INSIGHT

Trial Exam Paper

2011

CHEMISTRY

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	8	8	60
			Total 80

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

Materials provided

- The question and answer book of 23 pages, with a removable data book.
- An answer sheet for multiple-choice questions.

Instructions

- Remove the data book from this book during reading time.
- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination

- Place the multiple-choice answer sheet inside the front cover of this question and answer book.

Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.

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SECTION A – Multiple-choice questions

Question 1

The energy density of methane gas in kJ g^{-1} is

A. 0.0180

B. 27.8

C. 55.6

D. 889

Question 2

Hydrogen gas is produced industrially by the following reaction

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +207 \text{ kJ mol}^{-1}$$

The rate at which hydrogen gas is produced would be optimised by

A. low pressure, low temperature.

B. low pressure, high temperature.

C. high pressure, low temperature.

D. high pressure, high temperature.

Question 3

Propane and butane can both be burned to produce heat energy. The volume of propane gas, in L, at SLC that produces the same amount of energy as 1.50 L of butane gas at SLC is

A. 0.794

B. 1.16

C. 1.50

D. 1.94

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Question 4

Consider the following equilibrium system

$$4HCl(g) + O_2(g) \rightleftharpoons 2H_2O(g) + 2Cl_2(g) \qquad \Delta H = -116 \text{ kJ mol}^{-1}$$

Which of the following reaction conditions is most likely to result in the most improved rate **and** yield of reaction?

A. excess HCl, low temperature

B. excess O_2, high temperature

C. addition of a catalyst, low pressure

D. addition of a catalyst, low temperature

Question 5

A 2.00 g sample of benzoic acid, C_6H_5COOH (relative mass = 122), was used to calibrate a bomb calorimeter.

1 mol of benzoic acid releases 3227 kJ of heat energy. Complete combustion of the sample of benzoic acid resulted in the temperature of the water bath increasing from 23.10°C to 26.45°C. The calibration factor, in kJ °C^{-1}, for the calorimeter is

A. 2.00

B. 15.8

C. 52.9

D. 1.93×10^3

Question 6

Which of the following best explains the increase in reaction rate observed when a catalyst is added to a reaction mixture?

A. Adding a catalyst increases the activation energy of the reaction, making it easier for the reaction to occur.

B. Adding a catalyst causes the reactant particles to collide with each other more often.

C. Adding a catalyst provides a surface to which the reactant particles can form bonds and so react with each other more easily.

D. Adding a catalyst lowers the activation energy of the reaction, meaning the particles collide with each other more frequently.

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Question 7

The pH of a standard hydrogen half-cell is

A. 0

B. 1

C. 7

D. 13

Question 8

Hydrogen and iodine gas react to produce hydrogen iodide according to the equation

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

2.00 mol of H_2 and 1.00 mol of I_2 are added to a 2.0 L reaction vessel and allowed to reach equilibrium. If 0.500 mol of HI(g) is present at equilibrium, the equilibrium concentrations of $H_2(g)$ and $I_2(g)$ are

	[H_2]	**[I_2]**
A.	0.875	0.375
B.	1.75	0.750
C.	0.250	0.250
D.	1.00	0.500

Question 9

A mixture of $N_2O_4(g)$ and $NO_2(g)$ is at equilibrium according to the equation

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +57 \text{ kJ mol}^{-1}$$

Which of the following changes to the equilibrium mixture will result in an increase to the value of *K* for this reaction?

I Doubling the volume

II Doubling the temperature

III Addition of $N_2O_4(g)$

A. I and II only

B. II only

C. I, II and III

D. none of the above

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Question 10

Which of the following acids will show the greatest percentage ionisation in solution?

