

TEST SCHOOL
233/2 CHEMISTRY
Paper 2
Form 4 End Term Examination

Time: 2 ½ Hours

Name:

Adm No:

School:

Class:

Signature:

Date:

INSTRUCTIONS TO CANDIDATES

- (a) Write your name and index number in the spaces provided at the top of this page.
- (b) Write your school name, sign and write the date of the examination in the spaces provided above.
- (c) This paper consists of **Two** sections: **Section I** and **Section II**.
- (d) Answer all questions as instructed in each section.
- (e) Marks may be given for correct working, relevant points, and clear presentation.
- (f) Non-programmable silent electronic calculators may be used where necessary.
- (h) This paper consists of **4 printed pages**.
- (i) Candidates should check the question paper to ensure that all the pages are printed as indicated and no questions are missing.
- (j) Candidates should answer the questions in English.

For Examiner's Use Only

SECTION I

1	2	3	4	5	6	7	Total

SECTION II

8	9	10	11	12	13	14	15	Total	Grand Total

SECTION I (50 Marks)

Answer **all** questions in this section in the spaces provided.

1. Ethanol is a common alcohol used as a solvent and fuel. Answer the following questions based on ethanol and its derivatives. (12 mks)
- (a) Draw the full structural formulae of ethanol and ethanoic acid. (3 marks)
- (b) Describe a laboratory method to convert ethanol to ethanoic acid. (3 marks)
- (c) Write the equation for the reaction between ethanoic acid and sodium hydroxide. (3 marks)
- (d) Name the organic product when ethanol reacts with ethanoic acid in presence of concentrated sulfuric acid and state the type of reaction. (3 marks)
2. The following data was obtained from the reaction of excess hydrochloric acid (2.0 M) with magnesium ribbon. The volume of hydrogen gas produced was measured at regular time intervals. Time (s): 0, 10, 20, 30, 40, 50, 60, 70, 80 Volume (cm³): 0, 25, 45, 60, 70, 76, 80, 82, 83 (a) On the grid provided, plot a graph of volume of gas produced (vertical axis) against time. (4 marks)
- (b) From the graph, determine the initial rate of reaction in cm³/s. (3 marks)

(a) Plot a graph of volume of gas produced against time. (4 marks)

(b) From the graph, determine the initial rate of reaction. (3 marks)

(c) Explain why the rate decreases with time. (2 marks)

(d) State how the rate would change if the acid concentration is halved. (2 marks)

3. Lead(II) bromide is an ionic compound that can be electrolysed when molten. (12 mks)
Answer the following questions on the electrolysis of molten lead(II) bromide.

(a) Draw a labelled diagram of the apparatus used to electrolyse molten lead(II) bromide. Include: heat source, crucible, carbon electrodes, battery, connecting wires. (4 marks)

(b) Write the half-equations for the reactions occurring at each electrode. (3 marks)

(c) Describe the observations at each electrode. (3 marks)

(d) Explain why lead(II) bromide is heated until molten before electrolysis. (2 marks)

4. Iron is extracted from its ore, haematite (Fe_2O_3), in a blast furnace. Answer the following questions. (11 mks)

(a) Draw and label a diagram of a blast furnace used for iron extraction. Show: charge inlet, hot air blast, slag outlet, molten iron outlet. (5 marks)

(b) Write the chemical equations for the reduction of iron(III) oxide to iron. (3 marks)

(c) State the function of limestone in the blast furnace. (3 marks)

5. Propane is a hydrocarbon used as cooking gas. Answer the following questions. (12 mks)

(a) Draw the structural formula of propane. (3 marks)

(b) Write a balanced equation for the complete combustion of propane. (3 marks)

(c) Name the process of converting large hydrocarbons into smaller ones and state one condition required. (3 marks)

(d) Given a mixture of hydrocarbons from crude oil, describe how fractional distillation separates them. (3 marks)

6. Chlorine has two isotopes, chlorine-35 and chlorine-37. The relative atomic mass of chlorine is 35.5. Answer the following questions. (10 mks)

(a) Define the terms: atomic number, mass number, and isotope. (4 marks)

(b) Calculate the percentage abundance of each isotope of chlorine. (3 marks)

(c) Explain why isotopes of the same element have similar chemical properties. (3 marks)

7. The Haber process for ammonia synthesis is exothermic: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ $\Delta H = -92 \text{ kJ/mol}$. Answer the following questions. (12 mks)

