Neap:

Trial Examination 2009

VCE Chemistry Unit 4

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks	Suggested time (minutes)
A Multiple-choice	20	20	20	25
B Short-answer	6	6	55	65
			Total 75	Total 90

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

Materials supplied

Question and answer booklet of 17 pages.
Data booklet of 11 pages.
Answer sheet for multiple-choice questions.

Instructions

Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2009 VCE Chemistry Unit 4 Written Examination.

SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than one answer is completed for any question.

Question 1

When a lead-acid car battery is producing energy, the overall reaction may be represented by the equation:

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

During this process

A. oxidation occurs at the positive electrode and the electrolyte pH increases.
B. oxidation occurs at the negative electrode and the electrolyte pH decreases.
C. reduction occurs at the positive electrode and the electrolyte pH increases.
D. reduction occurs at the negative electrode and the electrolyte pH decreases.

Question 2

According to Le Chatelier's principle: 'If a chemical system at equilibrium is subjected to a change in conditions, the system will respond

A. in such a way that the equilibrium constant for the reaction is always unchanged'.
B. in order to return all concentrations to their original values'.
C. by altering the temperature and volume of the reaction vessel to achieve a new equilibrium'.
D. to re-establish equilibrium in such a way as to partially overcome the imposed change'.

Question 3

0.250 g of sodium hydroxide pellets were added to 50.0 g of water. The temperature rose from 19.0 °C to 20.3 °C.

Based on this experiment, the heat of solution of sodium hydroxide is closest to

A. –43 kJ mol^{-1}.
B. –1.1 kJ mol^{-1}.
C. +1.1 kJ mol^{-1}.
D. +43 kJ mol^{-1}.

Question 4

Which of the following systems could reach a state of equilibrium?

A. 4.0 g of solid barium sulfate added to a saturated solution of barium sulfate.
B. 1.0 g of sodium chloride dissolved in 1.0 L of water.
C. 0.2 g of magnesium added to 50.0 mL of 1.0 M hydrochloric acid solution.
D. 50.0 mL of hydrogen chloride gas bubbled through 500 mL of water in a beaker.

Questions 5 and 6 refer to the following information.

The table shows the variation in the pH of pure water with temperature.

Temperature (°C)	pH of pure water
0	7.47
5	7.37
15	7.17
25	7.00
35	6.83
45	6.70
55	6.57

Question 5

The reaction for the self-ionisation of water is represented by the equation:

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

It can be concluded from the data that the reaction for the self-ionisation of water is

A. endothermic and the reactants are favoured with increasing temperature.
B. endothermic and the products are favoured with increasing temperature.
C. exothermic and the reactants are favoured with increasing temperature.
D. exothermic and the products are favoured with increasing temperature.

Question 6

The ratio of $[H_3O^+]/[OH^-]$ at 45 °C would be

A. less than 1.
B. equal to 1.
C. greater than 1.
D. determined only from direct measurement of the relevant concentrations.

Question 7

A major reaction in an industrial production process is represented by the equation:

$$X_2(g) + Y_2(g) \rightleftharpoons X_2Y_2(g) \qquad \Delta H > 0$$

Which set of conditions listed below would be most likely to produce the greatest increase in both the rate of production and the yield of the product X_2Y_2 for this reaction?

A. no catalyst, high temperature and high pressure
B. no catalyst, low temperature and low pressure
C. use of a catalyst, low temperature and high pressure
D. use of a catalyst, high temperature and high pressure

Question 8

Nitrous acid ionises in water as shown in the equation:

$$HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$$

The equilibrium constant for this reaction at 25 °C is K.

What is the value of the equilibrium constant, at 25°C, for the reaction shown in the equation below?

$$2H_3O^+(aq) + 2NO_2^-(aq) \rightleftharpoons 2HNO_2(aq) + 2H_2O(l)$$

A. $2K$

B. $\frac{1}{2K}$

C. $\frac{1}{K^2}$

D. $\frac{K^2}{2}$

Question 9

The concentration of ions in a 1.0 M sulfuric acid solution is shown in the table below.

