VCE CHEMISTRY

2009

UNIT 4
TRIAL
EXAMINATION

Based on the Victorian Certificate of Education
Unit 4 Chemistry Study Design 2008 – 2011.
Accreditation expires 31 December 2011.

1. **Industrial chemistry**

2. **Supplying and using energy**

	KILBAHA MULTIMEDIA PUBLISHING **PO BOX 2227** **KEW** **VICTORIA 3101** **AUSTRALIA** **TEL: (03) 9817 5374** **FAX: (03) 9817 4334** **Email: kilbaha@gmail.com** **Internet: http://kilbaha.googlepages.com**

IMPORTANT COPYRIGHT NOTICE

NOTICE: This practice examination is not set by the Victorian Curriculum and Assessment Authority. It should not be seen as giving an idea of the material nor the presentation of the VCAA 2009 VCE Chemistry Written Examination 2.

Victorian Certificate of Education 2009

STUDENT NUMBER									Letter
Figures									
Words									

CHEMISTRY

Written examination 2 (Trial)

(not to be used before Monday October 5, 2009)

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

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	9	9	60
			Total 80

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and 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 book of 21 pages.
- A data book.
- Answer sheet for multiple-choice questions.

Instructions

- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination

- Place the multiple-choice answer sheet inside the front cover of this book.
- You may keep the data book.

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

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 marks will be given if more than one answer is completed for any question.

Questions 1, 2 and 3 refer to the following information.

The equilibrium between NO(g), O_2(g) and NO_2(g) is described by the equation:

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = -114 \text{ kJmol}^{-1}$$

At a temperature of 500 K, the equilibrium constant is 6.6×10^5.

1 mol of NO(g), 1 mol of O_2(g) and 1 mol of NO_2(g) are introduced into a 1 L container at 500 K and the system is allowed to reach equilibrium.

Question 1
At equilibrium, the concentrations of the three gases, from lowest to highest will be

A. NO , O_2 , NO_2

B. O_2 , NO , NO_2

C. NO_2 , NO , O_2

D. NO_2 , O_2 , NO

Question 2
Which one of the following changes would lead to the greatest increase in the equilibrium constant?

A. Increasing the temperature to 600 K

B. Increasing the volume of the container to 2 L

C. Decreasing the temperature to 400 K

D. Decreasing the volume of the container to 0.5 L

Question 3
The value of the equilibrium constant for the equation: $NO_2(g) \rightleftharpoons NO(g) + \frac{1}{2}O_2(g)$ is

A. $\frac{1}{2} \times 6.6 \times 10^5$

B. $\frac{1}{\sqrt{6.6 \times 10^5}}$

C. $\frac{1}{2 \times 6.6 \times 10^5}$

D. $\frac{\sqrt{6.6 \times 10^5}}{2}$

Questions 4 and 5 refer to the following information.

Hydrogen peroxide decomposes spontaneously into water and oxygen according to the equation:
$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ $\Delta H = -98.2$ kJmol^{-1}

The rate of decomposition is increased substantially by adding $MnO_2(s)$ to the hydrogen peroxide.

Question 4
This reaction is spontaneous because

A. hydrogen peroxide is a strong oxidant.

B. hydrogen peroxide is a strong reductant.

C. hydrogen peroxide has a higher E^0 value as an oxidant than as a reductant.

D. hydrogen peroxide has a higher E^0 value as a reductant than as a oxidant.

Question 5
The best explanation for the increased rate of decomposition is that, in the presence of MnO_2,

A. the number of collisions between the hydrogen peroxide molecules increases.

B. the proportion of hydrogen peroxide molecules with high kinetic energy increases.

C. the forward reaction is more exothermic.

D. the activation energy of the reaction decreases.

Question 6
Energy is released when hydrogen burns in oxygen to produce water because

A. the energy absorbed in breaking all of the chemical bonds within the hydrogen and oxygen molecules is less than the energy released when the chemical bonds form to produce the water molecules.

B. the energy absorbed in breaking all of the chemical bonds within the hydrogen and oxygen molecules is greater than the energy released when the chemical bonds form to produce the water molecules.

C. the energy released in breaking all of the chemical bonds within the hydrogen and oxygen molecules is less than the energy absorbed when the chemical bonds form to produce the water molecules.

D. the energy released in breaking all of the chemical bonds within the hydrogen and oxygen molecules is greater than the energy absorbed when the chemical bonds form to produce the water molecules.

