Section A

1. **(a)** HI > HBr > HCl > HF

Explanation:

As we move down the group 17, the size of atom increases as F<Cl<Br<I. Thus the bond strength of hydrogen halides reduces as HF>HCl>HBr>HI. So, it is easiest to break the H-I bond. Hence, the decreasing order of reactivity for the conversion of ROH to RX is HI>HBr>HCl>HF.

2. **(b)** Nucleotides

Explanation:

When nucleoside is linked to phosphoric acid at 5′-position of sugar moiety, we get a nucleotide and nucleotides are joined by a phosphodiester bond between 5′ and 3′ carbon atoms of the pentose sugar.

3. **(d)** a substitution reaction

Explanation:

Alkyl halides on alkaline hydrolysis (aqueous NaOH) get converted into alcohol. This takes place by a nucleophilic substitution reaction where the −X atom is substituted by a nucleophile i.e −OH group. The primary alkyl halides undergo nucleophilic substitution reaction by S_N2 substitution mechanism, while tertiary alkyl halides follow S_N1 substitution mechanism.

4. **(d)** Iodoform test

Explanation:

Iodoform test

5. **(c)** zero order reaction

Explanation:

Therefore, for a zero order reaction the units of rate of reaction and rate constants are same.

6. **(d)** (a) - (iv), (b) - (iii), (c) - (ii), (d) - (i)

Explanation:

(a) - (iv), (b) - (iii), (c) - (ii), (d) - (i)

7. **(c)** S_N1 reaction

Explanation:

Racemisation occurs in S_N1 reaction not in S_N2 reaction because in case of S_N1 a group (base/nucleophile) attack from (in front and back side) both sides.

8. **(b)** $CuCl_2$

Explanation:

$CuCl_2$ is used as a catalyst in Deacon's Process.

9.

(b) $\frac{R}{2k}$

Explanation:

$\frac{R}{2k}$ where [R]° is initial concentration of reactant and k is rate constant).

10.

(c) Prop-1-en-2-ol, tautomerism

Explanation:

$$CH_3 - C \equiv CH \xrightarrow[1\%HgSO_4]{40\%H_2SO_4} \underset{\substack{\text{Prop-1-en-2-ol}\\(A)}}{CH_3 - \underset{OH}{\overset{|}{C}} = CH_2} \xrightarrow{Isomerisation} \underset{Acetone}{CH_3 - \underset{O}{\overset{||}{C}} - CH_3}$$

Prop-1-en-2-ol (A) acetone are tautomers.

11. **(a)** Williamson's synthesis

Explanation:

Williamson's synthesis: When an alkyl halide reacts with sodium alkoxide, ether is formed. This reaction is known as Williamson's synthesis. The reaction generally follows the S_N2 mechanism for primary alcohols.

$$\underset{Williamson's\ synthesis}{R - X + R' - \ddot{\underset{..}{O}}\overset{+}{N}a} \rightarrow R - \ddot{\underset{..}{O}} - R' + Na\ X$$

12.

(b) III > II > I

Explanation:

III > II > I

13.

(c) A is true but R is false.

Explanation:

A is true but R is false.

14.

(c) A is true but R is false.

Explanation:

Aldehydes which contain α-hydrogens undergo aldol condensation.

15. **(a)** Both A and R are true and R is the correct explanation of A.

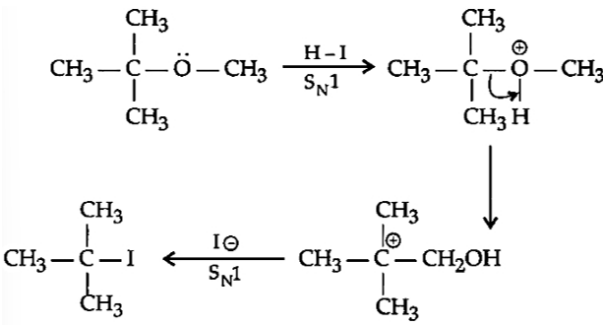
Explanation:

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

16. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation:

$(CH_3)_3C\text{-}O\text{-}CH_3$ gives $(CH_3)_3C\text{-}I$ and CH_3OH on treatment with HI. The reaction occurs by S_N1 mechanism.