A. boric acid

B. hypobromous acid

C. hydrocyanic acid

D. lactic acid

Question 11

The concentration, in mol L^{-1}, of a solution of barium hydroxide, $Ba(OH)_2$, which has a pH of 11.4 is

A. 1.99×10^{-12}

B. 3.98×10^{-12}

C. 1.26×10^{-3}

D. 2.51×10^{-3}

Question 12

Magnesium reacts with oxygen according to the thermochemical equation

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s) \quad \Delta H = -1200 \text{ kJ mol}^{-1}$$

The mass, in g, of magnesium that would need to be burned to release 4000 kJ of energy is

A. 7.29

B. 14.6

C. 81.0

D. 162

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Question 13

Consider the reaction system

$$2A(l) + 3B(g) \rightarrow 2C(g) + 4D(g) \qquad \Delta H = +345 \text{ kJ mol}^{-1}$$

It is correct to say that for this equation

I for each mol of A reacting, an enthalpy change of 345 kJ is produced.

II this is an endothermic reaction.

III the activation energy for this reaction is less than the ΔH value.

A. I and III only

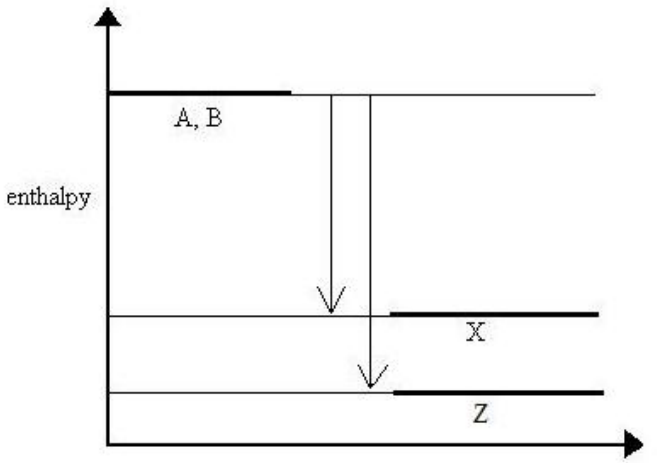
B. II only

C. II and III only

D. I, II and III

Question 14

The energy diagram below relates to two reactions.



$A(g) + B(g) \longrightarrow X(g) \qquad \Delta H = -183 \text{ kJ mol}^{-1}$

$A(g) + B(g) \longrightarrow Z(g) \qquad \Delta H = -215 \text{ kJ mol}^{-1}$

The ΔH value for the reaction $2X(g) \rightarrow 2Z(g)$ will be

A. $+32 \text{ kJ mol}^{-1}$

B. -32 kJ mol^{-1}

C. $+64 \text{ kJ mol}^{-1}$

D. -64 kJ mol^{-1}

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Question 15

The strongest reductant from the following list Fe^{3+}, Sn^{2+}, H_2O, K^+, Br^-, Au, Pb^{2+} is

A. K^+

B. Fe^{3+}

C. Sn^{2+}

D. Au

Question 16

An electric current is passed through a solution of 1.0 M KCl. The reaction that will occur at the cathode is

A. $K^+(aq) + e^- \rightarrow K(s)$

B. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

C. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

D. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

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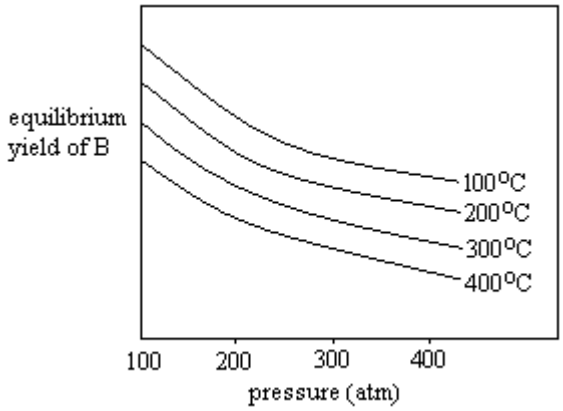
Question 17

Gaseous reactant A exists in equilibrium with gaseous product B. No other chemical species are present. The following graph shows the effect of increasing pressure and temperature on the equilibrium yield of product B.



