



Chemistry Model Paper 3 2025n

Time Allowed: 2 hours 30 minutes

Total Marks: 120

You must bring a soft pencil (preferably type B or HB), a clean eraser, and a dark blue or black pen.

Before attempting the paper, write your name, candidate number, centre name, and centre number clearly in the designated spaces.

Instructions for Candidates

- **Section A** contains multiple choice questions. You are required to attempt all questions by selecting the most appropriate option and marking it on the separate MCQ answer sheet using a soft pencil.
- **Section B** comprises both theoretical questions and practical questions. All questions in this section are compulsory. Answers must be written in the space provided on the question paper using a dark blue or black pen. You may use an HB pencil for any diagrams or graphs.
 - You may use a simple calculator if needed.
 - You should show all your working and use appropriate units.
 - Do not use an erasable pen or correction fluid.
 - Avoid writing over any barcodes printed on the paper.

Information for Candidates

- This paper consists of a total of **120 marks**.
 - **Section A** includes **40 multiple choice questions**, each carrying **1 mark**. There is no negative marking for incorrect answers.
 - **Section B** carries a total of **80 marks**, divided as follows:
 - Theoretical Questions:** 50 marks
 - Practical Questions:** 30 marks
 - The number of marks for each question or part question is shown in brackets [].
 - A copy of the periodic table will be provided with this paper.
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Please read all questions carefully and follow the instructions exactly to ensure your responses are properly evaluated.

SECTION A – MULTIPLE CHOICE QUESTIONS

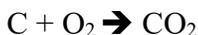
Attempt all questions. ($40 \times 1 = 40$ Marks)

1. A beam of protons, neutrons, and electrons is passed through an electric field between two charged parallel plates in a vacuum.

Which statement correctly describes the behavior of these particles based on their relative masses and charges?

- A. The neutrons are deflected toward the positive plate because they have a relative mass of 1.
 - B. The protons are deflected more significantly than the electrons because protons have a greater relative mass.
 - C. The electrons undergo a greater deflection than the protons toward the positive plate because they have a much smaller relative mass and a negative charge
 - D. All three particles are deflected by the same angle because their relative charges are equal in magnitude.
2. An experimental setup is used to determine the relative molecular mass of a volatile liquid. A 0.2g sample of the liquid is vaporized at 100°C and 101kPa pressure, occupying a volume of 65.0cm³. Using the ideal gas equation, which of the following is the most accurate calculation for the relative molecular mass $R = 8.31\text{J K}^{-1}\text{mol}^{-1}$ and assume the gas behaves ideally.

- A. 25.5
 - B. 95.1
 - C. 95100
 - D. 0.095
3. In a practical synthesis, 12g of Carbon reacts with excess oxygen to produce 33 g of CO₂. What are the percentage yield and the atom economy for this reaction?



	Percentage Yield	Atom Economy
A	75%	100%

B	100%	75%
C	75%	75%
D	100%	100%

4. Which of the following best defines a dative covalent bond?
- A bond formed by the overlap of atomic orbitals containing one electron each.
 - The attraction between a delocalized sea of electrons and positive metal ions
 - A bond formed by the electrostatic attraction between oppositely charged ions.
 - A shared pair of electrons where both electrons originate from the same atom.
5. Which statement correctly relates covalent bond strength to bond length in a homologous series of diatomic molecules?
- Longer bonds are stronger due to decreased electron-electron repulsion.
 - Shorter bonds are stronger because there is greater overlap of atomic orbitals.
 - Double bonds are longer and stronger than single bonds between the same atoms.
 - Bond length has no predictable effect on the energy required to break the bond.
6. In the dot-and-cross diagram for the hydroxonium ion (H_3O^+), how many dative covalent bonds are present?
- 3
 - 0
 - 2
 - 1
7. How does electron motion give rise to van der Waals (London dispersion) forces between non-polar molecules?
- Electrons are transferred from one molecule to another, creating ionic character.
 - Electrons become delocalized across the entire sample of the substance.
 - Continuous movement of electrons creates temporary dipoles which induce dipoles in neighboring molecules.
 - Permanent dipoles align to create a network of attraction.
8. Which of the following labels would be correct for a diagram illustrating metallic bonding?

