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CBSE Class 12 Chemistry Board Paper 2026 (56/4/1) with Solutions

PREVIOUS YEAR PAPER · CLASS XII · CHEMISTRY (043) · BOARD EXAM 2026 · Q.P. CODE 56/4/1

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 56/4/1). 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 56/4/1, 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. Oxidation of chloroform by air in the presence of sunlight produces a poisonous gas known as : 1

(A) Mustard gas
(B) Tear gas
(C) Chlorine gas
(D) Phosgene gas

2. Lucas reagent produces cloudiness immediately with : 1

(A) 2-methyl-1-propanol
(B) Butan-2-ol
(C) 2-methyl-2-propanol
(D) Butan-1-ol

3. Which of the following d-orbitals experience more repulsion in the crystal field splitting of octahedral complex ? 1

(A) d_{xy} , d_{yz} , d_{xz}
(B) $d_{x^2-y^2}$, d_{z^2}
(C) d_{xy} , $d_{x^2-y^2}$
(D) d_{xz} , d_{z^2}

4. The chelating ligand used for the treatment of lead poisoning is : 1

(A) Ethane-1,2-diamine
(B) Oxalate ion
(C) Dimethylglyoxime
(D) EDTA

5. Manganate ion is paramagnetic due to the presence of : 1

(A) one unpaired electron
(B) two unpaired electrons
(C) three unpaired electrons
(D) fully paired electrons

6. The correct order of decreasing basicities of $C_2H_5NH_2$, $(C_2H_5)_2NH$ and $(C_2H_5)_3N$ in aqueous solution is : 1

(A) $(C_2H_5)_3N > (C_2H_5)_2NH > C_2H_5NH_2$
(B) $(C_2H_5)_2NH > C_2H_5NH_2 > (C_2H_5)_3N$
(C) $C_2H_5NH_2 > (C_2H_5)_2NH > (C_2H_5)_3N$
(D) $(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2$

7. The boiling point of one molal NaCl solution, assuming NaCl to be completely dissociated in water is : 1
(K_b for water = 0·52 K kg mol^{-1})

(A) 100·52ºC
(B) 101·04ºC
(C) 100·04ºC
(D) 101·52ºC

8. When a liquid and its vapour are at equilibrium and the pressure is suddenly decreased : 1

(A) vapour pressure of the solution increases
(B) heating occurs
(C) cooling occurs
(D) equilibrium remains unaffected

9. Consider the following cell at 298 K : 1

Mg (s) | Mg^{2+} (1·0 M) || Cu^{2+} (1·0 M) | Cu (s)

How can we increase the emf of the cell using the same substances ?

(A) By decreasing only the [Mg^{2+}] to 0·1 M
(B) By decreasing only the [Cu^{2+}] to 0·1 M
(C) By increasing both [Mg^{2+}] and [Cu^{2+}] to 2·0 M
(D) By increasing only the [Mg^{2+}] to 2·0 M

10. The rate of a first order reaction is $5{\cdot}6 \times 10^{-4}$ mol L^{-1} s^{-1}, when the concentration of reactant is 0·2 mol L^{-1}. The rate constant 'k' is : 1

(A) $5{\cdot}6 \times 10^{-3}$ s^{-1} (B) $2{\cdot}8 \times 10^{-4}$ s^{-1}

(C) $2{\cdot}8 \times 10^{-5}$ s^{-1} (D) $2{\cdot}8 \times 10^{-3}$ s^{-1}

11. Nucleic acids are polymers of : 1

(A) amino acids (B) nucleosides

(C) nucleotides (D) pentose sugar

12. In the reaction of NaOBr with amide, the carbonyl carbon is lost as : 1

(A) HCO_3^- (B) CO_3^{2-}

(C) CO_2 (D) CO

13. **Assertion (A) :** Alcohols act as Bronsted bases as well as Bronsted acids. 1
Reason (R) : It is due to the presence of unshared electron pairs on oxygen atom and presence of polar O – H bond.

(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) :** Diazonium salts of aromatic amines are more stable than those of aliphatic amines. 1
Reason (R) : Diazonium salts of aliphatic amines undergo resonance.