Ions in $H_2SO_4(aq)$	$HSO_4^-(aq)$	$H^+(aq)$	$SO_4^{2-}(aq)$
Concentration	0.99 M	1.01 M	9.8×10^{-3} M

Which of the following cannot be reasonably concluded from the data?

A. sulfuric acid is a strong acid, capable of donating two protons

B. the K_a of sulfuric acid is lower than the K_a of the $HSO_4^-(aq)$ ion

C. the percentage hydrolysis of the $HSO_4^-(aq)$ ion is less than 10%

D. 1.0 M sulfuric acid has a pH less than zero

Question 10

Experimentally determined quantitative data from chemical reactions include:

I Equilibrium constant

II Heat of reaction

III Rates of the forward and reverse reactions

IV Activation energy of the forward and reverse reactions

For a particular chemical reaction, the presence of a suitable catalyst will change

A. I, II and III only.

B. II, III and IV only.

C. I, III only.

D. III and IV only.

Question 11

A student conducted an experiment using metals P, Q, R and S and solutions of their ions to determine an electrochemical series. The results are shown in the table below.

Chemicals Mixed	Observations
metal S with $Q^+(aq)$ ions	reaction
metal R with $P^{2+}(aq)$ ions	reaction
metal P with $Q^+(aq)$ ions	reaction
metal S with $R^{2+}(aq)$ ions	no reaction

Which of the following shows the correct order of **decreasing** oxidant strength based on the data obtained in the experiment?

A. R^{2+} P^{2+} S^{2+} Q^+

B. P^{2+} R^{2+} S^{2+} Q^+

C. Q^+ S^{2+} P^{2+} R^{2+}

D. S^{2+} Q^+ R^{2+} P^{2+}

Question 12

Consider the following thermochemical equations.

$$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g) \qquad \Delta H = +\ 67.7\ kJ\ mol^{-1}$$

$$N_2(g) + 2O_2(g) \rightarrow N_2O_4(g) \qquad \Delta H = +\ 9.7\ kJ\ mol^{-1}$$

The enthalpy of reaction for the reaction shown in the equation below would be

$$2NO_2(g) \rightarrow N_2O_4(g)$$

A. $-77.4\ kJ\ mol^{-1}$.

B. $-58.0\ kJ\ mol^{-1}$.

C. $+58.0\ kJ\ mol^{-1}$.

D. $+77.4\ kJ\ mol^{-1}$.

Question 13

Which of the following is likely to oxidise $Sn^{2+}(aq)$ but not $Fe^{2+}(aq)$?

A. $Br_2(l)$

B. $I_2(s)$

C. $H_2O_2(aq)$

D. $Pb^{2+}(aq)$

Questions 14 and 15 refer to the following information.

An amount of gaseous N_2O_4 was added to a sealed container of fixed volume and allowed to reach equilibrium according to the equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

An additional amount of gaseous N_2O_4 was then added to the container. The system was again allowed to reach equilibrium while the temperature was held constant.

Question 14

Compared to the first equilibrium, at the new equilibrium

A. the concentration of N_2O_4 has increased, and the pressure has increased.

B. the concentration of N_2O_4 has increased, and the pressure has decreased.

C. the concentration of N_2O_4 has decreased, and the pressure has increased.

D. the concentration of N_2O_4 has decreased, and the pressure has decreased.

Question 15

At the new equilibrium

A. the rate of the forward reaction will be greater than the rate of the reverse reaction.

B. the rate of the forward reaction will be less than the rate of the reverse reaction.

C. the rate of the forward reaction will equal the rate of the reverse reaction.

D. the rate of both the forward and reverse reactions will be zero.

Question 16

A metal ring is to be plated with another metal (M) from the second transition series of the Periodic Table. During the electrolysis, a current of 1.51 A was applied for 90 s and a mass of 0.150 g of metal M was deposited on the ring.

The magnitude of the positive charge carried by metal M ions is

A. 1

B. 2

C. 3

D. 4

Question 17

Methanoic acid and ethanoic acid are both weak acids. Separate 50.0 mL solutions of 0.1 M methanoic acid and 0.1 M ethanoic acid were prepared at 25 °C, and experiments were conducted to compare the acids. Three statements concerning the two acid solutions are given below.

