ISC 2026 EXAMINATION
Sample Question Paper - 1
Chemistry

Time Allowed: 3 hours and 15 minutes **Maximum Marks: 70**

General Instructions:

1. You are allowed additional 15 minutes for only reading the question paper.
2. You must NOT start writing during the reading time.
3. This question paper has 11 printed pages.
4. It is divided into four sections and has 21 questions in all.
5. All questions are compulsory. Answer all questions.
6. Section A has fourteen subparts. Each question carries 1 mark.
7. While attempting Multiple Choice Questions in Section A, you are required to write only ONE option as the answer.
8. Section B has ten questions. Each question carries 2 marks.
9. Section C has seven questions. Each question carries 3 marks.
10. Section D has three questions. Each question carries 5 marks.
11. Internal choices have been provided in one question each in Sections B, C and D.
12. The intended marks for questions are given in brackets [ ].
13. All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.
14. Balanced equations must be given wherever possible and diagrams where they are helpful.
15. When solving numerical problems, all essential workings must be shown.

Section A

1. **Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:** **[4]**

(a) Fill in the blanks by choosing the appropriate word! words from those given in the brackets: **[4]**

(Cannizzaro, aldol condensation, Cannizzaro, Rosenmund, benzoin, absence, presence, α-hydrogen, no α-hydrogen, $SOCl_2$, benzoic acid, benzoic acid, potassium cyanide, potassium hydroxide, PCl_5, aldol, benzal chloride, formaldehyde, lactic acid, acetaldehyde cyanohydrins, acetone, tartaric acid)

i. Acetaldehyde in the presence of dilute alkali gives _____ and the reaction is called _____.

ii. Benzaldehyde undergoes . reaction on treabnent with concentrated sodium hydroxide because it has _____ atom.

iii. Benzaldehyde when treated with an alcoholic solution of _____ forms _____.

iv. When benzaldehyde reacts with _____ it forms _____ and $POCl_3$.

v. Acetaldehdye reacts with HCN to give _____ which on hydrolysis gives _____.

vi. Benzaldehyde undergoes reaction due to _____ of α-hydrogen atom.

2. **Select and write the correct alternative from the choices given below.** **[7]**

(a) Correct the following statement and rewrite: **[1]**
Osmotic pressure and boiling point are colligative properties.

(b) Correct the following statement and rewrite: **[1]**
Addition of sodium chloride lowers the boiling point and freezing point of water.

(c) Correct the following statement and rewrite: **[1]**
Correct the following statement by changing the underlined part of the sentence.
Water boils <u>below 100°C</u> by the addition of NaCl.

(d) Correct the following statement and rewrite: **[1]**
Freezing point of a solution is directly proportional to its molality.

(e) Correct the following statement and rewrite: **[1]**
Chloroacetic acid is more acidic than acetic acid because of the -M effect.

(f) **Assertion (A):** Adding water to two beakers 'A' and 'B' containing NaOH and CH_3COOH solutions respectively will increase the molar conductance (Λ_m) of the solutions sharply in beaker 'A' and slowly in beaker 'B'. **[1]**
Reason (R): Molar conductance (Λ_m) increases with a decrease in concentration or upon dilution.

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

(g) **Assertion (A):** Specific conductance of all electrolytes decreases on dilution. **[1]**
Reason (R): On dilution, number of ions per unit volume decreases.

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

3. Show that the time required for the completion of 75% of a reaction of first order is twice the time required for the completion of 50% of the reaction. **[3]**

Section B

4. With the help of a diagram, explain the physical significance of energy of activation (E_a) in chemical reactions. **[2]**

5. The rate of reaction becomes four times when the temperature changes from 293K to 313 K. Calculate the energy of activation (E_a) of the reaction assuming that it does not change with temperature. **[2]**
($R = 8.314\ JK^{-1}\ mol^{-1}$) is

6. Calculate the mass of ascorbic acid (molecular mass =176 g/mol) that should be dissolved in 155 g of acetic acid to cause a depression of freeing point by 1.15 K. Assume that ascorbic acid does not dissociate or associate in the solution. **[2]**
[K_f for acetic acid = 3.9Kkg/mol]

7. A certain aqueous solution boils at 100.303°C. What is its freezing point? K_b for water = 0.5 K kg **[2]**

mol^{-1} and K_f = 1.87 K kg mol^{-1}.

