Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 2

19 May 2025

Zone A morning | **Zone B** morning | **Zone C** morning

Candidate session number

1 hour 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

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A008

2225–6224
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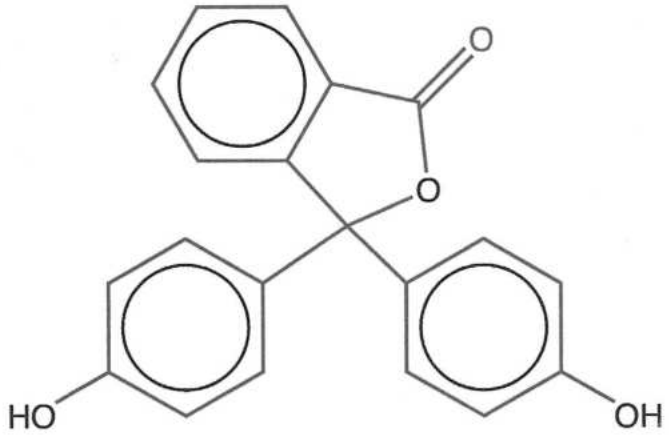
Answer **all** questions. Answers must be written within the answer boxes provided.

1. Phenolphthalein is an acid–base indicator.



Phenolphthalein

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(a) Determine the molecular and empirical formulas of phenolphthalein. [2]

Molecular formula: .....

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Empirical formula: .....

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(b) State an equation for phenol, C_6H_5OH, when it is acting as an acid. [1]

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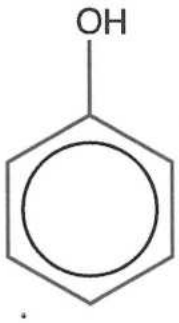

Phenol

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2. Models are useful for explaining characteristics and predicting outcomes.

State and explain **two** properties of a liquid using the kinetic molecular theory model. [2]

Property 1: .....

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Property 2: .....

