log\frac{a}{a-x}$$

Here,

$$a = 5g, a - x = 2.5g, k = 1.25 \times 10^{-3}s^{-1}$$

$$t = \frac{2.303}{1.25 \times 10^{-3}}\log\frac{5}{2.5}$$

$$t = \frac{2.303}{1.25 \times 10^{-3}}\log 2$$

Using $\log 2 = 0.301$,

$$t = \frac{2.303 \times 0.301}{1.25 \times 10^{-3}}$$

$$t \approx 554\ \text{s}$$

$$t \approx 5.54 \times 10^2\ \text{s}$$

$$t = \frac{2.303}{k}\log\frac{a}{a-x}$$

118. **(A)** Lanthanoid contraction is the gradual decrease in atomic and ionic radii of lanthanoids with increase in atomic number from La to Lu.
Reason for greater actinoid contraction:
In actinoids, $5f$ electrons shield the nuclear charge very poorly compared to $4f$ electrons in lanthanoids. Hence effective nuclear charge increases more rapidly, causing greater contraction.

OR

(B) Enthalpy of atomization of transition metals is high because of strong metallic bonding due to participation of large number of unpaired d-electrons.
The element of 3d-series having lowest enthalpy of atomization is Zinc.

119. **(A)** The compound containing 1 -Iodopropane undergoes S_N2 reaction faster than 1-Bromopropane.
Reason:
In S_N2 reaction, rate depends on leaving group ability. I^- is a better leaving group than Br^- because the $C-1$

bond is weaker than the $C-Br$ bond.

(B) Ethylbenzene on treatment with Chlorine in UV light undergoes side-chain chlorination.

Major product:

$C_6H_5CHClCH_3$

i.e. 1-Chloroethylbenzene.

120. **(A)** Denaturation of proteins:

It is the process in which the natural structure of a protein is destroyed by heat, chemicals, change in pH , etc., resulting in loss of its biological activity.

(B) Invert sugar :

The equimolar mixture of glucose and fructose obtained by hydrolysis of sucrose is called invert sugar. It shows inversion of optical rotation.

121. **(A)** $CH_3CH_2Br \xrightarrow{KCN} A$

Propanenitrile is formed.

So,

$A = CH_3CH_2CN$

Partial hydrolysis of nitrile gives amide:

$CH_3CH_2CN \xrightarrow{OH} CH_3CH_2CONH_2$

So,

$B = CH_3CH_2CONH_2$

Treatment with $Br_2/NaOH$ (Hofmann bromamide reaction) gives amine with one carbon less:

$CH_3CH_2CONH_2 \xrightarrow{Br_2/NaOH} CH_3CH_2NH_2$

So,

$C = CH_3CH_2NH_2$

(B) Nitrobenzene with Fe/HCl gives Aniline.

$A = C_6H_5NH_2$

Aniline with $NaNO_2/HCl$ at $273-278$ K forms Benzenediazonium chloride.

$B = C_6H_5N_2Cl$

Benzenediazonium chloride with ethanol gives Benzene.

$C = C_6H_6$

122. **(A)** Wolff-Kishner reduction :

It converts aldehydes or ketones into alkanes using hydrazine and strong base.

$R-CO-R' \xrightarrow[KOH]{NH_2NH_2,\Delta} R-CH_2-R'$

Example:

$CH_3COCH_3 \rightarrow CH_3CH_2CH_3$

(B) Decarboxylation reaction:

Removal of CO_2 from carboxylic acid salts.

$RCOONa + NaOH \xrightarrow[\Delta]{CaO} RH + Na_2CO_3$

Example:

$CH_3COONa + NaOH \rightarrow CH_4 + Na_2CO_3$

(C) Cannizzaro reaction:

Aldehydes without α-hydrogen undergo disproportionation in presence of concentrated alkali.

$2HCHO + NaOH \rightarrow CH_3OH + HCOONa$

or $2C_6H_5CHO + KOH \rightarrow C_6H_5CH_2OH + C_6H_5COOK$

123. **(A)** Preparation of Phenol from Chlorobenzene:

$C_6H_5Cl + NaOH \xrightarrow[623\ K,300\ atm]{} C_6H_5ONa$

$C_6H_5ONa + HCl \rightarrow C_6H_5OH + NaCl$

(B) Preparation of Salicylaldehyde from Phenol (Reimer-Tiemann reaction):

$C_6H_5OH + CHCl_3 + 3NaOH \rightarrow o-HOC_6H_4CHO + 3NaCl + 2H_2O$

(C) Preparation of 2-Methoxyacetophenone from Anisole (Friedel-Crafts acylation):

$C_6H_5OCH_3 + CH_3COCl \xrightarrow{AlCl_3} o-CH_3COC_6H_4OCH_3$

(D) Preparation of Picric acid from Phenol :

$C_6H_5OH \xrightarrow[\text{conc. } H_2SO_4]{} \text{Phenol sulphonic acid}$

$\text{Phenol sulphonic acid} \xrightarrow[\text{conc. } H_2SO_4]{\text{conc. } HNO_3} 2,4,6\text{-trinitrophenol}$

124. **(A)**Chlorine is ortho/para directing because it donates electron density to the benzene ring through resonance ($+R$ effect) using lone pairs, increasing electron density at ortho and para positions. Although chlorine shows electron withdrawing $(-I)$ effect, the resonance effect controls orientation.

(B) Racemic mixture is optically inactive because it contains equal amounts of dextro (+) and laevo (-) forms. Their optical rotations are equal and opposite, so the net rotation becomes zero.

(C) Allyl chloride is hydrolysed more readily than n-Propyl chloride because the allylic carbocation/intermediate formed during reaction is stabilized by resonance. Hence the reaction occurs faster.

125. For strong electrolyte AB :

$AB \rightarrow A^+ + B$

So, van't Hoff factor:

$i = 2$

Using relative lowering of vapour pressure:

$$\frac{P^0 - P}{P^0} = \frac{in_B}{n_A + in_B}$$

Given:

$P^0 = 100 \text{ mmHg}, n_B = 1, n_A = 50$

$$\frac{100 - P}{100} = \frac{2 \times 1}{50 + 2} = \frac{2}{52}$$

$100 - P = 3.85$

$P = 96.15 \text{ mmHg}$

126. Cell:

$Zn(s)|Zn^{2+}(0.1M)|Sn^{2+}(0.001M) \mid Sn(s)$

Standard emf:

$E^\circ_{\text{coll}} = E^\circ_{\text{cothode}} - E^\circ_{\text{anode}}$

$= (-0.14) - (-0.76) = 0.62 \text{ V}$

Cell reaction:

$Zn + Sn^{2+} \rightarrow Zn^{2+} + Sn$

$$Q = \frac{[Zn^{2+}]}{[Sn^{2+}]} = \frac{0.1}{0.001} = 100$$

Using Nernst equation:

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{2}\log Q$$

$$E_{\text{cell}} = 0.62 - \frac{0.0591}{2}\log 100$$

$$= 0.62 - \frac{0.0591}{2} \times 2$$

$= 0.62 - 0.0591$

$E_{\text{cell}} \approx 0.56 \text{ V}$

$$E_{\text{cxll}} = E^\circ_{\text{cell}} - \frac{0.0591}{n}\log Q$$

127. Using Arrhenius equation:

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Given:

$\frac{k_2}{k_1} = 3, T_1 = 290\text{K}, T_2 = 300\text{K}$

$$0.48 = \frac{E_a}{19.15}\left(\frac{300 - 290}{290 \times 300}\right)$$

$$0.48 = \frac{E_a}{19.15} \times \frac{10}{87000}$$

$$E_a = \frac{0.48 \times 19.15 \times 87000}{10}$$

$E_a \approx 7.99 \times 10^4$ J mol^{-1}

$E_a \approx 80$ kJ mol^{-1}

128. **(A)** Reducing sugars are sugars which reduce Tollens' reagent or Fehling's solution due to the presence of free aldehyde or keto group.