(a) Draw an energy level diagram for an exothermic reaction, labelling activation energy and overall energy change (ΔH). (4 marks)

(b) Define endothermic reaction and give one example. (3 marks)

(c) Calculate the energy change when 1 mole of ammonia is formed from its elements. (3 marks)

(d) State the effect of a catalyst on the activation energy and the rate of reaction. (2 marks)

233/2 CHEMISTRY MARKING SCHEME

Form 4 Paper 2

SECTION I (50 marks)

1. Ethanol is a common alcohol used as a solvent and fuel. Answer the following questions based on ethanol and its derivatives. (12 marks)

a) Ethanol: correct structural formula ($\text{CH}_3\text{-CH}_2\text{-OH}$) showing all bonds (1 mark). Ethanoic acid: correct structural formula ($\text{CH}_3\text{-COOH}$) showing C=O and O-H (1 mark). Both displayed with proper bonds (1 mark). [3]

b) Method: heat ethanol with acidified potassium dichromate(VI) (or KMnO_4) under reflux (1 mark). Conditions: acidify with dilute H_2SO_4 (1 mark). Observation: orange dichromate turns green (or purple KMnO_4 turns colourless) (1 mark). [3]

c) Equation: $\text{CH}_3\text{COOH(aq)} + \text{NaOH(aq)} \rightarrow \text{CH}_3\text{COONa(aq)} + \text{H}_2\text{O(l)}$ (1 mark for reactants and products, 1 mark for correct salt formula, 1 mark for balancing and state symbols). [3]

d) Product: ethyl ethanoate (1 mark). Reaction type: esterification / condensation (1 mark). Condition: concentrated sulfuric acid as catalyst (1 mark). [3]

Alternative method/answer:

b) Accept use of acidified potassium manganate(VII) with warming instead of reflux; observation: purple to colourless.

d) Accept ethyl acetate as name, and 'esterification' alone sufficient if condition mentioned.

2. The following data was obtained from the reaction of excess hydrochloric acid (2.0 M) with magnesium ribbon. The volume of hydrogen gas produced was measured at regular time intervals. Time (s): 0, 10, 20, 30, 40, 50, 60, 70, 80 Volume (cm^3): 0, 25, 45, 60, 70, 76, 80, 82, 83 (a) On the grid provided, plot a graph of volume of gas produced (vertical axis) against time. (4 marks) (b) From the graph, determine the initial rate of reaction in cm^3/s . (3 marks) (11 marks)

a) Graph: correct axes labels (Volume/ cm^3 and Time/s) and units (1 mark). Appropriate scale (1 mark). Points plotted accurately (1 mark). Smooth curve through points (1 mark). [4]

b) Initial rate: tangent drawn at $t=0$, gradient calculated (M1). Correct reading from graph e.g., $\Delta V=25 \text{ cm}^3$, $\Delta t=10 \text{ s}$, rate= $2.5 \text{ cm}^3/\text{s}$ (A1). Correct unit (cm^3/s) (A1). [3]

c) Rate decreases because concentration of hydrochloric acid decreases (1 mark). Fewer collisions per second between acid particles and magnesium (1 mark). [2]

d) Reducing acid concentration by half reduces the rate (1 mark). Less frequent collisions due to fewer acid particles per unit volume (1 mark). [2]

Alternative method/answer:

b) Accept initial rate calculated using first two data points (0,0) and (10,25) if tangent not drawn, provided assumption of linearity stated.

3. Lead(II) bromide is an ionic compound that can be electrolysed when molten. Answer the following questions on the electrolysis of molten lead(II) bromide. (12 marks)

a) Diagram: crucible containing molten PbBr_2 (1 mark), heat source (Bunsen burner) (1 mark), two carbon electrodes immersed in melt (1 mark), battery and wires connecting electrodes (1 mark). [4]

b) Cathode half-equation: $\text{Pb}^{2+}(\text{l}) + 2\text{e}^{-} \rightarrow \text{Pb(l)}$ (1.5 marks). Anode half-equation: $2\text{Br}^{-}(\text{l}) \rightarrow \text{Br}_2(\text{g}) + 2\text{e}^{-}$ (1.5 marks). [3]

c) Cathode: grey/silvery solid (lead) deposited (1.5 marks). Anode: reddish-brown gas (bromine) evolved (1.5 marks). [3]

d) In solid state, ions are fixed in lattice and cannot move to conduct electricity (1 mark). Heating melts the compound, freeing ions to move and carry charge (1 mark). [2]

Alternative method/answer:

- b) Accept half-equations without state symbols if consistent.
- c) Accept 'brown fumes' for bromine.