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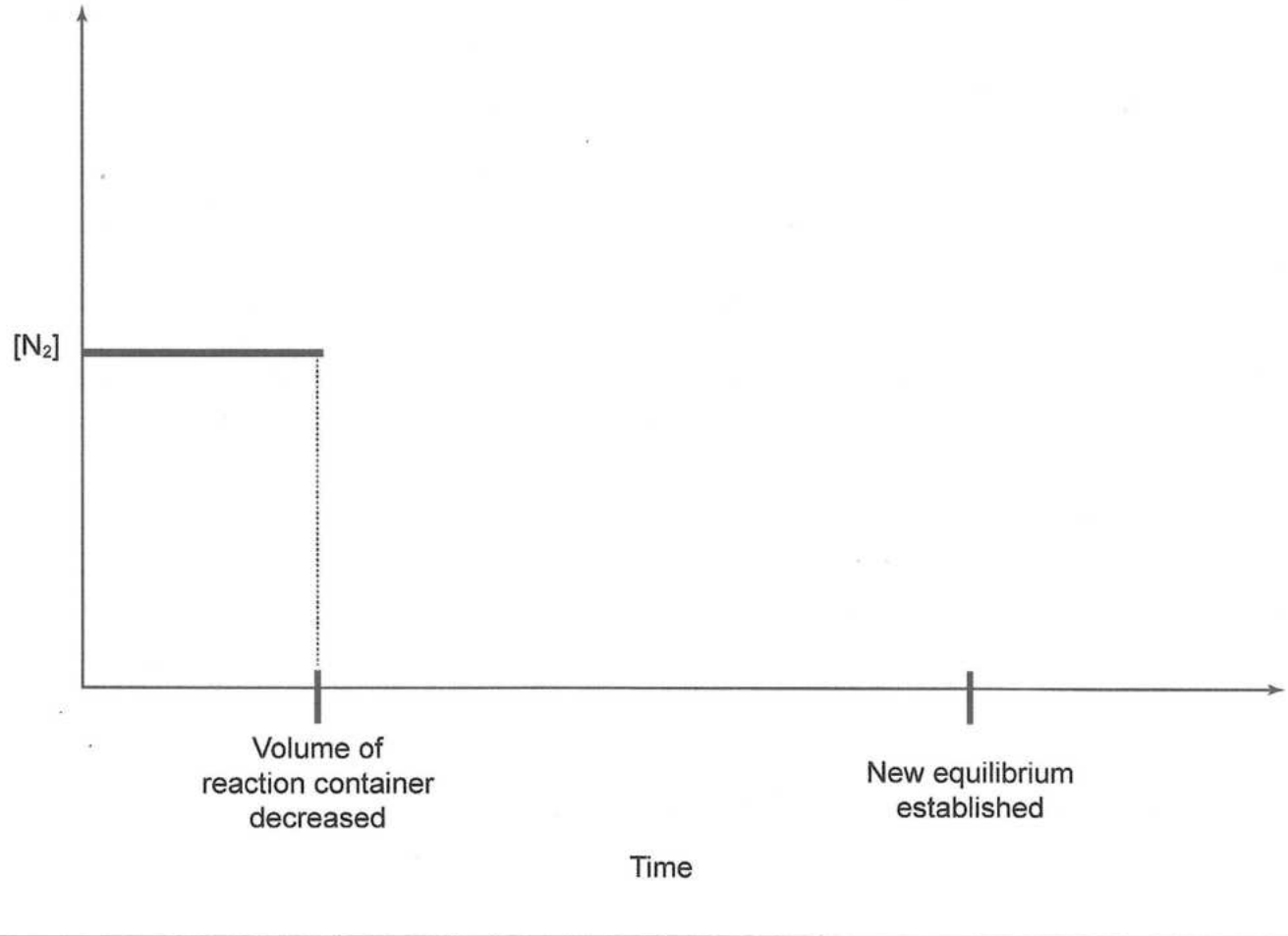
3. Ammonia is produced industrially using the reversible reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) Calculate the equilibrium constant, K, when 30.0 mol N_2, 40.0 mol H_2 and 6.17 mol NH_3 are at equilibrium in a 55.0 dm^3 reaction container at a temperature of 450 °C. [3]

(b) The volume of the reaction container of the mixture at equilibrium is suddenly decreased.

Sketch the graph of the concentration of nitrogen versus time on the axes below until after the new equilibrium is established at a constant temperature. [3]



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4. Halogenoalkanes are used as refrigerants and solvents.

(a) State the International Union of Pure and Applied Chemistry (IUPAC) name of substance **X**, $CH_3CHBrC(CH_3)_3$. [1]

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(b) Calculate the percentage by mass of hydrogen in substance **X** to **four** significant figures. Use section 7 of the data booklet. [2]

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(c) Draw a structural isomer of molecule **X**. [1]

(d) Substance **X** undergoes nucleophilic substitution with a hydroxide nucleophile.

(i) Describe the movement of electron pairs during the reaction using curly arrows. [2]

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(This question continues on the following page)

(Question 4 continued)

(ii) Contrast homolytic and heterolytic fission. [2]

Homolytic fission: . . . . . .

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Heterolytic fission: . . . . . .

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(iii) Explain, using collision theory, how an increase in temperature increases the reaction rate. [3]

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5. Ethyne, C_2H_2, is hydrogenated to form ethane.

$$C_2H_2(g) + 2H_2(g) \rightarrow C_2H_6(g)$$

(a) 140.0 cm^3 of ethyne is reacted with 160.0 cm^3 of hydrogen in a container at 420 K and 1.00×10^5 Pa. Ethane is the only product.