8. A 10% aqueous solution of cane sugar (mol. wt. 342) is isotonic with 1.754% aqueous solution of urea. Find the molecular mass of urea. **[2]**

9. Write the IUPAC names of the following coordination compounds. **[2]**

   i. $[Cr(NH_3)_4(H_2O)_2]Cl_3$

   ii. $[PtCl_2(NH_3)_4][PtCl_4]$

10. For the coordination complex ion $[Co(NH_3)_6]^{3+}$ **[2]**

    i. Give the IUPAC name of the complexion.

    ii. What is the oxidation number of cobalt in the complex ion?

    iii. State the type of hybridisation of the complex ion.

    iv. State the magnetic behaviour of the complex ion.

11. Explain the following. **[2]**

    i. Why do transition metal ions possess a great tendency to form complexes?

    ii. The paramagnetic character in 3d-transition series elements increases upto Mn and then decreases.

    OR

    Account for each of the following.

    i. Zirconium (Zr) and Hafuium (Hf) are difficult to separate.

    ii. Salts of cupric (Cu^{2+})ion are coloured whereas salts of cuprous (Cu^{+}) ion are colourless.

12. Give balanced equation and explain what happens when phenol is treated with bromine water? **[2]**

13. Identify the compounds A, B, C and D. **[2]**

$$C_6H_5COOH \xrightarrow{SOCl_2} [A] \xrightarrow{NH_3} [B] \xrightarrow{Br_2/KOH} [C] \xrightarrow[0-5^oC]{NaNO_2+HCl} [D]$$

Section C

14. Identify the compounds A, Band C. **[3]**

    i. $C_2H_5OH \xrightarrow{PCl_5} [A] \xrightarrow{KCN} [B] \xrightarrow{H_3O^+} C_2H_5COOH \xrightarrow[\Delta]{NH_3} [C]$

    ii. $C_6H_5COOH \xrightarrow{SOCl_2} [A] \xrightarrow{NH_3} [B] \xrightarrow{Br_2/KOH} [C]$

15. Rearrange the compounds of each of the following sets in order of reactivity towards S_N2 displacement. **[3]**

    i. 2-bromo-2-methylbutane, 1-bromopentane, 2-bromopentane.

    ii. 1-bromo-3-methylbutane, 2-bromo-2-methylbutane, 3-bromo-2-methylbutane.

    iii. 1-bromobutane, 1-bromo-2, 2-dimethylpropane, 1-bromo-2-methylbutane, 1-bromo-3-methylbutane.

16. i. $[Fe(CN)_6]^4$ is a coordination complex ion: **[3]**

    a. Is the complex ion diamagnetic or paramagnetic?

    b. What is the hybridisation state of the central metal atom?

    ii. Name the type of isomerism shown by the following pair of coordination compounds: $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4]$

    [3]

17. A conductivity cell has a cell constant of $0.5\ cm^{-1}$. This cell when filled with 0.01 M sodium chloride solution has a resistance of 384Ω at $25^{\circ}C$. Calculate the equivalent conductivity of 0.01 M sodium chloride at $25^{\circ}C$.

OR

0.05 M NaOH solution offered a resistance of 31.6Ω in a conductivity cell at 298 K . If the cell constant of the cell is $0.367\ cm^{-1}$, calculate the molar conductivity of the NaOH solution.

18. Define the following terms: **[3]**

i. Glycosidic linkage

ii. Invert sugar

iii. Oligosaccharides

19. i. Mention any two factors that influence the rate of a chemical reaction. **[3]**

ii. In a first order reaction, 20% of a reaction is consumed in 30 minutes. Calculate the following:

a. The half-life period of the reaction.

b. The time required for completing 93.75% of the reaction.