(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) :** For complex reaction, order of reaction is given by the slowest step. 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.

16. **Assertion (A) :** $E^{\circ}_{Sc^{3+}/Sc^{2+}}$ has low value. 1

Reason (R) : Because of the stability of Sc^{3+} ion which has a noble gas configuration.

(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. (a) Reactions of which order will show the rate to be independent of the concentration of the reactant ? Give one example of this order. 2

(b) State the condition under which a bimolecular reaction may be kinetically a first order reaction.

18. (a) Explain the following with the help of Henry's law : 2

(i) Bends (ii) Anoxia

OR

(b) How does sprinkling of salt help in clearing the snow covered roads in hilly areas ? Write the name of the colligative property involved in this process.

19. Write IUPAC names of the following compounds : 2

(a) $[Cr(NH_3)_4\ (ONO)Cl]\ NO_3$

(b) $Na[Ag(CN)_2]$

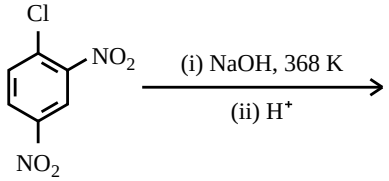
20. What are the hydrolysis products of the following ? 2

(a) Lactose

(b) DNA containing Thymine

21. Draw the structures of major product(s) in each of the following reactions : 2

(a)



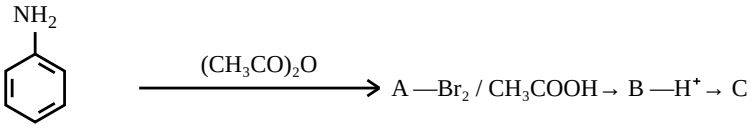
(b) $CH_3CH = C(CH_3)_2 + HBr \rightarrow$

SECTION C

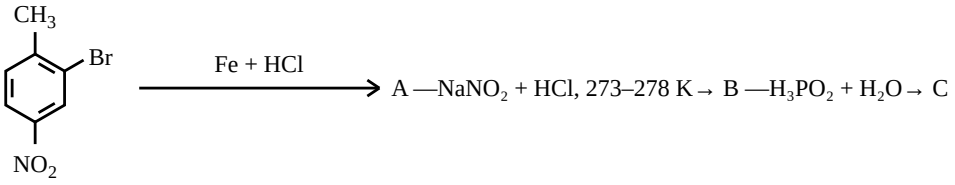
Short answer questions of 3 marks each.

22. Write the structures of A, B and C in the following reactions : 3

(a)



(b)



23. What happens when : 3

(a) Propanenitrile is treated with phenyl magnesium bromide followed by hydrolysis ?

(b) p-fluorotoluene is treated with CrO_3 in the presence of acetic anhydride followed by hydrolysis with aqueous acid.

(c) Phthalic acid is treated with NH_3 followed by heating ?

Write chemical reactions in support of your answer.

24. Answer the following questions : 3

(a) Why is direct current (DC) not used to measure the resistance of an ionic solution ?

(b) Why are the products of electrolysis different for the electrolysis of aqueous solution of $AgNO_3$ with silver electrodes and electrolysis of aqueous solution of $AgNO_3$ with platinum electrodes ?

(c) Why are magnesium blocks fixed to the iron pipelines carrying water ?

25. (a) When a coordination compound $CoCl_3 \cdot 6NH_3$ is mixed with excess of $AgNO_3$ solution, 3 moles of AgCl are precipitated per mole of the compound. Write the structural formula of the complex, IUPAC name, its hybridisation and magnetic behaviour on the basis of valence bond theory. 3

OR

(b) (i) How many geometrical isomers are possible in each of the following complexes ?

(I) $[Cr(C_2O_4)_3]^{3-}$ (II) $[Co(NH_3)_3Cl_3]$

(ii) $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex. Why ?

[Atomic number : Co = 27, Ni = 28]

(iii) Write the formula of Wilkinson catalyst and its use.

