

# 2006 Senior External Examination



## Chemistry

### Paper One

Wednesday 25 October 2006

9.00 am to 11.40 am

#### Directions

- Perusal time: **10 minutes**.  
Do not make notes in this paper during perusal time.
- Working time: **2 hours 30 minutes**.
- Materials provided:
  - multiple-choice response sheet
  - resource book.
- Equipment allowed:
  - 2B pencils and eraser (only for completing the multiple-choice response sheet and for graphing)
  - pens (blue or black ink)
  - ruler
  - normal writing implements
  - any hand-held, solar- or battery-operated non-programmable calculator
  - other QSA-approved equipment.
- This paper has **two** parts:
  - Part A: Knowledge and simple application  
Questions 1–10 Multiple choice  
Questions 11–18 Short response.
  - Part B: Scientific processes  
Questions 1–4 Short response.Attempt **all** questions.
- Do not take this paper, used or unused, from the examination room. Do not tear out any part of this paper. The supervisor will collect this paper when you leave the examination room.

#### Notes

##### Suggested time allocation:

Part A: 1 hour 50 minutes

Part B: 40 minutes.

##### Assessment:

This paper assesses the following criteria published in the 1998 Senior External Syllabus in Chemistry:

- Knowledge of subject matter
- Scientific processes.

Criteria and standards for assessment are on page 24 of this paper.

#### Candidate use

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Number of books used

#### Supervisor use only

Supervisor's initials	
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#### QSA use only

Examiner number	
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**Planning space**

## Part A — Knowledge and simple application

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Part A assesses knowledge and simple application of that knowledge based on the eight topics in the syllabus.

Part A is worth 70 marks.

Suggested time allocation: 1 hour 50 minutes.

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### Multiple choice

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This part has 10 questions of equal value. Attempt all questions.

Each question contains four options, **one** of which is correct or is the best option. Respond to each question by selecting one of the four possible options and blackening the appropriate circle on the multiple-choice response sheet provided. Use a 2B pencil to blacken the circles.

No credit for your response will be given if more than one circle is blackened.

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### Question 1

Covalent bonding is **not** found in which one of the following substances?

- A graphite
- B polythene
- C sodium hydroxide
- D potassium chloride

### Question 2

The shape of the molecule nitrogen trifluoride,  $\text{NF}_3$ , is best described as

- A bent triatomic.
- B planar trigonal.
- C pyramidal.
- D tetrahedral.

### Question 3

Which one of the following has the least mass?

- A 40 g of lead
- B 1 mole of iron
- C  $3.0 \times 10^{25}$  atoms of hydrogen
- D 22.4 litres of  $\text{CO}_2$  at STP

#### Question 4

Which of the following is **not** a redox reaction?

- A  $\text{SO}_2 + 2\text{H}_2\text{S} \rightarrow 2\text{H}_2\text{O} + 3\text{S}$
- B  $\text{BaO} + \text{SO}_3 \rightarrow \text{BaSO}_4$
- C  $\text{SO}_2 + 2\text{NO}_3^- \rightarrow \text{SO}_4^{2-} + 2\text{NO}_2$
- D  $2\text{Mg} + \text{SO}_2 \rightarrow 2\text{MgO} + \text{S}$

#### Question 5

Which of the following organic compounds is probably the most reactive?

- A  $\text{C}_2\text{H}_6$
- B  $\text{C}_3\text{H}_8$
- C  $\text{C}_2\text{H}_2$
- D  $\text{C}_4\text{H}_{10}$

#### Question 6

An element X has the electronic configuration  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ .

Judging from its electronic configuration the element is

- A an alkali metal.
- B an alkaline earth metal.
- C a halogen.
- D an inert gas.

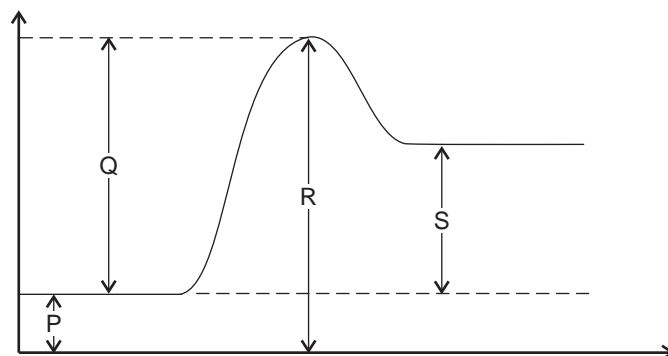
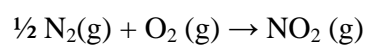
#### Question 7

A pure sample of a gas is at constant uniform temperature. Which of the following statements concerning the speed of the gaseous molecules is correct?