Which of the following conclusions about the reaction could be correct?

I There are more gaseous reactant particles than gaseous product particles in the equation.

II The reaction is exothermic.

A. I and II only

B. I only

C. II only

D. neither I nor II

Question 18

Which of the following best describes the source of energy in a nuclear power station?

A. Nuclei are split into smaller particles and energy is released in the process.

B. Nuclei are burnt in oxygen, releasing energy in the process.

C. Nuclei fuse with each other to make bigger particles, releasing energy in the process.

D. Nuclei release neutrons one at a time and release energy in the process.

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Question 19

An electroplating cell is devised to place a gold coating on a brass ring. A voltage of 2.80 V and a current of 1.35 A are passed through a solution of 1.00 M Au^+ ions, for 280 seconds. The mass of gold produced, in grams, is closest to

A. 0.0129

B. 0.386

C. 0.772

D. 2.16

Question 20

Water self-ionises according to the equation

$$H_2O(l) + H_2O(l) \rightleftharpoons OH^-(aq) + H_3O^+(aq) \qquad \Delta H = +57 \text{ kJ mol}^{-1}$$

At 25°C the pH of pure water is 7.00. At 35°C the pH of pure water is

A. 7.00 because the concentration of H_3O^+ ions has not changed.

B. 7.00 because although the reaction has shifted to the right, it is still neutral.

C. less than 7.00 because the reaction has shifted to the right and the solution is now slightly acidic.

D. less than 7.00 because the reaction has shifted to the right; however, the solution is still neutral

END OF SECTION A

END OF SECTION A
TURN OVER

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SECTION B – Short-answer questions

Question 1

Nitrosyl bromide ($NOBr_2$) decomposes according to the reaction

$$2NOBr_2(g) \rightleftharpoons 2NO(g) + Br_2(g) \qquad \Delta H < 0$$

a. **i.** Write an equilibrium expression for this reaction.

1 mark

ii. 3.00 mol of $NOBr_2$ was added to a 4.00 L reaction vessel at 300 K. Once equilibrium was reached, 0.805 mol of Br_2 was present in the mixture. Calculate the equilibrium constant for the reaction at this temperature.

3 marks

SECTION B – Question 1 – continued

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iii. In a second reaction mixture, also in a 4.0 L reaction vessel and at 300 K, the concentrations of the gases were found to be

$[NOBr_2] = 0.507$ M $\qquad$ $[Br_2] = 0.0405$ M

Calculate the concentration, in M, of NO in the reaction mixture.

2 marks

b. Would the equilibrium yield for this reaction be favoured by a low or high temperature? Use Le Chatelier's Principle to explain your answer.

3 marks

Total 9 marks

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Question 2

A student obtains four 0.10 M solutions of nitric acid, ethanoic acid, benzoic acid and sulfuric acid.

a. Calculate the pH of the

i. nitric acid solution

1 mark

ii. ethanoic acid solution

3 marks

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b. Will the molar concentration of H_3O^+ ions be the same, higher or lower in the benzoic acid solution compared to the ethanoic acid solution? Explain your answer.

_____

_____

_____

2 marks

c. List the four 0.100 M solutions in order from lowest pH to highest pH.

_____

_____

2 marks

d. 100 mL of distilled water is added, separately, to the nitric acid solution and to the ethanoic acid solution.

Indicate the effect on the pH and percentage ionisation of each acid by ticking the appropriate box in the table below.

	Decrease	**Increase**	**Not change**
Effect on pH of nitric acid			
Effect on percentage ionisation of nitric acid			
Effect on pH of ethanoic acid			
Effect on percentage ionisation of ethanoic acid			

4 marks

Total 12 marks

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Question 3

A bomb calorimeter can be used to determine the enthalpy changes in a chemical reaction. In one reaction, pentane is combusted in the bomb of a calorimeter that is surrounded by a 300 mL water bath.

a. Write a balanced thermochemical equation for the complete combustion of pentane.

