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

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

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 56/1/1). 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 56/1/1, as published by CBSE at cbse.gov.in; graphs 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.

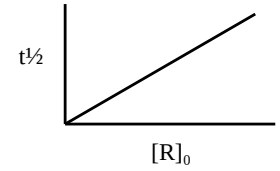
Chapters: Full syllabus · **Topics:** Solutions · Electrochemistry · Chemical Kinetics · d- and f-Block Elements · Coordination Compounds · Haloalkanes and Haloarenes · Alcohols, Phenols and Ethers · Aldehydes, Ketones and Carboxylic Acids · Amines · Biomolecules

SECTION A

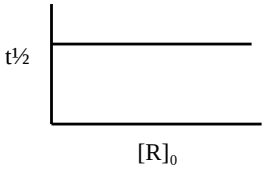
Multiple choice questions of 1 mark each (Q13–16 assertion-reason).

1. Which of the following curve represents the first order reaction ? 1

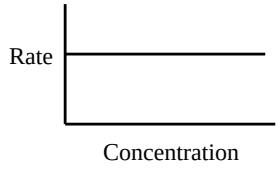
(A)



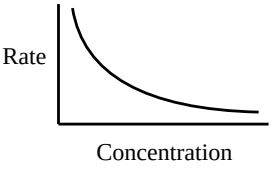
(B)



(C)



(D)



2. Which of the following solutions will have the lowest freezing point in water ? 1

(A) 0.1 M Glucose (B) 0.1 M $CaCl_2$

(C) 0.1 M KCl (D) 0.1 M Urea

3. Which of the following is <u>not</u> a transition metal ? 1

(A) Sc (B) Ag

(C) Hg (D) Cu

4. Which of the following represents the fraction of molecules with energies equal to or greater than E_a ? 1

(A) $+\frac{E_a}{RT}$ (B) $e^{-E_a/RT}$

(C) $-\frac{E_a}{RT}$ (D) $e^{+E_a/RT}$

5. What will happen during the electrolysis of aqueous solution of $CuCl_2$ by using platinum electrodes ? 1

(A) Cu will deposit at Anode (B) H_2 gas will be released at cathode

(C) O_2 gas will be released at anode (D) Cl_2 gas will be released at anode

6. Aspirin is obtained by acetylation of 1

(A) Phenol (B) Salicylaldehyde

(C) 2-Hydroxybenzoic acid (D) Benzoic acid

7. The secondary valency of Co in the complex $[Co(NH_3)_5(NO_2)]^{2+}$ is 1

(A) 5 (B) 1

(C) 4 (D) 6

8. At low temperature, phenol reacts with dil. HNO_3 to yield 1

(A) 2, 4, 6-Trinitrophenol
(B) o-Nitrophenol only
(C) p-Nitrophenol only
(D) ortho-and para-nitrophenol

9. Which of the following is 'not' true about enantiomers ? 1

(A) They have the same chemical reactivity.
(B) They have the same specific rotation.
(C) They have the same melting or boiling point.
(D) They have the same refractive index.

10. Aniline on direct nitration yields 1

(A) 51%-ortho, 47%-para, 2%-meta derivatives
(B) 51%-meta, 47%-ortho, 2%-para derivatives
(C) 51%-para, 47%-meta, 2%-ortho derivatives
(D) 51%-ortho, 47%-meta, 2%-para derivatives

11. Which of the following amines has lowest pK_b value ? 1

(A) $C_6H_5 – N(CH_3)_2$
(B) $C_6H_5 – NH(CH_3)$
(C) $C_6H_5 – NH_2$
(D) $O_2N–C_6H_4–NH_2$ (para)

12. The deficiency of which of the following vitamins causes increased fragility of red blood cells and muscular weakness : 1

(A) Vitamin A
(B) Vitamin K
(C) Vitamin E
(D) Vitamin D

13. **Assertion (A) :** It is not possible to separate the components of an azeotrope by fractional distillation. 1
Reason (R) : Components of an azeotrope have the same composition in liquid and vapour phase and boil at a constant temperature.

(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) :** The presence of –OH group in phenols directs the incoming group to meta position in the ring. 1
Reason (R) : –OH group in phenols activates the aromatic ring towards electrophilic substitution reaction.