(B) Classification:

Monosaccharides:

• Fructose

• Galactose

Disaccharides:

• Sucrose

• Lactose

(C) Glycogen is known as animal starch.

It is called animal starch because it is the storage polysaccharide present in animals.

OR

(C)(i) The cyclic isomers of Glucose differing in configuration of -OH at $C-1$ are:

• α-glucose

• β-glucose

These are called anomers.

(ii) Reaction with bromine water detected the presence of an aldehyde group $(-CHO)$ in glucose.

129. **(A)** Copper is a transition element because its atom or ion has incompletely filled d-orbitals.

Cu: $[Ar]3d^{10}4s^1$

Cuu^{2+}: $[Ar]3d^9$

Since Cu^{2+} has partially filled d-orbitals, Cu is a transition element.

Zinc is not a transition element because:

Zn: $[Ar]3d^{10}4s^2$

Zn^{2+}: $[Ar]3d^{10}$

Both have completely filled d-orbitals.

(B) Transition elements show variable oxidation states because both $(n-1)d$ and ns electrons participate in bonding, and their energies are very close.

(C) (i) The $E^{\circ}_{M^{2+}/M}$ values show irregular trend due to irregular stability of different electronic configurations and varying enthalpies of atomization and ionization energies.

(ii) In transition elements, oxidation states differ generally by one unit because both ns and $(n-1)d$ electrons are involved.

In non-transition elements, oxidation states usually differ by two units.

OR

(C) (i) Chromium $^{2+}$ is strongly reducing because it easily gets oxidized to stable $Cr^{3+}(3d^3)$ configuration.

Manganese $^{3+}$ is strongly oxidizing because it readily gets reduced to stable $Mn^{2+}(3d^5)$ configuration.

(ii) Ionic equation:

$2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

130. **(A)** Relation between crystal field splitting energies:

$$\Delta_t = \frac{4}{9}\Delta_o$$

$$\Delta_t = \frac{4}{9}\Delta_o$$

(B) IUPAC name of $[PtCl_2(en)_2](NO_3)_2$is:

Dichloridobis(ethane-1,2-diamine)platinum(IV) nitrate

(C) For Nickel tetracarbonyl:

• Geometry: Tetrahedral

• Hybridisation: sp^3

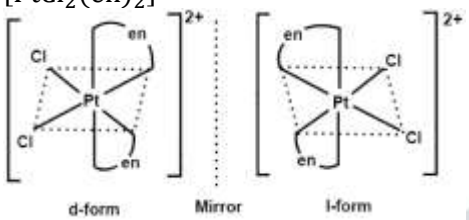
• Magnetic behaviour: Diamagnetic (all electrons paired)

(D) The complex

$[Co(NH_3)_6][Cr(CN)_6]$

shows Coordination isomerism.

(E) For d^4 ion in octahedral field when:
$\Delta_o < P$
electronic configuration is:
$t_{2g}^3 e_g^1$
It is a high spin complex.
$t_{2g}^3 e_g^1$
(F) Between
$[Co(NH_3)_6]^{3+}$ and $[Co(NH_3)_4Cl_2]^+$
the complex
$[Co(NH_3)_4Cl_2]^+$
is heteroleptic because it contains two different types of ligands (NH_3 and Cl^-).
(G) Optical isomerism in
$[PtCl_2(en)_2]^{2+}$



131. **(A) (i)** Explanations:
(1). Oxidation Ease: Aldehydes have a hydrogen atom directly bonded to the carbonyl carbon, which can be easily oxidized to an -OH group without breaking carboncarbon bonds. Ketones lack this hydrogen and require the breaking of strong $C-C$ bonds, making them much harder to oxidize.
(2). Acidity of $\boldsymbol{\alpha}$-hydrogen: The $\boldsymbol{\alpha}$-hydrogen atoms are acidic due to the strong electronwithdrawing effect (-1 effect) of the carbonyl group and the resonance stabilization of the resulting conjugate base (enolate ion) by the oxygen atom.
(ii) Reaction Products:
(1). $C_6H_5COCH_3 + NaOH/I_2 \longrightarrow C_6H_5COONa + CHI_3$ (Sodium benzoate and Iodoform)
(2). $C_6H_5COCl + (CH_3)_2Cd \longrightarrow C_6H_5COCH_3 + CdCl_2$ (Acetophenone)
(iii) Chemical Test:
• Tollen's Test: Ethanal will form a silver mirror when heated with Tollen's reagent, whereas ethanoic acid will not react.
• Alternatively: Sodium bicarbonate test: Ethanoic acid will produce effervescence (due to CO_2 gas) with $NaHCO_3$ solution, while ethanal will not.

OR

(B) (i) 2,4-DNP derivative of benzaldehyde:
Structure: $C_6H_5CH = N - NH - C_6H_3(NO_2)_2$
(An orange-red precipitate formed by the condensation of benzaldehyde and 2,4dinitrophenylhydrazine).
(ii) Increasing order of reactivity towards HCN :
$(CH_3)_3C - COCH_3 < CH_3COCH_3 < CH_3CHO$
(Reactivity decreases with increased steric hindrance and the +/effect of alkyl groups).
(iii) Conversion:
Treat phenyl magnesium bromide with solid $\boldsymbol{CO_2}$ (dry ice) in dry ether to form an adduct, followed by acid hydrolysis to yield benzoic acid.

$$C_6H_5MgBr + CO_2 \xrightarrow{\text{ether}} C_6H_5COOMgBr \xrightarrow{H_3O^+} C_6H_5COOH$$

(iv) Chemical Test:
• Iodoform Test: Ethanal reacts with $NaOH/I_2$ to give a yellow precipitate of iodoform (CHI_3). Benzaldehyde does not give this test as it lacks a methyl keto group (CH_3CO-).
(v) Main Product:
Ethyl 3-hydroxybutanoate $[CH_3CH(OH)CH_2COOC_2H_5]$
$NaBH_4$ selectively reduces the ketone group to a secondary alcohol but does not affect the ester group.

132. **(A) (i)** Molar Conductivity Calculation:
• Given: $C = 0.05M, R = 100\Omega, G^*$(cell constant) $= 0.0354\ cm^{-1}$.
• Step 1: Calculate Conductivity ($\boldsymbol{x}$):

$\kappa = \frac{G^*}{R} = \frac{0.0354}{100} = 3.54 \times 10^{-4}\ \text{s cm}^{-1}$

• Step 2: Calculate Molar Conductivity ($\boldsymbol{\Lambda_m}$) :

$\Lambda_m = \frac{\kappa \times 1000}{C} = \frac{3.54 \times 10^{-4} \times 1000}{0.05} = 7.08\ \text{S cm}^2\ \text{mol}^{-1}$

(ii) Faraday's First Law & Charge:

• Law: The mass of a substance deposited or liberated at any electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte. ($m = zQ$)

• Charge for Reduction: The reaction is: $MnO_4^- + 8H^+ + \mathbf{5e^-} \longrightarrow Mn^{2+} + 4H_2O$. Since 5 moles of electrons are involved, the charge required for 1 mol of MnO_4^- is 5 F.

OR

(B) (i) Degree of Dissociation (α):

• Step 1: Calculate Λ_m :

$\Lambda_m = \frac{\kappa \times 1000}{C} = \frac{5.25 \times 10^{-5} \times 1000}{0.0025} = 21\ \text{S cm}^2\text{mol}^{-1}$

• Step 2: Calculate $\boldsymbol{\alpha}$:

$\alpha = \frac{\Lambda_m}{\Lambda_m^\circ} = \frac{21}{390} \approx 0.0538$

(or 5.38%)

(ii) Lead Storage Battery Reactions (Discharging):

• Anode: $Pb(s) + SO_4^{2-}(aq) \longrightarrow PbSO_4(s) + 2e^-$

• Cathode: $PbO_2(\text{ s}) + SO_4^{2-}(\text{aq}) + 4H^+(\text{aq}) + 2e^- \longrightarrow PbSO_4(\text{ s}) + 2H_2O(\text{l})$

• Overall Reaction: $Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$

133. **(b)** Manganese has the highest third ionization enthalpy because after removal of two electrons it attains stable $3d^5$ configuration; removing the third electron breaks this stability.

