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CBSE Class 12 Chemistry Board Paper 2026 (56/3/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · CHEMISTRY (043) · BOARD EXAM 2026 · Q.P. CODE 56/3/1

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
3 hours	70	33 (A 16 · B 5 · C 7 · D 2 · E 3)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 33 questions. All questions are compulsory.
2. This question paper is divided into five sections – Section A, B, C, D and E.
3. Section A – questions number 1 to 16 are multiple choice type questions. Each question carries 1 mark.
4. Section B – questions number 17 to 21 are very short answer type questions. Each question carries 2 marks.
5. Section C – questions number 22 to 28 are short answer type questions. Each question carries 3 marks.
6. Section D – questions number 29 and 30 are case-based questions. Each question carries 4 marks.
7. Section E – questions number 31 to 33 are long answer type questions. Each question carries 5 marks.
8. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the sections except Section – A.
9. Use of calculator is not allowed.
10. This is the official 2026 board paper (Q.P. Code 56/3/1). The step marks shown in the solutions are our marking scheme in the CBSE style; CBSE's own marking scheme may award steps differently.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 3 hours before you look at them.

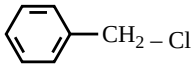
Questions: CBSE board examination 2026, Q.P. Code 56/3/1, as published by CBSE at cbse.gov.in; structures redrawn. Answers, step marks and worked solutions © Master Testing Agency. Free for personal practice; not for resale. Master Testing Agency is an independent test-prep publisher, not affiliated with, endorsed by or connected to the Central Board of Secondary Education (CBSE) or any other exam-conducting body.

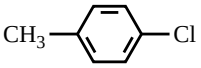
Chapters: Full syllabus · **Topics:** Solutions · Electrochemistry · Chemical Kinetics · d- and f-Block Elements · Coordination Compounds · Haloalkanes and Haloarenes · Alcohols, Phenols and Ethers · Aldehydes, Ketones and Carboxylic Acids · Amines · Biomolecules

SECTION A

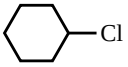
Multiple choice questions of 1 mark each (Q13–16 assertion-reason).

1. Which of the following will be the least reactive towards nucleophilic substitution reaction ? 1

(A) 

(B) 

(C) $CH_3 - Cl$

(D) 

2. The intermediate formed during the slowest step involved in the dehydration of alcohol is : 1

(A) protonated alcohol (B) carbanion

(C) free radical (D) carbocation

3. The oxidation number of Co in $[Co(en)_3]_2(SO_4)_3$ is : 1

(A) + 3 (B) + 2

(C) + 4 (D) + 6

4. According to Werner's theory, the primary valencies of the central metal atom : 1

(A) are satisfied by neutral molecules or negative ions. (B) are equal to its coordination number.

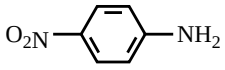
(C) are satisfied by negative ions. (D) are non-ionisable.

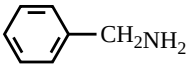
5. Which of the following reagent is used to distinguish between $(C_2H_5)_2NH$ and $(C_2H_5)_3N$? 1

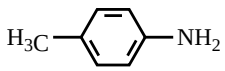
(A) $CHCl_3 + KOH$ (B) $C_6H_5SO_2Cl$

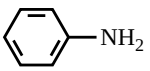
(C) Conc. $HCl + ZnCl_2$ (D) $NaOH + I_2$

6. Among the following, which is the strongest base ? 1

(A) 

(B) 

(C) 

(D) 

7. In aqueous solution, $Cr_2O_7^{2-}$ ion converts to which of the following in alkaline medium ? 1

(A) Cr^{3+} (B) CrO_4^{2-}

(C) CrO (D) CrO_3

8. The boiling point of an azeotropic mixture of water and ethanol is less than that of pure water and ethanol. The mixture shows : 1

(A) positive deviation from Raoult's Law. (B) negative deviation from Raoult's Law.