(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) :** Actinoids show wide range of oxidation states. 1

Reason (R) : Actinoids are radioactive in nature.

(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) :** The pentaacetate of glucose does not react with $H_2N - OH$. 1

Reason (R) : It indicates the presence of free – CHO group in glucose.

(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. What type of deviation from Raoult's law is shown by a mixture of phenol and aniline ? Give reason. What will happen to the boiling point of the solution on mixing phenol and aniline ? 2

18. Why are haloarenes less reactive towards nucleophilic substitution reaction ? Give two reasons. 2

19. (a) Write IUPAC names of the following coordination compounds : (i) $[Ag(NH_3)_2]$ $[Ag(CN)_2]$ (ii) $K_3[Fe(C_2O_4)_3]$ 2

OR

(b) (i) Give a chemical test to show that $[Co(NH_3)_5SO_4]Cl$ and $[Co(NH_3)_5Cl]SO_4$ are ionisation isomers. (ii) What is meant by the 'Chelate effect' ? Give an example.

20. Differentiate between the following : (i) Peptide linkage and Glycosidic linkage (ii) Essential amino acids and Non-essential amino acids 2

21. Following reaction takes place in one step : $2A + B \longrightarrow 2C$ 2

How will the rate of above reaction change if the volume of the reaction vessel is decreased to one third of its original volume ? Will there be any change in the order of reaction with the reduced volume ?

SECTION C

Short answer questions of 3 marks each.

22. For the first order thermal decomposition reaction, following data was obtained : $C_2H_5Cl(g) \rightarrow C_2H_4(g) + HCl(g)$ 3

S. No.	Time (s)	Total Pressure (atm)
1	0	0.30
2	30	0.50

Calculate rate constant. [Given : log 3 = 0.48]

23. (a) Answer the following : (i) Why is the Equilibrium Constant (K_c) related to $E°_{cell}$ and not to E_{cell} ? (ii) Two metals 'A' and 'B' have standard electrode potential values of −0.24 V and +0.80 V respectively. Which of these will liberate hydrogen gas from dil. H_2SO_4 ? (iii) Write the cell reaction which occurs in lead storage battery when it is in charging. 3

OR

(b) What type of battery is Mercury cell ? Why it is more advantageous than dry cell ? Write overall reaction taking place in Mercury cell.

24. Calculate the boiling point of a solution containing 0.61 g of benzoic acid (Molar mass = 122 g mol^{-1}) in 5 g of CS_2 in which it dimerises to the extent of 88%. The boiling point and K_b of CS_2 are 46.2 °C and 2.3 K kg mol^{-1} respectively. 3

25. Write the reactions of D-Glucose with the following : (a) HI (b) Br_2 water (c) Conc. HNO_3 3

26. Give reasons for the following : (a) Carboxylic acids have higher boiling point than alcohols of comparable molecular masses. (b) Alpha (α) hydrogens of aldehydes and ketones are acidic in nature. (c) Nucleophilic addition of ammonia and its derivatives does not occur with carbonyl group in strongly acidic medium. 3

27. Write the reaction involved in the following : (a) Reimer-Tiemann reaction (b) Kolbe's reaction (c) Friedal-Crafts acylation of anisole 3

28. Compound 'X' with molecular formula C_4H_9Br reacts with aqueous KOH to give an alcohol. The rate of this reaction depends only on the concentration of the compound 'X'. When an optically active isomer 'Y' of the compound 'X' was treated with aqueous KOH solution, the rate of reaction was found to be dependent on concentration of compound 'Y' and aqueous KOH both. 3

(a) Write down the structural formula of both 'X' and 'Y'.

(b) Out of 'X' and 'Y', which one will undergo racemisation and why ?

(c) Out of 'X' and 'Y', which one will form product with inversion of configuration and why ?

SECTION D

Case-based questions of 4 marks each.