Question 7
If 1.00 g of each substance listed below undergoes complete combustion with oxygen under SLC, the substance providing the greatest quantity of heat would be

A. H_2

B. C

C. CH_4

D. C_2H_6

Question 8
Hydrogen iodide dissociates into its elements according to the following equation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \quad \Delta H = +9 \text{ kJ mol}^{-1}$$

Which one of the following changes will cause the position of equilibrium to shift to the left?

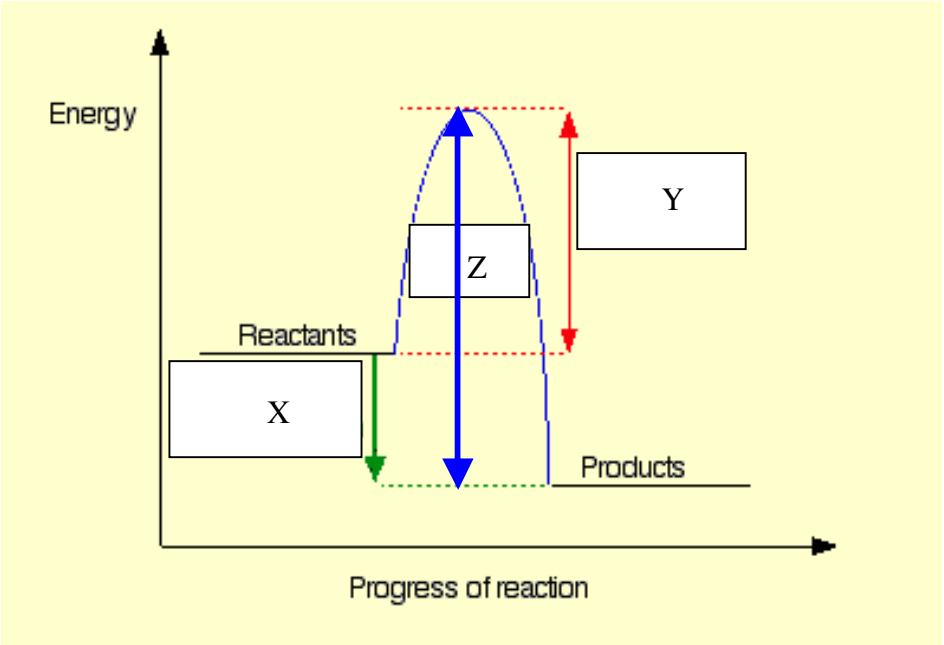
A. Decrease the temperature.

B. Increase the volume of the vessel containing the gases.

C. Increase the pressure by adding the inert gas argon to the gas mixture.

D. Add a catalyst.

Question 9
The diagram below is the energy profile for a chemical reaction.



From the information provided above, select the correct statement.

A. **Y** and **Z** are activation energies and **X** is the energy absorbed in the reaction.

B. **Y** and **Z** are activation energies and **X** is the energy released in the reaction.

C. **X** and **Z** are activation energies and **Y** is the energy absorbed in the reaction.

D. **X** and **Z** are activation energies and **Y** is the energy released in the reaction.

Questions 10 and 11 refer to the following information.

The equilibrium between NO_2 and N_2O_4 can be described by the equation:

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \quad K_c = 0.010\ M^{-1}\ ;\ \Delta H = -58\ kJ\ mol^{-1}$$

It can also be described by a second equation $\frac{1}{2}N_2O_4(g) \rightleftharpoons NO_2(g)$

Question 10
The value of K_c for the second equation is

A. $10\ M^{-\frac{1}{2}}$

B. $10\ M^{\frac{1}{2}}$

C. $50\ M^{-\frac{1}{2}}$

D. $50\ M^{\frac{1}{2}}$

Question 11
The value of ΔH for the second equation is

A. $+3.87\ kJ\ mol^{-1}$

B. $+3.87\ kJ\ mol^{-\frac{1}{2}}$

C. $+29\ kJ\ mol^{-1}$

D. $+29\ kJ\ mol^{-\frac{1}{2}}$

Question 12
Nitrous acid behaves in water as a weak acid according to the equation:

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

A small volume of 1 M HCl(aq) is added to 50 cm^3 of nitrous acid.