26. Calculate the vapour pressure of a solution containing 61 g of benzoic acid (molar mass = 122 g mol^{-1}) dissolved in 500 g of benzene when the vapour pressure of pure benzene at this temperature of experiment is 66 torr. Assume complete dimerization of benzoic acid in benzene. 3

27. Consider the decomposition of hydrogen peroxide (H_2O_2) as per the equation given below : 3

$2H_2O_2 \xrightarrow{(I^-,\ \text{Alkaline medium})} 2H_2O + O_2$

The mechanism for this reaction was found to be :

Step I : $H_2O_2 + I^- \longrightarrow H_2O + IO^-$ (slow)

Step II : $H_2O_2 + IO^- \longrightarrow H_2O + I^- + O_2$ (fast)

(a) Write the rate law expression.

(b) Determine the order of reaction with respect to H_2O_2, I^- and overall order of reaction.

(c) What is the molecularity of the reaction in Step II ?

28. Answer the following : 3

(a) Which isomer of C_4H_9Br is most reactive towards S_N1 reaction ?

(b) Predict the alkene that would be formed by dehydrohalogenation of 1-Bromo-1-methylcyclohexane.

(c) Although chlorine shows strong – I effect, yet it is ortho- and para-directing in electrophilic aromatic substitution reactions. Why ?

SECTION D

Case-based questions of 4 marks each.

29. Alcohols and Phenols are acidic in nature. Electron withdrawing groups in phenol increase its acidic strength and electron releasing groups decrease it. Alcohols undergo nucleophilic substitution with hydrogen halides to yield alkyl halides. Dehydration of alcohols gives alkenes. On oxidation, primary alcohols yield aldehydes with mild oxidising agents and carboxylic acids with strong oxidising agents, while secondary alcohols yield ketones. Tertiary alcohols are resistant to oxidation. 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.

Answer the following questions :

(a) Write the mechanism of acid dehydration of ethanol to yield ethene. [2]

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

OR

(b) Write the structure of the major product expected from the dinitration of 3-methylphenol. [1]

(c) Why is ortho-nitrophenol more acidic than ortho-methoxyphenol ? [1]

30. Carbohydrates are optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis. They have been broadly classified into three groups — monosaccharides, oligosaccharides and polysaccharides. The carbohydrates may also be classified as either reducing or non-reducing sugars. An important monosaccharide glucose is an aldohexose and is correctly named as D(+)–glucose. It was assigned the open structure on the basis of its reactions with HI, NH_2OH, Br_2 water, $(CH_3CO)_2O$ and nitric acid.

Despite having the – CHO group, glucose does not give Schiff's test and hydrogen sulphite addition product with $NaHSO_3$. It was found that glucose forms a six-membered ring in which one of the – OH groups add to the – CHO group and form a cyclic hemiacetal structure.

Answer the following questions :

(a) How do you explain the following ?

(i) Presence of a carbonyl group in glucose

(ii) Presence of five – OH groups in glucose which are attached to different carbon atoms. [2]

(b) What type of carbohydrates are called reducing sugars ? [1]

(c) In D(+)–glucose, what do the letter 'D' and sign '(+)' represent ? [1]

OR

(c) Draw the six-membered ring structure of α–D(+)–glucose. [1]

SECTION E

Long answer questions of 5 marks each.

31. (a) (i) Account for the following : 5

(I) MnO is basic while Mn_2O_7 is acidic.

(II) Iron has higher enthalpy of atomization than that of copper.

(III) Mn^{3+} is a stronger oxidising agent than Cr^{3+}.

(ii) How do you prepare potassium dichromate from sodium chromate ? Write balanced chemical equation for each step.

OR

(b) Answer the following questions :

(i) Why is chemistry of actinoids more complicated as compared to lanthanoids ?

(ii) $E^\circ_{M^{2+}/M}$ values are not regular for first row transition elements (3d series). Why ?

(iii) Identify the following : (I) Oxoanion of chromium which is stable in acidic medium. (II) The lanthanoid element that exhibits +4 oxidation state.

(iv) Write the products obtained on heating $KMnO_4$.