29. The reaction of amines with mineral acids to form ammonium salts shows that these are basic in nature. Aliphatic amines are stronger bases than ammonia whereas aromatic amines are weaker bases than ammonia. Aliphatic and aromatic primary and secondary amines react with acid chlorides, anhydrides and esters by nucleophilic substitution reaction. The main problem encountered during electrophilic substitution reactions of aromatic amines is that of their high reactivity. Substitution tends to occur at ortho-and para-positions. Hinsberg reagent is used for the identification and distinction between primary, secondary and tertiary amines. Aryldiazonium salts, usually obtained from arylamines, undergo replacement of the diazonium group with a variety of nucleophiles to provide advantageous methods for producing aryl halides, cyanides, phenols and arenes.
Answer the following questions :

(a) (i) Why $CH_3 – NH_2$ is a stronger base than $(CH_3)_3N$ in aqueous solution ? (ii) Write structural formulae of the compound A and B : $CH_3CONH_2 \xrightarrow{(NaOBr)} A \xrightarrow{(C_6H_5COCl,\ Base)} B$ [2]

(b) A compound 'X' with molecular formula C_3H_9N reacts with Hinsberg reagent to give a product insoluble in alkali. Identify 'X'. [1]

OR

(b) How can you convert aniline to benzonitrile ? [1]

(c) Why is $–NH_2$ group of aniline acetylated before carrying out nitration ? [1]

30. The Valence Bond Theory (VBT) explains the formation, magnetic behaviour and geometry of coordination compounds. The Crystal Field Theory (CFT) of coordination compounds is based on the effect of different crystal fields (provided by the ligands taken as point charges), on the degeneracy of d-orbital energies of the central metal atom/ion. The splitting of the d-orbitals provides different electronic arrangements in strong and weak crystal fields.
Answer the following questions :

(a) In octahedral crystal field, energies of which d-orbitals will be raised when ligands approach the central metal atom/ion ? Give reason in support of your answer. [2]

(b) Using crystal field theory, write the electronic configuration of central metal atom/ion of the following : (i) $[CoF_6]^{3-}$ (ii) $[Co(NH_3)_6]^{3+}$ [At. No. : Co = 27] [1]

(c) $[NiCl_4]^{2-}$ is paramagnetic while $[Ni(CO)_4]$ is diamagnetic though both are tetrahedral. Why ? [Atomic No. : Ni = 28] [1]

OR

(c) Write hybridization and magnetic behaviour of the complex $[Fe(CN)_6]^{3-}$. [Atomic No. : Fe = 26] [1]

SECTION E

Long answer questions of 5 marks each.

31. (a) (i) An organic compound (X) has the molecular formula $C_5H_{10}O$. Draw structures for (X) if it : (I) does not give Tollen's test but gives a positive iodoform test. (II) does not give Tollen's test and iodoform test but undergoes Aldol condensation. (III) undergoes Cannizzaro's reaction. [3] 5
(ii) Show how each of the following compounds can be converted to benzoic acid : (I) Acetophenone (II) Ethyl benzene [2]

OR

(b) Answer the following questions : (i) Draw structure of the 2, 4-dinitrophenyl hyzdrazone derivative of benzaldehyde. (ii) Arrange the following in increasing order of their reactivity towards HCN : Di-tert. butyl ketone, Acetaldehyde, Acetone (iii) Give a simple chemical test to distinguish between benzoic acid and ethyl benzoate. (iv) Write the name of the reagent to convert Ethanenitrile to Ethanal. (v) Draw the structure of 'X' in the following reaction : cyclohexanol (C_6H_{11}–OH) —(CrO_3)→ 'X'

32. (a) (i) From the given data of E° values, answer the following questions : 5

$E°_{M^{2+}/M}$	V	Cr	Mn	Fe	Co	Ni	Cu
(V)	−1.18	−0.91	−1.18	−0.44	−0.28	−0.25	+0.34

(I) Why $E°_{M^{2+}/M}$ show irregular trend in the above values ? (II) Why is $E°_{Cu^{2+}/Cu}$ value exceptionally positive ? (III) Why $E°_{Mn^{2+}/Mn}$ value is highly negative ? [3]

(ii) Write the ionic equations for the oxidising action of potassium permanganate for its reaction with I^- in both acidic and alkaline solutions. [2]

OR

(b) Answer the following questions : (i) Name a member of the lanthanoid series (I) which exhibits +4 oxidation state (II) which exhibits +2 oxidation state. (ii) Why transition metals act as good catalyst ? (iii) Why Cr has higher melting point than Mn ? (iv) What happens when acidic solution of potassium permanganate is allowed to stand for sometime ? Give the equation involved. What is this type of reaction called ?