134. **(d)**

135. **(b) Explanation:** DNA is a polymer of nucleotides. Each nucleotide consists of three parts: a pentose sugar (β-D-2-deoxyribose) a nitrogenous base, and phosphoric acid (which forms the phosphate backbone).

136. **(d)** For an electrolyte undergoing association, number of particles decreases, therefore van't Hoff factor: $i < 1$

137. **(a)** For reaction:

$X + 2Y \rightarrow P$

Rate expression:

$\text{Rate} = -\frac{1}{2}\frac{d[Y]}{dt} = \frac{d[P]}{dt}$

Hence,

$-2\frac{d[P]}{dt} = d[Y]/dt$

Equivalent correct option:

$-2d[P]/dt = -d[Y]/dt$

138. **(a)** Explanation:

S_N1 Reaction Mechanism: The rate of an S_N1 reaction depends on the stability of the carbocation formed after the leaving group (Br^-)departs.

• Option (a): Removing Br^-creates an allylic carbocation. This carbocation is highly stable because the positive charge is delocalized through resonance with the adjacent double bond.

• Option (b) & (c): These would form primary and secondary alkyl carbocations, respectively, which are much less stable than a resonance-stabilized one.

• Option (d): This is Bromobenzene. The $C - Br$ bond has partial double-bond character due to resonance, and the resulting phenyl cation is extremely unstable, so it practically doesn't undergo S_N1.

139. **(c)** Acetic acid reacts with PCl_5 to give:

Explanation:

When carboxylic acids like acetic acid (CH_3COOH) react with phosphorus pentachloride (PCl_5), the hydroxyl group ($-OH$) is replaced by a chlorine atom ($-Cl$) to form an acid chloride.

• The Reaction:

$CH_3COOH + PCl_5 \rightarrow CH_3COCl + POCl_3 + HCl$

The product formed is acetyl chloride.

Here are the answers to your questions:

140. **(a)** The carbonyl carbon is electrophilic (electron-poor). The cyanide ion (CN^-) acts as a nucleophile, attacking the carbon to initiate the addition.

141. **(d)** slope is $-E_a/(2.303R)$ and interept is logA.

The logarithmic form of the Arrhenius equation is $\log k = \log A - \frac{E_a}{2.303RT}$. In a plot of logk vs $1/T$, the equation follows $y = mx + c$, where the slope $m = -E_a/2.303R$.

142. **(c)** This is the standard laboratory method for preparing ethers by reacting a primary alkyl halide with a sodium alkoxide ($R - X + R' - ONa \rightarrow R - O - R' + NaX$).

143. **(a)** Dehydration involves the formation of a carbocation. Tertiary (3°) alcohols form the most stable carbocations, making them the easiest to dehydrate, followed by secondary (2°) and then primary (1°) alcohols.

144. **(b)** In glucose, the -OH group at the 5th carbon attacks the aldehyde group at C -1. This creates a six-membered ring (5 carbons +1 oxygen) known as the pyranose structure.

145. **(a)** Assertion (A) is true and Reason (R) is true, and Reason (R) is the correct explanation of Assertion (A).

- Sodium chloride dissociates into $Na^+$and Cl^-ions in water, increasing the number of solute particles.
- Due to this, depression in freezing point occurs.

146. **(a)** Assertion (A) is true and Reason (R) is true, and Reason (R) is the correct explanation of Assertion (A).

- Zirconium and Hafnium have similar radii because of lanthanoid contraction.
- Therefore, they show similar chemical properties and are difficult to separate.

147. **(d)** Assertion (A) is false and Reason (R) is true.

- Ethanoic acid has higher pK_a than Chloroacetic acid.
- Chlorine shows -1 effect, stabilizing the conjugate base and increasing acidity, so chloroacetic acid has lower pK_a.

148. **(d)** Assertion (A) is false and Reason (R) is true.

- Aniline is less basic than Ammonia.
- In aniline, the lone pair on nitrogen is involved in resonance with the benzene ring, making it less available for protonation.

149. For the electrode reaction:

$Fe^{2+} + 2e^- \rightarrow Fe$

Using Nernst equation :

$$E = E^\circ + \frac{0.0591}{2}\log[Fe^{2+}]$$

Given:

$E^0 = -0.45\ V, [Fe^{2+}] = 0.01M$

$$E = -0.45 + \frac{0.0591}{2}\log(0.01)$$

$\log(0.01) = -2$

$$E = -0.45 + \frac{0.0591}{2} \times (-2)$$

$E = -0.45 - 0.0591$

$E = -0.5091\ V \approx -0.51\ V$

150. Molecularity :

The number of reacting species (atoms, ions or molecules) taking part simultaneously in an elementary reaction is called molecularity.

A bimolecular reaction may become kinetically first order when one of the reactants is present in large excess so that its concentration remains practically constant.

151. Reactions of D-Glucose :

(A) With HI :

On prolonged heating with HI in presence of red phosphorus, D-glucose gives n-hexane.

(B) With conc. HNO_3 :

D-glucose is oxidised to saccharic acid (glucaric acid) containing two carboxyl groups.

152. **(A)** Major monohalo products :

(i) Styrene +HBr

HBr adds according to Markovnikov's rule :

$C_6H_5CH = CH_2 + HBr \rightarrow C_6H_5CHBrCH_3$

Major product : 1-bromo-1-phenylethane

(ii) Cyclohexene $+Br_2/UV$ light

Allylic bromination occurs :

Major product : 3-bromocyclohexene

OR

(B) Reasons :

(i) Grignard reagent reacts immediately with water and gets hydrolysed. Therefore, it must be prepared under anhydrous conditions.

(ii) With aqueous KOH, OH^- ion acts as nucleophile and alkyl halides undergo nucleophilic substitution to form alcohols.

With alcoholic KOH, elimination of HX occurs leading to formation of alkenes.

Here are the chemical equations for the reactions:

153. **(A)** Clemmensen Reduction of Butan-2-one

When butan-2-one is treated with zinc amalgam and concentrated hydrochloric acid, the carbonyl group ($> C = O$) is reduced to a methylene group ($-CH_2-$), forming n butane.

$$CH_3 - CO - CH_2 - CH_3 \xrightarrow[\text{conc. HCl}]{\text{Zn(Hg)}} CH_3 - CH_2 - CH_2 - CH_3 + H_2O$$

(B) Cannizzaro Reaction of Benzaldehyde

Since benzaldehyde lacks an α-hydrogen, it undergoes a self oxidation-reduction reaction (disproportionation) in the presence of concentrated NaOH . One molecule is reduced to benzyl alcohol, and the other is oxidized to sodium benzoate.

$$2C_6H_5CHO \xrightarrow{\text{conc. NaOH}} C_6H_5CH_2OH + C_6H_5COONa$$

154. Given :

For $0.05M$KCl solution,

• Resistance $R_1 = 100\Omega$

• Conductivity.

$k_1 = 1.35 \times 10^{-2}\Omega^{-1}\ cm^{-1}$

Cell constant:

Cell constant $= \kappa_1 \times R_1$

$= 1.35 \times 10^{-2} \times 100$

$= 1.35\ cm^{-1}$

For $0.02M AgNO_3$.