(C) no deviation from Raoult's Law. (D) that the solution is an ideal solution.

9. The mole fraction of a solute in 2·0 molal aqueous solution is : 1

(A) 1·87 (B) 0·347

(C) 0·0347 (D) 0·00347

10. On electrolysis of very dilute aqueous solution of NaCl using platinum electrodes : 1

Options : (A) H_2 gas is evolved at anode. (B) Na is produced at cathode. (C) O_2 gas is evolved at anode. (D) H_2 gas is evolved at cathode.

11. For a reaction $3A \rightarrow 2B$, the rate of reaction $\frac{+ d[B]}{dt}$ is equal to : 1

(A) $-\frac{3}{2}\frac{d[A]}{dt}$ (B) $-\frac{2}{3}\frac{d[A]}{dt}$

(C) $-\frac{1}{3}\frac{d[A]}{dt}$ (D) $+2\frac{d[A]}{dt}$

12. On hydrolysis, which of the following carbohydrates gives only glucose ? 1

(A) Sucrose (B) Galactose

(C) Lactose (D) Maltose

13. **Assertion (A) :** Separation of Zr and Hf is difficult. 1

Reason (R) : Because Zr and Hf lie in the same group of the periodic table.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

14. **Assertion (A) :** Phenol is less acidic than 4-methylphenol. 1

Reason (R) : The presence of an electron releasing group in phenol makes it less acidic.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

15. **Assertion (A) :** Aromatic primary amines cannot be prepared by Gabriel phthalimide synthesis. 1
Reason (R) : Gabriel phthalimide synthesis is used for the preparation of primary aliphatic amines.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

16. **Assertion (A) :** Order of reaction is applicable to elementary as well as complex reactions. 1
Reason (R) : Order of a reaction is an experimental quantity.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

SECTION B

Very short answer questions of 2 marks each.

17. For the compound having molecular formula C_4H_9Br, write : 2

(a) the isomer which is most reactive towards S_N1 displacement.

(b) the isomer which, on reacting with Na metal in the presence of dry ether, gives 2,5-Dimethylhexane.

18. For a reaction A + B → Products, the rate law is : Rate = $k[A][B]^{3/2}$ 2
Write the overall order of the reaction. Can this reaction be an elementary reaction ? Give reason in support of your answer.

19. Explain why, on addition of 1 mol of KCl to 1 litre of water, the boiling point of water increases, while the addition of 1 mol of methyl alcohol to 1 litre of water decreases the boiling point. 2

20. (a) Write IUPAC names of the following compounds : 2
(i) $[PtCl_2(en)_2]SO_4$
(ii) $(NH_4)_2[CoF_4]$

OR

(b) Define the following terms with a suitable example in each case :
(i) Ambidentate ligand
(ii) Double salt

21. How do you explain the following ? 2
(a) Presence of a straight chain in glucose
(b) Presence of five – OH groups in glucose which are attached to different carbon atoms

SECTION C

Short answer questions of 3 marks each.

22. The half-life period of a radioactive element is $1{\cdot}5 \times 10^{10}$ years. Calculate the time in which the activity of the element is reduced to 75% of its original value. [Given : log 2 = 0·30, log 3 = 0·48, log 4 = 0·60] 3

23. State Kohlrausch's law of independent migration of ions. With the help of a curve, explain why it is not easy to determine Λ°_m for weak electrolytes by extrapolating the concentration – molar conductivity curve, as it is for strong electrolytes. 3

24. An antifreeze solution is prepared by dissolving 31 g of ethylene glycol (Molar mass = 62 g mol^{-1}) in 600 g of water. Calculate the freezing point of the solution. (K_f for water = 1·86 K kg mol^{-1}) 3

25. (a) Answer the following questions about the complexes $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ 3

(i) Write the hybridization involved in each case.

(ii) Which of them is the inner orbital complex and which one is the outer orbital complex ?

(iii) Compare their magnetic behaviour. [Atomic number : Ni = 28]

OR

(b) (i) Name two coordination compounds which are important in biological systems.