33. (a) Calculate emf and ΔG for the following cell at 298 K : Mg(s) / Mg^{2+}(0.01 M) // Ag^+(0.001 M) / Ag(s) 5
Given : $E°_{Mg^{2+}/Mg}$ = −2.37 V, $E°_{Ag^+/Ag}$ = +0.80 V [1 F = 96500 C mol^{-1}, log 10 = 1]

OR

(b) For the reaction : $2AgCl(s) + H_2(g)\ (0.4\ atm) \longrightarrow 2Ag(s) + 2H^+(0.1\ M) + 2Cl^-(0.2\ M)$
Calculate emf of the cell at 25 °C. Given : ΔG° = − 43500 J mol^{-1} [log 10 = 1, 1 F = 96500 C mol^{-1}]

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
(B)	(B)	(C)	(B)	(D)	(C)	(D)	(D)	(B)	(C)	(A)	(C)	(A)	(D)	(B)	(C)

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). For a first order reaction t½ = 0.693/k does not depend on $[R]_0$: a horizontal line (B). (A) is zero order ($t_{½} \propto [R]_0$); a constant rate (C) is also zero order.

Q2. Answer (B). $\Delta T_f = i K_f m$. $CaCl_2$ gives 3 ions (i = 3), KCl 2, glucose and urea 1. The largest ΔT_f, so the lowest freezing point, is for $CaCl_2$.

Q3. Answer (C). Zn, Cd and Hg have completely filled d^{10} orbitals in the ground state and in their common oxidation states, so they are not regarded as transition metals. Sc ($3d^1$), Cu^{2+} ($3d^9$) and Ag^{2+} ($4d^9$) have incomplete d orbitals.

Q4. Answer (B). From the Arrhenius equation k = A e^(−Ea/RT), the factor e^(−Ea/RT) is the fraction of molecules with energy ≥ Ea.

Q5. Answer (D). Cu^{2+} is reduced more easily than water, so copper deposits at the cathode. At the anode Cl^- is oxidised to Cl_2 (oxygen's overpotential makes chlorine evolve).

Q6. Answer (C). Salicylic acid (2-hydroxybenzoic acid) + acetic anhydride gives acetylsalicylic acid (aspirin).

Q7. Answer (D). Secondary valency = coordination number = 5 NH_3 + 1 NO_2 = 6. (The primary valency, the oxidation state, is +3.)

Q8. Answer (D). With dilute nitric acid at low temperature (298 K) phenol gives a mixture of o- and p-nitrophenols; conc. HNO_3 gives picric acid.

Q9. Answer (B). Enantiomers rotate plane-polarised light by equal amounts in opposite directions, so their specific rotations are equal in magnitude but opposite in sign. Their other physical properties are identical.

Q10. Answer (C). In the strongly acidic medium much aniline is protonated to the anilinium ion (meta-directing), so direct nitration gives about 51% p-, 47% m- and 2% o-nitroaniline (NCERT).

Q11. Answer (A). Lowest pK_b means the strongest base. pK_b: N,N-dimethylaniline 8.92 < N-methylaniline 9.30 < aniline 9.38; the $–NO_2$ group makes p-nitroaniline much weaker.

Q12. Answer (C). Vitamin E deficiency: increased fragility of RBCs and muscular weakness. (A: night blindness; K: delayed clotting; D: rickets.)

Q13. Answer (A). Fractional distillation needs the vapour to be richer in one component; an azeotrope boils with the same composition in liquid and vapour, so it cannot be separated. A is true and R explains it. Answer (A).

Q14. Answer (D). –OH is ortho- and para-directing: A is false. It activates the ring (+R effect): R is true. Answer (D).

Q15. Answer (B). Both are true, but the wide range of oxidation states is due to the comparable energies of the 5f, 6d and 7s levels, not radioactivity. Answer (B).

Q16. Answer (C). Glucose pentaacetate does not react with hydroxylamine: A is true. This shows the absence of a free –CHO group (glucose exists in a cyclic form): R is false. Answer (C).