- A The molecular speeds are equal.
- B The speeds are continually changing.
- C The average speed of the molecules is directly proportional to the absolute temperature.
- D The average speed would halve if the molar mass of the gas were halved at constant temperature.

### Question 8

The diagram below represents the potential energy diagram for the reaction:



Which letter corresponds to the activation energy for this reaction?

- A P
- B Q
- C R
- D S

### Question 9

Equilibrium occurs only when

- A the reactants are used up.
- B all chemicals stop reacting.
- C the concentration of reactants is equal to the concentration of products.
- D the products react together at the same rate as they are formed.

### Question 10

If the equilibrium system:



was in a container of fixed volume, which change in condition would decrease the partial pressure of the  $\text{N}_2\text{O}_4(\text{g})$ ?

- A cooling the equilibrium mixture
- B adding a catalyst
- C adding more  $\text{NO}_2$  gas
- D heating up the equilibrium mixture

## Short response (60 marks)

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Attempt all questions.

You must show all working.

Respond in the spaces provided.

Marks are shown for each question.

If you need more space for a response, you may continue on pages 22 and 23.

Make sure you label the page used with the question number that relates to your response.

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### Question 11

- (a) Why are metals far better conductors of electricity than ionic solids like solid sodium chloride?

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(3 marks)

- (b) How many of each type of sub-atomic particle are present in a bromide ion containing the  $^{79}\text{Br}$  isotope?

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(3 marks)

- (c) Name the following compounds according to the accepted naming system.

(i)  $\text{Fe}_2\text{O}_3$  ..... (1 mark)

(ii)  $\text{Ag}_2\text{S}$  ..... (1 mark)

(d) Draw an electron dot diagram for hydrogen sulfide,  $\text{H}_2\text{S}$ , a gas when dry at room temperature.

(1 mark)

(e) Draw an electron dot diagram for sodium bromide which is an ionic solid.

(1 mark)

### Question 12

(a) Calculate the percentage composition by mass for the nitrogen in ammonium sulfate  $(\text{NH}_4)_2\text{SO}_4$ .

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(2 marks)

(b) Copper is found in minerals such as chalcopyrites  $\text{CuFeS}_2$  and malachite  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ .

(i) What mass of chalcopyrites must be smelted to produce 100 kg of copper?

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(2 marks)

(ii) What assumptions have you made in solving this problem?

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(2 marks)



(c) In 25.0 mL of a 0.20 mol L<sup>-1</sup> solution of aluminium sulfate Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> calculate:

(i) the concentration of the Al<sup>3+</sup> ions

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(1 mark)

(ii) the number of moles of Al<sup>3+</sup> ions in the 25.0 mL sample.

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(1 mark)

### Question 13

(a) Calculate the standard cell voltage for a cell which consists of the Ag|Ag<sup>+</sup> half-cell and the Br<sub>2</sub>|Br<sup>-</sup> half-cell. There is no need to draw a diagram.

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(3 marks)

(b) How much aluminium could be produced in an electrolytic cell using 2000 amperes for 24 hours?

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(3 marks)

### Question 14

- (a) Write the balanced equation for the complete combustion of octane. Include states of all substances.

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(2 marks)

- (b) The boiling point of octane is 126°C whereas the boiling point of methane is -161°C. Why is the boiling point of octane so much higher than that of methane?

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(2 marks)

- (c) Write a balanced equation for the reaction of methanoic acid with methanol in the presence of a small amount of concentrated sulfuric acid.

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(1 mark)

Name the organic product.

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(1 mark)

What is the purpose of the sulfuric acid used?

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(1 mark)

- (d) Name one polymer and write its repeat unit.

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(1 mark)

## Question 15

From your knowledge of the *Periodic Table of Elements*, answer the following questions concerning the element strontium which is in group 2.

(a) Is strontium a metal or a non-metal? Give a reason for your answer.

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(1 mark)

(b) What is the formula of the oxide of strontium? Explain how you arrived at your answer.

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(1 mark)

(c) Write a balanced equation for the reaction of strontium oxide with dilute hydrochloric acid.

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(1 mark)

(d) What particles are present in an aqueous solution of strontium chloride?

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(1 mark)

(e) How could **one** insoluble strontium substance be made from strontium chloride?

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(1 mark)

## Question 16

- (a) A sample of oxygen gas occupies 5.00 L volume at 90.0 kPa pressure. Calculate the volume of the same gas sample at 110.0 kPa pressure if the temperature remains constant.

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(2 marks)

- (b) A small sample of hydrogen gas was prepared and collected in the laboratory.