20. i. Define molecularity of a reaction. Give one difference between the order of reaction and its molecularity. **[3]**

ii. The rate constant (k) of a first order reaction is $4.5 \times 10^{-2}\ s^{-1}$. What will be the time required for the initial concentration of 0.4 M of the reactant to be reduced to 0.2 M?

Section D

21. An organic compound [A]having molecular formula C_2H_7N when treated with nitrous acid gives a compound [B] which has molecular formula C_2H_6O. **[5]**

[B) on treating with an organic compound [C) gives a carboxylic acid [D] and a sweet-smelling compound [E]. D is also obtained by oxidation of [B] with acidified potassium dichromate.

i. Identify [A], [B], [C), [D] and [E].

ii. Write a balanced chemical equation of [D] with chlorine in the presence of red phosphorus and name the reaction.

22. i. Write the formula of reagents used in the following reactions: **[5]**

a. Bromination of phenol to 2,4,6-trlbromophenol

b. Hydroboration of propene and then oxidation to propanol.

ii. Arrange the following compound groups in the increasing order of their property indicated:

a. p-nitrophenol, ethanol, phenol (acidic character)

b. Propanol, Propane, Propanal (boiling point)

iii. Write the mechanism (using curved arrow notation) of the following reaction:

$$2CH_3 - CH_2 - OH \xrightarrow{H^+} CH_3 - CH_2 - \overset{+}{\underset{|}{O}}\underset{H}{} - CH_2 - CH_3 + H_2O$$

23. The following results were obtained for the decomposition of nitrogen peroxide in an inert solvent: **[5]**

t(c)	0	300	600	900	∞
Vol. of O_2 evolved (cm^3)	0	3.42	6.30	8.95	34.75

Show that the reaction is of first order and also calculate the rate constant.

OR

Consider the reaction, $A + B \longrightarrow C + D$

The initial rates for different initial concentrations of the reactants are given below.

Initial concentration (mol/L)			**Initial rate**
	[A]	**[B]**	**(mol/L-s)**
(a)	1.0	1.0	2.0×10^{-3}
(b)	2.0	1.0	4.0×10^{-3}
(c)	4.0	1.0	8.0×10^{-3}
(d)	1.0	2.0	2.0×10^{-3}
(e)	1.0	4.0	2.0×10^{-3}

i. What are the order of reaction with respect to A and B?

ii. What is the overall order?

iii. Write the rate law equation.

iv. Calculate the rate constant.

v. Suggest a possible mechanism.