- A. Anions in a sea of delocalized protons.
 - B. Molecules held together by intermolecular hydrogen bonds.
 - C. Positive metal ions in a sea of delocalized electrons.
 - D. Alternating positive and negative ions in a crystal lattice.
9. Which statement correctly defines the term mean bond enthalpy?
- A. The energy required to break a specific bond in a specific molecule in the gaseous state
 - B. The average energy required to break one mole of a specific type of bond across a range of different gaseous compounds.
 - C. The energy released when one mole of a gaseous bond is formed from its constituent atoms.
 - D. The total energy required to break all bonds in one mole of a liquid compound.
10. In the context of lattice enthalpy, which combination of ionic properties leads to the greatest degree of polarization of an anion?
- A. Large cation radius and small anion charge.
 - B. Small cation radius and small anion charge.
 - C. Small, highly charged cation and large, highly charged anion.
 - D. Large, lowly charged cation and small, lowly charged anion.
11. For an ionic compound to be highly soluble in water, how does entropy usually influence the process?
- A. The system's entropy must decrease significantly to allow for hydration.
 - B. The increase in entropy ($\Delta S_{\text{sys}} > 0$) from the breakdown of the lattice must help compensate for an endothermic enthalpy of solution.
 - C. Entropy has no effect on solubility; only enthalpy determines it.
 - D. The entropy of the surroundings must decrease to facilitate ion-dipole transitions.
12. In electrochemical and thermodynamic measurements, what are the **standard conditions** for pressure, temperature, and concentration?
- A. 100kPa, 273K, and 0.1 mol dm^{-3}
 - B. 101.3kPa, 298K, and 1 mol dm^{-3}
 - C. 100kPa, 298K, and 1 mol dm^{-3}
 - D. 1 atm, 25°C, and 2 mol dm^{-3}
13. Which of the following is a key characteristic of the **Standard Hydrogen Electrode**?
- A. It uses a solid magnesium electrode to catalyze the reaction.
 - B. The hydrogen gas is bubbled at a pressure of 200 kPa
 - C. It contains a platinum electrode coated in platinum black in contact with 1 mol dm^{-3} of H^+ (aq)

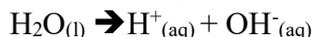
- D. The potential of the SHE is measured as 1.00 V by definition.
14. In a hydrogen-oxygen fuel cell using an alkaline electrolyte, what is the correct half-equation occurring at the anode?
- A. $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$
 - B. $2\text{H}_2 + 4\text{OH}^- \rightarrow 4\text{H}_2\text{O} + 4\text{e}^-$
 - C. $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
 - D. $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$
15. Which of the following correctly describes the behavior of a reducing agent?
- A. It gains electrons and its oxidation state increases.
 - B. It loses electrons and its oxidation state decreases.
 - C. It gains electrons and its oxidation state decreases.
 - D. It loses electrons and its oxidation state increases.
16. For the equilibrium $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightarrow 2\text{NH}_{3(\text{g})}$, the partial pressures at equilibrium are: $P(\text{N}_2) = 10\text{kPa}$, $P(\text{H}_2) = 20\text{kPa}$, and $P(\text{NH}_3) = 50\text{kPa}$.
What is the value of K_p for this reaction?
- A. $3.125 \times 10^{-2} \text{kPa}^{-2}$
 - B. 0.25kPa^{-2}
 - C. 31.25kPa^{-2}
 - D. 12.5kPa^{-2}
17. A catalyst increases the rate of a chemical reaction by:
- A. Increasing the frequency of collisions between reactant particles.
 - B. Increasing the average kinetic energy of the reacting molecules.
 - C. Providing an alternative reaction pathway with a lower activation energy.
 - D. D. Shifting the equilibrium position to favor the formation of products.
18. What information is primarily conveyed by the area under a Maxwell-Boltzmann distribution curve?
- A. The total number of particles in the sample.
 - B. The activation energy required for the reaction.
 - C. The rate of the reaction at a specific temperature.
 - D. The most probable velocity of the gas particles.
19. How does a heterogeneous catalyst, such as finely divided iron in the Haber process, facilitate a reaction?
- A. By reacting with the gaseous reactants to form a liquid intermediate.