4. Iron is extracted from its ore, haematite (Fe₂O₃), in a blast furnace. Answer the following questions. (11 marks)

- a) Diagram: vertical tower shape (1 mark). Charge inlet (ore/coke/limestone) at top (1 mark). Hot air blast inlets near bottom (1 mark). Slag outlet above molten iron (1 mark). Molten iron outlet at bottom (1 mark). [5]
- b) Main reduction: $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$ (2 marks). Acceptance of correct states and balancing (1 mark). [3]
- c) Limestone (CaCO₃) decomposes to CaO and CO₂ (1 mark). CaO reacts with silica (SiO₂) impurities to form slag (CaSiO₃) (1 mark). Slag floats on molten iron and is tapped off (1 mark). [3]

Alternative method/answer:

- b) Also accept the two-step process: $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$; $\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$, followed by reduction equation (full set accepted for full marks).

5. Propane is a hydrocarbon used as cooking gas. Answer the following questions. (12 marks)

- a) Propane structural formula: CH₃-CH₂-CH₃ with all bonds shown (2 marks). Correct representation (1 mark). [3]
- b) Balanced equation: $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$ (1 mark for reactants and products, 1 mark for balancing, 1 mark for state symbols). [3]
- c) Process: cracking (1 mark). Conditions: high temperature (600-700°C) (1 mark) and catalyst (e.g., alumina or silica) (1 mark). [3]
- d) Crude oil is heated to vaporise it (1 mark). Vapours rise up a fractionating column (1 mark). Components condense at different heights according to their boiling points (lower boiling point liquids condense higher up) (1 mark). [3]

Alternative method/answer:

- c) Accept thermal cracking (high temperature, high pressure) or catalytic cracking (with catalyst).
- d) Accept description of temperature gradient in column.

6. Chlorine has two isotopes, chlorine-35 and chlorine-37. The relative atomic mass of chlorine is 35.5. Answer the following questions. (10 marks)

- a) Atomic number: number of protons in nucleus of an atom (1 mark). Mass number: sum of protons and neutrons in nucleus (1 mark). Isotope: atoms of same element with same atomic number but different mass number (due to different number of neutrons) (2 marks: 1 for definition, 1 for explanation of neutron difference). [4]
- b) Let x be fraction of Cl-35: $35x + 37(1-x) = 35.5$ [M1]. Solving: $35x + 37 - 37x = 35.5 \rightarrow -2x = -1.5 \rightarrow x = 0.75$ [A1]. Therefore, Cl-35 = 75%, Cl-37 = 25% [A1]. [3]
- c) Isotopes of same element have the same number of electrons (1 mark). Chemical properties depend on electron arrangement (1 mark). Since electron configuration is identical, chemical properties are similar (1 mark). [3]

Alternative method/answer:

- b) Alternative method: $(35.5 - 37)/(35 - 37) = 0.75$; accept any correct algebraic method.

7. The Haber process for ammonia synthesis is exothermic: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ $\Delta H = -92 \text{ kJ/mol}$. Answer the following questions. (12 marks)

- a) Diagram: y-axis labelled 'Energy', x-axis 'Reaction progress' (1 mark). Reactants level, products lower (exothermic) (1 mark). Activation energy (E_a) shown as upward arrow from reactants to peak (1 mark). ΔH shown as downward arrow from reactants to products (1 mark). [4]
- b) Endothermic reaction: absorbs heat energy, ΔH positive (1 mark). Example: thermal decomposition of calcium carbonate ($\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$) or photosynthesis (2 marks for example with detail or equation). [3]

c) From equation, 2 moles NH_3 release 92 kJ (M1). For 1 mole NH_3 : $92/2 = 46$ kJ released. Therefore $\Delta H = -46$ kJ/mol (A1 for value, A1 for sign and unit). [3]

d) Catalyst lowers activation energy (1 mark). It increases the rate of reaction (1 mark). [2]

Alternative method/answer:

b) Other acceptable examples: melting ice, dissolving ammonium nitrate in water.

c) Accept 46 kJ released, or $\Delta H = -46$ kJ.