Solution

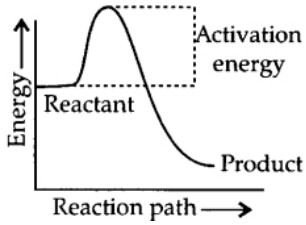
Section A

1. Fill in the blanks by choosing the appropriate word(s) from those given in the brackets:
   (a) i. aldol, aldol condensation
   ii. Cannizzaro, no α-hydrogen
   iii. potassium cyanide, benzoin
   iv. PCl_5, benzal chloride
   v. Acetaldehyde cyanohydrin, lactic acid
   vi. Cannizzaro, absence
2. Select and write the correct alternative from the choices given below.
   (a) Osmotic pressure and elevation in boiling point are colligative properties.
   (b) Addition of sodium chloride increases the boiling point and decreases the freezing point of water.
   (c) Water boils **above 100°C** by the addition of NaCl. It is because, NaCl is a strong electrolyte and it dissociates into 2 ions, therefore its van't Hoff value, i is 2 and the elevation of boiling point ΔT_b proportional to i.
   (d) Depression in freezing point of a solvent is directly proportional to its molality.
   i.e. $\Delta T_f \propto m$
   (e) The correct statement is chloroacetic acid is more acidic than acetic acid because of the -I effect of Cl group.
   (f) **(a)** Both A and R are true and R is the correct explanation of A.
   Explanation:
   When NaOH is added to acetic acid, there is firstly a gradual increase in the conductance and then there is a rapid increase in the conductance. This is because firstly the more hydrated protons are replaced by sodium ions and then after neutralisation of acetic acid.
   Sodium ions and hydroxide ions are added to the solution.
   (g) **(a)** Both A and R are true and R is the correct explanation of A.
   Explanation:
   Specific conductance always decreases with the decrease in concentration both for weak and strong electrolytes.
3. For 75% completion, suppose $[A]_0$ = 100, then [A] = 100 - 75 = 25
   k = $\frac{2.303}{t}\log\frac{100}{25}$
   = $\frac{1.386}{t}$ [As, log 4 = 2 log 2 = 2 $\times$ 0.3010]
   For 50% completion, k = $\frac{0.693}{t_{\frac{1}{2}}}$
   But, for a given reaction, k is constant
   $\therefore \frac{1.386}{t} = \frac{0.693}{t_{\frac{1}{2}}}$
   $\Rightarrow \frac{t}{t_{\frac{1}{2}}} = \frac{1.386}{0.693}$ = 2
   or t = $2t_{\frac{1}{2}}$
   So, time (t) required for completion of 75% of a reaction is twice the time required for completion of 50% (half-life) of the reaction.

Section B

4. The excess energy which must be supplied to the reactants to undergo chemical reactions is called activation energy E_a. It is equal to the difference between the threshold energy E_p, needed for the reaction and the average of all the reacting molecules, E_R.

Activation energy = Threshold energy - Average kinetic energy of the reacting molecule



5. Given, T_1 = 293 K, k_1 = k (Suppose)

   when T_2 = 313 K, k_2 = 4k

   Substituting these values in the equation,

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

   $\log \frac{4k}{k} = \frac{E_a}{2.303 \times 8.314 \text{JK}^{-1}\text{ mol}^{-1}} \times \left(\frac{313\text{ K} - 293\text{ K}}{313\text{ K} \times 293\text{ K}}\right)$

   $\log 4 = \frac{E_a}{2.303 \times 8.314} \times \frac{20}{313 \times 293}$

   $\therefore E_a = \frac{0.6021 \times 2.303 \times 8.314 \times 313 \times 293}{20}$ J mol^{-1}

   E_a = 52.86 kJ mol^{-1}

6. W_1, Mass of acetic acid = 155 g

   M_2, Molecular mass of (C_6HgO_6) = 176 g/mol

   Depression of freezing point = 1.15 K

   We know,

   $\Delta T_f = \frac{K_f \times 1000 \times w_2}{M_2 \times W_1}$

   $1.15 = \frac{39 \times 1000 \times w_2}{176 \times 155}$

   $w_2 = \frac{176 \times 155 \times 1.15}{3.9 \times 1000} = 8.04\ g$

7. Boiling point of pure water = 100^{o}C

   Boiling point of aqueous solution = 100.303^{o}C

   ΔT = 100.303 - 100 = 0.303^{o}C

   $\Delta T = m \times K_b$

   $0.303 = m \times 0.5$

   m = 0.606

   $\Delta T = m \times K_f$

   $= 0.606 \times 1.87$

   $= 1.133^\circ C$

   Therefore, the freezing point of aqueous solution

   = 0^{o}C - 1.133^{o}C = -1.13^{o}C

8. Number of moles of cane sugar = $\frac{10}{342}$ = 0.0292

   Number of moles of urea = $\frac{1.754}{x}$

   $\pi_{\text{cane sugar}} = \pi_{\text{urea}}$ (isotonic solution)

   $n_1 \frac{RT}{V} = n_2 \frac{RT}{V}, 0.0292 = \frac{1.754}{x}$

   x = 60.07

9. IUPAC name

   i. $[Cr(NH_3)_4(H_2O)_2]\ Cl_3$

   Tetraamminediaquachromium (III) chloride

   ii. $[PtCl_2(NH_3)_4][PtCl_4]$

   Tetraamminedichloroplatinum (IV) tetrachloroplatinate (II)

