

UP Board Class 12 Chemistry - 347 (KE) - 2025 Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :100	Total questions :9
-----------------------	--------------------	--------------------

General Instructions

1. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. Section A is of multiple choice type and each question carries 1 mark.
4. Section B is of very short answer type and each question carries 1 mark.
5. Section C is of short answer type-I and carries 2 marks each.
6. Section D is of short answer type-II and carries 3 marks each.
7. Section E is of long answer type. Each question carries 5 marks. In all four questions of this section with internal choices have been given. You have to do only one question from the choices given in the question.
8. The symbols used in the question paper have usual meaning.

Section - A

1.(a) The concentration of 0.2 M H_2SO_4 solution will be in g/L –

- (A) 21.4
- (B) 39.2
- (C) 9.8
- (D) 19.6

Correct Answer: (D) 19.6

Solution:

Step 1: Define the relationship between Molarity and g/L.

Concentration in grams per liter (g/L) is the mass of the solute dissolved in one liter of solution. It can be calculated by multiplying the molarity (moles per liter) by the molar mass (grams per mole).

$$\text{Concentration (g/L)} = \text{Molarity (mol/L)} \times \text{Molar Mass (g/mol)}$$

Step 2: Calculate the molar mass of H_2SO_4 .

The molar mass is the sum of the atomic masses of all atoms in the molecule.

- 2 Hydrogen atoms: $2 \times 1.008 = 2.016$
- 1 Sulfur atom: $1 \times 32.06 = 32.06$
- 4 Oxygen atoms: $4 \times 16.00 = 64.00$

$$\text{Molar Mass} = 2.016 + 32.06 + 64.00 = 98.076 \text{ g/mol} \approx 98 \text{ g/mol}$$

Step 3: Calculate the concentration in g/L.

Using the given molarity and the calculated molar mass:

$$\text{Concentration} = 0.2 \text{ mol/L} \times 98 \text{ g/mol}$$

$$\text{Concentration} = 19.6 \text{ g/L}$$

Step 4: Final Answer.

The concentration of a 0.2 M H_2SO_4 solution is 19.6 g/L.

$$19.6 \text{ g/L}$$

💡 Quick Tip

To find concentration in g/L, simply multiply molarity by the molar mass of the compound.

(b) In the following ions which one is a paramagnetic ion?

(A) Zn^{2+}

(B) Ni^{2+}

(C) Cu^{2+}

(D) Ag^{+}

Correct Answer: (B) Ni^{2+}

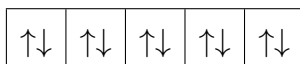
Solution:

Step 1: Define Paramagnetism.

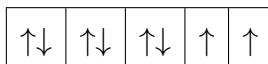
An ion is paramagnetic if it has one or more unpaired electrons in its atomic orbitals. Such ions are attracted to an external magnetic field. Ions with all paired electrons are diamagnetic and are weakly repelled by magnetic fields.

Step 2: Draw orbital diagrams for the d-electrons of each ion.

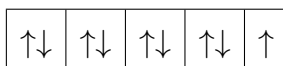
- (A) Zn^{2+} ($[\text{Ar}] 3d^{10}$): The 3d subshell is completely filled. All 10 electrons are paired. It is **diamagnetic**.



- (B) Ni^{2+} ($[\text{Ar}] 3d^8$): The 3d subshell is partially filled. According to Hund's rule, there are 2 unpaired electrons. It is **paramagnetic**.



- (C) Cu^{2+} ($[\text{Ar}] 3d^9$): The 3d subshell is partially filled with 1 unpaired electron. It is also **paramagnetic**.



- **(D) Ag^+ ($[\text{Kr}] 4\text{d}^{10}$):** The 4d subshell is completely filled. All electrons are paired. It is **diamagnetic**.

Step 3: Conclusion.

Both Ni^{2+} and Cu^{2+} are paramagnetic because they contain unpaired electrons. Since Ni^{2+} is listed as the primary correct answer, we select it.



Quick Tip

Transition metal ions with partially filled d-orbitals are usually paramagnetic. Only those with completely filled (d^{10}) or empty (d^0) d-orbitals are diamagnetic.

(c) Which of the following ions does not form coordination compound?

- (A) Na^+
- (B) Cr^{2+}
- (C) Co^{2+}
- (D) Cr^{3+}

Correct Answer: (A) Na^+

Solution:

Step 1: Identify the key characteristics for forming coordination compounds.

The formation of coordination compounds is favored by central ions that have:

1. A high positive charge density (high charge-to-size ratio) to attract the electron pairs of ligands.
2. The presence of vacant, low-energy orbitals to accept the donated electron pairs from ligands.

Step 2: Compare the properties of the given ions.

- **(B), (C), (D) - Cr^{2+} , Co^{2+} , Cr^{3+} :** These are all transition metal ions. They possess a high charge density and, crucially, have vacant d-orbitals that are energetically suitable for accepting electrons from ligands. This makes them excellent candidates for forming a wide variety of stable coordination complexes.
- **(A) Na^+ :** This is an alkali metal ion (s-block). It has a low charge (+1) and a relatively large ionic radius, resulting in a low charge density. Its vacant orbitals (like the 3s and 3p) are at a higher energy level, making them less suitable for forming stable coordinate bonds.