(ii) What is meant by chelate effect ? Give an example.

(iii) Why are low spin tetrahedral complexes rarely formed ?

26. Give reasons for the following : 3

(a) Although chlorine is an electron-withdrawing group, yet it is ortho-, para-directing in electrophilic aromatic substitution reactions.

(b) Aryl halides cannot be prepared by reacting phenol with concentrated halogen acids or phosphorus halides.

(c) Chloroform is stored in closed dark coloured bottles.

27. How will you obtain the following from benzenediazonium chloride ? Give chemical equations involved : 3

(a) Chlorobenzene

(b) Benzene

(c) Benzonitrile

28. An organic compound (A) with molecular formula C_3H_5N on reaction with C_6H_5MgBr followed by hydrolysis, gives a compound (B). Compound (B) forms an orange-red precipitate with 2,4-DNP reagent and does not give iodoform test. It neither reduces Tollens' or Fehling's reagent nor does it decolourise bromine water. On drastic oxidation with chromic acid it gives a carboxylic acid (C) having molecular formula $C_7H_6O_2$. Identify the compounds (A), (B) and (C). Write the reactions of compound (A) with C_6H_5MgBr followed by hydrolysis to give compound (B). 3

SECTION D

Case-based questions of 4 marks each.

29. Living systems are made up of various complex biomolecules like carbohydrates, proteins, nucleic acids, lipids, etc. Proteins and carbohydrates are essential constituents of our food. In addition, some simple molecules like vitamins and mineral salts also play an important role in the functions of organisms. All proteins are polymers of α-amino acids. Proteins can be classified into two types on the basis of their molecular shape — Fibrous and Globular proteins. Vitamins are accessory food factors required in the diet. They are classified as fat-soluble and water-soluble. Deficiency of vitamins leads to many diseases. Nucleic acids are the polymers of nucleotides which in turn consist of a base, a pentose sugar and phosphate moiety. There are two types of nucleic acids — DNA and RNA. Nucleic acids are responsible for the transfer of characters from parents to offsprings.

(a) Write the name of basic building units of proteins and nucleic acids. How can you differentiate between Fibrous and Globular proteins on the basis of their structures ? [2]

(b) What products would be formed when a nucleotide from DNA containing thymine is hydrolyzed ? [1]

OR

(b) Write one structural difference between DNA and RNA. [1]

(c) Give one example each of a fat-soluble vitamin and a water-soluble vitamin. [1]

30. Alcohols have higher boiling points than other compounds, namely hydrocarbons, ethers and haloalkanes of comparable molecular masses. On oxidation, primary alcohols yield aldehydes with mild oxidizing agents and carboxylic acids with strong oxidizing agents. Secondary alcohols yield ketones on oxidation while tertiary alcohols are resistant to oxidation. Ethers may be prepared by dehydration of alcohols and Williamson synthesis. The C – O bond in ethers can be cleaved by hydrogen halides. The presence of – OH group in phenols activates the aromatic ring towards electrophilic substitution and directs the incoming group to ortho and para positions due to resonance effect. In presence of NaOH, phenol generates phenoxide ion which is even more reactive than phenol. Thus, in alkaline medium, phenol undergoes Kolbe's reaction.

(a) Name the reagents used in the following reactions :
(i) Oxidation of a primary alcohol to aldehyde
(ii) Oxidation of a primary alcohol to carboxylic acid [2]

(b) Write the reaction involved in Kolbe's reaction. [1]

(c) Why are tertiary alcohols resistant to oxidation ? [1]

OR

(c) Write the products of the following reaction : $(CH_3)_3\ C - O - C_2H_5 \xrightarrow{HI}$ [1]

SECTION E

Long answer questions of 5 marks each.