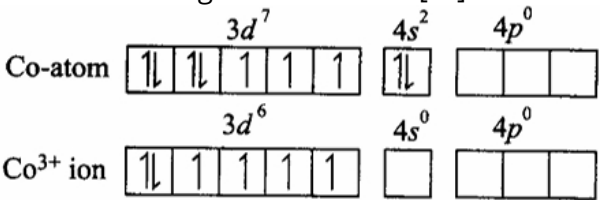
10. i. Hexaamminecobalt (III) ion.

ii. Let the oxidation number of Co in the complex $[Co(NH_3)_6]^{3+}$ be x.

$x + 6 \times (0) = +3$

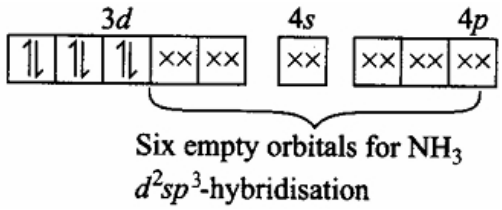
$x = +3$

iii. Electronic configuration of Co is $[Ar]3d^7\ 4s^2$.



NH_3 is a strong field ligand, it causes pairing of $3d^6$ electrons.

Thus, $[Co(NH_3)_6]^{3+}$ =



Thus, hybridisation of $[Co(NH_3)_6]^{3+}$ is d^2sp^3.

iv. As all electrons are paired so, it is diamagnetic.

11. i. Due to small size of transition metal atoms or their cations and high effective nuclear charge, they have a high positive charge density on them. This high positive charged density makes the atoms or cation to attract the lone pair of electrons from the ligand and transition metal cation or atoms have vacant d-orbital in which they can accommodate the lone pair of electrons donated by ligands and thus, can form L $\rightarrow$ M coordinate bonds.

ii. Paramagnetic character increases with the increase in the number of unpaired electrons. The larger is the number of unpaired electron in central atom or ion greater is the paramagnetic character hence on moving from Sc to Mn, number of unpaired electron increases and then from Fe to Zn decreases.

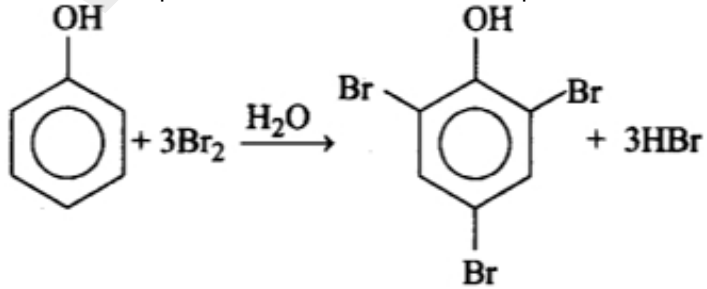
Thus, paramagnetic character also increases from Sc to Mn and then decreases from Fe to Zn.

OR

i. Due to lanthanoid contraction, there is a small difference in the size of Zr and Hf. So, there is difference in some properties of lanthanoids like solubility, degree of hydration and complex formation. These differences enable the separation of lanthanoids by ion exchange method.

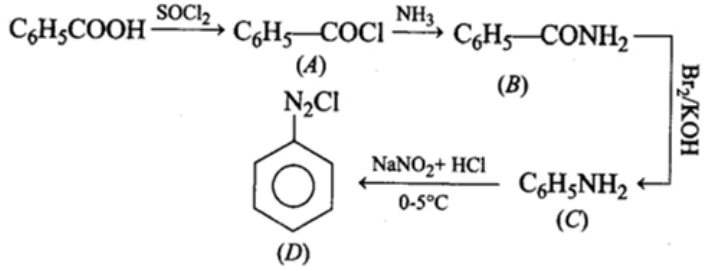
ii. Cu^{2+} ion has an electronic configuration $3d^9$ whereas Cu^+ ion has an $3d^{10}$. Hence, an unpaired electron is present in Cu^{2+} due to which d-d electronic transition takes place. The energy of excitation corresponds to the frequency of light absorbed. The colour observed corresponds to the complementary colour of the light absorbed. In contrast, due to lack of unpaired electrons Cu^+ is colourless.