Section B

17. π = CRT

4.98 = (30/180/1) × RT

4.98= 0.166 RT …(i)

1.52 = CRT …(ii)

Divide eq. (ii) by (i)

0.305 = C/0.166

C = 0.0506 mol l^{-1}

Hence, its concentration would be 0.0506 mol l^{-1}

OR

i. Ideal solutions follow Raoult's law exactly over the entire range of concentration. So $P_A = P^0_A.x_A$ and $P_B = P^0_B.x_B$

ii. They can be separated by fractional distillation.

18. i. The hybridization and magnetic character of $[Fe(H_2O)_6]^{2+}$ are sp^3d^2 and paramagnetic.

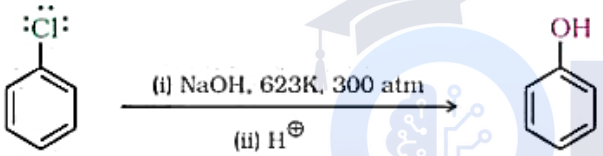
ii. The hybridization and magnetic character of $[Ni(CN)_4]^{2-}$ are dsp^2 and diamagnetic

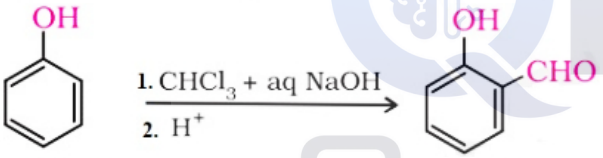
19. Sc does not exhibit variable oxidation states because it contains only 3 electrons in its valence shell ($3d^14s^2$ configuration) and after losing them, it achieves inert gas configuration, i.e, highest stability.

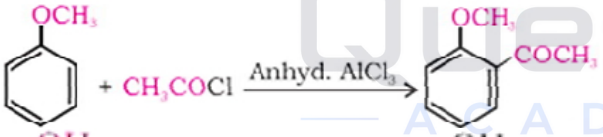
20. Answer the following:

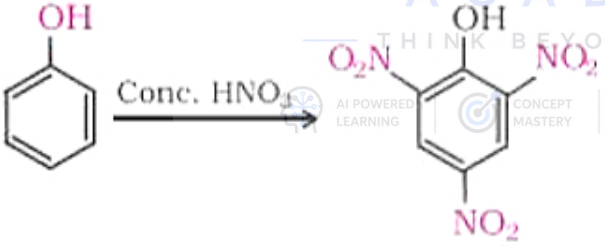
(i) Slope = -k

(ii) Rate = k $[NO]^2$ $[H_2]^1$

21. a. 

b. 

c. 

d. 

Section C

22. Kohlrausch's law of independent migration of ions states that the limiting molar conductivity of an electrolyte can be expressed as the sum of the individual contributions of the anion and the cation of the electrolyte, e.g.

$\Lambda^\circ_{m(CH_3COOH)} = \lambda^\circ_{CH_3COO^-} + \lambda^\circ_{H^+}$

The conductivity of a solution is related to the number of ions present per unit volume of the solution. When the solution is diluted, the number of ions per unit volume decreases. Hence, conductivity or specific conductance of the solution decreases.

23. Since, the reaction is of first order wrt A and second order wrt B, then the rate law can be given as,

$(Rate)_1 = k [A] [B]^2$

i. When the concentration of B is increased to three times (3B), the rate would be

$(Rate)_2 = k [A] [3B]^2$

$(Rate)_2 = 9\ k [A] [B]^2 = 9 \times (Rate\}$,

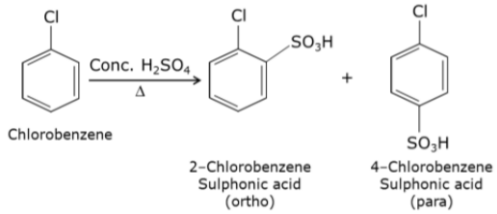
∴ Rate is increased by 9 times.