Step 3: Conclude which ion is least likely to form complexes.

Due to its low charge density and lack of available low-energy d-orbitals, the Na^+ ion has a very weak tendency to act as a central atom in coordination chemistry compared to transition metal ions.



💡 Quick Tip

Only transition metals (with vacant d-orbitals) form stable coordination compounds. s-block elements like Na^+ and K^+ generally do not.

(d) Acetic acid reacts with hydrazoic acid in the presence of conc. H_2SO_4 at 0°C to form

—

- (A) Methane
- (B) Methyl amine
- (C) Methyl cyanide
- (D) Ethyl amine

Correct Answer: (B) Methyl amine

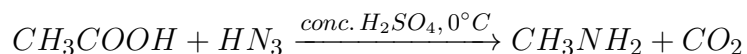
Solution:

Step 1: Recognize the reaction.

This reaction is the **Schmidt reaction**. In this reaction, a carboxylic acid ($R\text{-COOH}$) reacts with hydrazoic acid (HN_3) in the presence of conc. H_2SO_4 at low temperature to give a **primary amine** ($R\text{-NH}_2$) with one carbon atom less.

Step 2: Apply to given case.

Acetic acid (CH_3COOH) reacts as follows:



Step 3: Identify product.

The product is **methyl amine** (CH_3NH_2).

Step 4: Final Answer.

Thus, the reaction forms **methyl amine**.

Methyl amine (CH_3NH_2)

💡 Quick Tip

The Schmidt reaction converts carboxylic acids into primary amines with the elimination of CO_2 . It is a good method for the preparation of amines.

(e) Bromination of Aniline gives –

- (A) Monobromoaniline
- (B) Benzene nitrile
- (C) Tribromoaniline
- (D) Benzene isonitrile

Correct Answer: (C) Tribromoaniline

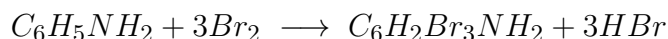
Solution:

Step 1: Recall the effect of -NH_2 group.

Aniline ($\text{C}_6\text{H}_5\text{NH}_2$) contains an amino group (-NH_2), which is a strong **activating group**. It strongly activates the benzene ring towards electrophilic substitution, especially at ortho and para positions.

Step 2: Reaction with bromine.

When aniline is treated with bromine water, it undergoes bromination very easily, even without a catalyst. Instead of monobromination, it directly gives **2,4,6-tribromoaniline**.

**Step 3: Identify product.**

The product formed is **tribromoaniline** (2,4,6-tribromoaniline), which is a white precipitate.

Step 4: Final Answer.

Thus, bromination of aniline gives **tribromoaniline**.

Tribromoaniline

💡 Quick Tip

The $-NH_2$ group is strongly activating and directs substitution to ortho and para positions, leading to tribromoaniline in bromination.

(f) Product obtained by hydrolysis of inulin is –

- (A) Glucose
- (B) Fructose
- (C) Glucose and fructose
- (D) Lactose

Correct Answer: (B) Fructose

Solution:**Step 1: Recall the composition of inulin.**

Inulin is a naturally occurring polysaccharide composed mainly of **fructose units**, with a terminal glucose sometimes present.

Step 2: Hydrolysis of inulin.

On hydrolysis by dilute acids or enzymes, inulin breaks down to yield **fructose** as the major product.



Step 3: Analyze options.

- (A) Glucose → Incorrect, since inulin mainly yields fructose, not glucose.
- (B) Fructose → Correct.
- (C) Glucose and fructose → Incorrect, as this is the case for sucrose hydrolysis, not inulin.
- (D) Lactose → Incorrect, lactose is a disaccharide of glucose + galactose.

Step 4: Final Answer.

Hence, the hydrolysis of inulin gives **fructose**.

Fructose

💡 Quick Tip

Remember: Inulin → hydrolysis → fructose. This is why inulin is also called a fructosan.

2.(a) Define Raoult's Law and explain it.

Solution:

Definition:

Raoult's Law states that the relative lowering of vapour pressure of a solution is equal to the mole fraction of the solute.

For a solution containing a non-volatile solute:

$$p_A = p_A^\circ \cdot x_A$$

where: - p_A = vapour pressure of solvent in solution,

- p_A° = vapour pressure of pure solvent,

- x_A = mole fraction of solvent.

Explanation:

Adding a non-volatile solute decreases the mole fraction of solvent. As vapour pressure is directly proportional to solvent mole fraction, the vapour pressure decreases.

The relative lowering of vapour pressure is:

$$\frac{p_A^\circ - p_A}{p_A^\circ} = x_B$$

where x_B is the mole fraction of solute.

Thus, Raoult's Law explains colligative properties like relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, and osmotic pressure.