12. Reaction of phenol with bromine water produces white ppt. of 2, 4, 6-tribromophenol.



2, 4, 6-tribromophenol

13.



Section C

14. i. $C_2H_5OH \xrightarrow{PCl_5} C_2H_5Cl + POCl_3 + HCl$

(A)

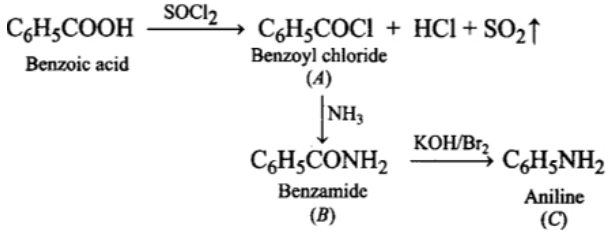
$C_2H_5Cl \xrightarrow{KCN} C_2H_5CN \xrightarrow{H_3O^+} C_2H_5COOH$

(B)

$C_2H_5COOH \xrightarrow[\Delta]{NH_3} C_2H_5COONH_4$

(C)

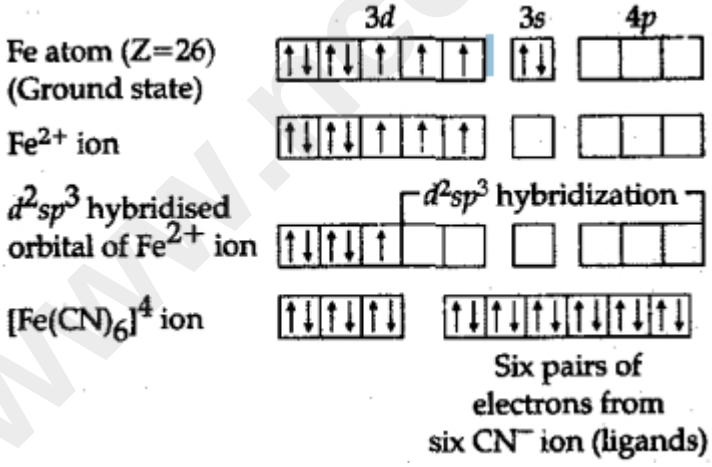
ii.



15. i. 1-bromopentane > 2-bromopentane > 2- bromo-2-methylbutane
ii. 1-bromo-3-methylbutane > 3-bromo-2-methylbutane > 2-bromo-2-methylbutane
iii. 1-bromobutane > 1-bromo-3-methylbutane > 1-bromo-2-methylbutane > 1-bromo-2, 2 dimethylpropane

16. i. a. The complex $[Fe(CN)_6]^{4-}$ is diamagnetism nature because of the absence of unpaired electrons as all electrons are paired.

b. The hybridization of Fe in the complex is d^2Sp^3



ii. The type of isomerism present in the complex $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ is ionization isomerism.

17. Given, cell constant $= 0.5\ cm^{-1}$

Concentration, C = 0.01 M, $R = 384\Omega$

Equivalent conductance,

$\Lambda_{eq} = \frac{1000}{0.01} \times \kappa = \frac{1000}{0.01} \times \frac{G^*}{R} = \frac{1000}{0.01} \times \frac{0.5}{384}$

(For NaCl, 0.01 M = 0.01 N)

$= 130.2\Omega^{-1}\ cm^2$ equiv $^{-1}$

OR

Given, concentration, C = 0.05 M,
Resistance, $R = 31.6\Omega$
Cell constant = 0.367 cm^{-1}
$\kappa = \frac{0367}{31.6}\Omega^{-1}\ cm^{-1}$
$\Lambda_m = \frac{1000}{C} \times \kappa = \frac{1000}{C} \times \frac{G^*}{R}$
$\Lambda_m = \frac{1000}{0.05} \times \frac{0.367}{31.6}$
$= 232.278\Omega^{-1}\ cm^2\ mol^{-1}$