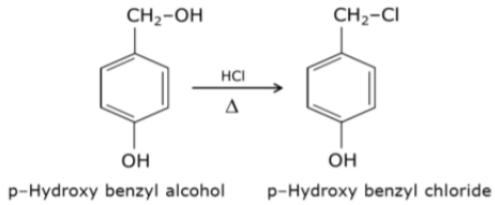
ii. $(Rate)_3 = k\,[2A]\,[2B]^2$

$(Rate)_3 = 2 \times 2 \times 2 \times k\,[A]\,[B]^2 = 8 \times (Rate)$

$\therefore$ Rate is increased by 8 times

24. The major project are:

i. 

ii. 

iii. $\underset{Tert.\ Bu\tan ol}{(CH_3)_3C-OH} \xrightarrow[573K]{Cu} \underset{2-Methylpropene}{CH_3-\overset{CH_3}{\overset{|}{C}}=CH_2}$

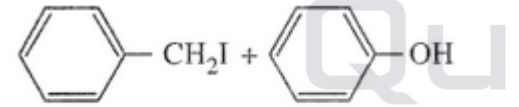
OR

i. $CH_3-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_2OH + CH_3CH_2I$

$2-$Methylbutane$-1-ol$

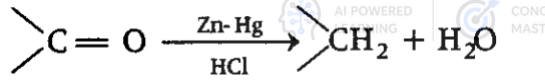
ii. $CH_3CH_2CH_2OH + CH_3CH_2-\underset{CH_3}{\overset{CH_3}{\overset{|}{\underset{|}{C}}}}-I$

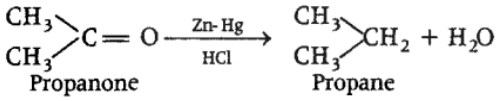
$2-Iodo-2-$methylbutane

iii. 

Benzyl iodide

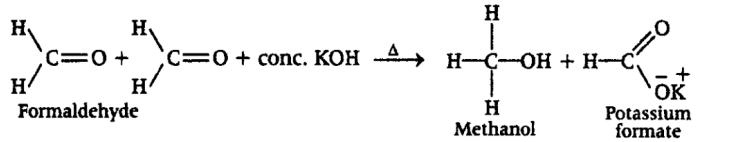
25. i. **Clemmensen reduction** The carbonyl group of aldehydes and ketones is reduced to - CH_2 group on treatment with zinc-amalgam and concentrated hydrochloric acid. This reaction is known as Clemmensen reduction.

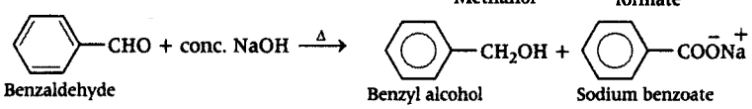


e.g. 

Propanone Propane

ii. **Cannizzaro reaction** Aldehydes which do not have n-H atoms undergo self oxidation and reduction reaction on treatment with cone. alkali this reaction is known as Cannizzaro reaction. In this reaction, one molecule of aldehyde is reduced to alcohol while another molecule is oxidised to the salt of carboxylic acid.





26. We have,

$Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$

For the reaction n = 2, E^θ_{cell} = 1.05 V

$\Delta G^\theta = -nFE^\theta$

$\Delta G^\theta = -2 \times 96500\,C \times 1.05\,V$

$\Delta G^{\theta} = -202.65\, kJ\, mol^{-1}$

For Equilibrium constant, we have,

$\Delta G^{\theta} = -2.303\, RT \log\, K_c$

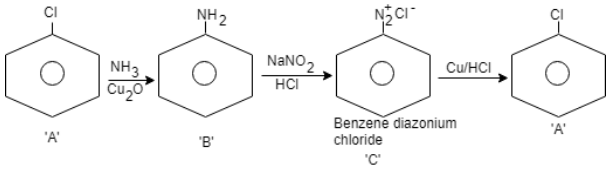
$\log K_c = -\frac{\Delta G^{\Theta}}{2.303RT}$