• Resistance $R_2 = 90\Omega$

Conductivity :

$$k_2 = \frac{\text{Cell constant}}{R_2}$$

$$= \frac{1.35}{90}$$

$= 0.015\Omega^{-1}\ cm^{-1}$

$k = 1.5 \times 10^{-2}\Omega^{-1}\ cm^{-1}$

Molar conductivity :

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

$$= \frac{0.015 \times 1000}{0.02}$$

$= 750\Omega^{-1}\ cm^2\ mol^{-1}$

Therefore,

• Conductivity:

$1.5 \times 10^{-2}\Omega^{-1}\ cm^{-1}$

• Molar conductivity :

$750\Omega^{-1}\ cm^2\ mol^{-1}$

155. Rate $= k[NO]^x[Br_2]^y$

From Expt. 1 & 2 :

$[Br_2] \times 3 \Rightarrow$ Rate $\times 3$

$y = 1$

From Expt. 1 & 3 :

$[NO] \times 3 \Rightarrow$ Rate $\times 9$

$3^x = 9 \Rightarrow x = 2$

(A)• Order w.r.t. $NO = 2$

• Order w.r.t. $Br_2 = 1$

Overall order $= 3$

(B)$k = \frac{1.0\times10^{-3}}{(0.05)^2(0.05)}$

$k = 8L^2\ mol^{-2}\ s^{-1}$

(C) Rate $= 8(0.4)^2(0.2)$

Rate $= 0.256\ molL^{-1}\ s^{-1}$

156. **(A)** Chemical Formula

The formula for Potassium tetrahydroxidozincate (II) is $K_2[Zn(OH)_4]$.

• Breakdown: The complex consists of a zincate ion (anionic) with zinc in a +2 oxidation state and four hydroxide (OH^-)ligands, giving the coordination sphere a total charge of $-2([Zn(OH)_4]^{2-})$. Two potassium (K^+)ions are needed to balance this charge.

(B) Increasing Order of Conductivity

Conductivity depends on the number of ions produced in an aqueous solution. The more ions a complex dissociates into, the higher its conductivity.

(1)$[Cr(NH_3)_3Cl_3]$: This is a neutral complex and does not dissociate into ions(0 ions).

(2)$[Cr(NH_3)_5Cl]Cl_2$: Dissociates into 3 ions (1 complex ion $+2Cl^-$).

(3)$[Cr(NH_3)_6]Cl_3$: Dissociates into 4 ions (1 complex ion $+3Cl^-$).

Increasing Order:

$[Cr(NH_3)_3Cl_3] < [Cr(NH_3)_5Cl]Cl_2 < [Cr(NH_3)_6]Cl_3$

(C) Type of Isomerism

(i) $[Co(NH_3)_5NO_2]^{2+}$: Exhibits Linkage Isomerism. This occurs because the $\mathbf{NO_2^-}$ ligand is ambidentate and can bind to the metal through either the nitrogen atom (nitro) or the oxygen atom (nitrito).

(ii) $[Co(en)_3]Cl_3$: Exhibits Optical Isomerism. The complex lacks a plane of symmetry, resulting in two non-superimposable mirror images (enantiomers).

157. **(A)** Allylic Halide

The correct answer is (ii): $CH_2 = CH - CH(Br) - CH_3$.

• Reason: In an allylic halide, the halogen atom is bonded to an sp^3 hybridized carbon atom next to a carbon-carbon double bond $(C = C)$.

In (i), the bromine is attached directly to a double-bonded carbon, making it a vinylic halide.

(B) Reactivity towards Nucleophilic Substitution

2,4,6-trinitrochlorobenzene is significantly more reactive than chlorobenzene.

• Why? The nitro group $(-NO_2)$ is a very strong electron-withdrawing group. When placed at ortho and para positions, it withdraws electron density from the benzene ring, making the carbon attached to the chlorine more susceptible to nucleophilic attack. Furthermore, it stabilizes the intermediate carbanion through resonance.

(C) Lowest Boiling Point Isomer

The isomer with the lowest boiling point is tert-butyl chloride (2-chloro-2methylpropane).

• Reason: As branching increases, the molecule becomes more spherical, which decreases its surface area. This leads to weaker intermolecular van der Waals forces, resulting in a lower boiling point.

158. **(A)** Mechanism: Dehydration of Ethanol to Ethene

The reaction proceeds in three main steps:

(1) Protonation: The alcohol reacts with the acid to form a protonated alcohol (ethyl oxonium ion).

$CH_3CH_2OH + H^+ \rightleftharpoons CH_3CH_2OH_2^+$

(2) Carbocation Formation: The oxonium ion loses a water molecule to form an ethyl carbocation (Slowest step).

$CH_3CH_2OH_2^+ \xrightarrow{slow} CH_3CH_2^+ + H_2O$

(3) Elimination: A proton is lost from the β-carbon to form the double bond.

$CH_3CH_2^+ \rightarrow CH_2 = CH_2 + H^+$

(B) Main Products

(i) $CH_3CH_2CH_2CH_2OH$ (Butan-1-ol)

• Note: This is a hydroboration-oxidation reaction, which results in the antiMarkovnikov addition of water.

(ii) Salicylic acid (2-hydroxybenzoic acid)

• Note: This is Kolbe's reaction, where phenol is converted into a hydroxy acid.

159. **(A)** Peptide Linkage

A peptide linkage (or peptide bond) is an amide bond formed between the carboxyl group $(-COOH)$ of one amino acid and the amino group $(-NH_2)$ of another. During this process, a molecule of water is eliminated $(-H_2O)$.

• Structure: $-CO-NH-$

(B) Bonds in DNA Double Helix

The two strands of a DNA double helix are held together by hydrogen bonds between complementary nitrogenous bases:

• Adenine (A) forms two hydrogen bonds with Thymine (T).

• Guanine (G) forms three hydrogen bonds with Cytosine (C).

(C) Polysaccharide Identification

Among the options provided, Starch is the polysaccharide.

• Note: Glucose and Fructose are monosaccharides, while Sucrose is a disaccharide.

(D) Vitamin Examples

• Water-Soluble Vitamins: Vitamin C (Ascorbic acid) or Vitamin B complex.

• Fat-Soluble Vitamins: Vitamin A, D, E, or K.

160. Step-by-Step Identification

(1) Identify (F): Compound (F) is a monobasic acid with a molecular weight of 60 . The general formula for such an acid is $R-COOH$.

(i) $R+12+(16\times2)+I=60 \Longrightarrow R+45=60 \Longrightarrow R=15$ (which is a $-CH_3$ group).

(ii) Therefore, (F) is Ethanoic acid (CH_3COOH).

(2) Identify (D): Since (D) is oxidized to form (F) (Ethanoic acid), (D) is Ethanal (CH_3CHO).

(3) Identify (B): (B) is oxidized with PCC to give (D) (Ethanal). PCC oxidizes primary alcohols to aldehydes.

(i) Therefore, (B) is Ethanol (CH_3CH_2OH).

(4) Identify (E): (D) (Ethanal) treated with dilute NaOH and heated undergoes an Aldol Condensation.

(i) $2CH_3CHO \xrightarrow{\text{dil. NaOH},\Delta} CH_3-CH=CH-CHO$

(ii) Therefore, (E) is But-2-enal (Crotonaldehyde).

(5) Identify (C): (E) undergoes catalytic hydrogenation (reducing both the double bond and the aldehyde) to give (C).

(i) $CH_3-CH=CH-CHO \xrightarrow{H_2/Ni} CH_3CH_2CH_2CH_2OH$

(ii) Therefore, (C) is Butan-1-ol.

(6) Identify (A): Compound (A) $(C_6H_{12}O_2)$ is reduced by $LiAlH_4$ to give (B) (Ethanol) and (C) (Butan-1-ol). This indicates (A) is an ester.

(i) An ester splits into its constituent alcohol and the alcohol derived from the acid part.

(ii) Acid part (2 carbons) + Alcohol part (4 carbons) = 6 carbons.

(iii) Therefore, (A) is Butyl ethanoate $(CH_3COOCH_2CH_2CH_2CH_3)$.