18. i. **Glycosidic linkage:** The two monosaccharides units are joined together through an oxide linkage formed by loss of a molecule of H_2O. Such a linkage between two monosaccharide units through oxygen atom is called as glycosidic linkage.
    ii. **Invert sugar:** Hydrolysis of sucrose brings about a change in a sign of rotation from dextro (+) to laevo (-) and the product is known as invert sugar.
    iii. **Oligosaccharides:** Carbohydrates that yields two to ten monosaccharides units, on hydrolysis are called as oligosaccharides. Examples are sucrose, maltose, etc.

19. i. The two factors that affect the rate of a chemical reaction are:
    a. Concentration of reactant: Increase in the concentration of reactant increases the rate of reaction.
    b. Temperature: As the temperature increases, the rate of chemical reaction also increases.

    ii. a. According to the first order reaction
    $k = \frac{2.303}{t}\log\frac{a}{a-x}$
    t = 30 min
    Initial concentration (a) = 100
    If the reaction is 20% completed in 30 min
    Final concentration (a - x) = 100 - 20 = 80
    Putting the values in equation,
    $k = \frac{2.303}{30}\log\frac{100}{80}$
    k = 0.145s^{-1}
    Half-life, $t_{1/2} = \frac{0.693}{k}$
    $t_{1/2} = \frac{0.693}{0.145} = 4.77\ min$
    b. Initial concentration (a) = 100
    If the reaction is 93.75% completed in time t min,
    Final concentration (a - x) = 100 - 93.75 = 6.25
    $t = \frac{2.303}{0.145}\log\frac{100}{6.25}$
    = 19.12min
    Time required to complete 93.75 % is 19.12 m

20. i. Molecularity is defined as the number of reacting species undergoing simultaneous collisions in the elementary or simple reactions.

Order of a reaction	Molecularity of reaction
It is the sum of powers raised on concentration term in the rate expression.	It is the number of molecules of raectants taking part in elementary step of a reaction.

    ii. Given, $k = 4.5 \times 10^{-2}\ s^{-1}$
    Since the initial concentration is to be reduced to one half, the time required will be equal to half life period, $t_{0.5}$. For a first order reaction,
    $t_{0.5} = \frac{0.693}{k}$
    $= \frac{0.693}{4.5\times10^{-2}}$
    = 15.4 s
    Therefore, time required to reduce the initial concentration of 0.4 M to 0.2 M is 15.4 s.

Section D

21. A: $C_2H_5NH_2$ - ethylamine

B: C_2H_5OH - ethanol

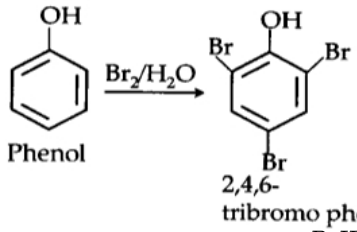
C: $CH_3COOCOCH_3$ - acetic anhydride

D: CH_3COOH - acetic acid

E: $CH_3COOC_2H_5$ - ethyl acetate

$$CH_3COOH + Cl_2 \xrightarrow[-HCl]{RedP} \underset{\text{Monochloro acetic acid}}{CH_2ClCOOH}$$

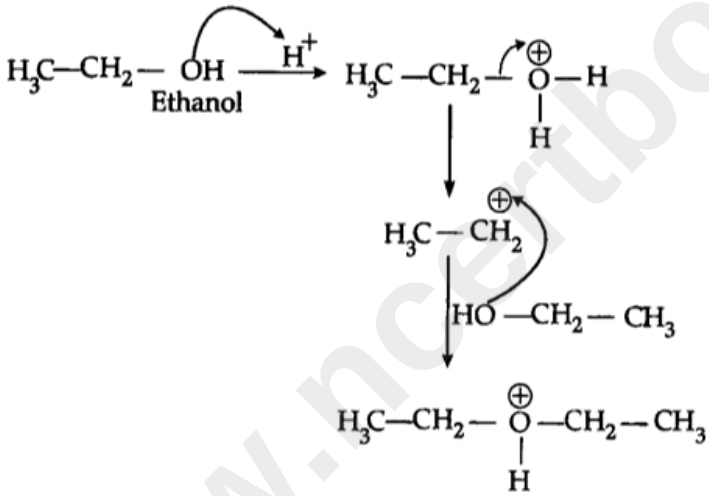
Reaction is: Hell-volhards-Zelinsky (HVZ) reaction