- B. By adsorbing reactant molecules onto its surface, weakening their internal bonds.
- C. By increasing the pressure of the reactants within the catalyst pores.
- D. By absorbing heat from the surroundings to provide activation energy.

20. Which of the following correctly defines activation energy?

- A. The heat energy released when one mole of a compound is formed.
- B. The minimum energy that colliding particles must possess for a reaction to occur.
- C. The change in concentration of a reactant per unit time.
- D. The energy required to break all the bonds in a gaseous molecule.

21. The dissociation of water is an endothermic process:



Which statement correctly describes the ionic product of water, K_w ?

- A. K_w is the equilibrium constant for the formation of water from its ions.
- B. At a constant temperature, the value of K_w remains the same even if acid is added to the water.
- C. K_w is equal to $1.0 \times 10^{-14} \text{ mol}^2\text{dm}^{-6}$ at all temperatures.
- D. D. As temperature increases, the value of K_w decreases.

22. What is the pH of a 0.05 mol dm^{-3} solution of sulfuric acid (H_2SO_4)?

- A. 1.00
- B. 1.30
- C. 2.00
- D. 0.70

23. A student titrates 25.0cm^3 of 0.10 mol dm^{-3} ethanoic acid (weak acid) with 0.10 mol dm^{-3} sodium hydroxide (strong base). Based on the vertical section of the pH curve (pH approx 7.0 to 10.0), which indicator is most suitable?

	Indicator	pH Range of Color Change
A	Methyl Orange	3.1 – 4.4
B	Bromophenol Blue	3.0 – 4.6
C	Phenolphthalein	8.3 – 10.0
D	Methyl Red	4.4 – 6.2

24. Ethane-1,2-diamine ($\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$) and the oxalate ion ($\text{C}_2\text{O}_4^{2-}$) are both capable of forming two coordinate bonds to a single central metal cation. Which term correctly classifies these ligands based on their bonding capability?
- A. Monodentate
 - B. Bidentate
 - C. Multidentate (Hexadentate)
 - D. Ambidentate
25. Which of the following complex ions is correctly matched with its molecular geometry?
- A. $[\text{Ag}(\text{NH}_3)_2]^+$: Tetrahedral
 - B. $[\text{CuCl}_4]^{2-}$: Square Planar
 - C. $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$: Octahedral
 - D. $[\text{Pt}(\text{NH}_3)_4]^{2+}$: Linear
26. Which of the following is **not** a distinguishing feature of a homologous series?
- A. They share the same general formula.
 - B. They have identical physical properties such as boiling points.
 - C. Each successive member differs by a $-\text{CH}_2$ -group.
 - D. They possess the same functional group and similar chemical properties.
27. Which condition is essential for an alkene to exhibit E/Z (cis-trans) isomerism?
- A. The molecule must contain at least four carbon atoms.
 - B. There must be restricted rotation around the $\text{C}=\text{C}$ double bond and two different groups attached to each carbon of the double bond.
 - C. The molecule must have a chiral center.
 - D. The double bond must be at the end of the carbon chain (terminal alkene).
28. A sample of dodecane ($\text{C}_{12}\text{H}_{26}$) is cracked to produce one molecule of octane and two molecules of a gaseous alkene. What is the balanced equation for this reaction?
- A. $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_4\text{H}_8$
 - B. $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_8\text{H}_{18} + 2 \text{C}_2\text{H}_4$
 - C. $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_8\text{H}_{18} + 2 \text{C}_2\text{H}_6$
 - D. $\text{C}_{12}\text{H}_{26} \rightarrow \text{C}_7\text{H}_{16} + \text{C}_5\text{H}_{10}$
29. When a primary haloalkane undergoes nucleophilic substitution with OH^- , which statement regarding the mechanism is correct?
- A. It proceeds via a stable carbocation intermediate.