_____

_____

2 marks

b. **i.** Calculate the mass of pentane that would need to undergo combustion in a calorimeter to produce a temperature change in the water of 1.65°C. Be sure to give your answer with the correct number of significant figures.

_____

_____

_____

_____

_____

_____

_____

4 marks

ii. State one assumption you made when calculating your answer to **part i**.

_____

_____

1 mark

Total 7 marks

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Question 4

During this semester, you looked at one of the following reactions as part of your study of the industrial production of an important chemical. Place a tick in the box next to the reaction that is part of the production of the chemical you studied.

	$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
	$C_3H_8(g) \rightleftharpoons C_2H_4(g) + CH_4(g)$
	$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$
	$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

a. **i.** What conditions of temperature and pressure favour optimum yield for your chosen reaction?

_____

_____

1 mark

ii. Are these conditions used on an industrial scale? Give a reason for your answer.

_____

_____

_____

2 marks

b. **i.** Identify one specific risk to human health associated with the production of your selected chemical.

_____

_____

1 mark

ii. Give one precaution that is taken in response to the risk you identified in **part i.**

_____

_____

1 mark

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c. **i.** Name one useful commercial product formed from the chemical you chose.

_____

1 mark

ii. Write a chemical equation to show the formation of the commercial product named in **part c i**.

_____

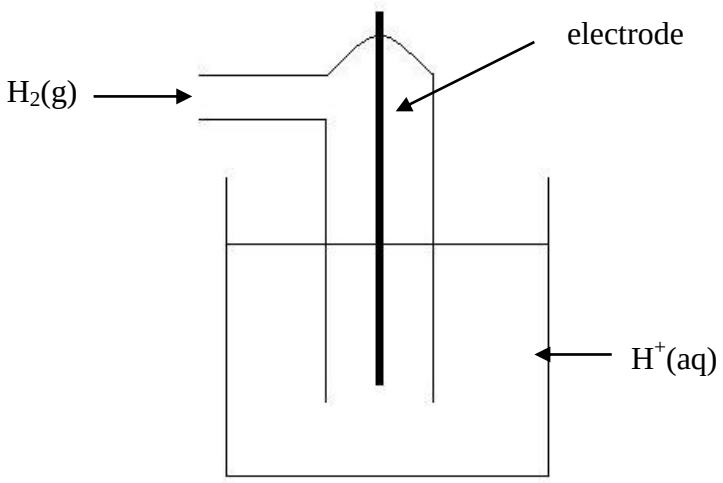
_____

1 mark

Total 7 marks

Question 5

The $H^+(aq)/H_2(g)$ half-cell is the standard used to obtain the $E°$ values listed in the electrochemical series. A diagram of the cell is shown below.



a. State the temperature and pressure required for this cell to be used as a half-cell.

_____

1 mark

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b. **i.** After several minutes, will the pH in the $H^+(aq)/H_2(g)$ half-cell have increased, decreased or be unchanged?

_____

1 mark

ii. Explain your answer to **part i**.

_____

_____

_____

2 marks

c. **i.** Write an overall ionic equation for a galvanic cell in which one half-cell is the $Fe^{3+}(aq)/Fe^{2+}(aq)$ cell and which has a potential difference of 1.05 V.

_____

_____

1 mark

ii. Identify the strongest reductant in this reaction.

_____

1 mark

Total 7 marks

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Question 6

Primary, secondary and fuel cells are all types of galvanic cells used for the production of electricity.

a. What is the main difference between a primary cell and a fuel cell?

_____

_____

1 mark

b. The nickel–cadmium cell is a secondary cell used to power small appliances. When the cell is being used the overall reaction is

$$NiO_2(s) + 2H_2O(l) + Cd(s) \rightarrow Ni(OH)_2(s) + Cd(OH)_2(s)$$

i. What feature of this cell enables it to be recharged?