Determine the maximum possible volume of ethane formed under these conditions of temperature and pressure. [2]

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(b) Determine the total volume of gas present in the container at the end of the reaction under the same conditions of temperature and pressure. [2]

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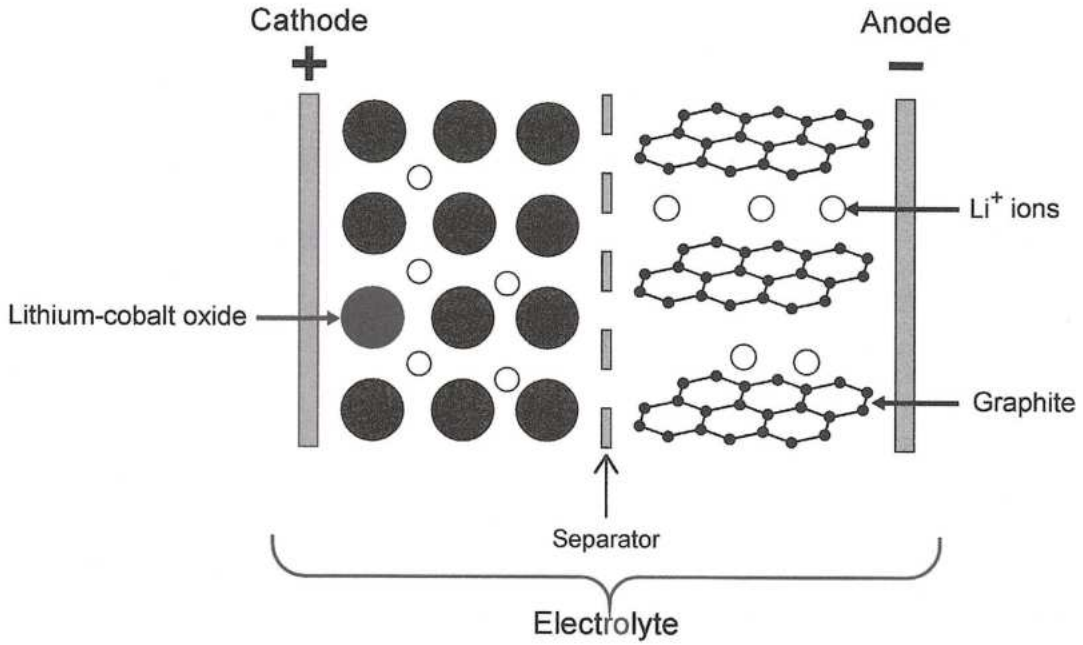
6. A lithium-ion battery consists of lithium ions on lithium-graphite (LiC_6) and lithium-cobalt oxide ($LiCoO_2$) in an electrolyte.



Lithium-ion battery

(a) The lithium ions are produced at the anode from the lithium atoms embedded in graphite.

(i) State a half-equation for the reaction occurring at the anode during discharge. [1]