$= -\frac{202650}{2.303 \times 8.314 \times 298}$

$K_c =$ Antilog(35.5161)

$K_c = 3.284 \times 10^{35}$

27. $A \xrightarrow[Cu_2O]{NH_3} B \xrightarrow[0-5^{\circ}C]{NaNo_2 \atop HCl} C \xrightarrow{Cu/HCl} A$



28. $E_{cell} = E^0_{\text{cell}} - \frac{0.059}{6} \log \frac{\left[Cr^{3+}\right]^2}{\left[Fe^{2+}\right]^3}$

$E^0_{\text{cell}} = -0.45 - (-0.75)$

= 0.30 V

$E_{\text{cell}} = 0.3 - \frac{0.059}{6} \log \frac{(0-1)^2}{(0.01)^3}$

$= 0 \cdot 3 - .00985 \log \frac{\left(10^{-1}\right)^2}{\left(10^{-2}\right)^3}$

= 0.3 - .00985 × 4 log10

= 0.3 - 0.0394

= 0.2606 V

Section D

29. i. It is because neither they nor their ions have incompletely filled d-orbitals.

ii. Scandium (Sc) and Zinc (Zn).

iii. It is because they show variable oxidation state, can form intermediate complexes and have large surface area for adsorption of gases.

OR

It is due to strong interatomic forces of attraction due to presence of unpaired electrons.

30. i. A plant cell gets shrink when it is kept in a hypertonic solution.

ii. 1.2% sodium chloride solution is hypertonic with respect to 0.9% sodium chloride solution or blood cells. When blood cells are placed in this solution, water flows out of the cells and they shrink due to loss of water by osmosis.

iii. When the external pressure applied becomes more than the osmotic pressure of the solution, then the solvent molecules from the solution pass through the semipermeable membrane to the solvent side. This process is called reverse osmosis.

OR

In an upward direction, osmosis helps in the transportation of water in a plant.

Section E

31. Attempt any five of the following:

(i) Glycosidic linkage

(ii) Fibrous Proteins

(iii) The component of starch which is water-soluble - Amylose.

(iv) i. **Peptide linkage:** A linkage formed when two amino acids are joined through -CONH- bond.
Glycosidic linkage: When two monosaccharides are joined through oxygen atom.

ii. **Nucleoside:** Base + Sugar
Nucleotide: Base + Sugar + Phosphate

(v) a. When a protein in its native form, is subjected to physical change like change in pH, temperature etc it loses its biological activity. (Or destruction of secondary and tertiary structure.)

b. Hydrolysis of sucrose brings about a change in the sign of rotation, from dextro (+) to laevo (−) and the product is named an invert sugar.

(vi) i. A linkage between two monosaccharide units through oxygen atom.
ii. Protein having a unique three-dimensional structure and biological activity.

(vii) i. Glycogen
liver/muscles/brain
ii. Starch is a polymer of α-Glucose whereas Cellulose is a polymer of β-Glucose.

32. **Coordination** entity: This entity usually constitutes a central metal atom or ion, to which are attached a fixed number of other atoms or ions or groups by coordinate bonds. Examples are $[Ni(CO)_4]$, $[COCl_3(NH_3)_3]$, etc.

Ligands: It is an ion having at least one lone pair of electrons and capable of forming a coordinate bond with central atom / ion in the coordination entity.

Examples are : Cl^-, $(OH)^-$, $(CN)^-$etc.

Coordinate number: The total number of coordinate bonds with which central atom/ ion is linked to ligands in the coordination entity is called coordination number of central atom / ion.

Coordination polyhedron : The spatial arrangement of the ligands which are directly attached to the central atom / ion defines a coordination polyhedron about the central atom.

Examples are: $[Co(NH_3)_6]^{3+}$is octahedral,

$[Ni(CO)_4]$is tetrahedral.

Homoleptic and hedroleptic: Complexes in which a metal is bound to only one kind of donor groups are known as homoleptic.