_____

_____

1 mark

ii. When the cell is recharging, which species is reacting at the negative electrode?

_____

_____

1 mark

c. The overall equation for a fuel cell used in 'breathalyser' instruments is

$$C_2H_5OH(aq) + O_2(g) \rightarrow CH_3COOH(aq) + H_2O(l)$$

i. Write the equation for the half-reaction that occurs at the anode.

_____

_____

1 mark

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ii. A motorist blows into a fuel cell for 5.0 seconds and provides 1.4×10^{-4} g ethanol at the rate of 2.8×10^{-5} g per second. Calculate the maximum current, in A, that the cell would produce.

4 marks

iii. What is the energy, in kJ, that would be produced in **part c ii** if the voltage is measured at 4.0 V?

1 mark

Total 9 marks

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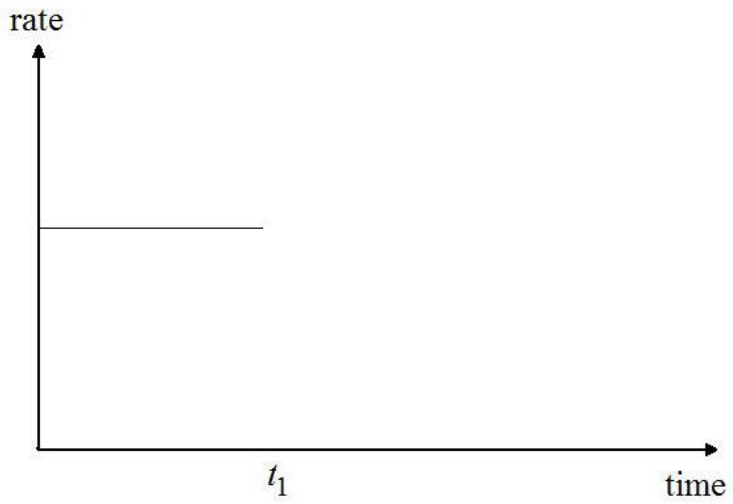
Question 7

The same amounts of reactants X and Z are placed in two sealed containers and allowed to react according to the equation

$$X(g) + Z(g) \rightleftharpoons 2Y(g) \quad \Delta H = -345 \text{ kJ mol}^{-1}$$

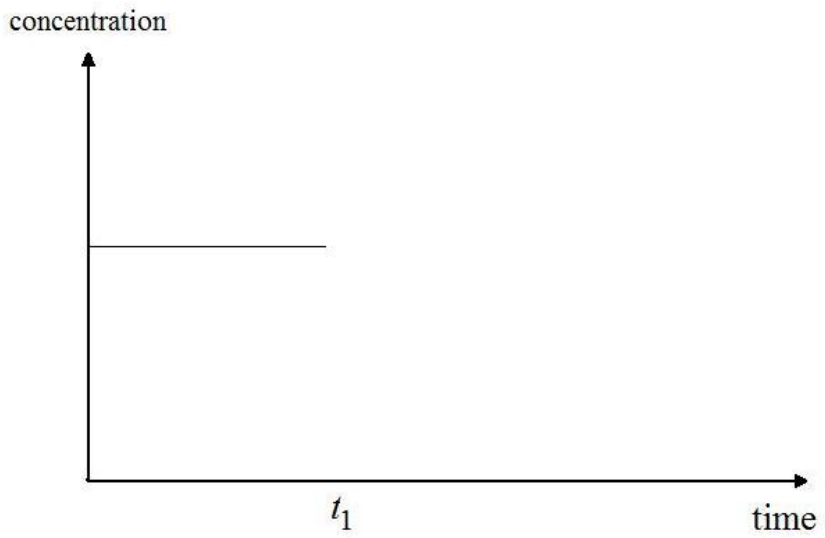
a. After the reaction reaches equilibrium in container 1, a small amount of catalyst is added to the container at time t_1.

i. On the rate–time graph below, continue the line to show what will happen to the rate of the forward reaction after time t_1 in container 1.