31. (a) (i) Describe giving reason which one of the following pairs has the property indicated : 5

(I) Fe or Cu – higher melting point

(II) Ti^{3+} or Sc^{3+} – coloured in aqueous solution

(III) Cr or Zn – higher third ionisation enthalpy

(ii) Write the ionic equations for the oxidizing action of MnO_4^- in acidic medium with :

(I) Fe^{2+} ion

(II) I^- ion

OR

(b) (i) A black-brown coloured solid (A) when fused with KOH in the presence of air, produces a dark green coloured compound (B) which on electrolytic oxidation in alkaline medium gives a dark purple coloured compound (C). Identify (A), (B) and (C). Write the reactions involved.

(ii) What happens when an acidic solution of the green compound (B) is allowed to stand for some time ? Also write the equation involved. What is this type of reaction called ?

32. (a) (i) Write the product(s) when : 5

(I) One mol of ethanal is treated with 1 mol of CH_3OH in the presence of dry HCl gas.

(II) Benzaldehyde is treated with conc. NaOH.

(III) Ethanoic acid is heated in the presence of P_2O_5.

(ii) Write a simple chemical test to distinguish between Ethanal and Propanal.

(iii) Write the name of the reagent to transform Allyl alcohol to Propenal.

OR

(b) (i) Draw the structure of the semicarbazone of acetone.

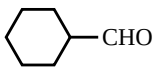
(ii) Why are α-hydrogen atoms of aldehydes and ketones acidic in nature ?

(iii) Arrange the following compounds in increasing order of their reactivity towards HCN :

CH_3COCH_3, CH_3CHO, $(CH_3)_3C – CO – CH_3$

(iv) Write the reaction involved in Etard reaction.

(v) Write the product when



reacts with Zn(Hg)/conc. HCl.

33. (a) (i) Calculate the electrode potential of a half-cell for zinc electrode dipping in 0·01 M $ZnSO_4$ solution at 25°C. Given : $E°_{Zn^{2+}/Zn} = -0·76$ V [log 10 = 1] 5

(ii) Write anode, cathode and overall reaction involved in dry cell.

(iii) Equilibrium constant (K_c) is related to $E°_{cell}$, but not to E_{cell}. Why ?

OR

(b) (i) The conductivity of 0·001 M solution of acetic acid is $3·905 \times 10^{-5}$ S cm^{-1}. Calculate its molar conductivity and degree of dissociation (α). Given : $\lambda°_{CH_3COO^-} = 40·9$ S cm^2 mol^{-1}, $\lambda°_{H^+} = 349·6$ S cm^2 mol^{-1}

(ii) Give reasons for the following :

(I) Why does a mercury cell deliver a constant voltage for its entire life ?

(II) Why is it necessary to use salt bridge in a galvanic cell ?

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q11	Q12	Q13	Q14	Q15	Q16
(B)	(D)	(A)	(C)	(B)	(B)	(B)	(A)	(C)	(B)	(D)	(B)	(D)	(B)	(A)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (B). In an aryl halide (4-chlorotoluene) the C–Cl bond has partial double bond character from resonance and the carbon is sp^2: it hardly undergoes nucleophilic substitution. Benzyl chloride, CH_3Cl and chlorocyclohexane react much more readily.

Q2. Answer (D). Acid-catalysed dehydration: protonation (fast), loss of water to form a carbocation (slow, rate-determining), loss of H^+ (fast).

Q3. Answer (A). Three SO_4^{2-} (−6) balance two complex ions, so each is $[Co(en)_3]^{3+}$; en is neutral, so Co is +3.

Q4. Answer (C). Primary valencies are ionisable and are satisfied by negative ions; secondary valencies (the coordination number) are non-ionisable and are satisfied by neutral molecules or negative ions.

Q5. Answer (B). Hinsberg's reagent (benzenesulphonyl chloride) gives a sulphonamide (insoluble in alkali) with the secondary amine and does not react with the tertiary amine.

Q6. Answer (B). In benzylamine the lone pair on N is not delocalised into the ring (the NH_2 is on a CH_2 group), so it is a much stronger base than any of the aromatic amines; among those, $–NO_2$ lowers and $–CH_3$ raises the basicity slightly.