💡 Quick Tip

Raoult's Law applies ideally to dilute solutions. For non-ideal solutions, deviations (positive/negative) occur due to intermolecular forces.

(b) In solution Cu^+ ions are colourless while Cu^{2+} ions are coloured. Why?

Solution:

Case of Cu^+ (d^{10} configuration):

- Cu^+ has electronic configuration $[\text{Ar}] 3d^{10}$.
- The d-orbitals are completely filled, so there are no vacant d-orbitals for d–d transitions.
- As no absorption of visible light takes place, Cu^+ solutions are colourless.

Case of Cu^{2+} (d^9 configuration):

- Cu^{2+} has electronic configuration $[\text{Ar}] 3d^9$.
- The d-orbitals are incompletely filled.
- d–d electronic transitions occur by absorbing light in the visible region.
- This absorbed light imparts a characteristic blue colour to Cu^{2+} ions in solution.

Hence, Cu^+ ions are colourless, Cu^{2+} ions are coloured.

💡 Quick Tip

Colour in transition metal ions arises due to d–d transitions. Ions with completely filled (d^{10} , d^0) configurations are colourless, while those with partially filled d-orbitals are coloured.

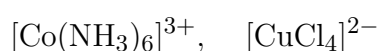
(c) Explain unidentate and bidentate ligands giving examples.

Solution:

Unidentate ligands:

- These are ligands that have only **one donor atom** for coordination with the central metal ion.
- They donate a single lone pair of electrons.

Examples: H_2O (aqua), NH_3 (ammine), Cl^- (chloro), CN^- (cyano).



Bidentate ligands:

- These ligands possess **two donor atoms** which can coordinate to a single metal ion simultaneously.
- They form chelate rings with the central atom, increasing stability of the complex.

Examples: $\text{C}_2\text{O}_4^{2-}$ (oxalato, donor O atoms), en (ethylenediamine, donor N atoms).



Unidentate ligands bind through one atom, bidentate ligands through two atoms.
--

Quick Tip
--

Chelating (multidentate) ligands enhance stability of complexes via the chelate effect . Unidentate ligands bind only at one site, but bidentate ligands form stable rings by binding at two sites.
--

(d) Write the application of Grignard reagent.

Solution:

Grignard reagents (RMgX , where R = alkyl/aryl, X = halogen) are highly reactive organometallic compounds used widely in organic synthesis.

Applications:

1. Synthesis of alcohols:



(Formation of primary alcohol).

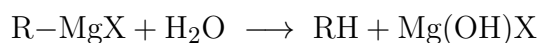


(Formation of secondary alcohol).



(Formation of tertiary alcohol).

2. Formation of hydrocarbons:



3. Synthesis of carboxylic acids:



Thus, Grignard reagents are versatile tools for forming C–C bonds and synthesising alcohols, hydrocarbons, and carboxylic acids.

💡 Quick Tip

Grignard reagents are powerful nucleophiles that add to carbonyl compounds to build carbon–carbon bonds. Always prepare them under anhydrous conditions since they react violently with water.

3.(a) Find the osmotic pressure of $\frac{M}{10}$ urea solution at 27°C (Given: $R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$).

Solution:

For a non-electrolyte (urea), osmotic pressure is given by $\pi = iMRT$ with $i = 1$.

Given $M = \frac{M}{10} = 0.10 \text{ mol L}^{-1}$, $T = 27^\circ\text{C} = 300 \text{ K}$.

$$\pi = (1) \times 0.10 \times 0.0821 \times 300 = 2.463 \text{ atm}$$

$$\pi \approx 2.46 \text{ atm}$$

💡 Quick Tip

Use $\pi = iMRT$ and remember to convert temperature to Kelvin. For non-electrolytes, $i = 1$; for electrolytes, include i (van't Hoff factor).

(b) Write the structures of all possible isomers of alcohol having molecular formula $\text{C}_4\text{H}_{10}\text{O}$.

Solution:

All *alcohol* isomers (no ethers) with formula $\text{C}_4\text{H}_{10}\text{O}$ are four in number.

1. **Butan-1-ol (n-butanol):** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$.
2. **Butan-2-ol (sec-butanol):** $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$.
3. **2-Methylpropan-1-ol (isobutanol):** $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$.
4. **2-Methylpropan-2-ol (tert-butanol):** $(\text{CH}_3)_3\text{COH}$.

$$\text{Total alcohol isomers of } \text{C}_4\text{H}_{10}\text{O} = 4$$

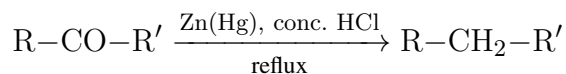
💡 Quick Tip

Count alcohol isomers by arranging the C_4 skeleton (straight vs branched) and then placing the OH group at unique positions (primary, secondary, tertiary).

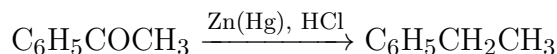
(c) Explain Clemmensen reduction giving example.