22. i. a. 

$$3CH_3 - CH = CH_2 \xrightarrow{B_2H_6} (CH_3 - CH_2 - CH_2)_3 - B \xrightarrow[H_2O_2/3OH]{} 3CH_3 - CH_2 - CH_2OH$$

ii. a. ethanol < phenol < p-nitrophenol

b. Propane < Propanal < propanol

iii. 

23. The reaction will be of first order, if it obeys the equation,

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

In this reaction, oxygen is liberated and collected at different times. The total volume of oxygen collected at the end of reaction (after infinite time, t = ∞) gives a measure of the total concentration of nitrogen peroxide taken initially, i.e., a. If Vt is the volume collected after time t and V_∞ is the total volume collected at the end of the reaction, then the concentration of nitrogen peroxide at any time t, i.e., (a - x) is V_∞ - V_t

Thus, the above equation becomes

$k = \frac{2.303}{t} \log \frac{V_\infty}{V_i - V_t}$

Substituting the values,

t = 300 s, V_∞ = 34.75, V_t = 3.42

$\therefore k = \frac{2.303}{300} \log \frac{34.75}{34.75-3.42}$

= 0.000345

$t = 600\ s, V_\infty = 34.75, V_t = 6.30$

$k = \frac{2.303}{600} \log \frac{34.75}{34.75-6.30} = 0.000333$

$t = 900\ s, V_\infty = 34.75, V_t = 8.95$

$k = \frac{2.303}{900} \log \frac{34.75}{34.75 - 8.95} = 0.000332$

Since the value of k is almost constant, the reaction is of first order. The average value of rate constant is 0.000336.

OR

Given reaction, A + B $\longrightarrow$ C + D

Suppose the given reaction is of order p with respect to A and q with respect to B.

The rate of formation of C and D can also be written as

$2.0 \times 10^{-3} = k[A]^p [B]^q = k(1)^p (1)^q$ ...(i)

$4.0 \times 10^{-3} = k(2)^p (1)^q$ ...(ii)

$2.0 \times 10^{-3} = k(1)^p (2)^q$ ...(iii)

From Eqs. (i) and (ii), we get

$\frac{4.0 \times 10^{-3}}{2.0 \times 10^{-3}} = \frac{k(2)^p(1)^q}{k(1)^p(1)^q} \Rightarrow (2)^1 = 2^p$

Hence, p = 1

From Eqs. (i) and (iii), we get

$\frac{2.0 \times 10^{-3}}{2.0 \times 10^{-3}} = \frac{k(1)^p(2)^q}{k(1)^p(1)^q}$

$\Rightarrow 1 = 2^q \Rightarrow 2^0 = 2^q$

Hence, q = 0

i. The order of reaction with respect to A is first order, i.e. $r \propto [A]$ and with respect to B is zero order, i.e. $r \propto [B]^0$.

ii. Overall order is one (1 + 0 = 1).

iii. Rate law equation is, $r = k[A][B]^0$ where, k is rate constant.

iv. Since, r = k[A]. Then rate constant,

$k = \frac{r}{[A]} = \frac{2 \times 10^{-3}}{1.0} = 2 \times 10^{-3}\ s^{-1}$

v. So first either A or B takes part in the reaction to generate reactive intermediate, which the attacks on other to give the product.

$A \longrightarrow A^*$

$A^* + B \longrightarrow C + D$