I The percentage ionisation is higher in methanoic acid than ethanoic acid.

II The ethanoic acid solution has a higher pH than the methanoic acid solution.

III Both acid solutions require the same volume of 0.1 M NaOH(aq) to achieve neutralisation of the acid.

Which of the statements are correct?

A. I and II only

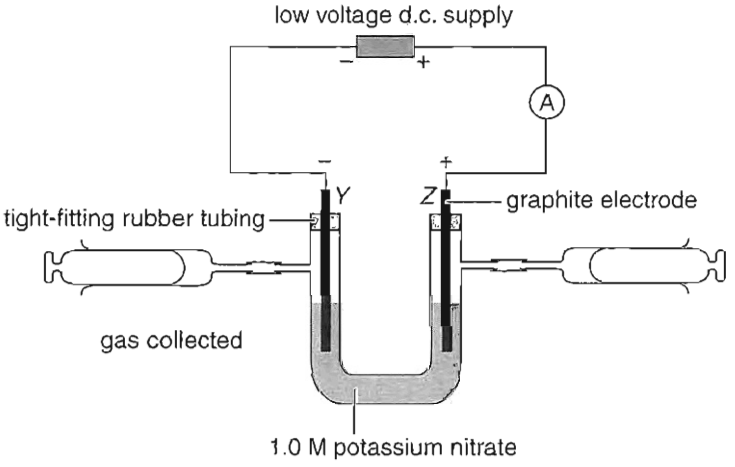
B. I and III only

C. II and III only

D. I, II and III

Questions 18 and 19 refer to the following information.

An experiment to investigate the electrolysis of solutions using graphite electrodes was conducted using the apparatus shown below. Gases may be collected at either electrode, and their volumes measured using the syringes.



Question 18

During the electrolysis of a 1.0 M solution of potassium nitrate x mL of gas was collected at electrode Y under standard laboratory conditions.

The volume of gas collected at electrode Z under these same conditions would be expected to be

A. $0.5x$.

B. x.

C. $2.0x$.

D. zero, as no gas is generated at electrode Z.

Question 19

A second experiment was conducted using the same apparatus, and the same conditions, but with **copper electrodes** replacing the graphite electrodes used previously. A voltage was selected so that again, x mL of gas was collected at electrode Y.

The volume of gas collected at electrode Z when using the copper electrodes would be expected to be

A. $0.5x$.

B. x.

C. $2.0x$.

D. zero, as no gas is generated at electrode Z.

Question 20

Which of the following fuels has the highest energy density (measured in kJ kg^{-1})?

A. methanol

B. ethanol

C. 1–propanol

D. 2–propanol

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

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

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1

Natural gas is a very important and widely used energy source in society. It consists primarily of methane, with small amounts of ethane and propane.

a. The gas is piped to homes to be burnt for heating and cooking purposes.

i. Give a balanced chemical equation for the complete combustion of methane.

ii. Calculate the mass of methane (in grams) required to bring to the boil 750 mL of water at an initial temperature of 15 °C. Assume that 65% of the energy produced is used to heat the water.

1 + 3 = 4 marks

b. Natural gas is also used for electricity generation in gas-fired power stations. In these stations, hot gases produced in a combustion reaction expand air in a combustion turbine, spinning the blades and the attached generator.

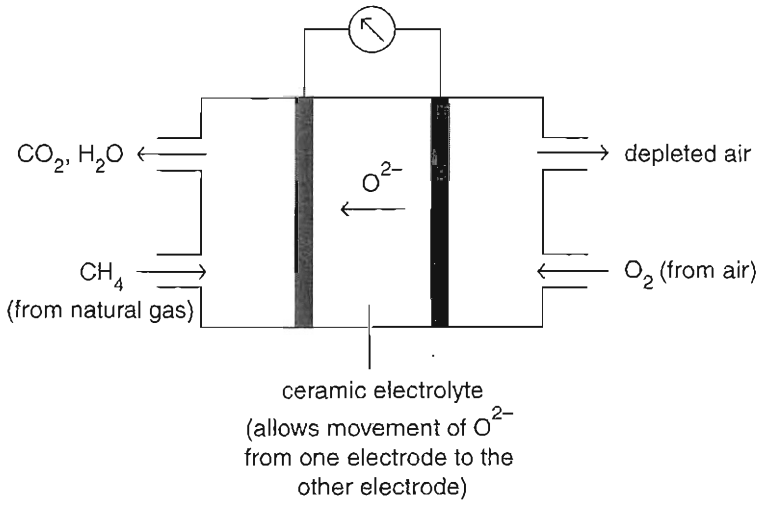
i. List in order the energy conversions that take place in the gas-fired power station during this process.