Q7. Answer (B). $Cr_2O_7^{2-} + 2OH^- \rightleftharpoons 2CrO_4^{2-} + H_2O$: in alkaline medium dichromate changes to yellow chromate (Cr stays +6).

Q8. Answer (A). A minimum boiling azeotrope has a vapour pressure higher than expected: positive deviation from Raoult's law (ethanol–water).

Q9. Answer (C). 2.0 mol solute in 1000 g (55.5 mol) water: $x = 2.0/(2.0 + 55.5) \approx 0.0347$.

Q10. (1 marks) Answer: (C) and (D) are both correct.
In a very dilute solution water is oxidised at the anode: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ (O_2 at the anode), and water is reduced at the cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (H_2 at the cathode). [½]
So both (C) and (D) are correct statements; (A) and (B) are wrong. Write both and check CBSE's marking scheme for the option it accepted. [½]

Q11. Answer (B). Rate = $-(1/3)\, d[A]/dt = +(1/2)\, d[B]/dt$, so $d[B]/dt = -(2/3)\, d[A]/dt$.

Q12. Answer (D). Maltose → 2 glucose. Sucrose gives glucose + fructose, lactose gives glucose + galactose; galactose is a monosaccharide.

Q13. Answer (B). Zr and Hf are hard to separate (A true), and they are in group 4 (R true). But the reason is the lanthanoid contraction, which makes their atomic radii almost equal; being in the same group alone does not explain it. Answer (B).

Q14. Answer (D). The electron-releasing $–CH_3$ destabilises the phenoxide ion, so 4-methylphenol is less acidic than phenol: A is false, R is true. Answer (D).

Q15. Answer (B). Both statements are true. The reason aromatic amines cannot be made is that aryl halides do not undergo nucleophilic substitution with the phthalimide anion; R does not say this. Answer (B).

Q16. Answer (A). Order is found experimentally from the rate law, so it can be determined for any reaction, elementary or complex (unlike molecularity, which applies only to elementary steps). R explains A. Answer (A).

Q17. (2 marks) Answer: $(CH_3)_3CBr$; $(CH_3)_2CHCH_2Br$.
(a) 2-Bromo-2-methylpropane, $(CH_3)_3C–Br$: it forms the most stable (tertiary) carbocation. [1]
(b) 1-Bromo-2-methylpropane, $(CH_3)_2CH–CH_2Br$: Wurtz reaction $2(CH_3)_2CHCH_2Br + 2Na \rightarrow (CH_3)_2CHCH_2–CH_2CH(CH_3)_2 + 2NaBr$. [1]

Q18. (2 marks) Answer: 2.5; no.
Overall order = 1 + 3/2 = 5/2 (2.5). [1]
No. For an elementary reaction the order equals the molecularity and the exponents equal the stoichiometric coefficients (here 1 and 1); a fractional order of 2.5 cannot belong to an elementary step. [1]

Q19. (2 marks) Answer: non-volatile vs more volatile solute.
KCl is a non-volatile solute: it lowers the vapour pressure of water, so a higher temperature is needed to reach atmospheric pressure (elevation of boiling point, more so as it gives 2 ions). [1]
Methyl alcohol is more volatile than water (lower boiling point); the solution's vapour pressure is higher than that of water, so it boils at a lower temperature. [1]

Q20. (2 marks) Answer: see the model answer.
(a) (i) Dichloridobis(ethane-1,2-diamine)platinum(IV) sulphate. [1]
(ii) Ammonium tetrafluoridocobaltate(II). [1]
OR (b) (i) A ligand that can bind through either of two different donor atoms: NO_2^- (through N, nitrito-N, or through O, nitrito-O) or SCN^-/NCS^-. [1]
(ii) A double salt is formed from two simple salts in definite proportions and dissociates completely into simple ions in water: Mohr's salt $FeSO_4·(NH_4)_2SO_4·6H_2O$, potash alum. [1]