1 mark

ii. On the concentration–time graph below, continue the line to show what will happen to the concentration of reactant X after time t_1 in container 1.



1 mark

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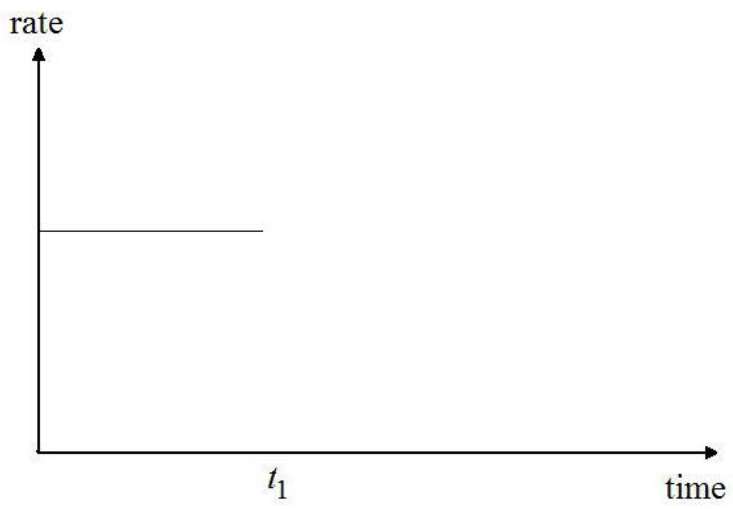
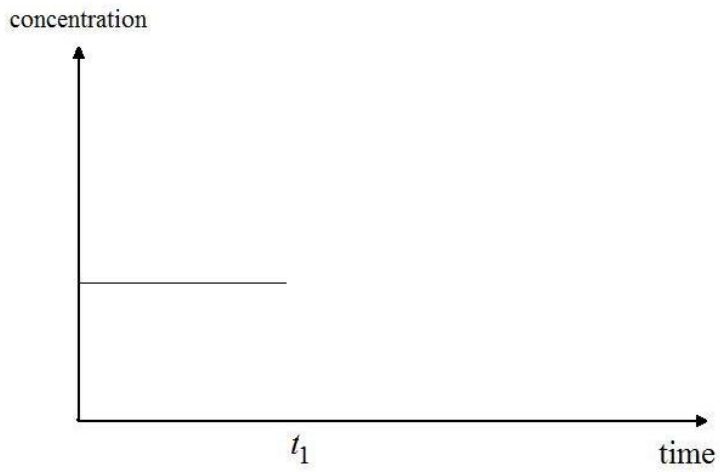
b. After the reaction reaches equilibrium in container 2, the volume of the reaction vessel is halved at time t_1.

i. On the rate–time graph below, continue the line to show what will happen to the rate of the forward reaction after time t_1 in container 2.



1 mark

ii. On the concentration–time graph below, continue the line to show what will happen to the concentration of reactant X at time t_1 in container 2.



2 marks

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iii. Explain the graph you drew in **part i**.

_____

_____

_____

1 mark

Total 6 marks

Question 8

A panel of experts is making recommendations to a government group regarding future choices for energy sources. The experts have been comparing the energy sources brown coal, natural gas, nuclear fission and ethanol (a biochemical fuel).

a. Which energy source would you recommend on the basis of sustainability? Give a reason for your answer.

_____

_____

_____

1 mark

b. Which energy source would you recommend on the basis of energy density; that is, which fuel has the highest kJ g^{-1}?

_____

_____

_____

1 mark

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c. Which **two** energy sources would you recommend as producing the least amount of greenhouse gas emissions per gram? Explain your answer.

_____

_____

_____

_____

_____

2 marks

Total 4 marks

END OF SECTION B

END OF QUESTION AND ANSWER BOOK

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