Solution:

Definition: Clemmensen reduction converts aldehydes and ketones to the corresponding methylene compounds using zinc amalgam and concentrated hydrochloric acid.



Example: Acetophenone to ethylbenzene



Note: Works best for acid-stable substrates; for base-sensitive substrates use Wolff–Kishner instead.

💡 Quick Tip

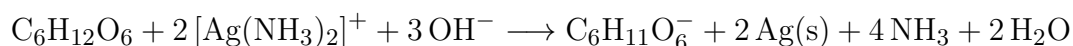
Clemmensen = $\text{Zn(Hg)}/\text{HCl}$ (acidic); Wolff–Kishner = $\text{NH}_2\text{NH}_2/\text{KOH}$ (basic). Both reduce $>\text{C}=\text{O}$ to $-\text{CH}_2-$.

(d) What is Tollen’s reagent? Write the chemical equation of its reaction with glucose.

Solution:

Tollen’s reagent: Ammoniacal silver nitrate containing the complex ion $[\text{Ag}(\text{NH}_3)_2]^+$ (often represented as $[\text{Ag}(\text{NH}_3)_2]\text{OH}$); it oxidises aldehydes to carboxylates giving a silver mirror.

With glucose:



On acidification: $\text{C}_6\text{H}_{11}\text{O}_6^- \rightarrow \text{C}_6\text{H}_{12}\text{O}_7$ (gluconic acid).

💡 Quick Tip

Tollen’s tests for $-\text{CHO}$ groups; glucose is reducing and gives a bright silver mirror due to $\text{Ag}^+ \rightarrow \text{Ag}^0$.

4.(a) A solution of urea is 6% by mass. Calculate the mole fractions of urea and water in the solution. (Molecular mass of urea = 60).

Solution:

Assume 100 g of solution $\Rightarrow$ 6 g urea and 94 g water.

$$\text{Moles of urea} = \frac{6}{60} = 0.10 \text{ mol.}$$

$$\text{Moles of water} = \frac{94}{18} = 5.222 \text{ mol.}$$

$$\text{Total moles} = 0.10 + 5.222 = 5.322 \text{ mol.}$$

$$\text{Mole fraction of urea } x_{\text{urea}} = \frac{0.10}{5.322} = 0.0188.$$

$$\text{Mole fraction of water } x_{\text{water}} = \frac{5.222}{5.322} = 0.9812.$$

$$x_{\text{urea}} \approx 0.0188, \quad x_{\text{water}} \approx 0.9812$$

💡 Quick Tip

When given a percentage by mass, assume 100 g of solution to simplify calculation. Then convert grams to moles and calculate mole fraction by dividing each mole value by the total moles.

(b) Find the emf of the cell reaction: $\text{Zn(s)} + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{Ag(s)}.$

$$E_{\text{Zn}^{2+}/\text{Zn}}^{\circ} = -0.76 \text{ V}, \quad E_{\text{Ag}^+/\text{Ag}}^{\circ} = +0.80 \text{ V}.$$

Solution:

Cathode (reduction): $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$, $E_{\text{cathode}}^{\circ} = +0.80 \text{ V}.$

Anode (oxidation): $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ (reverse of the reduction couple), $E_{\text{anode (red)}}^{\circ} = -0.76 \text{ V}.$

Standard emf: $E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode (red)}}^{\circ}.$

$$E_{\text{cell}}^{\circ} = 0.80 - (-0.76) = 1.56 \text{ V}$$

$$E_{\text{cell}}^{\circ} = 1.56 \text{ V}$$

💡 Quick Tip

Always identify cathode (reduction, more positive potential) and anode (oxidation).

Use the formula:

$$E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$$

This ensures correct sign and value for the emf of the cell.

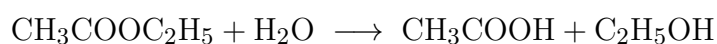
(c) Explain order and molecularity of a reaction giving example.

Solution:

Order of a reaction:

- The order is the sum of the powers of concentration terms in the experimentally determined rate law.
- It is determined *experimentally*, not from the balanced equation.

Example: For hydrolysis of an ester:



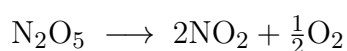
Rate law: $r = k[\text{CH}_3\text{COOC}_2\text{H}_5]^1[\text{H}_2\text{O}]^0 = k[\text{CH}_3\text{COOC}_2\text{H}_5]$.

Thus, the reaction is **first order**.

Molecularity of a reaction:

- It is the number of molecules or species taking part in an elementary step of the reaction mechanism.
- Molecularity is always a whole number (1, 2, 3 ...).

Example: Unimolecular decomposition:



Here, molecularity = 1.

Order is experimental and may be fractional; molecularity is theoretical and always an integer.

💡 Quick Tip

Order is derived from rate law; molecularity refers to the mechanism of a single step. Order can be zero or fractional, molecularity cannot.

(d) Which elements are called transition elements? Explain: (i) Transition metals generally form coloured compounds, (ii) Transition metals or ions and many of their compounds show paramagnetic behaviour.