Q17. (2 marks) Answer: negative deviation; boiling point increases.
Negative deviation. [½]
Reason: the phenol–aniline interaction (hydrogen bond between the –OH of phenol and the N of aniline) is stronger than the phenol–phenol and aniline–aniline interactions, so the vapour pressure falls. [1]
The boiling point rises (it forms a maximum-boiling azeotrope at a particular composition). [½]

Q18. (2 marks) Answer: see the model answer.
Any two: (i) resonance gives the C–X bond partial double-bond character, so it is harder to break; (ii) the carbon is sp^2 hybridised, more electronegative, so the C–X bond is shorter and stronger; (iii) the phenyl cation is not stabilised by resonance, so S_N1 does not occur; (iv) the electron-rich ring repels the approaching nucleophile. [1 + 1]

Q19. (2 marks) Answer: (a) diamminesilver(I) dicyanidoargentate(I); potassium trioxalatoferrate(III).
(a) (i) Diamminesilver(I) dicyanidoargentate(I). [1] (ii) Potassium trioxalatoferrate(III). [1]
OR (b) (i) With $BaCl_2$ solution, $[Co(NH_3)_5Cl]SO_4$ gives a white precipitate of $BaSO_4$ (free SO_4^{2-}); $[Co(NH_3)_5SO_4]Cl$ does not, but it gives a white precipitate of AgCl with $AgNO_3$ (free Cl^-). [1]
(ii) A chelating (polydentate) ligand forms a ring with the metal and gives a more stable complex than the same number of similar monodentate ligands: e.g. $[Ni(en)_3]^{2+}$ is more stable than $[Ni(NH_3)_6]^{2+}$. [1]

Q20. (2 marks) Answer: see the model answer.
(i) A peptide linkage (–CO–NH–) joins amino acids in proteins; a glycosidic linkage (–O–) joins monosaccharide units in di- and polysaccharides. [1]
(ii) Essential amino acids cannot be made by the body and must come from food (e.g. valine, leucine); non-essential ones are made by the body (e.g. glycine, alanine). [1]

Q21. (2 marks) Answer: rate becomes 27 times; order unchanged (3).
One step (elementary): rate = $k[A]^2[B]$. Reducing the volume to one third makes each concentration three times. [½]
New rate = $k(3[A])^2(3[B]) = 27 \times$ the original rate. [1]
No change in order: it stays 3. [½]

Q22. (3 marks) Answer: $3.68 \times 10^{-2}\ s^{-1}$.
If the pressure of C_2H_5Cl falls by x, the total pressure is $P_0 + x$: $0.30 + x = 0.50$, $x = 0.20$ atm, so the reactant pressure is $0.30 - 0.20 = 0.10$ atm. [1]
$k = (2.303/t) \log(P_0/(P_0 - x)) = (2.303/30) \log(0.30/0.10)$ [1]
$= (2.303 \times 0.48)/30 = 3.68 \times 10^{-2}\ s^{-1}$. [1]

Q23. (3 marks) Answer: see the model answer.
(a) (i) At equilibrium E_cell = 0, and the Nernst equation then gives E°_cell = (2.303RT/nF) log K_c; E_cell changes with concentrations and is zero at equilibrium. [1]
(ii) A, because its E° is negative (it lies below hydrogen). [1]
(iii) $2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$. [1]
OR (b) A primary battery. [1]
It gives a constant voltage (about 1.35 V) throughout its life, because the overall reaction has no ions whose concentration changes. [1]
$Zn(Hg) + HgO(s) \rightarrow ZnO(s) + Hg(l)$. [1]

Q24. (3 marks) Answer: 47.49 °C.
Molality $m = (0.61/122)/0.005 = 0.005/0.005 = 1\ mol\ kg^{-1}$. [½]
$2C_6H_5COOH \rightleftharpoons (C_6H_5COOH)_2$ with $\alpha = 0.88$: $i = 1 - \alpha/2 = 1 - 0.44 = 0.56$. [1]
$\Delta T_b = i K_b m = 0.56 \times 2.3 \times 1 = 1.288$ K. [1]
Boiling point = 46.2 + 1.29 = 47.49 °C. [½]