(v) Predict which of the following ions will be coloured in aqueous solution : Cu^+, Sc^{3+}, Fe^{2+}, Ti^{3+}, Zn^{2+}

32. (a) (i) How will you bring about the following conversions : 5

(I) Bromobenzene to 1-phenylethanol

(II) Benzene to m-nitroacetophenone

(ii) An organic compound with the molecular formula C_8H_8O forms 2,4-DNP derivative, reduces Tollens' reagent and undergoes Cannizzaro reaction. On vigorous oxidation with acidic or alkaline $KMnO_4$ it gives Benzene-1,2-dicarboxylic acid. Identify the compound and write the products when it undergoes Cannizzaro reaction.

(iii) Arrange the following compounds in increasing order of their acid strength : C_6H_5COOH, $O_2N - CH_2 - COOH$, $CF_3 - COOH$, HCOOH

OR

(b) (i) Write the products formed when benzaldehyde reacts with the following reagents :

(I) 2,4-Dinitrophenylhydrazine

(II) Acetophenone in the presence of dilute NaOH followed by heating

(ii) Give reasons for the following :

(I) Benzoic acid does not undergo Friedel-Crafts reaction.

(II) Carboxylic acids have higher boiling point than alcohols of comparable molecular mass.

(iii) Write simple chemical test to distinguish between propanal and propanone.

33. (a) (i) Calculate $E°_{cell}$ for the following reaction which is at equilibrium : 5

$Cu\ (s) + 2Ag^+\ (aq) \rightleftharpoons Cu^{2+}\ (aq) + 2Ag\ (s)$

Equilibrium constant (K_c) for the cell is 10^{15}. [Given : log 10 = 1]

(ii) Write anode, cathode and overall reaction of lead storage battery when it is in use.

(iii) How much electricity is required in coulombs for the oxidation of 1 mol of FeO to Fe_2O_3 ?

OR

(b) (i) Conductivity of 0·0024 M acetic acid is $7·2 \times 10^{-5}$ S cm^{-1}. If $\Lambda°_m$ for acetic acid is 390·5 S cm^2 mol^{-1}, then calculate the degree of dissociation (α) of acetic acid.

(ii) Calculate the cell potential for the following half cell reaction at 25°C : $Ag^+\ (aq) + 1\ e^- \rightarrow Ag\ (s)$.

Given that : $[Ag^+] = 0·01$ M and $E°_{Ag^+/Ag} = + 0·80$ V [log 10 = 1]

(iii) Write the name of the electrolyte used in : (I) Dry cell (II) Fuel cell ($H_2 - O_2$)

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
(D)	(C)	(B)	(D)	(A)	(D)	(B)	(C)	(A)	(D)	(C)	(B)	(A)	(C)	(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 (D). $2CHCl_3 + O_2 \xrightarrow{\text{light}} 2COCl_2 + 2HCl$: carbonyl chloride, phosgene.

Q2. Answer (C). Tertiary alcohols react at once with conc. $HCl/ZnCl_2$ (stable tertiary carbocation): 2-methyl-2-propanol. Secondary alcohols take about 5 minutes; primary ones do not react at room temperature.

Q3. Answer (B). In an octahedron the ligands lie along the axes; $d(x^2-y^2)$ and $d(z^2)$ point at them and are raised (e_g).

Q4. Answer (D). Lead is removed by forming a stable chelate with EDTA (as calcium disodium EDTA).

Q5. Answer (A). In MnO_4^{2-} manganese is +6, $3d^1$: one unpaired electron (permanganate, Mn +7, d^0, is diamagnetic).

Q6. Answer (D). For ethyl amines in water (NCERT): $(C_2H_5)_2NH$ (pK_b 3.00) > $(C_2H_5)_3N$ (3.25) > $C_2H_5NH_2$ (3.29), the balance of inductive effect, solvation and steric hindrance.

Q7. Answer (B). $i = 2$: $\Delta T_b = iK_b m = 2 \times 0.52 \times 1 = 1.04$ K, so the solution boils at 101.04 °C.