ii. Gas-fired power stations achieve a higher energy efficiency in electricity output than coal-fired power stations.

Explain why.

2 + 2 = 4 marks

c. An innovative way of using natural gas with a fuel cell is being developed by an Australian company. These cells use a ceramic electrolyte with natural gas and oxygen being channelled onto the appropriate electrodes. Stacks of the individual fuel cells provide the high voltages required for domestic applications such as water heating and electricity generation. The design of the cell is shown below.



i. Write an equation for the chemical reaction occurring at the anode. Symbols of state are not required.

ii. Write an equation for the chemical reaction occurring at the cathode. Symbols of state are not required.

iii. When the fuel cell operates for 25.0 minutes at a current of 0.450 A, it delivers 0.405 kJ of electrical energy.

Calculate the voltage of the fuel cell.

iv. This fuel cell produces carbon dioxide when operating.

Explain why it is still proposed as an effective method of tackling the greenhouse gas emission problem.

1 + 1 + 1 + 2 = 5 marks
Total 13 marks

Question 2

A 4.0 M solution of the weak acid hypobromous acid, HOBr, was prepared. The acid ionises in water according to the equation:

$$HOBr(aq) + H_2O(l) \rightleftharpoons OBr^-(aq) + H_3O^+(aq)$$

a. Write an expression for the ionisation constant, K_a, for hypobromous acid.

1 mark

b. Calculate the pH of the 4.0 M acid solution.

3 marks

c. **i.** State the colour of the solution which would form if a few drops of bromophenol blue indicator were added to the 4.0 M HOBr solution.

ii. 10.0 mL of the 4.0 M HOBr solution containing bromophenol blue indicator was diluted to a total volume of 1.0 L.

What colour change, if any, would be expected? Explain your choice.

1 + 2 = 3 marks

d. A solution of hydrochloric acid is prepared so that it has the same pH as the 4.0 M hypobromous acid solution. Small samples of calcium carbonate, of equal mass, are added to 20.0 mL of each of the acid solutions.

What difference, if any, would be expected in the rate of reaction in the two acid solutions? Explain your choice.

2 marks

Total 9 marks

Question 3

The table below lists chemicals produced on an industrial scale in Australia. For each chemical, one chemical reaction which occurs during its production, is displayed.

Choose ONE of these reactions by **ticking one box** in the middle column of the table and **answer all parts of this question for your selected reaction only**.

Chemical	Tick ONE only	A chemical reaction occurring during the chemical's production
Ethene		$C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$
Sulfuric acid		$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
Ammonia		$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
Nitric acid		$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

a. Show that your selected reaction is a redox reaction.