Solution:

Transition elements:

- Transition elements are those d-block elements which have partially filled d-orbitals in their atoms or in one of their common oxidation states.
- General definition: Elements of groups 3 to 12 (except Zn, Cd, Hg which have completely filled d-orbitals).

(i) Coloured compounds:

- Transition metal ions form coloured salts/complexes due to **d–d electronic transitions**.
- In the presence of ligands, the d-orbitals split into two sets of different energies (Crystal Field Splitting).
- Absorption of light promotes an electron from lower to higher d-orbital; the complementary colour is observed.

Examples: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (blue), $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ (purple).

(ii) Paramagnetic behaviour:

- Transition metals and their ions often contain **unpaired d-electrons**.
- Unpaired spins produce magnetic moments, giving paramagnetism.
- Paramagnetism is measured in Bohr magnetons (BM).

Examples: Fe^{2+} (d^6 , 4 unpaired e^-), Mn^{2+} (d^5 , 5 unpaired e^-).

Thus, coloured compounds and paramagnetism are due to partially filled d-orbitals.

💡 Quick Tip

Transition elements differ from s- and p-block elements because their d-orbitals allow variable oxidation states, colour (d–d transitions), and magnetism (unpaired electrons).

5.(a) What is electrode potential? Give the factors which affect the electrode potential of a metal.

Solution:

Definition:

Electrode potential is the potential difference developed between a metal electrode and the solution of its ions when the electrode is in equilibrium with those ions.

It expresses the tendency of the electrode to lose or gain electrons.

Factors affecting electrode potential:

1. **Nature of the metal:** Different metals have different intrinsic tendencies to be oxidized or reduced.
2. **Ion concentration:** Electrode potential varies with the concentration (activity) of metal ions according to the Nernst equation.
3. **Temperature:** Change in temperature alters activities of species and hence the potential.
4. **Pressure of gas (for gas electrodes):** For electrodes like SHE, the gas pressure affects the potential.

Nernst relation (298 K, base-10):

$$E = E^\circ - \frac{0.0591}{n} \log \left(\frac{[Ox]}{[Red]} \right)$$

This shows explicitly how concentration and n influence E .

💡 Quick Tip

At standard conditions ($[] = 1 \text{ M}$, $p = 1 \text{ atm}$, $T = 298 \text{ K}$), $E = E^\circ$. Any deviation in concentration, temperature, or pressure shifts E from E° .

(b) Prove that the time taken to complete 99.9% reaction is ten times the half-life period ($t_{1/2}$) for a first-order reaction.

Solution:

For a first-order reaction, the integrated rate law is

$$kt = 2.303 \log \left(\frac{a}{a-x} \right)$$

where a is the initial amount and $(a-x)$ is the amount remaining at time t .

Half-life $t_{1/2}$: at $x = \frac{a}{2}$, so $\frac{a}{a-x} = 2$.

$$kt_{1/2} = 2.303 \log 2 = 0.693 \quad \Rightarrow \quad t_{1/2} = \frac{0.693}{k}$$

Time for 99.9% completion $t_{99.9}$: 99.9% reacted $\Rightarrow$ 0.1% remains, so $(a-x) = 0.001 a$.

Thus $\frac{a}{a-x} = \frac{a}{0.001 a} = 1000$.

$$kt_{99.9} = 2.303 \log 1000 = 2.303 \times 3 = 6.909$$

$$\Rightarrow t_{99.9} = \frac{6.909}{k}$$

Ratio:

$$\frac{t_{99.9}}{t_{1/2}} = \frac{6.909/k}{0.693/k} = \frac{6.909}{0.693} \approx 9.97 \approx 10$$

$$\boxed{t_{99.9} \approx 10 t_{1/2}}$$

💡 Quick Tip

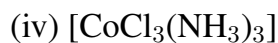
For any first-order decay, the fraction remaining is $f = (a-x)/a = 10^{-n} \Rightarrow t = (2.303 n/k)$. Each factor of 10 in reduction adds $\frac{2.303}{k}$ to the time.

(c) Write the IUPAC names of the following coordinate compounds:

(i) $[\text{CrCl}_2(\text{en})]\text{Cl}$

(ii) $\text{Cs}[\text{FeCl}_4]$

(iii) $\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3]$



Solution:



- Central metal: Cr (oxidation state = +3).
- Ligands: 2 Cl^- (chloro), 1 en (ethane-1,2-diamine, bidentate).
- Outside Cl^- = counter ion.

IUPAC name: Dichlorido(ethane-1,2-diamine)chromium(III) chloride



- Central metal: Fe (oxidation state = +3).
- Ligands: 4 Cl^- = tetrachlorido.
- Cs^+ = counter ion.

IUPAC name: Caesium tetrachloridoferrate(III)



- Central metal: Co (oxidation state = +3).
- Ligand: oxalato ($\text{C}_2\text{O}_4^{2-}$, bidentate).
- Three oxalato ligands.