Q8. Answer (C). Lowering the pressure makes the liquid evaporate rapidly; the latent heat of vaporisation is drawn from the liquid, which cools.

Q9. Answer (A). $E = E° - (0.059/2) \log([Mg^{2+}]/[Cu^{2+}])$: lowering $[Mg^{2+}]$ (or raising $[Cu^{2+}]$) increases E. Raising both equally leaves E unchanged.

Q10. Answer (D). Rate = k[R]: $k = 5.6 \times 10^{-4}/0.2 = 2.8 \times 10^{-3}\ s^{-1}$.

Q11. Answer (C). Nucleic acids are polynucleotides: chains of nucleotides (base + sugar + phosphate).

Q12. Answer (B). Hoffmann bromamide degradation: $RCONH_2 + Br_2 + 4NaOH \rightarrow RNH_2 + Na_2CO_3 + 2NaBr + 2H_2O$; the carbonyl carbon leaves as carbonate.

Q13. Answer (A). The lone pairs on O accept a proton (Brønsted base) and the polar O–H bond can release one (Brønsted acid). R explains A. Answer (A).

Q14. Answer (C). Arenediazonium salts are stabilised by resonance with the benzene ring (A is true). It is the aromatic, not the aliphatic, diazonium salts that are resonance stabilised (R is false). Answer (C).

Q15. Answer (B). For a complex reaction the overall rate (and so the order) is decided by the slowest, rate-determining step (NCERT): A is true. Order is found experimentally: R is true, but it does not explain A. Answer (B).

Q16. Answer (A). Sc^{3+} has the stable [Ar] configuration, so it is very hard to reduce to Sc^{2+}: $E°(Sc^{3+}/Sc^{2+})$ is very low (negative). R explains A. Answer (A).

Q17. (2 marks) Answer: zero order; one reactant in large excess.
(a) Zero order reactions. Example: decomposition of ammonia on a hot platinum surface at high pressure, $2NH_3 \xrightarrow{\text{Pt, 1130 K}} N_2 + 3H_2$ (or decomposition of HI on gold). [1]
(b) When one reactant is present in large excess, so that its concentration hardly changes (pseudo first order), e.g. hydrolysis of an ester or of sucrose in a large excess of water. [1]

Q18. (2 marks) Answer: (a) Henry's law; (b) depression of freezing point.
(a) (i) Deep under water the pressure is high, so more nitrogen dissolves in a diver's blood (solubility ∝ partial pressure). On coming up quickly the pressure falls, the nitrogen comes out as bubbles in the blood and blocks capillaries: the bends, painful and dangerous. [1]
(ii) At high altitudes the partial pressure of oxygen is low, so less oxygen dissolves in the blood; climbers become weak and unable to think clearly: anoxia. [1]
OR (b) Salt dissolves in the water on the snow and lowers its freezing point, so the snow melts at the prevailing temperature and the road is cleared. [1] The property is depression of freezing point. [1]

Q19. (2 marks) Answer: see the model answer.
(a) Tetraamminechloridonitrito-O-chromium(III) nitrate. [1]
(b) Sodium dicyanidoargentate(I). [1]

Q20. (2 marks) Answer: galactose + glucose; bases, deoxyribose, phosphoric acid.
(a) β-D-galactose and β-D-glucose. [1]
(b) The nitrogenous bases (thymine, with adenine, guanine and cytosine), 2-deoxy-D-ribose and phosphoric acid. [1]

Q21. (2 marks) Answer: 2,4-dinitrophenol; 2-bromo-2-methylbutane.
(a) The two $–NO_2$ groups (ortho and para to Cl) activate the ring for nucleophilic substitution: 2,4-dinitrophenol, $HO–C_6H_3(NO_2)_2$ (OH at C1, NO_2 at C2 and C4). [1]
(b) Markovnikov addition: H goes to CH and Br to the carbon with more alkyl groups: $CH_3CH_2–CBr(CH_3)_2$, 2-bromo-2-methylbutane. [1]