- B. The reaction is a two-step process (SN1).
C. It involves a single transition state where the carbon is momentarily bonded to five groups.
D. The stereochemical outcome is always a racemic mixture.
30. A student warms an unknown alcohol with acidified potassium dichromate(VI). The solution changes from orange to green.
Which of the following could the alcohol be?
- A. 2-methylpropan-2-ol
B. Propan-1-ol
C. Ethane-1,2-diol (excess)
D. Both B and C
31. A student distills a sample of ethyl ethanoate. The literature boiling point is 77° C. The experimental sample begins to boil at 72° C and the temperature continues to rise to 76° C. What does this data indicate?
- A. The sample is pure ethyl ethanoate.
B. The sample is contaminated with a substance that has a lower boiling point.
C. The atmospheric pressure was higher than standard.
D. The thermometer was improperly calibrated.
32. Unlike alkenes, benzene does not readily undergo addition reactions with bromine water at room temperature. What is the primary reason for this?
- A. Benzene is a saturated hydrocarbon.
B. The pi-electrons in benzene are delocalized, providing extra stability (resonance energy).
C. Benzene is a non-polar molecule.
D. The carbon-carbon bonds in benzene are longer than those in alkenes.
33. Which reagent(s) would be required to convert propanone into 2-hydroxy-2-methylpropanenitrile?
- A. NaBH₄ followed by dilute HCl.
B. HCN in the presence of KCN.
C. LiAlH₄ in dry ether.
D. K₂Cr₂O₇ / H₂SO₄.
34. A batch of salicylic acid crystals is tested for purity. The measured melting point is 154-156°C (Literature value: 158.6°C). Which conclusion is most valid?
- A. The crystals are pure because the range is only 2 degrees.
B. The crystals are impure as the melting point is lower and wider than the literature value.
C. The crystals are pure but the heating rate was too fast.
D. The sample contains a higher-melting impurity.

35. In Thin Layer Chromatography (TLC), the "stationary phase" and "mobile phase" are respectively:
- The solvent and the silica gel plate.
 - The silica gel plate and the solvent.
 - The baseline and the solvent front.
 - The sample spots and the developing tank.
36. Which of the following 3D representations correctly shows a pair of enantiomers for butan-2-ol?
- Two structures that can be perfectly superimposed on each other.
 - Two structures that are non-superimposable mirror images using wedged and dashed bonds.
 - Two structures where the -OH group is in the same plane as the C-H bond.
 - A mixture where one molecule is a structural isomer of the other.
37. How many chiral carbon atoms are present in the following molecule: 2-bromo-3-chlorobutane?
- 1
 - 2
 - 3
 - 4
38. A student tests the acidity of phenol and ethanol by reacting them with Sodium Hydroxide (NaOH) and Sodium Carbonate (Na₂CO₃). Which set of observations is correct?

	Reaction with NaOH (Strong Base)	Reaction with Na₂CO₃ (Weak Base)
A	Phenol reacts; Ethanol reacts	Both react with effervescence
B	Phenol reacts; Ethanol does not	Neither reacts with effervescence
C	Neither reacts	Both react to form a salt
D	Phenol does not react; Ethanol reacts	Phenol reacts with effervescence

39. When comparing organic compounds of similar relative molecular mass (M_r), which statement correctly explains the difference in their boiling points?
- Aldehydes have higher boiling points than carboxylic acids because they contain a polar carbonyl group.
 - Carboxylic acids have higher boiling points than aldehydes because they can form intermolecular hydrogen bonds, whereas aldehydes only have dipole-dipole interactions.

- C. Ketones have higher boiling points than carboxylic acids because they have stronger Van der Waals forces.
- D. Both have similar boiling points because they both contain the C=O group.
40. In a practical synthesis of an ester, a student heats a mixture of a carboxylic acid and an alcohol.