Example $[CO(NH_3)_6]^{3+}$

Complex in which a metal is bound to more than one kind of donor groups are called hetroleptic. Example : $[Co(NH_3)_4Cl_2]^+$

OR

$CoSO_4Cl.5NH_3$:

i. Isomer A reacts with $AgNO_3$ but not with $BaCl_2$, it shows that it has Cl ion outside the coordination sphere. Hence, A = $[CO(NH_3)_5SO_4]CI$

Isomer B reacts with $BaCl_2$ but not with $AgNO_3$, it shows that it has SO_4^- outside the coordination sphere

Hence, B = $[CO(NH_3)_5Cl]SO_4$

ii. Type of isomerism - Ionization isomerism.

iii. IUPAC name of, A = Pentaamminesulphatocobalt (III) chloride and B = Pentaamminesulphatocobalt (III) sulphate.

33. i. a. Nitration is carried out in acidic medium. In an acidic medium, aniline is protonated to form the anilinium ion which is meta directing. That is why besides the ortho and para derivatives, a substantial amount of meta derivative (m-nitroaniline) is also formed.

b. $(CH_3)_2NH$ is a secondary amine and $(CH_3)_3N$ is a tertiary amine. Tertiary amine due to the presence of three alkyl groups is more hindered than secondary amine which has only two alkyl groups attached to it. Therefore formation of ammonium ion is easier in secondary amine than the tertiary amine. Therefore, it makes secondary amine less basic than the tertiary amine.

c. The ammonolysis of alkyl halide leads to the formation of the mixture of primary, secondary and tertiary amine along with the formation of quaternary salt. It is very difficult to separate pure primary amine from this mixture.

ii. a.

Test	**$CH_3CH_2NH_2$**	**$(CH_3CH_2)_2NH$**
Carbylamine test (add chloroform and alcoholic KOH to both the compounds separately in a test tube)	Forms a foul-smelling compound (gives positive test)	No reaction take place (gives negative test)

b.

Azo dye Test	**Aniline**	**Methyl Amine (CH_3NH_2)**
Add a small amount of nitrous acid with aq. HCl	Forms a yellow coloured dye (gives positive test)	No dye is formed(gives negative test)

OR

i. These can be distinguished by the carbylamine test.

$$\underset{\substack{Methyla\min e\\(1^0\ A\min e)}}{CH_3NH_2} + CHCl_3 + 3KOH \xrightarrow[(alc)]{\Delta} \underset{\substack{Methylisocyanide\\(offensive\ smell)}}{CH_3NC} + 3KCl + 3H_2O$$

$$\underset{\substack{Dimethylamine\\(2^0)\ amine)}}{CH_3NH} \xrightarrow{CHCl_3/KOH(alc)} No\ reaction$$

ii. Secondary and tertiary amines can be distinguished by Libermann nitrosoamine test. 2° amines react with nitrous acid to form N-nitrosamines while 3° do not.

$$\underset{Diethylamine}{(CH_3CH_2)_2}NH + HO - N = 0 \rightarrow \underset{\substack{N-Nitrosodiethylamine\\(Yellow\ colour)}}{(CH_3CH_2)_2N - N = O} + H_2O$$

iii. **Azo dye test:** Aniline and ethylamine can be distinguished by azo dye test. It involves the reaction of aniline with HNO_2 at 273-278 K followed by treatment with an alkaline solution of β-naphthol, which gives a brilliant yellow, orange or red coloured dye. Ethylamine under these condition gives a brisk evolution of N_2 gas with the formation of primary alcohol.

iv. **Nitrous acid test:** Benzylamine reacts with nitrous acid to form a diazonium salt which being unstable even at low temperature, decomposes with evolution of N_2 gas.

Aniline, on the other hand, reacts with nitrous acid to form benzene diazonium chloride which is stable at 273 - 278 K and hence does not decompose to evolve N_2 gas.

v. **Carbylamine test:** Aniline being a primary amine gives carbylamine test whereas N-methylamine being a secondary amine does not give this test. when aniline is heated with an alcoholic solution of KOH and $CHCl_3$, it gives the offensive smell of phenyl isocyanide.