Q22. (3 marks) Answer: acetanilide, p-bromoacetanilide, p-bromoaniline; 3-bromo-4-methylaniline, its diazonium salt, 2-bromotoluene.
(a) A = acetanilide, $C_6H_5NHCOCH_3$; B = 4-bromoacetanilide (the $–NHCOCH_3$ group directs Br to the para position); C = 4-bromoaniline, $Br–C_6H_4–NH_2$ (acid hydrolysis of the amide). [1½]
(b) A = 3-bromo-4-methylaniline ($–NO_2$ reduced to $–NH_2$); B = 3-bromo-4-methylbenzenediazonium chloride; C = 2-bromotoluene (1-bromo-2-methylbenzene): H_3PO_2 replaces $–N_2^+Cl^-$ by H. [1½]

Q23. (3 marks) Answer: propiophenone; p-fluorobenzaldehyde; phthalimide.
(a) $CH_3CH_2CN + C_6H_5MgBr \rightarrow CH_3CH_2C(=NMgBr)C_6H_5 \xrightarrow{H_3O^+} CH_3CH_2COC_6H_5$ (propiophenone). [1]
(b) The $–CH_3$ is oxidised to a benzylidene diacetate, which is hydrolysed to the aldehyde: $F–C_6H_4–CH_3 \xrightarrow{CrO_3}$, $(CH_3CO)_2O \rightarrow F–C_6H_4–CH(OCOCH_3)_2 \xrightarrow{H_3O^+}$ 4-fluorobenzaldehyde. [1]
(c) Phthalic acid + $NH_3 \rightarrow$ ammonium phthalate $\xrightarrow{heat}$ phthalamide $\xrightarrow{strong\ heating}$ phthalimide (+ NH_3, H_2O). [1]

Q24. (3 marks) Answer: see the model answer.
(a) DC would electrolyse the solution: the composition near the electrodes changes and the electrodes become polarised, so the measured resistance would be wrong. AC is used. [1]
(b) With silver electrodes the silver anode itself dissolves ($Ag \rightarrow Ag^+ + e^-$) and silver deposits on the cathode. Platinum is inert, so at the anode water is oxidised and O_2 is given off (silver still deposits on the cathode). [1]
(c) Mg is more reactive than iron; it acts as a sacrificial anode and corrodes instead of the iron (cathodic protection). [1]

Q25. (3 marks) Answer: (a) $[Co(NH_3)_6]Cl_3$, d^2sp^3, diamagnetic; (b) 0 and 2; $[RhCl(PPh_3)_3]$.
(a) All three Cl^- are ionisable, so all six NH_3 are ligands: $[Co(NH_3)_6]Cl_3$, hexaamminecobalt(III) chloride. [1]
Co^{3+} is $3d^6$; NH_3 pairs the electrons into three 3d orbitals, leaving two 3d orbitals for bonding: d^2sp^3 hybridisation (inner orbital, octahedral). [1]
No unpaired electron: diamagnetic. [1]
OR (b) (i) (I) None: a tris-chelate has no geometrical isomers (it shows optical isomerism). (II) Two: facial and meridional. [1]
(ii) In Co^{3+} ($3d^6$) NH_3 pairs the electrons and frees two inner 3d orbitals: d^2sp^3. In Ni^{2+} ($3d^8$) two inner 3d orbitals cannot be vacated, so the outer 4d orbitals are used: sp^3d^2. [1]
(iii) $[RhCl(PPh_3)_3]$; used as a catalyst for the hydrogenation of alkenes. [1]

Q26. (3 marks) Answer: ≈ 63.5 torr.
Moles of benzoic acid = 61/122 = 0.5; complete dimerisation gives i = ½, so effective moles = 0.25. Moles of benzene = 500/78 = 6.41. [1]
Mole fraction of solute particles $x_2 = 0.25/(0.25 + 6.41) = 0.0375$. [1]
$p = p^\circ (1 - x_2) = 66 \times 0.9625 \approx 63.5$ torr. [1]

Q27. (3 marks) Answer: $k[H_2O_2][I^-]$; 1, 1, 2; 2.
(a) The slow step decides the rate: Rate = $k[H_2O_2][I^-]$. [1]
(b) First order in H_2O_2, first order in I^-; overall order 2. [1]
(c) Two molecules/ions react in Step II: bimolecular (molecularity 2). [1]