- (i) Write a balanced equation for the reaction used to prepare the gas.

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(1 mark)

- (ii) Describe how the gas could be collected.

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(1 mark)

- (iii) Describe a test that could be conducted to confirm that the gas collected is hydrogen.

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(1 mark)

### Question 17

- (a) Find the enthalpy change at 25°C for the polymerisation of acetylene  $C_2H_2(g)$  to form benzene  $C_6H_6(l)$ . Their heats of formation at 25°C are 227 kJ/mol and 49.0 kJ/mol respectively. You also need to comment on the value you obtained.

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(4 marks)

- (b) Give an example of a very slow reaction,

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(1 mark)

and explain why the reaction is slow.

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(2 marks)

How could the rate of that reaction be increased?

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(1 mark)

### Question 18

(a) A solution whose pH is 4.0 has base added until the pH is 9.0. How has the hydrogen ion concentration changed? By what factor? Explain.

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(3 marks)

(b) Describe two physical properties of a strong base such as sodium hydroxide.

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(2 marks)

(c) Write two different types of chemical reactions of sodium hydroxide.

(i) An acid-base reaction: .....

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(ii) A precipitation reaction: .....

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(2 marks)

(d) For the homogenous equilibrium reaction  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$  it was found that the equilibrium concentrations were:

$$[\text{H}_2] = 0.46 \text{ mol dm}^{-3}$$

$$[\text{I}_2] = 0.39 \text{ mol dm}^{-3}$$

and  $[\text{HI}] = 3.0 \text{ mol dm}^{-3}$  at a constant temperature.

Calculate the equilibrium constant for the reaction at that temperature.

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(3 marks)

**End of Part A**

## Part B — Scientific processes

Part B assesses scientific processes based on the eight topics in the syllabus and practical work.

Attempt all questions. All questions are of equal value.

Your responses will be assessed using the assessment criteria listed at the end of each question.

Suggested time allocation: 40 minutes.

### Short response

#### Question 1 — Nutrition and food analysis

Shown below is a label from a Kellogg's All Bran cereal box.

NUTRITION INFORMATION			
Servings per package – 12.5			
Serving size – 30g (½ cup)			
	PER 30G SERVE	PER 30G WITH ½ CUP SKIM MILK	PER 100G
ENERGY	319kJ (76 Cal)	497kJ (119 Cal)	1062kJ (254 Cal)
PROTEIN	4.6g	9.0g	15.4g
FAT	1.0g	1.2g	3.3g
CARBOHYDRATE			
–TOTAL	22.0g	28.0g	73.4g
–SUGARS	4.1g	10.1g	13.5g
DIETARY FIBRE	9.3g	9.3g	31.0g
SODIUM	306mg	370mg	1020mg
POTASSIUM	369mg	552mg	1229mg
CHOLESTEROL	0mg	2.5mg	0mg
THIAMINE (VIT B <sub>1</sub> )	0.28mg (% Aust R.D.I.*)	0.33mg (30%)	0.93mg (85%)
RIBOFLAVIN (VIT B <sub>2</sub> )	0.4mg (% Aust R.D.I.*)	0.6mg (37%)	1.3mg (81%)
NIACIN	2.8mg (% Aust R.D.I.*)	2.9mg (26%)	9.3mg (85%)
IRON	2.5mg (% Aust R.D.I.*)	2.6mg (26%)	8.3mg (83%)

(\* Recommended Dietary Intake)

Respond to the following questions in the spaces provided, giving your calculations and reasoning.

(a) Which ingredient on the label is not present in skim milk?

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(b) How much fat is present in 10 grams of cereal without milk?

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(c) How much cereal should you eat to obtain 23 grams of protein?

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(d) Use the data given to deduce the nutrition information for a half-cup of skim milk. Working should be given.

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**ASSESSMENT CRITERIA**

**The candidate:**

A	B	C	D	E
<ul style="list-style-type: none"><li>• answers correctly all four sections</li><li>• explains fully the reasons for the answers.</li></ul>	<ul style="list-style-type: none"><li>• answers correctly three of the four sections</li><li>• explains fully the reasons for the answers.</li></ul>	<ul style="list-style-type: none"><li>• answers correctly two of the four sections</li><li>• explains the reasoning with some success.</li></ul>	<ul style="list-style-type: none"><li>• answers correctly only one of the sections</li><li>• attempts a reasoned explanation.</li></ul>	<ul style="list-style-type: none"><li>• makes no attempt at the question.</li></ul>

## Question 2 — Heats of combustion of alcohols

The heats of combustion for the four simplest alcohols are shown in the table below.