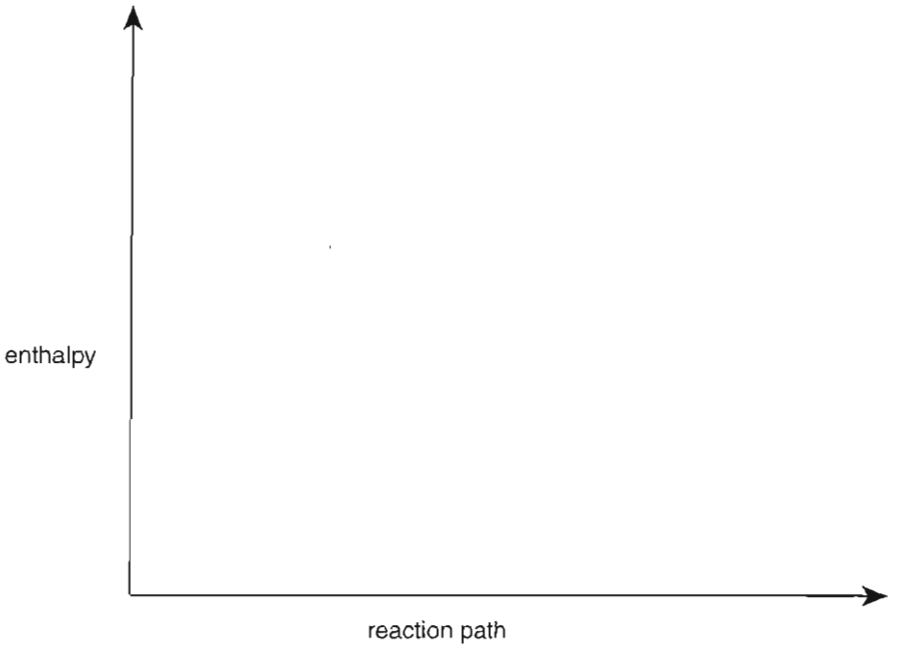
1 mark

b. On the axes below, sketch an energy profile for your selected reaction. Label on the profile:

i. energy levels of reactants (R) and products (P)

ii. activation energy for the reaction (E_A)

iii. enthalpy change for the reaction (ΔH)



2 marks

c. For your selected reaction, indicate in the table below which conditions of pressure and temperature would produce the maximum equilibrium yield. Explain your choices using equilibrium principles.

Condition affecting yield	Choice of condition to produce maximum yield (indicate as high or low)	Explanation (using equilibrium principles)
Pressure		
Temperature		

3 marks

d. Fertiliser is often distributed in plastic sacks.

i. For your selected chemical, write a chemical equation for the formation of a fertiliser OR the production of a plastic (polymer).

_____

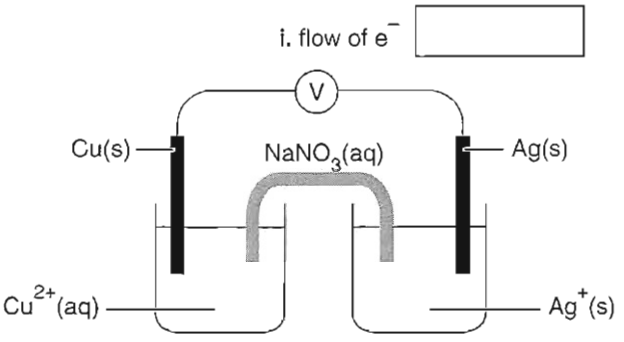
ii. Name the product of the reaction in part **i**.

_____

1 + 1 = 2 marks
Total 8 marks

Question 4

a. An electrochemical cell was constructed using Cu^{2+}/Cu and Ag^{+}/Ag half-cells at standard conditions. The two half-cells were joined by an inverted U-tube containing a solution of sodium nitrate.



i. Indicate the direction of the flow of the electrons through the wire when the cell is operating by placing an arrow in the appropriate box in the above diagram.

ii. Which ions in the salt bridge would migrate into the copper half-cell when the cell is operating?

_____

iii. State two observations which could be made in the beakers to indicate that the cell is operating.

_____

_____

_____

_____

iv. Explain why it would be unsuitable to use a solution of potassium chloride in the salt bridge in this cell.