Q28. (3 marks) Answer: $(CH_3)_3CBr$; 1-methylcyclohexene; resonance.
(a) 2-Bromo-2-methylpropane, $(CH_3)_3CBr$: it gives the most stable tertiary carbocation. [1]
(b) Saytzeff rule: the more substituted alkene, 1-methylcyclohexene (the double bond inside the ring). [1]
(c) The −I effect deactivates the ring, but Cl donates its lone pairs by resonance (+R), which increases the electron density at the ortho and para positions more than at meta, so the electrophile attacks there. [1]

Q29. (4 marks) Answer: protonation, carbocation, deprotonation; no α-H on the carbinol carbon; 3-methyl-4,6-dinitrophenol; $–NO_2$ vs $–OCH_3$.
(a) Step 1: protonation: $CH_3CH_2–OH + H^+ \rightleftharpoons CH_3CH_2–OH_2^+$ (fast). Step 2: loss of water gives the carbocation $CH_3CH_2^+$ (slow). Step 3: loss of a proton: $CH_3–CH_2^+ \rightarrow CH_2=CH_2 + H^+$. Conditions: conc. H_2SO_4, 443 K. [2]
(b) The carbon carrying the –OH has no hydrogen atom, so it cannot form C=O without breaking a C–C bond. [1]
OR (b) Both –OH and $–CH_3$ direct to the positions ortho/para to –OH; avoiding the crowded position between them, the major product is 3-methyl-4,6-dinitrophenol (5-methyl-2,4-dinitrophenol). [1]
(c) $–NO_2$ withdraws electrons (−I, −R) and stabilises the phenoxide ion; $–OCH_3$ releases electrons by resonance (+R) and destabilises it. So o-nitrophenol loses H^+ more easily. [1]

Q30. (4 marks) Answer: oxime/cyanohydrin; pentaacetate; free CHO or C=O; configuration and dextrorotation.
(a) (i) Glucose forms an oxime with hydroxylamine and a cyanohydrin with HCN: it has a carbonyl group. [1] (ii) Acetylation with acetic anhydride gives a pentaacetate, and the compound is stable, so there are five –OH groups on different carbon atoms. [1]
(b) Sugars that reduce Fehling's solution and Tollens' reagent, because they have a free aldehyde or ketone group (all monosaccharides, maltose, lactose). [1]
(c) ‘D’ gives the configuration: the –OH on the lowest chiral carbon (C5) is on the right, as in D-glyceraldehyde. ‘(+)’ means it is dextrorotatory (rotates plane-polarised light to the right). [1]
OR (c) Haworth (pyranose) ring: five carbons and one O in a six-membered ring, O between C1 and C5. At C1: OH below the plane (α), H above; C2: OH below; C3: OH above; C4: OH below; C5: CH_2OH above the plane. [1]

Q31. (5 marks) Answer: (a) Na_2CrO_4 → $Na_2Cr_2O_7$ (acid) → $K_2Cr_2O_7$ (KCl); (b) $Cr_2O_7^{2-}$, Ce; $K_2MnO_4 + MnO_2 + O_2$; Fe^{2+}, Ti^{3+}.

(a) (i) (I) In MnO, Mn is in its lowest (+2) state and the oxide is ionic and basic; in Mn_2O_7, Mn is +7 and the oxide is covalent and acidic (higher oxidation state, more acidic). [1] (II) Fe has more unpaired d electrons than Cu ($3d^6 4s^2$ vs $3d^{10} 4s^1$), so stronger metallic bonding and a higher enthalpy of atomisation. [1] (III) Mn^{3+} ($3d^4$) readily takes an electron to form the stable half-filled Mn^{2+} ($3d^5$); Cr^{3+} (t_2g^3) is itself stable. [1]

(ii) Acidify: $2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$. Then double decomposition with KCl: $Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$ (the less soluble $K_2Cr_2O_7$ crystallises). [2]