Which of the following experimental observations or procedures is correct for this process?

- A. The reaction is irreversible, so the yield is always 100%.
- B. Concentrated sulfuric acid is added to act as both a catalyst and a dehydrating agent to shift the equilibrium toward the products.
- C. The ester is typically collected by reacting the mixture with sodium carbonate to remove the alcohol.
- D. The product can be identified by its characteristic "vinegar-like" smell.

SECTION B – THEORETICAL QUESTIONS

Q1. (20 Marks)

a) A reaction is zero order with respect to reactant X. Explain how the rate law would change if the concentration of X is tripled. (2)

b) A student uses an enthalpy cycle to find $\Delta H_{\text{Reaction}}$. State Hess's Law and explain its importance when a reaction cannot be measured directly. (2)

c) A buffer solution contains a weak acid and its salt. Describe the role of the reservoir of $A^{-}(\text{aq})$ ions when a small amount of $H^{+}(\text{aq})$ is added. (2)

d) In the reaction $\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$, define oxidation in terms of oxidation state changes for the Manganese atom. (2)

e) Write the skeletal formula and name the fourth member of the alkyne homologous series. (2)

f) A student sets up a Zn/Cu cell. State two functions of the salt bridge required to keep the current flowing. (2)

g) Define activation energy and explain why a reaction might not occur even if a collision meets this energy requirement. (2)

h) In a titration, 25.0 cm³ of 0.1 mol dm⁻³ HCl reacts with 1.0g of CaCO₃. Show by calculation which is the limiting reagent. (2)

i) For the equilibrium $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightarrow 2\text{NH}_{3(\text{g})}$ ($\Delta H = -92 \text{ kJ mol}^{-1}$), state Le Chatelier's principle regarding a temperature increase. (2)

j) A solution contains 2.12g of Na₂CO₃ in 500cm³. Calculate the molarity? (2)

Q2. (18 Marks)

2a) (i) Describe collision theory and explain why most collisions do not lead to a reaction. (3)

2c) A student sets up an electrolytic cell to electrolyze concentrated aqueous sodium chloride (brine) using inert carbon electrodes.

(i) Draw a labeled diagram of the cell. On your diagram, clearly indicate the direction of electron flow in the external circuit and the polarity (+ or -) of both electrodes. (3)

(ii) At the anode, both $\text{Cl}^-_{(\text{aq})}$ and $\text{OH}^-_{(\text{aq})}$ ions are present. Identify which gas is liberated at the anode and justify your answer based on the relative concentrations of the ions. (2)

(iii) Write the reduction half-equation occurring at the cathode. (1)

Q3 (12 marks)

3a (i) For a first-order reaction, the rate constant k is related to half-life by $k = \frac{\ln 2}{t_{1/2}}$. A drug decomposes with a half-life of 10 minutes. Calculate k with units. (2)

(ii) If the initial concentration is 1.0mol dm^{-3} , calculate the concentration after 20minutes
(2)

Q3b (i) Outline the free radical substitution of methane with chlorine, showing the equations for the two propagation steps only. (2)

(ii) Explain why the C-H bond in an alkane is resistant to attack by nucleophiles like OH, referring to bond polarity and electronegativity. (2)

Q3c. A student monitors the decomposition of a reactant and plots a graph of Concentration vs. Time.