Q21. (2 marks) Answer: HI → n-hexane; pentaacetate.
(a) On prolonged heating with HI glucose gives n-hexane, showing that all six carbon atoms are in a straight chain. [1]
(b) Glucose is acetylated by acetic anhydride to glucose pentaacetate; and since the compound is stable, the five –OH groups are on different carbon atoms. [1]

Q22. (3 marks) Answer: 6.0×10^9 years.
Radioactive decay is first order: $k = 0.693/t_{½} = 2.303 \log 2/t_{½}$. [1]
$t = (2.303/k) \log(100/75) = t_{½} \times \log(4/3)/\log 2 = 1.5 \times 10^{10} \times (0.60 - 0.48)/0.30$ [1]
$= 1.5 \times 10^{10} \times 0.4 = 6.0 \times 10^9$ years. [1]

Q23. (3 marks) Answer: $\Lambda°m = \nu_+\lambda°_+ + \nu_-\lambda°_-$; steep rise near c = 0.
Kohlrausch's law: the limiting molar conductivity of an electrolyte is the sum of the limiting molar conductivities of its cation and anion: $\Lambda°m = \nu_+\lambda°_+ + \nu_-\lambda°_-$. [1]
Curve of Λm against √c: for a strong electrolyte (KCl) a nearly straight line that can be extrapolated to c = 0; for a weak electrolyte (CH_3COOH) Λm stays low and rises very steeply as $c \rightarrow 0$. [1]
For a weak electrolyte the degree of dissociation increases sharply on dilution, so the curve is almost parallel to the Λm axis near zero concentration and cannot be extrapolated reliably. [1]

Q24. (3 marks) Answer: ≈ 271.6 K (−1.55 °C).
Moles of glycol = 31/62 = 0.5 mol; molality m = 0.5/0.600 = 0.833 mol kg^{-1}. [1]
$\Delta T_f = K_f m = 1.86 \times 0.833 = 1.55$ K. [1]
Freezing point = 273.15 − 1.55 ≈ 271.6 K (−1.55 °C). [1]

Q25. (3 marks) Answer: (a) sp^3 (outer, paramagnetic) and dsp^2 (inner, diamagnetic).
(a) Ni^{2+} is $3d^8$. (i) $[NiCl_4]^{2-}$: Cl^- is weak field, the 3d electrons stay unpaired: sp^3 (tetrahedral). $[Ni(CN)_4]^{2-}$: CN^- is strong field, pairs the electrons and frees a 3d orbital: dsp^2 (square planar). [1]
(ii) $[Ni(CN)_4]^{2-}$ uses an inner (3d) orbital: inner orbital complex; $[NiCl_4]^{2-}$ uses only 4s and 4p: outer orbital complex. [1]
(iii) $[NiCl_4]^{2-}$ has 2 unpaired electrons: paramagnetic; $[Ni(CN)_4]^{2-}$ has none: diamagnetic. [1]
OR (b) (i) Chlorophyll (Mg complex), haemoglobin (Fe complex), vitamin B_{12} (cyanocobalamin, Co complex): any two. [1]
(ii) Chelate effect: a polydentate (chelating) ligand forms a much more stable complex than comparable monodentate ligands; e.g. $[Ni(en)_3]^{2+}$ is more stable than $[Ni(NH_3)_6]^{2+}$ (or the EDTA complexes). [1]
(iii) The tetrahedral splitting $\Delta t \approx (4/9)\Delta_0$ is small and almost always less than the pairing energy, so electrons occupy the higher orbitals rather than pair: high spin. [1]