Summary Table

Compound	Name	Chemical Formula
(A)	Butyl ethanoate	$CH_3COOC_4H_9$
(B)	Ethanol	CH_3CH_2OH
(C)	Butan-1-ol	$CH_3CH_2CH_2CH_2OH$
(D)	Ethanal	CH_3CHO
(E)	But-2-enal	$CH_3CH=CHCHO$

(F)	Ethanoic acid	CH_3COOH

161. **(A)** Difference between Primary and Secondary Batteries

• Primary Batteries: The chemical reaction occurs only once. After the reactants are consumed over a period of time, the battery becomes "dead" and cannot be reused or recharged (e.g., Dry cell, Mercury cell).

• Secondary Batteries: These can be recharged by passing an electric current through them in the opposite direction. This reverses the chemical reactions, allowing the battery to be used multiple times (e.g., Lead storage battery, Nickel-cadmium cell).

(B) Constant Potential of Mercury Cell

The cell potential of a Mercury cell remains constant (1.35 V) throughout its life because the overall cell reaction does not involve any ions in solution whose concentration could change during use.

• The overall reaction is: $Zn(Hg) + HgO(s) \rightarrow ZnO(s) + Hg(l)$

• Since all reactants and products are either solids or liquids, their activities remain constant, keeping the voltage steady.

(C) Recharging of Lead Storage Battery

When the battery is recharged, the reactions that occurred during discharge are reversed. Electrical energy is provided from an external source to convert lead sulfate back into lead and lead dioxide:

• At Anode (originally Cathode): $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$

• At Cathode (originally Anode):

$PbSO_4(s) + 2H_2O(l) \rightarrow PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$

• Overall Reaction: $2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$

OR

(C) Advantages of Fuel Cells

(1) High Efficiency: Fuel cells convert the energy of combustion directly into electrical energy, making them much more efficient (about 70%) compared to thermal plants (about 40%).

(2) Pollution-Free: They do not produce harmful byproducts. For example, in a HydrogenOxygen fuel cell, the only byproduct is water vapor, which is environmentally friendly and was even used as drinking water by astronauts in the Apollo program.

162. **(A)**Crystal field splitting energy (Δ) is the energy difference between the two sets of d-orbitals formed due to splitting in a ligand field (e.g., t_{2g} and e_g in octahedral complexes).

(B) In $[Ti(H_2O)_6]^{3+}$, Ti^{3+} has one electron in the d-orbital. In octahedral field, d-orbitals split and the electron absorbs visible light for d - d transition from $t_{2g} \rightarrow \epsilon_g$, and the transmitted light appears violet.

(C)• $[Cr(NH_3)_6]^{3+}: Cr^{3+} = d^3$, has unpaired electrons - paramagnetic

• $[Ni(CN)_4]^{2-}: Ni^{2+} = d^8, CN^-$is strong field ligand → pairing occurs → square planar, all electrons paired → diamagnetic

OR

(C)• $[Fe(CN)_6]^{3-}: CN^-$is strong field ligand → electrons pair in inner 3d orbital - inner orbital complex

• $[Fe(H_2O)_6]^{3+}: H_2O$ is weak field ligand → no pairing in 3 d → uses outer 4 d orbital → outer orbital complex

163. **(A) (i)** Henry's Law Constant (K_H) :

O_2 will have a higher K_H value.

• Reason: According to Henry's Law ($P = K_H \cdot \chi$), solubility (χ) is inversely proportional to K_H at a constant pressure. Since CO_2 is more soluble than O_2, O_2 must have a higher K_H value.

(ii) Change in Blood Cell Size:

The blood cells will shrink (crenation).

• Reason: A 0.9%(m/v)NaCl solution is isotonic with blood cells. A solution $> 0.9\%$ is hypertonic. Water will move out of the cells via osmosis into the more concentrated salt solution.

(iii) Boiling Point Calculation:

(1)Find van't Hoff factor (i): For $A_2B_3 \rightarrow 2A + 3B$. $n = 5$. Degree of ionization $\alpha = 0.6$.

$i = 1 + \alpha(n - 1) = 1 + 0.6(5 - 1) = 1 + 2.4 = 3.4$.

(2)Calculate Elevation in Boiling Point (ΔT_b):

$\Delta T_b = i \cdot K_b \cdot m = 3.4 \times 0.52 \times 1 = 1.768$ K.

(3)Boiling Point of Solution (T_b) :

$T_b = T_b^* + \Delta T_b = 373.15\ K + 1.768\ K = 374.918\ K$ (or $101.768°C$).

OR

(B) (i) Mole Fraction in Vapour Phase (y_B) :

(1)Total Pressure (P_{total}) :

(a) $P_A = P_A^\circ \chi_A = 75 \times 0.4 = 30\ mmHg$

(b) $P_B = P_B^* \chi_B = 25 \times 0.6 = 15\ mmHg$ (since $\chi_B = 1 - 0.4 = 0.6$)

(c) $P_{total} = 30 + 15 = 45\ mmHg$

(2)Vapour Phase Mole Fraction of B(y_B) :

(a) $y_B = \frac{P_B}{P_{lodd}} = \frac{15}{45} = 0.33$

(ii) Colligative Properties:

• Definition: These are properties of a solution that depend solely on the number of solute particles (concentration) and not on their chemical identity.

• Preferred Property: Osmotic Pressure is preferred for macromolecules (like proteins/polymers) because the pressure change is large enough to be measured accurately at room temperature, even at low molar concentrations.

(iii) Isotonicity of NaCl vs. Glucose:

Equimolar solutions are not isotonic because NaCl is an electrolyte while glucose is a non-electrolyte.

• NaCl dissociates into two ions ($Na^+$and Cl^-), doubling the number of particles ($i = 2$).

• Glucose does not dissociate ($i = 1$).

• Since osmotic pressure depends on the number of particles, the NaCl solution will have a higher osmotic pressure than the glucose solution.

164. **(A)** Solubility of N,N-diethyl-benzenesulphonamide

N, N-diethyl-benzenesulphonamide is insoluble in alkali because it lacks an acidic hydrogen atom attached to the nitrogen atom. In primary amines, the sulfonamide has two acidic hydrogens and is soluble; in secondary amines, it has one and is soluble. Since this is derived from a tertiary amine, there is no hydrogen to be pulled off by the base to form a soluble salt.

(B) Aniline and Friedel-Crafts Reaction

Aniline does not undergo Friedel-Crafts reactions because the Lewis acid catalyst ($AlCl_3$) reacts with the basic amino group ($-NH_2$) of aniline to form a salt complex. This creates a strong positive charge on the nitrogen ($NH_2^+ - AlCl_3^-$), which acts as a powerful electronwithdrawing group, thereby deactivating the benzene ring toward electrophilic substitution.

(C) Distinguishing Methylamine and Aniline

You can use the Azo-dye Test:

• Aniline: Dissolve in HCl , cool to $0 - 5°C$, and add $NaNO_2$ followed by an alkaline solution of β-naphthol. A brilliant orange/red dye is formed.

• Methylamine: Does not form a dye; instead, it reacts with nitrous acid to evolve nitrogen gas (bubbles) and form methanol.

(D) Gabriel Phthalimide Synthesis

This synthesis is used to prepare pure primary aliphatic amines.

(1)Phthalimide $+KOH \rightarrow$ Potassium phthalimide

(2)Potassium phthalimide $+R - X \rightarrow$ **N**-Alkylphthalimide

(3)N-Alkylphthalimide $+NaOH(aq) \rightarrow$ Primary Amine $(R - NH_2) +$ Sodium phthalate

(E) Conversion of Aniline to p-bromoaniline

Direct bromination of aniline yields 2,4,6-tribromoaniline. To get the para-isomer, we must protect the amino group:

(1)Acetylation: React aniline with acetic anhydride $((CH_3CO)_2O)$ to form acetanilide. This reduces the activating power of the $-NH_2$ group.