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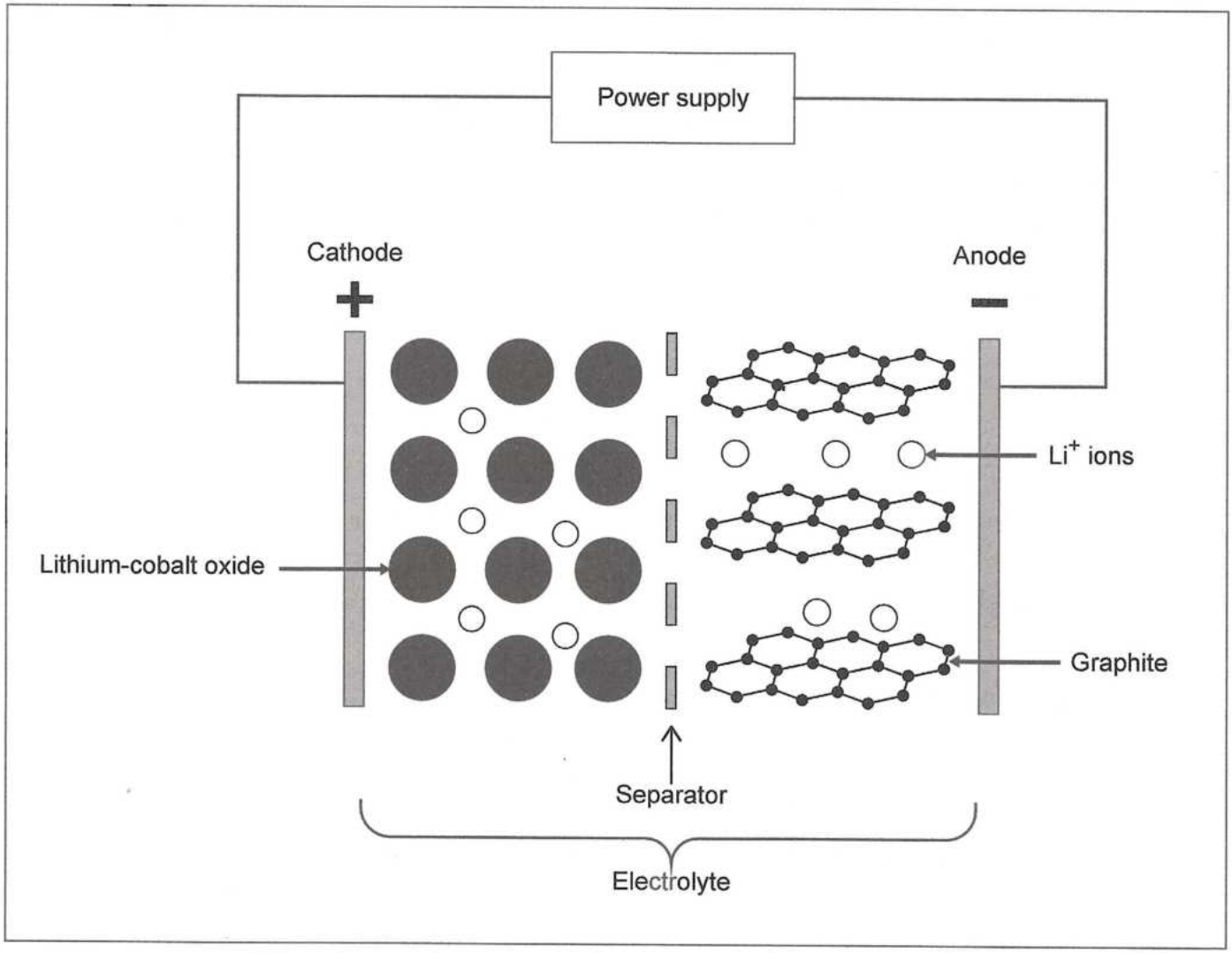
(Question 6 continued)

(ii) The lithium-ion battery is rechargeable. Annotate the diagram below to show the direction of the flow of electrons in the wire while the battery is recharging. [1]



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(b) Suggest why solar panels are often connected in parallel with lithium-ion batteries. [1]

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7. Sulfur dioxide, SO_2, is involved in the formation of acid rain.

(a) (i) State the electron configuration for S. [1]

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(ii) Draw the Lewis formula of SO_2. [1]

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(iii) Deduce the electron domain geometry and molecular geometry of SO_2. [2]

Electron domain geometry: . . . . . .

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Molecular domain geometry: . . . . . .

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(iv) Explain the polarity of the SO_2 molecule. [2]

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(Question 7 continued)

(b) Sulfur dioxide reacts with rain water and oxygen to form sulfuric acid, H_2SO_4.

(i) State an equation for this reaction including the state symbols. [2]

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(ii) Explain, with reference to the oxidation states of **two** elements, why this is a redox reaction. [2]

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(iii) Describe the effect of acid rain on buildings that are made of limestone (calcium carbonate). Include a chemical equation in your answer. [2]

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