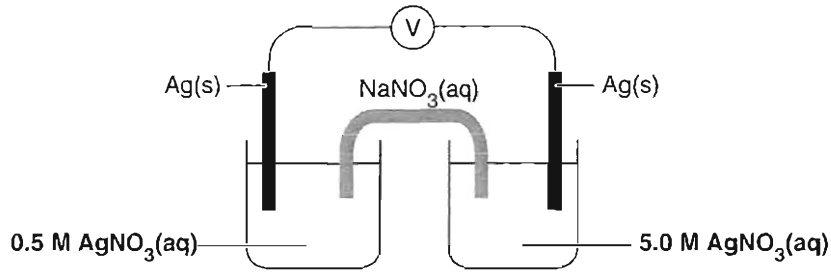
_____

_____

_____

1 + 1 + 2 + 1 = 5 marks

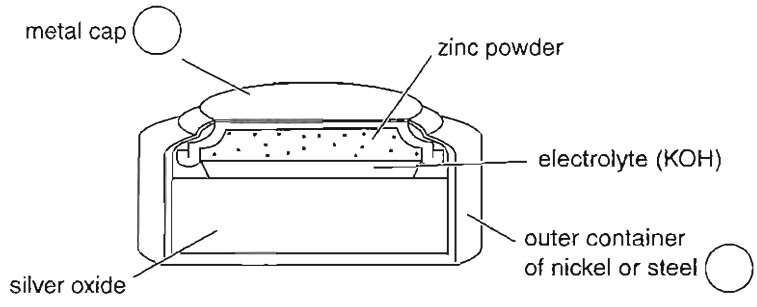
b. A second electrochemical cell, also using the silver half-cell, was constructed as shown in the diagram below. The two half-cells were again joined by an inverted U-tube containing a solution of sodium nitrate.



Would you expect to detect a flow of electrons through the wire in this cell? Explain your choice.

2 marks

c. Silver is also used as the basis for some button cells. Button cells are primary cells developed to meet the need for very small cells in devices such as watches and calculators. The basic design features and overall reaction occurring in the silver-zinc button cell are shown below.



$$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow Zn(OH)_2(s) + 2Ag(s)$$

i. Label the positive and negative electrodes of the cell by placing the appropriate symbols (+ and –) in the circles on the diagram above.

ii. Write the half-equation for the reaction occurring at the anode when the cell is operating.

1 + 1 = 2 marks
Total 9 marks

Question 5

An experiment was conducted to determine the heat of combustion of brown coal. A sample of freshly dug coal was crushed to a fine powder and burnt completely in a bomb calorimeter using an excess of oxygen gas. A quantity of electrical energy was then passed through the calorimeter.

The results obtained are shown below:

Mass of brown coal: 5.19 g

Initial temperature of calorimeter and contents: 17.319 °C

Temperature of calorimeter and contents after combustion: 18.170 °C

Temperature of calorimeter and contents after adding 31.4 kJ of electrical energy: 19.626 °C

a. Explain why the brown coal was crushed to a fine powder.

1 mark

b. Calculate the calibration factor for the calorimeter in kJ $°C^{-1}$.

1 mark

c. Determine the heat of combustion of the brown coal in kJ g^{-1}.

2 marks

d. Explain why the heat of combustion was calculated in kJ g^{-1} rather than kJ mol^{-1}.

1 mark

e. Another 5.19 g sample of powdered brown coal from the same batch used in the calorimetry experiment was heated in an oven at 100 °C for 180 minutes and then cooled. The heat of combustion of this coal sample was determined using the same calorimeter.

Would the heat of combustion of the second coal sample be higher, lower or the same as that of the original coal sample? Explain your choice.