(2)Bromination: React acetanilide with Br_2 in acetic acid. The major product is **p** bromoacetanilide.

(3)Hydrolysis: Treat with acid (H^+) or base (OH^-) to remove the acetyl group, yielding pbromoaniline.

(F) Completion of Reaction

This is a two-step process involving the conversion of a diazonium salt to a nitro compound:

(1) Benzene diazonium chloride $+HBF_4 \rightarrow$ Benzene diazonium fluoroborate ($C_6H_5N_2^+BF_4^-$).

(2) Heating with $NaNO_2$ and Copper powder $\rightarrow$ Nitrobenzene ($C_6H_5NO_2$).

(G) Structures of A and B

• A (Benzamide): Benzoic acid reacts with NH_3 and heat to form an amide.

• Structure: $C_6H_5CONH_2$
• B (Aniline): Benzamide undergoes Hofmann Bromamide Degradation when treated with Br_2 and NaOH .
• Structure: $C_6H_5NH_2$

165. **(A) (i)** Reasoning:

(1) Low Melting/Boiling Points: Zn, Cd, and Hg have completely filled d-orbitals (d^{10} configuration). Because they have no unpaired d-electrons, the metallic bonding is weak, resulting in low melting and boiling points.
(2) Cr^{2+} vs. Mn^{3+}: Cr^{2+} is reducing because it oxidizes to Cr^{3+}, which has a stable halffilled t_{2g} level (d^3). Mn^{3+} is oxidizing because it reduces to Mn^{2+}, which has a stable half-filled d-subshell (d^5).
(3) Positive E° for Cu^{2+}/Cu. This is because the high energy required to transform solid copper into gaseous ions (atomization + ionization enthalpies) is not balanced by its hydration enthalpy.
(ii) Completed Equations:
(1) $2KMnO_4 \xrightarrow{\text{heat}} K_2MnO_4 + MnO_2 + O_2$
(2) $Cr_2O_7^{2-} + 6I^- + 14H^+ \longrightarrow 2Cr^{3+} + 3I_2 + 7H_2O$
(B) (i) Stability of $CuCl_2$:
$CuCl_2(Cu^{2+})$ is more stable in aqueous solution. Although $Cu^+(Cu_2Cl_2)$ has a stable d^{10} configuration, the high hydration enthalpy of Cu^{2+} more than compensates for the energy required to remove the second electron. In water, Cu^+typically disproportionates:
$2Cu^+ \rightarrow Cu^{2+} + Cu.$
(ii) Electronic Configuration:
The general configuration for f-block elements is: $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$.
(iii) Coloured lons:
Fe^{3+} will be coloured.
• Reason: Fe^{3+} has an incomplete d-subshell ($3d^5$), which allows for $d-d$ transitions of electrons. $Sc^{3+}(3d^0)$ and $Zn^{2+}(3d^{10})$ have either empty or completely filled d orbitals, so no $d-d$ transition occurs.
(iv) Conversion to Potassium Dichromate:
(1) Acidification: Sodium chromate is treated with an acid (like H_2SO_4) to form sodium dichromate.
$2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$
(2) Metathesis: Sodium dichromate is reacted with KCl . Potassium dichromate is less soluble and crystallizes out.
$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$
(v) Catalytic Activities:
Transition metals are effective catalysts because of:
• Their ability to adopt variable oxidation states.
• Their ability to form complexes with reactants.
• Providing a large surface area for reactants to be adsorbed.

166. **(b)** At high altitudes, the partial pressure of oxygen is less than at sea level. This leads to lower concentrations of oxygen in the blood and tissues, a condition often called hypoxia.

167. **(c)** To reduce one mole of Al^{3+} ions (from Al_2O_3) to Al metal, 3 moles of electrons are required $(Al^{3+} + 3e^- \rightarrow Al)$. Since the charge of 1 mole of electrons is 1 Faraday (F), 3 F are needed.

168. **(d)** The +3 oxidation state is the most stable and common oxidation state for all lanthanoid elements.

169. **(a)** Chromium $(Cr, Z = 24)$ has the configuration $[Ar]3d^54s^1$. Losing three electrons (one from 4s and two from 3d) results in Cr^{3+} having a $[Ar]3d^3$ configuration.

170. **(a)** Since 2 moles of AgCl are formed, 2 chloride ions must be outside the coordination sphere (ionizable). This means the formula is $[Co(NH_3)_5Cl]Cl_2$. The secondary valency (coordination number) is the number of ligands bonded directly to the metal, which is $5(NH_3) + 1(Cl) = 6$.

171. **(a)** Primary alkyl halides prefer the S_N2 mechanism because they are sterically unhindered, allowing the nucleophile to attack easily, and they do not form stable carbocations required for $S_N1.\theta$

172. **(d)** Phenol is more acidic than ethanol and cresols, but less acidic than nitro-substituted phenols.
o-nitrophenol has strong -I and -M effect - increases acidity.
So phenol is less acidic than o-nitrophenol.

173. **(c)** Nitro group $(-NO_2)$ reduced by Sn/HCl gives amine:
$ArNO_2 \xrightarrow[HCl]{Sn} ArNHH_2$
Aromaticprimaryamine

174. **(a)** Nucleic acids (DNA/RNA) are polymers of nucleotides.

175. **(c)** Methylamine with nitrous acid:

$CH_3NH_2 + HNO_2 \rightarrow CH_3OH + N_2 + H_2O$

So product is methanol.

$= CH_3OH$

176. **(d)** Lowest pK_b = strongest base.

Order of basicity:

$(CH_3)_2NH > CH_3NH_2 > NH_3 > C_6H_5NH_2$

So strongest base is dimethylamine → lowest pK_b.

177. **(a)** CH_3CHO (Acetaldehyde)

The reactivity of carbonyl compounds toward nucleophilic addition depends on two main factors:

• Electronic Factor: Nucleophiles attack the partially positive carbon of the carbonyl group ($C = O$). Alkyl groups (like $-CH_3$) are electron-donating ($+I$ effect), which reduces the positive charge on that carbon. Therefore, aldehydes (with one alkyl group) are more reactive than ketones (with two).

• Steric Factor: Larger groups around the carbonyl carbon hinder the approach of the nucleophile. Acetaldehyde has only one methyl group and a tiny hydrogen atom, making it less crowded and more accessible than the other options.

178. **(c)** Assertion (A) is true; Reason (R) is false.

• Correction: Vitamin C is water-soluble, not fat-soluble. Because it dissolves in water, it cannot be stored in large amounts in the body and is readily excreted in urine. Fatsoluble vitamins (like A, D, E, and K) are the ones stored in liver and adipose tissues.

179. **(a)** Both Assertion (A) and Reason (R) are true, and (R) is the correct explanation of (A).

• The carboxyl group (-COOH) is an electron-withdrawing group. It withdraws electron density from the benzene ring, making the ring less reactive (deactivating) and specifically directing the incoming electrophile (Bromine) to the meta position.

180. **(a)** Both Assertion (A) and Reason (R) are true, and (R) is the correct explanation of (A).

As discussed, adding a non-volatile solute like NaCl lowers the vapor pressure of the water. Since freezing happens when the vapor pressure of the liquid equals that of the solid, this "dip" in vapor pressure forces the solution to reach that equilibrium at a lower temperature.

181. **(c)** Assertion (A) is true; Reason (R) is false.

• Assertion: Linkage isomerism definitely occurs with ambidentate ligands (like SCN^- or NO_2^-) because they can attach to the metal through different atoms.

• Correction: The reason is false because an ambidentate ligand has two different donor atoms, not the same ones. For example, NO_2^-can bond via Nitrogen (nitro) or Oxygen (nitrito). If the atoms were the same, the "linkage" wouldn't change the structure of the isomer.

182. A non-volatile solute lowers the vapour pressure of the solvent. So the solution needs a higher temperature to reach atmospheric pressure, hence it boils at a higher temperature.