Q26. (3 marks) Answer: see the model answer.
(a) Its −I effect deactivates the ring, but its lone pairs are donated by resonance (+R), raising the electron density at the ortho and para positions more than at meta; so it directs the electrophile to o- and p-positions. [1]
(b) The C–O bond in phenol has partial double bond character (resonance) and the carbon is sp^2; it is very difficult to break, so –OH cannot be replaced by halogen. [1]
(c) In air and light chloroform is slowly oxidised to carbonyl chloride (phosgene), a very poisonous gas: $2CHCl_3 + O_2 \rightarrow 2COCl_2 + 2HCl$. [1]

Q27. (3 marks) Answer: CuCl/HCl; H_3PO_2; CuCN.
(a) Sandmeyer reaction: $C_6H_5N_2^+Cl^- \xrightarrow{Cu_2Cl_2/HCl} C_6H_5Cl + N_2$ (or Gattermann: Cu/HCl). [1]
(b) $C_6H_5N_2^+Cl^- + H_3PO_2 + H_2O \rightarrow C_6H_6 + N_2 + H_3PO_3 + HCl$. [1]
(c) $C_6H_5N_2^+Cl^- \xrightarrow{CuCN/KCN} C_6H_5CN + N_2$. [1]

Q28. (3 marks) Answer: A CH_3CH_2CN; B $C_6H_5COCH_2CH_3$; C C_6H_5COOH.
A = propanenitrile, CH_3CH_2CN; B = 1-phenylpropan-1-one (propiophenone), $C_6H_5COCH_2CH_3$ (a ketone: 2,4-DNP positive, no $–COCH_3$ so no iodoform, not an aldehyde, no C=C); C = benzoic acid, C_6H_5COOH. [1½]
$CH_3CH_2C{\equiv}N + C_6H_5MgBr \rightarrow CH_3CH_2C(=NMgBr)C_6H_5 \xrightarrow{H_3O^+} CH_3CH_2COC_6H_5 + NH_3 + Mg(OH)Br$. [1]
$C_6H_5COCH_2CH_3 \xrightarrow{\text{chromic acid (drastic oxidation)}} C_6H_5COOH$. [½]

Q29. (4 marks) Answer: amino acids, nucleotides; thymine + deoxyribose + phosphoric acid; A and C.
(a) Proteins: α-amino acids; nucleic acids: nucleotides. [1] Fibrous proteins have long, thread-like polypeptide chains lying side by side, held by H-bonds and disulphide bonds (insoluble: keratin, myosin); globular proteins have chains coiled into a spherical shape (water soluble: insulin, albumin). [1]
(b) Thymine (base), 2-deoxy-D-ribose (sugar) and phosphoric acid. [1]
OR (b) DNA contains 2-deoxyribose and RNA ribose (also: DNA has thymine, RNA uracil; DNA is double stranded, RNA single stranded). [1]
(c) Fat-soluble: vitamin A (or D, E, K); water-soluble: vitamin C (or B-group). [1]

Q30. (4 marks) Answer: PCC; $KMnO_4$; salicylic acid; $(CH_3)_3CI + C_2H_5OH$.
(a) (i) Pyridinium chlorochromate (PCC) in CH_2Cl_2 (or CrO_3 in anhydrous medium). [1] (ii) Acidified (or alkaline) potassium permanganate, $KMnO_4$ (or acidified $K_2Cr_2O_7$). [1]
(b) $C_6H_5OH + NaOH \rightarrow C_6H_5ONa$; $C_6H_5ONa + CO_2$ (4–7 atm, 400 K) → sodium salicylate $\xrightarrow{H^+}$ salicylic acid (2-hydroxybenzoic acid). [1]
(c) The carbon carrying –OH has no hydrogen atom, so it cannot form a C=O without breaking a C–C bond. [1]
OR (c) $(CH_3)_3C–I + C_2H_5OH$: the tertiary carbocation forms (S_N1), so iodide goes to the tertiary carbon. [1]

Q31. (5 marks) Answer: (a) Fe; Ti^{3+}; Zn; (b) MnO_2, K_2MnO_4, $KMnO_4$; disproportionation.