IUPAC name: Potassium tris(oxalato)cobaltate(III)



- Central metal: Co (oxidation state = +3).
- Ligands: 3 Cl^- (chloro), 3 NH_3 (ammine).

IUPAC name: Triamminetrichloridocobalt(III)

💡 Quick Tip

While naming coordination compounds: 1. Name ligands in alphabetical order before the metal.

2. Use oxidation state of metal in Roman numerals.

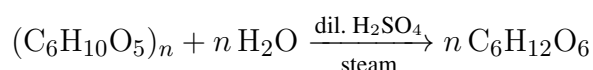
3. Anionic complexes end with “-ate” (e.g., ferrate, cobaltate).

(d) Write chemical equations of two methods of preparation of glucose. How will you obtain saccharic acid and gluconic acid from glucose?

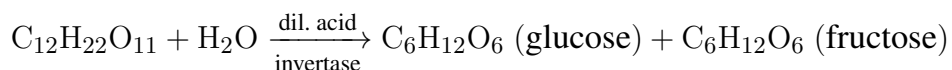
Solution:

Two preparations of glucose:

(1) *Hydrolysis of starch*

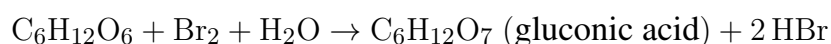


(2) *Hydrolysis of sucrose*

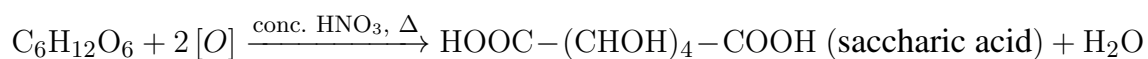


From glucose to saccharic acid and gluconic acid:

(a) *Gluconic acid (oxidise –CHO only)*



(b) *Saccharic (glucaric) acid (oxidise –CHO and –CH₂OH)*



💡 Quick Tip

Mild oxidant (Br₂/H₂O) stops at the aldonic acid (gluconic acid), while hot conc. HNO₃ over-oxidises both ends of glucose to the dicarboxylic saccharic (glucaric) acid.

6.(a) Write chemical equation for the formation of chlorobenzene by Sandmeyer reaction. How can the following compounds be obtained from chlorobenzene? Clarify giving chemical equations.

(i) Phenol

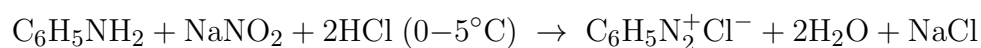
(ii) Toluene

(iii) Diphenyl

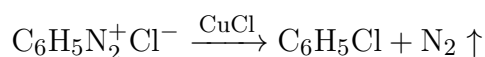
Solution:

Formation of chlorobenzene (Sandmeyer reaction):

Step 1: Diazotization of aniline

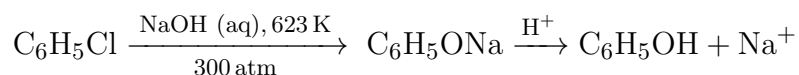


Step 2: Replacement by Cl (CuCl)

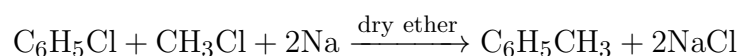


Conversions starting from chlorobenzene:

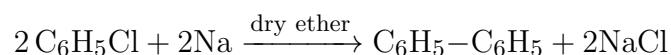
(i) Chlorobenzene $\rightarrow$ Phenol (Dow process):



(ii) Chlorobenzene $\rightarrow$ Toluene (Wurtz-Fittig):



(iii) Chlorobenzene $\rightarrow$ Diphenyl (Fittig):



💡 Quick Tip

Sandmeyer: $\text{Ar-N}_2^+ \xrightarrow{\text{CuX}} \text{Ar-X}$.

From chlorobenzene: **Dow** (NaOH, 623 K, high pressure) $\rightarrow$ phenol.

Wurtz-Fittig with $\text{CH}_3\text{Cl} \rightarrow$ toluene.

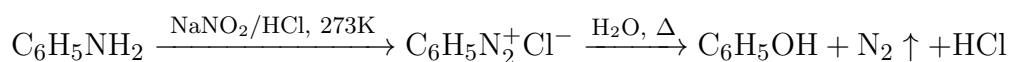
Fittig ($2 \text{ ArX} + 2 \text{ Na}$) $\rightarrow$ biaryl (diphenyl).

(b) Write down the method of preparation of phenol. Write chemical equations of the reaction of phenol with the following: (i) Conc. HNO_3 (ii) Bromine water (iii) Zinc

Solution:

Preparation of phenol:

One important laboratory method is from diazonium salts (benzene diazonium chloride).

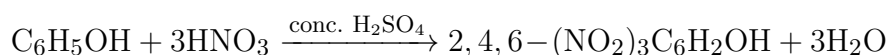


Thus, phenol is obtained by hydrolysis of benzene diazonium chloride.