Elevation of boiling point is a colligative property because it depends only on the number of solute particles, not their nature.

183. **(A) (i)** Potassium tetrahydroxidozincate (II):

$K_2[Zn(OH)_4]$

(ii) Hexaammineplatinum (IV) chloride:

$[Pt(NH_3)_6]Cl_4$

OR

(B) (i) Homoleptic complex: A complex in which the central metal is bonded to only one type of ligand.

(ii) Chelate ligand: A ligand that forms ring structure with metal ion by donating multiple electron pairs (bidentate or polydentate).

184. **(A)** Reactivity towards S_N1

$(CH_3)_3C - I$ is more reactive towards S_N1 than $(CH_3)_3C - Br$.

• Reason: S_N1 reactions depend on the ability of the leaving group to depart. Iodine $(I^-)$is a better leaving group than bromine (Br^-)because it is larger and the $C - I$ bond is weaker than the $C - Br$ bond.

(B) Reaction of p-nitrochlorobenzene with aq. NaOH

Heating p-nitrochlorobenzene with aqueous NaOH at 443 K followed by acidification produces p-nitrophenol.

• Reaction: $p - NO_2 - C_6H_4 - Cl + OH^- \xrightarrow{443\ K} p - NO_2 - C_6H_4 - OH + Cl^-$

185. **(A)** Reimer-Tiemann Reaction

Phenol reacts with chloroform ($CHCl_3$) in the presence of aqueous sodium hydroxide (NaOH), followed by acidification, to produce salicylaldehyde (2hydroxybenzaldehyde).

• Reaction: $C_6H_5OH + CHCl_3 + 3NaOH \rightarrow$ Salicylaldehyde $+3NaCl + 2H_2O$

(B) Friedel-Crafts Alkylation of Anisole

Anisole reacts with an alkyl halide (e.g., CH_3Cl) in the presence of a Lewis acid (e.g., $AlCl_3$) to produce a mixture of 2-methylanisole (ortho-isomer) and 4-methylanisole (para-isomer).

• Reaction: Anisole $+CH_3Cl \xrightarrow{AlCl_3}$ 2-Methylanisole (minor) + 4-Methylanisole (major)

186. Formulae of Isomers A and B

For the molecular formula C_3H_6O, the two primary functional isomers are propanal (an aldehyde) and propanone (acetone, a ketone).

• Isomer B (Acetone): $CH_3 - CO - CH_3$

• Reasoning: It contains the CH_3CO - (methyl keto) group, which reacts with NaOH and I_2 to give a yellow precipitate of iodoform (CHI_3).

• Isomer A (Propanal): $CH_3 - CH_2 - CHO$

• Reasoning: It does not contain the methyl keto group, so it gives a negative iodoform test.

187. Calculation of Boiling Point

The boiling point of the solution is 373.346 K (or $100.346°C$).

(1) Determine van't Hoff factor (i): $MgSO_4$ ionises completely as $MgSO_4 \rightarrow Mg^{2+} + SO_4^{2-}$, so $i = 2$

(2) Calculate Molality (m):

$$m = \frac{\text{moles of solute}}{\text{mass of solvent in kg}} = \frac{4\ g/120\ g\ mol^{-1}}{100\ g/1000\ g/kg} = 0.333\ mol/kg$$

(3) Calculate Elevation in Boiling Point (ΔT_b):

$\Delta T_b = i \times K_b \times m = 2 \times 0.52\ K\ kg\ mol^{-1} \times 0.333\ mol/kg = 0.346\ K$

(4) Calculate Final Boiling Point (T_b):

$T_b = T_b^* + \Delta T_b = 373\ K + 0.346\ K = 373.346\ K$

188. Conductivity and Molar Conductivity

• Conductivity (k): The conductance of a unit volume (e.g., 1 cm^3) of an electrolytic solution.

• Variation: Decreases with dilution (lower concentration) because the number of ions per unit volume decreases.

• Molar Conductivity (Λ_m) : The conducting power of all ions produced by dissolving one mole of electrolyte in a solution.

• Variation: Increases with dilution (lower concentration). For weak electrolytes, this is due to an increase in the degree of dissociation; for strong electrolytes, it is due to decreased inter-ionic attractions.

189. Reaction Order and Rate

(A) Differential Rate Equation:

The rate (r) is given by: $\frac{dx}{dt} = k[A]^1[B]^2$

(B) B increased 3 times:

If [B] becomes 3[B], the new rate $r' = k\,|\,A\|[3B]^2 = 9k[A\|B]^2$.

The rate increases 9 times.

(C) A and B both doubled:

If [A] becomes 2[A] and [B] becomes 2[B], the new rate $r'' = k[2A][2B]^2 = k(2|A|)(4[B]^2) = 8k[A\|B]^2$.

The rate increases 8 times.

190. Crystal Field Theory (CFT)

Definition: Crystal Field Splitting Energy (Δ_0) is the energy difference between the two sets of d-orbitals (t_{2g} and e_g) that arises when the degeneracy of the d-orbitals is lifted due to the approach of ligands in a coordination complex.

(A) $\Delta_0 >$ P (Strong Field/Low Spin): Pairing energy is less than splitting energy, so electrons will pair up in the lower orbitals.

Configuration: $t_{2g}^5 e^0$

(B) $\Delta_0 <$ P (Weak Field/High Spin): Splitting energy is less than pairing energy, so electrons will occupy the higher orbitals before pairing.

Configuration: $t_{2g}^3 e^2$

191. Main Products

(A) Methyl chloride +KCN :
Forms Methyl cyanide (Ethanenitrile).
$CH_3Cl + KCN \rightarrow CH_3CN + KCl$
(B) 2,4,6-trinitrochlorobenzene + Hydrolysis:
Forms Picric acid (2,4,6-trinitrophenol). The presence of three nitro groups makes the chlorine extremely reactive toward substitution.
(C) Methyl chloride + Sodium (Dry Ether):
Forms Ethane (Wurtz Reaction).
$2CH_3Cl + 2Na \xrightarrow{\text{dry ether}} CH_3 - CH_3 + 2NaCl$
(D) n-butylchloride + alcoholic KOH :
Forms But-1-ene (Dehydrohalogenation).
$CH_3CH_2CH_2CH_2Cl \xrightarrow{\text{alc. KOH}} CH_3CH_2CH = CH_2 + HCl$

192. **(A)** Carbylamine reaction
Primary amines react with chloroform and alcoholic KOH to form isocyanides (foul smell):
$RNH_2 + CHCl_3 + 3KOH \rightarrow RNC + 3KCl + 3H_2O$
Used as test for primary amines.
(B) Hofmann bromamide degradation reaction
An amide reacts with bromine and alkali to form a primary amine with one carbon less:
$RCONH_2 + Br_2 + 4KOH \rightarrow RNH_2 + K_2CO_3 + 2KBr + 2H_2O$
(C) Ammonolysis
Reaction of alkyl halides with ammonia to form amines:
$RX + NH_3 \rightarrow RNH_2 + HX$
Further substitution can form secondary and tertiary amines.

193. Conversions
(A) Propan-2-ol → Propanone
Oxidation:
$(CH_3)_2CHOH \xrightarrow{[O](K_2Cr_2O_7/H^+)} (CH_3)_2CO$
(B) Phenol → Benzene
Reduction (zinc dust):
$C_6H_5OH \xrightarrow{2n,\Delta} C_6H_6$
(C) Propene → Propan-2-ol
Markovnikov addition of water (acid-catalyzed hydration):
$CH_3CH = CH_2 \xrightarrow{H_2O/H^+} CH_3CHOHCH_3$

194. **(A)** Rate law:
$\text{Rate} = k[A]^1[B]^{1/2}$
Overall order:
$\text{Overall order} = \frac{3}{2}$
(B) Order vs Molecularity (complex reactions):
• Order: Sum of powers of concentrations in rate law (experimental, can be fractional or zero).
• Molecularity: Number of reacting species in elementary step (theoretical, always whole number).
(C) For first-order reaction:
$t = \frac{2.303}{k}\log\frac{a}{a-x}$
For 90% completion:
$\frac{a}{a-x} = \frac{100}{10} = 10$
$t_{90} = \frac{2.303}{k}\log 10 = \frac{2.303}{k}$
For 99% completion:
$\frac{a}{a-x} = \frac{100}{1} = 100$
$t_{99} = \frac{2.303}{k}\log 100 = \frac{2.303}{k} \times 2 = \frac{4.606}{k}$

Now:

$t_{99} = 2t_{90}$

$t_{99} = 2t_{90}$

OR

(C) Zero order reaction:

A reaction whose rate is independent of concentration of reactants.