2 marks

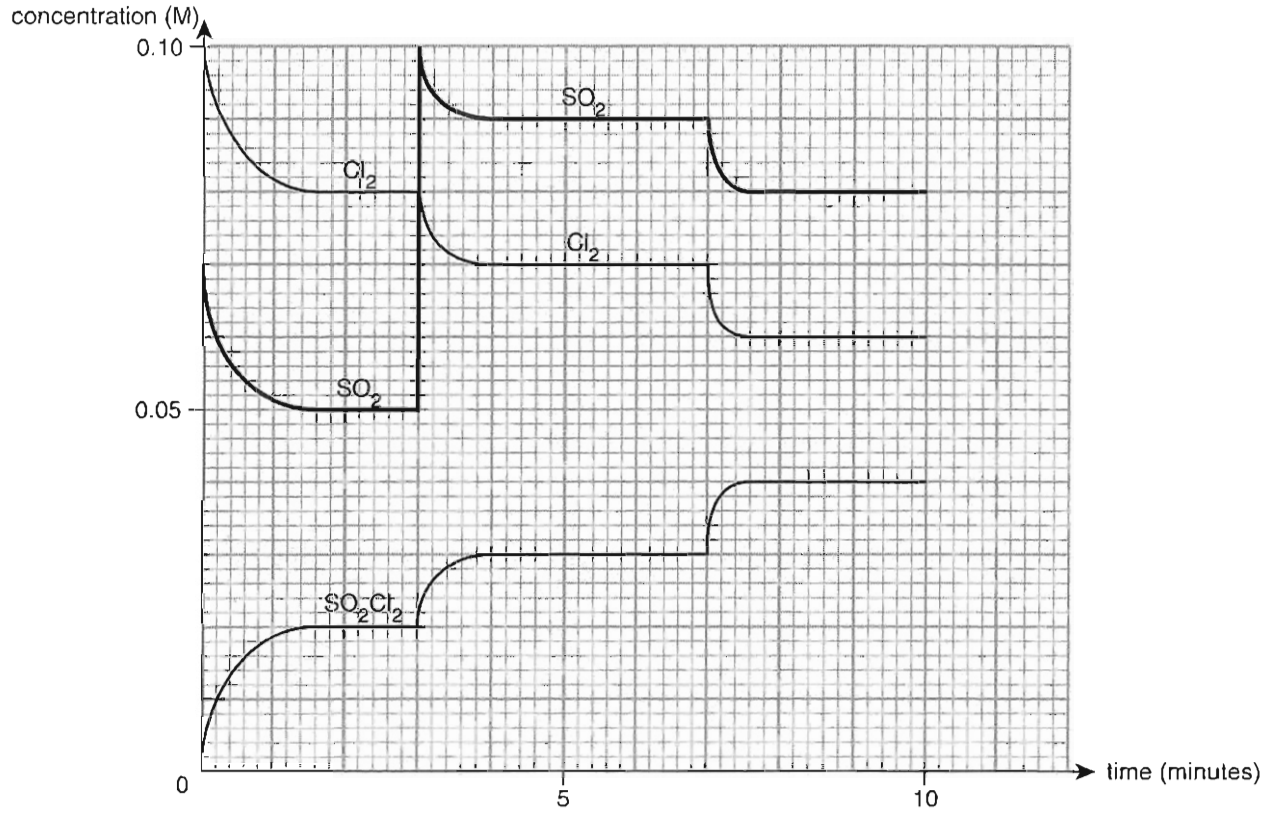
Total 7 marks

Question 6

An experiment was conducted to investigate the equilibrium reaction shown in the equation below.

$$SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g)$$

The concentrations of the three substances involved were plotted against time. The results are shown in the graph below.



a. Explain why the concentration of SO_2 decreased during the time interval between 3 and 4 minutes.

2 marks

b. Calculate the value of the equilibrium constant, K, for the reaction as it was occurring at 5 minutes.

2 marks

c. At 7 minutes the temperature of the equilibrium mixture was decreased.

Is the reaction shown exothermic or endothermic? Explain your choice.

2 marks

d. At 10 minutes, the volume of the reaction vessel was increased by 25%, while the temperature was held constant.

i. Calculate the concentration of SO_2 immediately after the volume was changed.

ii. Would the concentration of SO_2 at 15 minutes be greater than, less than or the same as the concentration of SO_2 at 9 minutes? Explain your choice.

1 + 2 = 3 marks
Total 9 marks

END OF QUESTION AND ANSWER BOOKLET

Neap:

Trial Examination 2009

VCE Chemistry Unit 4

Written Examination

Multiple-choice Answer Sheet

Student's Name: _____

Teacher's Name: _____

Instructions

Use a **pencil** for **all** entries. If you make a mistake, **erase** the incorrect answer – **do not** cross it out.
Marks will **not** be deducted for incorrect answers.
No mark will be given if more than **one** answer is completed for any question.

All answers must be completed like **this** example: [A] [B] [C] [D]

Use pencil only

1	A	B	C	D
2	A	B	C	D
3	A	B	C	D
4	A	B	C	D
5	A	B	C	D
6	A	B	C	D
7	A	B	C	D
8	A	B	C	D
9	A	B	C	D
10	A	B	C	D

11	A	B	C	D
12	A	B	C	D
13	A	B	C	D
14	A	B	C	D
15	A	B	C	D
16	A	B	C	D
17	A	B	C	D
18	A	B	C	D
19	A	B	C	D
20	A	B	C	D