OR (b) (i) Actinoids show many oxidation states (5f, 6d and 7s levels are close in energy) and most are radioactive with short half-lives, which makes them hard to study. [1]

(ii) Because of irregular variation of the ionisation enthalpies ($I_1 + I_2$) and of the sublimation enthalpies (and hydration enthalpies) across the series. [1]

(iii) (I) Dichromate, $Cr_2O_7^{2-}$. (II) Cerium (Ce^{4+}). [1]

(iv) $2KMnO_4 \xrightarrow{\text{heat}} K_2MnO_4 + MnO_2 + O_2$. [1]

(v) Fe^{2+} ($3d^6$) and Ti^{3+} ($3d^1$), which have unpaired d electrons; Cu^+, Zn^{2+} ($3d^{10}$) and Sc^{3+} ($3d^0$) are colourless. [1]

Q32. (5 marks) Answer: (a) 2-methylbenzaldehyde; $C_6H_5COOH < HCOOH < O_2NCH_2COOH < CF_3COOH$; (b) 2,4-DNP derivative; chalcone.

(a) (i) (I) $C_6H_5Br \xrightarrow{Mg,\ \text{dry ether}} C_6H_5MgBr \xrightarrow{CH_3CHO,\ \text{then } H_3O^+} C_6H_5CH(OH)CH_3$. [1] (II) $C_6H_6 \xrightarrow{CH_3COCl,\ \text{anhyd. } AlCl_3} C_6H_5COCH_3 \xrightarrow{\text{conc. } HNO_3 + \text{conc. } H_2SO_4}$ m-nitroacetophenone. [1]

(ii) An aldehyde (Tollens', 2,4-DNP) with no α-H (Cannizzaro) whose side chains are ortho (phthalic acid on oxidation): 2-methylbenzaldehyde (o-tolualdehyde). [1] Cannizzaro: $2\ CH_3C_6H_4CHO + \text{conc. } NaOH \rightarrow CH_3C_6H_4CH_2OH$ (2-methylbenzyl alcohol) + $CH_3C_6H_4COONa$ (sodium 2-methylbenzoate). [1]

(iii) $C_6H_5COOH < HCOOH < O_2N–CH_2–COOH < CF_3–COOH$. [1]

OR (b) (i) (I) Benzaldehyde 2,4-dinitrophenylhydrazone, $C_6H_5CH=N–NH–C_6H_3(NO_2)_2$. [1] (II) Cross aldol (Claisen–Schmidt) condensation: $C_6H_5CH=CH–CO–C_6H_5$ (1,3-diphenylprop-2-en-1-one, chalcone). [1]

(ii) (I) –COOH deactivates the ring, and the catalyst $AlCl_3$ (a Lewis acid) bonds to the carboxyl group. [1] (II) Carboxylic acids form more extensive hydrogen bonding and exist as dimers. [1]

(iii) Tollens' test: propanal gives a silver mirror, propanone does not (or iodoform test: propanone gives yellow CHI_3, propanal does not). [1]

Q33. (5 marks) Answer: (a) ≈ 0.44 V; 96 500 C; (b) α ≈ 0.077; 0.682 V.

(a) (i) $E°_{cell} = (0.059/n) \log K_c$ with n = 2: $E° = (0.059/2) \times 15 = 0.4425$ V ≈ 0.44 V. [2]

(ii) Anode: $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$. Cathode: $PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$. Overall: $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$. [2]

(iii) $Fe^{2+} \rightarrow Fe^{3+} + e^-$: 1 mol of electrons per mol of FeO = 1 F = 96 500 C. [1]

OR (b) (i) $\Lambda_m = \kappa \times 1000/C = 7.2 \times 10^{-5} \times 1000/0.0024 = 30$ S cm² mol⁻¹. [1] α = 30/390.5 ≈ 0.077. [1]

(ii) $E = E° - 0.059 \log(1/[Ag^+]) = 0.80 - 0.059 \times 2 = 0.682$ V. [2]

(iii) (I) A moist paste of NH_4Cl and $ZnCl_2$. (II) Concentrated aqueous KOH (or NaOH). [1]

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