(i) Explain how the student can use this graph to confirm that the reaction is first-order with respect to the reactant. Refer to the concept of half-life in your answer. (2)

(ii) Describe how the initial rate of the reaction could be accurately determined from this specific graph. (2)

SECTION B – PRACTICAL QUESTIONS

Q4. Qualitative Analysis (10 Marks)

a) Name the two confirmatory test for chloride ion along with its observation (4)

b) Write observation and inference for sulfate ion.(2)

c) Identify the cation using flame test. (4)

Sodium: _____

Lithium: _____ \

Potassium: _____

Copper: _____

Chemistry Model Paper 3 – 2025

Marking Scheme

Total Marks: 120

Section A: 40 Marks

Section B: 80 Marks (Theoretical: 50, Practical: 30)

Section A – MCQs (40 Marks)

1.	C
2.	B
3.	D
4.	D
5.	B
6.	A
7.	C
8.	C
9.	B
10.	C
11.	B
12.	C
13.	C
14.	B
15.	D
16.	A
17.	C
18.	A
19.	C
20.	B
21.	B
22.	A
23.	D
24.	C
25.	B
26.	C
27.	C
28.	B
29.	C
30.	B
31.	B
32.	B
33.	B
34.	B

35.	B
36.	B
37.	C
38.	B
39.	B
40.	B

Section B – Theoretical Questions (50 Marks)

1(a)	Rate independent of [X]; tripling concentration does not change rate.	2
1(b)	Hess's Law: Total enthalpy change independent of pathway; used when direct measurement not possible.	2
1(c)	A ⁻ ions react with added H ⁺ forming HA; minimizes pH change.	2
1(d)	Oxidation is increase in oxidation state; Mn changes from +7 to +2 (reduction).	2
1(e)	But-1-yne; skeletal formula with four carbons and triple bond.	2
1(f)	Completes circuit; maintains electrical neutrality.	2
1(g)	Minimum energy for reaction; improper orientation may prevent reaction.	2
1(h)	Moles HCl = 0.0025; moles CaCO ₃ = 0.01; HCl limiting.	2
1(i)	Increase temperature shifts equilibrium left (endothermic direction).	2
1(j)	Moles Na ₂ CO ₃ = 0.02; Molarity = 0.04 mol dm ⁻³ .	2
2(a)(i)	Particles must collide with sufficient energy and correct orientation; most lack E _a or orientation.	3
2(a)(ii)	Higher T shifts distribution; greater fraction above E _a ; exponential increase in rate.	3
2(b)(i)	CaC ₂ + 2H ₂ O → C ₂ H ₂ + Ca(OH) ₂ ; description of setup and gas collection.	3
2(b)(ii)	Ethyne burns with smoky flame (higher C:H ratio); ethane cleaner flame.	3
2(c)(i)	Correct labeled diagram; anode +, cathode -; electron flow indicated.	3
2(c)(ii)	Chlorine gas; higher Cl ⁻ concentration favors discharge.	2
2(c)(iii)	2H ₂ O + 2e ⁻ → H ₂ + 2OH ⁻	1
3(a)(i)	k = 0.693 / 10 = 0.0693 min ⁻¹	2
3(a)(ii)	After 20 min (2 half-lives), concentration = 0.25 mol dm ⁻³	2
3(b)(i)	Propagation steps: Cl• + CH ₄ → CH ₃ • + HCl; CH ₃ • + Cl ₂ → CH ₃ Cl + Cl•	2
3(b)(ii)	C-H bond non-polar; no partial positive carbon; resists nucleophilic attack.	2
3(c)(i)	Constant half-life indicates first-order reaction.	2
3(c)(ii)	Gradient of tangent at t=0 gives initial rate.	2

Section B – Practical Questions (30 Marks)

4(a)	Chloride: Acidify with HNO ₃ , add AgNO ₃ → white ppt (AgCl); soluble in NH ₃ .	4
4(b)	Sulfate: Acidify, add BaCl ₂ → white ppt (BaSO ₄).	2
4(c)	Flame tests: Na – yellow; Li – crimson; K – lilac; Cu – blue-green.	4
5(a)	Use M ₁ V ₁ = M ₂ V ₂ ; M(NaOH)=0.1 mol dm ⁻³	7
5(b)	Precautions: rinse burette; remove air bubbles; read at eye level; add dropwise near endpoint.	3
6(a)	Correct labeled simple distillation setup: flask, thermometer, condenser, receiver, heat source.	6
6(b)	Errors: heat loss; thermometer misplacement. Precautions: tight connections; steady heating.	4