Rate $= k$

Example: Photochemical decomposition of HI or catalytic decomposition of NH_3 on metal surface.

195. Aldehydes, Ketones, and Carboxylic Acids

(A) Why Methanal (Formaldehyde) doesn't undergo Aldol condensation:

Aldol condensation requires the presence of at least one α-hydrogen (a hydrogen atom attached to the carbon adjacent to the carbonyl group). Methanal (HCHO) has only one carbon atom; it lacks an α-carbon and therefore has no α-hydrogens to participate in the reaction.

(B) Acidity of α-hydrogens:

The α-hydrogens of aldehydes and ketones are acidic due to two factors:

(1) Resonance Stabilization: Once the proton is removed, the resulting conjugate base (enolate ion) is stabilized by resonance with the carbonyl oxygen.

(2) Inductive Effect: The strong electron-withdrawing nature of the carbonyl group $(-C=O)$ weakens the $C-H$ bond on the α-carbon.

(C) (i) Ease of Oxidation:

Aldehydes have a hydrogen atom attached to the carbonyl carbon, which can be easily converted into an $-OH$ group without breaking any $C-C$ bonds. Ketones, however, lack this hydrogen and require the cleavage of strong carbon-carbon bonds to be oxidized, which necessitates much harsher conditions.

(ii) Sodium Hydrogen Sulphite Addition:

When $NaHSO_3$ is added to an aldehyde, it forms a crystalline bisulphite addition compound that is usually solid and insoluble in the organic layer. This solid can be filtered out to separate the aldehyde from other impurities. The reaction is reversible; heating the solid with dilute acid or alkali regenerates the pure aldehyde.

OR

(C) What happens when:

(i) Ethanal is treated with dilute NaOH ?

It undergoes Aldol condensation to form 3-hydroxybutanal (aldol).

$2CH_3CHO \xrightarrow{\text{dil. NaOH}} CH_3CH(OH)CH_2CHO$

(ii) Propanone is treated with HCN ?

It undergoes nucleophilic addition to form Propanone cyanohydrin (2-hydroxy-2methylpropanenitrile).

$CH_3COCH_3 + HCN \rightarrow (CH_3)_2C(OH)CN$

196. **(A)** Glucose pentaacetate has all its -OH groups acetylated, so no free carbonyl group is available to react with hydroxylamine to form an oxime.

(B) Amino acids behave like salts because they contain both acidic $(-COOH)$ and basic $(-NH_2)$ groups. In aqueous solution, they exist as zwitterions ($^+NH_3 - CHR - COO^-$).

(C) Water-soluble vitamins (like B and C) are not stored in the body in significant amounts and are easily excreted through urine, so they must be taken regularly.

(D) The two DNA strands are complementary because of specific base pairing: adenine pairs with thymine, and guanine pairs with cytosine via hydrogen bonds.

(E) When D-glucose is heated with HI , it gets completely reduced to n-hexane due to replacement of all functional groups by hydrogen.

(F) A glycosidic linkage is the bond formed between two monosaccharide units through an oxygen atom by removal of a water molecule.

(G) Enzymes are biological catalysts (mostly proteins) that speed up biochemical reactions in living organisms without being consumed.

197. **(A)** Answer the following

(i) Which element shows +1 oxidation state?

Cu (Copper) - due to stable $3d^{10}$ configuration in Cu^+.

(ii) Which element is a strong reducing agent in +2 oxidation state and why?

V^{2+} (Vanadium)
Because V^{2+} readily gets oxidised to V^{3+}, which is more stable (higher stability of $d^2 \rightarrow d^3$ configuration).
(iii) Which element shows maximum number of oxidation states? Give reason.
Mn (Manganese)
Because it has maximum unpaired electrons and uses both 3d and 4s electrons in bonding, showing oxidation states from +2 to +7 .
(iv) Which element has the lowest enthalpy of atomization and why?
Zn (Zinc)
Because it has completely filled $3d^{10}$ configuration, leading to weak metallic bonding.
(v) Which element shows only +3 oxidation state?
Sc (Scandium)
Because Sc^{3+} has stable d^0 configuration.

OR

(B) (i) Account for the following:
(1) Cu^{2+} salts are coloured while Zn^{2+} salts are white.
Cu^{2+} has partially filled d -orbitals $\rightarrow$ d $-$ d transitions $\rightarrow$ colour.
Zn^{2+} has fully filled d^{10} configuration $\rightarrow$ no d-d transitions $\rightarrow$ colourless/white.
(2) Mn^{3+} is a strong oxidising agent.
Mn^{3+} easily gains an electron to form stable Mn^{2+} (half-filled d^5 configuration), so it acts as a strong oxidising agent.
(3) Transition metals and their compounds act as good catalysts.
Because they show variable oxidation states and can adsorb reactants on their surface, increasing reaction rate.
(ii) Lanthanoid contraction & one consequence
Lanthanoid contraction:
Gradual decrease in atomic/ionic radii of lanthanoids (La $\rightarrow$ Lu) due to poor shielding of 4 f electrons.
One consequence:
Zr and Hf have almost identical sizes and similar chemical properties, making their separation difficult.

198. The reaction $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$ constitutes a galvanic cell where zinc is oxidized at the anode and silver is reduced at the cathode, with the cell depicted as $Zn(s)|Zn^{2+}(aq)||Ag^+(aq)|Ag(s)$. The Zinc electrode (anode) is negative, with electrons flowing externally to the Silver electrode.

(A) (i) Galvanic Cell Representation & Characteristics
• Cell Representation: $Zn(s)|Zn^{2+}(aq)||Ag^+(aq)|Ag(s)$.
• Negatively Charged Electrode: The Zinc (Zn) electrode, acting as the anode, is negatively charged.
• Carriers of Current: In the external circuit, electrons are the carriers (flowing from Zn to Ag), while inside the cell, ions (Zn^{2+}, Ag^+, and salt bridge ions) carry the current.
(ii) Fuel Cell Definition and Fuels
• Definition: A fuel cell is a type of galvanic cell designed to continuously convert the chemical energy of a fuel (like H_2, CH_4, CH_3OH) and an oxidant (like O_2) directly into electrical energy through redox reactions.
• Two Fuels: Hydrogen (H_2) and Methane (CH_4).

OR

(B) (i) Definitions
(1) Kohlrausch Law: At infinite dilution, each ion contributes a definite value to the total molar conductivity of an electrolyte, irrespective of the nature of the other ion with which it is associated.
(2) Faraday's First Law of Electrolysis: The mass (m) of a substance deposited or liberated at an electrode during electrolysis is directly proportional to the quantity of electricity (Q) passing through the electrolyte ($m = zQ$ or $m = zIt$
(ii) Definitions and Examples
(1) Corrosion: The slow destruction or deterioration of materials (usually metals) by chemical or electrochemical reaction with their environment (e.g., rusting of iron).
(2) Primary Batteries: Cells that cannot be recharged and used again because their electrochemical reactions are not reversible (e.g., Dry Cell / Leclanché cell).
(3) Secondary Batteries: Cells that can be recharged and used multiple times because their electrochemical reactions are reversible (e.g., Lead-acid storage battery).