Alcohol	Formula	Standard heat of combustion (kcal mol <sup>-1</sup> )
Methanol	CH <sub>3</sub> OH	-171
Ethanol	C <sub>2</sub> H <sub>5</sub> OH	-327
Propan-1-ol	C <sub>3</sub> H <sub>7</sub> OH	-483
Butan-1-ol	C <sub>4</sub> H <sub>9</sub> OH	-639

(a) What do you notice about the values for the heats of combustion of the four alcohols?

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(b) If you detected a pattern in these values, write a scientific hypothesis concerning the values in relation to the size of the alcohols.

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(c) Test your hypothesis against any known facts about the alcohols.

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- (d) Predict the standard heats of combustion for the next two primary alcohols – pentan-1-ol and hexan-1-ol.

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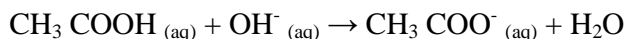
### ASSESSMENT CRITERIA

#### The candidate:

A	B	C	D	E
<ul style="list-style-type: none"><li>• makes correct conclusions</li><li>• develops a feasible hypothesis</li><li>• tests hypothesis against known facts</li><li>• predicts other two values successfully.</li></ul>	<ul style="list-style-type: none"><li>• makes correct conclusions</li><li>• develops a feasible hypothesis</li><li>• attempts to test hypothesis but without success</li><li>• predicts other two values successfully.</li></ul>	<ul style="list-style-type: none"><li>• makes a correct conclusion in (a)</li><li>• attempts an hypothesis but without success</li><li>• has difficulty testing hypothesis</li><li>• predicts at least one value successfully.</li></ul>	<ul style="list-style-type: none"><li>• makes a correct conclusion in (a)</li><li>• has not attempted the hypothesis</li><li>• has not tested the hypothesis against known facts</li><li>• predicts one value.</li></ul>	<ul style="list-style-type: none"><li>• makes no attempt at most parts.</li></ul>

### Question 3 — Acetic acid in vinegar

Acetic acid in vinegar can be determined by reaction with a standard solution of sodium hydroxide using a suitable indicator to detect the end-point. The reaction occurring will be:



In such an experiment, 10 mL of a commercial vinegar solution was diluted by adding water and made up to 100 mL in a volumetric flask. Then 10 mL aliquots of this diluted vinegar were pipetted into clean conical flasks and titrated with 0.0500 mol L<sup>-1</sup> sodium hydroxide with phenolphthalein indicator. The results from successive burette readings were:

Titration	Burette reading (mL)		Titre (mL)
	Initial	Final	
Pilot	0.8	18.9	18.1
1	18.9	33.9	15.0
2	2.5	17.5	15.0
3	17.5	32.5	15.0

Answer the following questions about this procedure.

(a) What is the purpose of the pilot titration?

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(b) Why is the pilot titre different from the other three titres?

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(c) What is the concentration of the acetic acid in the undiluted vinegar?

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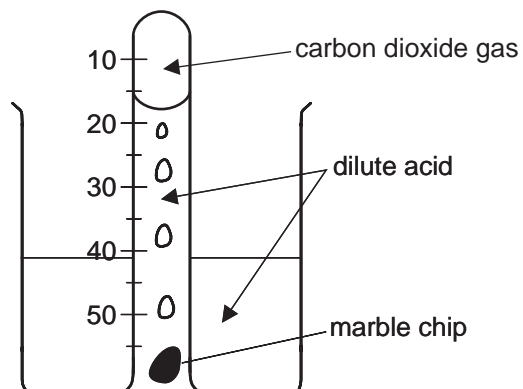
**ASSESSMENT CRITERIA**

**The candidate:**

A	B	C	D	E
<ul style="list-style-type: none"><li>gives correct explanations in (a) and (b) and calculates correctly the concentration in undiluted solution.</li></ul>	<ul style="list-style-type: none"><li>gives reasonable explanations in (a) and (b) but calculates correctly the concentration in undiluted solution.</li></ul>	<ul style="list-style-type: none"><li>gives some explanations in (a) and (b) but calculates only the concentration in the diluted solution.</li></ul>	<ul style="list-style-type: none"><li>attempts the question with some explanations given, and some attempt at calculating a concentration.</li></ul>	<ul style="list-style-type: none"><li>makes little or no attempt at the question.</li></ul>