Reactions of phenol:

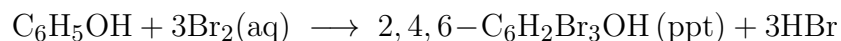
(i) With conc. HNO_3 (Nitration):

Phenol reacts with concentrated nitric acid to give picric acid (2,4,6-trinitrophenol).



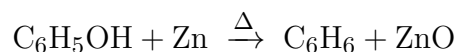
(ii) With bromine water (Bromination):

Phenol reacts with bromine water to give a white precipitate of 2,4,6-tribromophenol.



(iii) With zinc (Reduction):

Phenol reacts with zinc on heating to give benzene.



Hence, phenol undergoes nitration, bromination, and reduction with Zn.

💡 Quick Tip

Phenol is highly reactive towards electrophilic substitution due to the activating effect of the –OH group. Therefore, it readily gives nitration (picric acid) and bromination (2,4,6-tribromophenol) without needing catalysts. With reducing agents like Zn, phenol can be deoxygenated to benzene.

OR

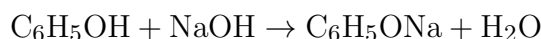
Write the chemical equation for the preparation of anisole. Write the chemical equations of its reactions with:

- i) Acetyl chloride
- ii) Hydrogen iodide
- iii) Mixture of conc. H_2SO_4 and conc. HNO_3

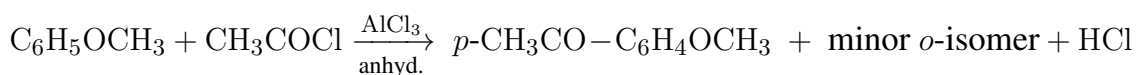
Solution:

Preparation of anisole (Williamson ether synthesis):

First form sodium phenoxide, then methylate.

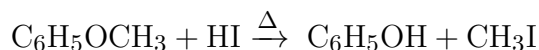


i) With acetyl chloride (Friedel–Crafts acylation):

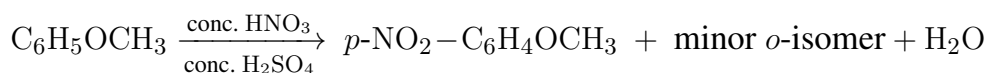


(para-methoxyacetophenone major, ortho minor).

ii) With hydrogen iodide (ether cleavage):



iii) With conc. H_2SO_4 /conc. HNO_3 (nitration):



💡 Quick Tip

The $-\text{OCH}_3$ group is a strong ortho/para director, so electrophilic substitutions (acylation, nitration) give mainly para products; with HI, anisole cleaves at the alkyl–oxygen bond to yield phenol and methyl iodide.

7.(a) Write the structural formula of benzaldehyde. Write chemical equations of the reactions of benzaldehyde with (i) NH_2NH_2

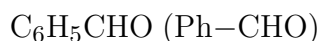
(ii) Tollen's reagent

(iii) HNO_3 and H_2SO_4

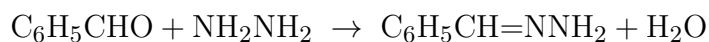
(iv) NaOH .

Solution:

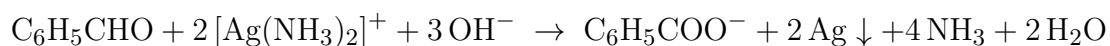
Structural formula of benzaldehyde:



(i) With hydrazine (formation of hydrazone):

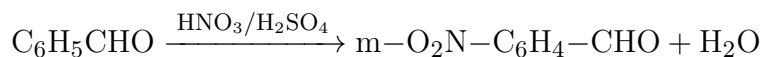


(ii) With Tollen's reagent (silver mirror test; oxidation to benzoate/benzoic acid):



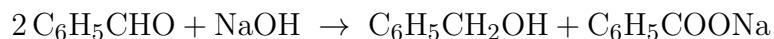
(On acidification $\rightarrow \text{C}_6\text{H}_5\text{COOH}$).

(iii) Nitration ($\text{HNO}_3/\text{H}_2\text{SO}_4$; meta directing):



(Product: m-nitrobenzaldehyde).

(iv) With NaOH (Cannizzaro reaction; no α -H):



(On acidification of benzoate $\rightarrow \text{C}_6\text{H}_5\text{COOH}$).

💡 Quick Tip

Benzaldehyde ($\text{Ph}-\text{CHO}$) has no α -H, so it **does not enolize** and undergoes Cannizzaro with base; $-\text{CHO}$ is **meta-directing** in electrophilic substitution; carbonyls form **hydrazones** with NH_2NH_2 ; Tollen's reagent oxidizes aldehydes to acids/benzoates with a **silver mirror**.

OR

Write the IUPAC name of Acetaldehyde. Write its chemical equations with (i) NaHSO_3

(ii) NaOH

(iii) NH_2OH

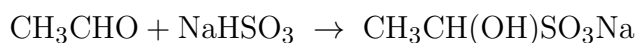
(iv) CH_3OH in the presence of HCl gas.

Solution:

IUPAC name:

Acetaldehyde = **ethanal** (CH_3CHO).