(a) (i) (I) Fe: it has more unpaired d electrons taking part in metallic bonding, so stronger bonds (Cu has a nearly full $3d^{10}$). [1] (II) Ti^{3+} ($3d^1$): d–d transition possible; Sc^{3+} ($3d^0$) is colourless. [1] (III) Zn: its third electron must be removed from the stable, completely filled $3d^{10}$ of Zn^{2+} (Cr^{2+} is $3d^4$). [1]

(ii) (I) $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ [1] (II) $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$ [1]

OR (b) (i) A = MnO_2, B = K_2MnO_4 (potassium manganate), C = $KMnO_4$. [1½]

$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$; $MnO_4^{2-} \rightarrow MnO_4^- + e^-$ (electrolytic oxidation at the anode). [1½]

(ii) In acid the manganate disproportionates into permanganate and MnO_2: $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$. This is a disproportionation reaction. [2]

Q32. (5 marks) Answer: (a) hemiacetal; benzyl alcohol + sodium benzoate; ethanoic anhydride; iodoform test; PCC; (b) $(CH_3)_2C{=}NNHCONH_2$; methylcyclohexane.

(a) (i) (I) The hemiacetal $CH_3CH(OH)OCH_3$ (1-methoxyethanol); with excess methanol it goes on to the acetal $CH_3CH(OCH_3)_2$. [1] (II) Cannizzaro reaction: benzyl alcohol + sodium benzoate. [1] (III) Ethanoic anhydride, $(CH_3CO)_2O$ (dehydration). [1]

(ii) Iodoform test: ethanal (CH_3CHO) gives a yellow precipitate of CHI_3 with I_2/NaOH; propanal does not. [1]

(iii) Pyridinium chlorochromate (PCC), which does not attack the C=C. [1]

OR (b) (i) $(CH_3)_2C{=}N{-}NH{-}CO{-}NH_2$. [1]

(ii) The carbonyl group withdraws electrons (−I) and the carbanion (enolate) formed on losing α-H^+ is stabilised by resonance with C=O. [1]

(iii) $(CH_3)_3C{-}CO{-}CH_3 < CH_3COCH_3 < CH_3CHO$. [1]

(iv) Toluene + CrO_2Cl_2 (in CS_2) → chromium complex —H_3O^+→ benzaldehyde. [1]

(v) Clemmensen reduction: –CHO → $–CH_3$, giving methylcyclohexane. [1]

Q33. (5 marks) Answer: (a) −0.819 V; (b) 39.05 S cm² mol^{-1}, α = 0.1.

(a) (i) $Zn^{2+} + 2e^- \rightarrow Zn$: $E = E° - (0.059/2)\log(1/[Zn^{2+}]) = -0.76 - 0.0295 \log 100 = -0.76 - 0.059 = -0.819$ V. [2]

(ii) Anode: $Zn \rightarrow Zn^{2+} + 2e^-$. Cathode: $MnO_2 + NH_4^+ + e^- \rightarrow MnO(OH) + NH_3$. Overall: $Zn + 2MnO_2 + 2NH_4^+ \rightarrow Zn^{2+} + 2MnO(OH) + 2NH_3$. [2]

(iii) At equilibrium $E_{cell} = 0$ and $Q = K$, so the Nernst equation gives $E°_{cell} = (0.059/n)\log K_c$; E_{cell} changes with concentrations and is zero at equilibrium, so it cannot give K. [1]

OR (b) (i) $\Lambda_m = \kappa \times 1000/C = 3.905 \times 10^{-5} \times 1000/0.001 = 39.05$ S cm² mol^{-1}. [1]

$\Lambda°_m = 349.6 + 40.9 = 390.5$ S cm² mol^{-1}; $\alpha = 39.05/390.5 = 0.1$. [2]

(ii) (I) The overall reaction, Zn(Hg) + HgO → ZnO + Hg, involves no ions in solution whose concentration changes. [1] (II) It completes the inner circuit and keeps both half-cells electrically neutral (and removes the liquid junction potential). [1]

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