Q25. (3 marks) Answer: (a) n-hexane; (b) gluconic acid; (c) saccharic acid.
(a) Prolonged heating with HI gives n-hexane: $CHO–(CHOH)_4–CH_2OH \rightarrow CH_3–(CH_2)_4–CH_3$. [1]
(b) Bromine water oxidises the –CHO group: gluconic acid, $COOH–(CHOH)_4–CH_2OH$. [1]
(c) Conc. HNO_3 oxidises both ends: saccharic (glucaric) acid, $COOH–(CHOH)_4–COOH$. [1]

Q26. (3 marks) Answer: see the model answer.
(a) Carboxylic acids form more extensive intermolecular hydrogen bonding, existing as dimers even in the vapour phase. [1]
(b) The C=O group is strongly electron-withdrawing and the carbanion (enolate) formed after losing an α-H is stabilised by resonance. [1]
(c) In strongly acidic medium ammonia and its derivatives are protonated (e.g. NH_4^+), lose their lone pair and are no longer nucleophiles. [1]

Q27. (3 marks) Answer: see the model answer.
(a) Phenol + $CHCl_3$ + aq. NaOH (343 K), then H^+: salicylaldehyde (2-hydroxybenzaldehyde). [1]
(b) Sodium phenoxide + CO_2 (4–7 atm, 400 K), then H^+: salicylic acid (2-hydroxybenzoic acid). [1]
(c) Anisole + CH_3COCl, anhyd. $AlCl_3$: 2-methoxyacetophenone (minor) and 4-methoxyacetophenone (major). [1]

Q28. (3 marks) Answer: X = $(CH_3)_3CBr$, Y = $CH_3CH_2CHBrCH_3$; (b) X (S_N1); (c) Y (S_N2).
(a) X (S_N1, rate = k[X]): 2-bromo-2-methylpropane, $(CH_3)_3C–Br$. Y (S_N2, rate = k[Y][OH^-], chiral): 2-bromobutane, $CH_3CH_2CH(Br)CH_3$. [1]
(b) X: it reacts by S_N1 through a planar carbocation, which the nucleophile can attack from either face; for a chiral substrate this gives a racemic mixture. (X itself is achiral, so its product is not optically active.) [1]
(c) Y: S_N2 is a one-step backside attack, so the configuration is inverted (Walden inversion). [1]

Q29. (4 marks) Answer: (a)(ii) A = CH_3NH_2, B = $C_6H_5CONHCH_3$; (b) $CH_3NHC_2H_5$.
(a)(i) In water the $CH_3NH_3^+$ ion is stabilised much more by hydrogen bonding with water (solvation) than $(CH_3)_3NH^+$, which has only one N–H; steric crowding in the tertiary amine also hinders solvation. [1]
(a)(ii) Hoffmann bromamide degradation: A = CH_3NH_2 (methanamine); B = $C_6H_5CONHCH_3$ (N-methylbenzamide). [1]
(b) A secondary amine gives an alkali-insoluble sulphonamide: X = N-methylethanamine, $CH_3–NH–C_2H_5$. [1]
OR (b) Aniline + $NaNO_2$/HCl (273–278 K) → benzenediazonium chloride; then CuCN/KCN → benzonitrile, C_6H_5CN. [1]
(c) To reduce the strong activating effect of $–NH_2$ and protect it from oxidation, so that mainly the p-nitro product is obtained (the acetyl group is removed afterwards). [1]

Q30. (4 marks) Answer: (a) e_g; (b) $t2g^4eg^2$, $t2g^6eg^0$; (c) see model answer.
(a) The e_g orbitals ($d_{x^2-y^2}$ and d_{z^2}) are raised (the t_{2g} set is lowered). [1] Their lobes point along the axes, directly at the approaching ligands, so they are repelled more. [1]
(b) Co^{3+} is $3d^6$. (i) F^- is a weak field ligand: $t_{2g}^4\ e_g^2$ (high spin). (ii) NH_3 is a strong field ligand here: $t_{2g}^6\ e_g^0$ (low spin). [½ + ½]
(c) In $[NiCl_4]^{2-}$, Ni^{2+} ($3d^8$) with the weak ligand Cl^- keeps two unpaired electrons (sp^3): paramagnetic. In $[Ni(CO)_4]$, Ni(0) with the strong ligand CO has the configuration $3d^{10}$ (4s electrons paired into 3d), no unpaired electrons (sp^3): diamagnetic. [1]
OR (c) Fe^{3+} ($3d^5$) with strong field CN^-: d^2sp^3 hybridisation (inner orbital, octahedral), one unpaired electron: paramagnetic. [1]

Q31. (5 marks) Answer: see the model answer.