(i) With sodium bisulfite (NaHSO_3): addition product



(Product: sodium 1-hydroxyethanesulfonate; bisulfite addition compound.)

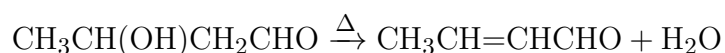
(ii) With NaOH (aldol reaction)

Cold, dilute NaOH (aldol):



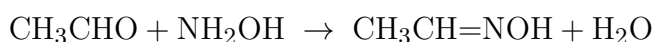
(3-hydroxybutanal)

On warming (dehydration to unsaturated aldehyde):



(crotonaldehyde)

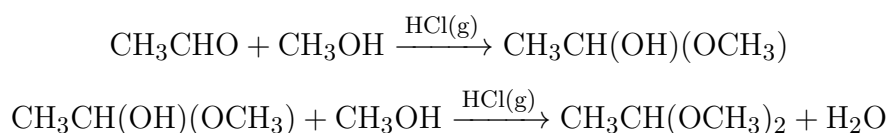
(iii) With hydroxylamine (oxime formation)



(acetaldoxime)

(iv) With methanol in presence of dry HCl (acetal formation)

Via hemiacetal, then acetal:



(Product: acetal, 1,1-dimethoxyethane)

💡 Quick Tip

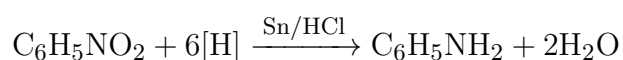
Carbonyls give **bisulfite addition** solids (useful for purification), undergo **aldol** with dilute base, form **oximes** with NH_2OH , and in **acidic alcohol** convert to **acetals** (protecting groups).

(b) Describe the laboratory method to prepare aniline and write the related chemical equation. Write also the equations of its two chemical properties and uses.

Solution:

Preparation of Aniline:

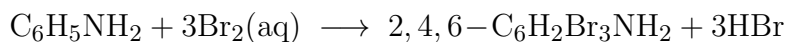
- Aniline ($\text{C}_6\text{H}_5\text{NH}_2$) is prepared in the laboratory by the reduction of nitrobenzene.
- Nitrobenzene is reduced using tin (Sn) and concentrated HCl, followed by neutralisation with NaOH.



Two Chemical Properties:

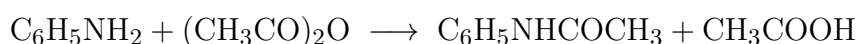
(i) Bromination:

Aniline reacts with bromine water to give 2,4,6-tribromoaniline (a white precipitate).



(ii) Acetylation:

Aniline reacts with acetic anhydride to form acetanilide.



Uses of Aniline:

1. Used in the manufacture of dyes such as aniline yellow, methyl orange.
2. Important raw material for drugs, rubber processing chemicals, and polymers.
3. Used for the preparation of paracetamol (acetaminophen).

Thus, aniline is prepared by reduction of nitrobenzene, shows EAS and acylation, and has wide industrial uses.

💡 Quick Tip

In lab preparation, Sn/HCl reduces nitrobenzene effectively. Always neutralise with alkali to free the amine. Aniline is highly reactive in electrophilic substitution due to the strong +M effect of $-\text{NH}_2$.

OR

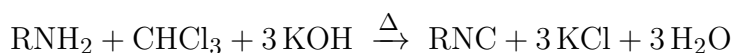
Write short notes on the following:

- i) Carbylamine reaction
- ii) Hofmann's bromamide reaction
- iii) Acetylation

Solution:

i) Carbylamine Reaction (Isocyanide Test):

- When a **primary amine** (aliphatic or aromatic) is heated with chloroform and alcoholic KOH, it forms an **isocyanide (carbylamine)** with a very foul smell.
- Secondary and tertiary amines do *not* give this test, hence it is a **specific test for primary amines**.



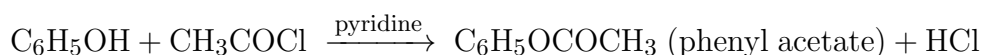
ii) Hofmann's Bromamide Reaction (Hofmann Rearrangement):

- An **amide** on treatment with bromine and aqueous/alkaline base gives a **primary amine with one carbon less** (loss of CO, migration of R group).
- Useful for stepping down the homologous series and preparing 1° amines from amides.



iii) Acetylation:

- Introduction of an **acetyl group** ($-\text{COCH}_3$) into a compound using acetylating agents such as CH_3COCl or $(\text{CH}_3\text{CO})_2\text{O}$.
- Commonly used to **protect** $-\text{OH}$ and $-\text{NH}_2$ groups, to reduce basicity/nucleophilicity, and to control orientation in electrophilic substitution.



💡 Quick Tip

Carbylamine test $\Rightarrow$ only 1° amines (foul isocyanide smell).

Hofmann rearrangement $\Rightarrow$ amide $\rightarrow$ 1° amine with -1 carbon.

Acetylation $\Rightarrow$ protection/activation control using Ac_2O or CH_3COCl .