### Question 4 — Experimental determination of reaction rate

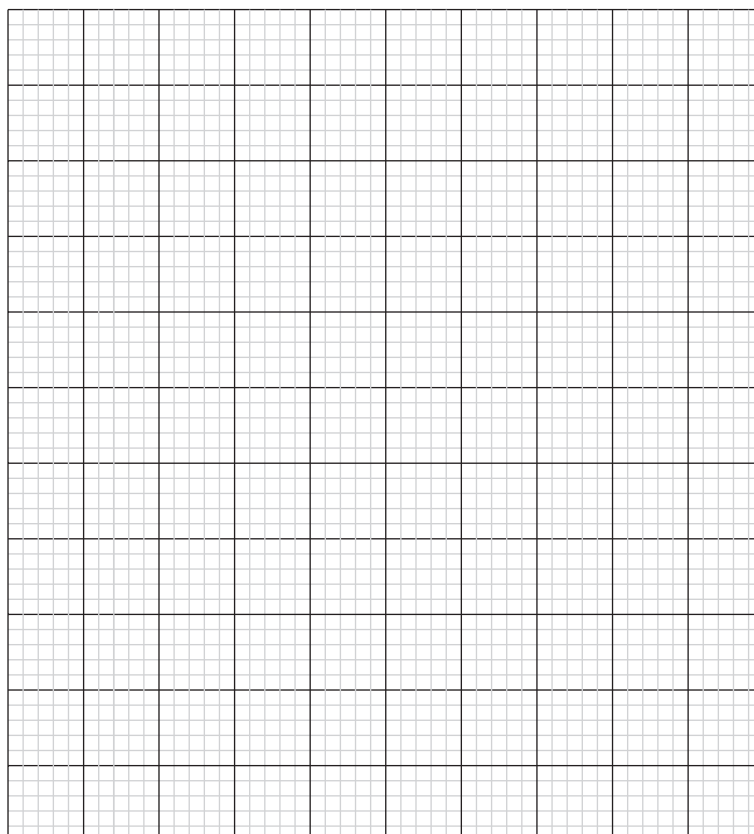
A piece of calcium carbonate in the form of a marble chip was added to dilute hydrochloric acid, and the carbon dioxide gas produced was collected in a graduated tube. The volume of gas collected was read at one minute intervals. A diagram of the apparatus is shown.



The results from the experiment were recorded as follows:

Time (min)	0	1	2	3	4	5	6	7
Volume (mL)	0	3	10	29	48	51	52	52

- (a) On the graph paper below, plot a graph in pencil of the progress of the reaction. Put volume on the vertical axis, and time on the horizontal axis.



(b) Label the region on your graph which represents the region of fastest reaction. Label it AB.

(c) Why is the reaction fastest near this region?

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(d) At what time does the reaction stop?

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### ASSESSMENT CRITERIA

#### The candidate:

A	B	C	D	E
<ul style="list-style-type: none"><li>correctly draws the graph as instructed, labeling correctly the region AB, and gives satisfactory explanations in (c) and (d).</li></ul>	<ul style="list-style-type: none"><li>correctly draws the graph as instructed, but has some minor omissions in answers (b), (c) or (d).</li></ul>	<ul style="list-style-type: none"><li>draws a graph to a reasonable degree of correctness, but omits essential information. Makes reasonable explanations in (c) and (d).</li></ul>	<ul style="list-style-type: none"><li>draws the graph poorly with essential information omitted, and without a reasonable explanation in (d).</li></ul>	<ul style="list-style-type: none"><li>makes little or no attempt at the question and with very limited success.</li></ul>

## Additional response page

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## Minimum standards associated with exit criteria

	Very High Achievement	High Achievement	Sound Achievement	Limited Achievement	Very Limited Achievement
<b>Knowledge of subject matter</b>	A very high ability to recall and apply knowledge of chemistry in simple situations.	A high ability to recall and apply knowledge of chemistry in simple situations.	A satisfactory ability to recall and apply knowledge of chemistry in simple situations.	Limited ability to recall and apply knowledge of chemistry in simple situations.	Very limited ability to recall and apply knowledge of chemistry in simple situations
<b>Scientific processes</b>	A very high ability to succeed in simple scientific process tasks—collecting and organising data, processing information, making simple judgments, communicating information in various contexts, devising and designing simple and/or single-step investigations.	A high ability to succeed in simple scientific process tasks—collecting and organising data, processing information, making judgments, communicating information in various contexts, devising and designing simple and/or single-step investigations.	A satisfactory ability to succeed in simple scientific process tasks—collecting and organising data, processing information, making judgments, communicating information in various contexts, devising and designing simple and/or single-step investigations.	Limited ability to succeed in simple scientific process tasks	Very limited ability to succeed in simple scientific process tasks.

## **Acknowledgments**

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ESA Publications (NZ) Ltd, Auckland, and E.M. Sayes for two graphics from *Form 6 Chemistry Revision* by E.M. Sayes.

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