(a) (i)(I) A methyl ketone: pentan-2-one, $CH_3COCH_2CH_2CH_3$ (or 3-methylbutan-2-one, $CH_3COCH(CH_3)_2$). [1]

(II) A ketone with α-H but no $CH_3CO–$ group: pentan-3-one, $CH_3CH_2COCH_2CH_3$. [1]

(III) An aldehyde with no α-H: 2,2-dimethylpropanal, $(CH_3)_3C–CHO$. [1]

(ii)(I) $C_6H_5COCH_3$ + NaOI (I_2/NaOH), then $H^+ \rightarrow C_6H_5COOH + CHI_3$ (or $KMnO_4$/KOH, then H^+). [1]

(II) $C_6H_5CH_2CH_3$ + $KMnO_4$/KOH, heat, then $H_3O^+ \rightarrow C_6H_5COOH$. [1]

OR (b) (i) $C_6H_5–CH=N–NH–C_6H_3(NO_2)_2$ (2,4-dinitro on the phenyl ring). [1]

(ii) Di-tert-butyl ketone < Acetone < Acetaldehyde. [1]

(iii) $NaHCO_3$ solution: benzoic acid gives brisk effervescence of CO_2; ethyl benzoate does not. [1]

(iv) $SnCl_2$ + HCl, then H_3O^+ (Stephen reaction); or DIBAL-H, then H_2O. [1]

(v) X = cyclohexanone. [1]

Q32. (5 marks) Answer: see the model answer.

(a) (i)(I) The irregular variation of ionisation enthalpies (IE_1 + IE_2) and of the sublimation (atomisation) enthalpies across the series. [1]

(II) For Cu the high enthalpy of atomisation and ionisation is not balanced by its hydration enthalpy. [1]

(III) Mn^{2+} has the stable half-filled $3d^5$ configuration. [1]

(ii) Acidic: $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$. [1] Neutral or faintly alkaline: $2MnO_4^- + I^- + H_2O \rightarrow 2MnO_2 + IO_3^- + 2OH^-$. [1]

OR (b) (i)(I) Cerium (Ce^{4+}). (II) Europium or ytterbium (Eu^{2+}, Yb^{2+}). [½ + ½]

(ii) They show variable oxidation states and can form complexes; their surfaces adsorb the reactants and form unstable intermediates. [1]

(iii) Cr ($3d^54s^1$) has more unpaired electrons for metallic bonding; Mn ($3d^54s^2$) has a stable half-filled configuration with weaker metallic bonding. [1]

(iv) It slowly decomposes, faster in light: $4MnO_4^- + 4H^+ \rightarrow 4MnO_2 + 3O_2 + 2H_2O$. [1] It is a (photo-catalysed) decomposition, a redox reaction in which Mn is reduced and oxygen is oxidised. [1]

Q33. (5 marks) Answer: (a) 3.05 V, −589 kJ mol^{-1}; (b) 0.314 V.

(a) Cell reaction: $Mg + 2Ag^+ \rightarrow Mg^{2+} + 2Ag$, n = 2. E°cell = 0.80 − (−2.37) = 3.17 V. [1]

$E = E° - (0.059/2) \log([Mg^{2+}]/[Ag^+]^2) = 3.17 - 0.0295 \log(0.01/10^{-6})$ [1½]

$= 3.17 - 0.0295 \times 4 = 3.05$ V. [1]

$\Delta G = -nFE = -2 \times 96500 \times 3.05 \approx -5.89 \times 10^5$ J mol^{-1} (−589 kJ mol^{-1}). [1½]

OR (b) n = 2: $E° = -\Delta G°/nF = 43500/(2 \times 96500) = 0.225$ V. [1½]

$E = E° - (0.059/2) \log([H^+]^2[Cl^-]^2/p(H_2)) = 0.225 - 0.0295 \log((0.1)^2(0.2)^2/0.4)$ [1½]

$(0.01 \times 0.04)/0.4 = 10^{-3}$, so $E = 0.225 - 0.0295 \times (-3) = 0.225 + 0.089 = 0.314$ V. [2]

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