The temperature is kept constant. After a period of time,

A. the pH will have increased.

B. more NO_2^- ions will have been produced from HNO_2.

C. the value of the fraction $\frac{[H_3O^+][NO_2^-]}{[HNO_2]}$ will have increased.

D. the value of the fraction $\frac{[H_3O^+][NO_2^-]}{[HNO_2]}$ will not have changed.

Question 13
Sodium metal is used as a test for alcohols. Of the following, the best method for disposing of excess sodium metal left over from these tests, is

A. Wash the sodium metal down the sink.

B. Add the sodium metal to dilute hydrochloric acid.

C. Add the sodium metal to dilute sodium hydroxide.

D. Store the sodium metal under nitrogen gas or kerosene.

Question 14
When 228 g of octane reacts with excess oxygen, the energy released is closest to

A. 5464 kJ.

B. 10 928 kJ.

C. 16 392 kJ.

D. 21 856 kJ.

Question 15
In a laboratory experiment, 0.100 mol of $NH_4NO_3(s)$ was dissolved in water in a calorimeter with a calibration factor of 900 J K^{-1}.
The ΔH calculated for $NH_4NO_3(s)$ dissolving in water was +24.75 kJ mol^{-1}.
The temperature change measured in the experiment was

A. +2.75 K

B. -2.75 K

C. +27.5 K

D. -27.5 K

Question 16
1.876 g of copper(II) nitrate and 0.8495 g of silver(I) nitrate were dissolved in water.
The quantity of electricity required to deposit all of the copper **and** silver on the cathode of an electrolytic cell is closest to

A. 724 C

B. 1206 C

C. 1448 C

D. 2413 C

Items 17, 18 and 19 refer to the following information.

The cell reaction occurring in a small galvanic cell as current is drawn is:

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

The cell potential is 1.50 V.

Question 17
In the galvanic cell referred to above, $Ag_2O(s)$ is the

A. negative electrode, is reduced and is the cathode.

B. positive electrode, is oxidised and is the anode.

C. positive electrode, is reduced and is the cathode.

D. negative electrode, is oxidized and is the anode.

Question 18
This galvanic cell can be used as the power supply for a hearing aid that draws a continuous current of 0.05 mA. Assuming that the reaction goes to completion, the mass of $Ag_2O(s)$ needed to keep the cell running continuously for 100 days is closest to

A. 0.52 g.

B. 1.04 g.

C. 5.2 g.

D. 10.4 g.

Question 19
The electrolyte in the cell is 1 M KOH(aq) and the $Ag_2O(s)/Ag(s)$ electrode in alkaline solution has an E^0 value of +0.34 V.

The E^0 of the $Zn(OH)_2(s)/Zn(s)$ electrode in alkaline solution must be

A. -1.16 V.

B. -1.84 V.

C. +1.16 V.

D. +1.84 V.

Question 20
Three unknown metals X(s), Y(s) and Z(s) and their corresponding nitrate solutions gave the following experimental results.

(1) X(s) dissolved in 1M $YNO_3(aq)$, and a deposit of Y(s) was formed.

(2) Z(s) did **not** react with 1M $X(NO_3)_2(aq)$.

(3) Y(s) did **not** react with 1M $Z(NO_3)_2(aq)$.

From this information, the size of the E^0 of the metals X, Y and Z from most positive to most negative is

A. $E^0(X) > E^0(Z) > E^0(Y)$

B. $E^0(X) > E^0(Y) > E^0(Z)$

C. $E^0(Y) > E^0(X) > E^0(Z)$

D. $E^0(Y) > E^0(Z) > E^0(X)$

END OF SECTION A
VCE CHEMISTRY 2009 TRIAL WRITTEN EXAMINATION 2

KILBAHA MULTIMEDIA PUBLISHING **PO BOX 2227** **KEW VIC 3101** **AUSTRALIA**	**TEL: (03) 9817 5374** **FAX: (03) 9817 4334** **Email: kilbaha@gmail.com** **Internet: kilbaha.googlepages.com**

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

In a coal-fired power station, the electrical energy produced is derived ultimately from energy generated by the sun. This is shown in the flowchart below.
sun → plants → coal → power station furnace → power station turbine generator → electrical power → end users

Complete the table below.

(1) Write an equation for each stage.

(2) Give the sign of ΔH (+ or -) for each equation.

Stage	**Equation**	***ΔH* value (+ or -)**
Energy produced by the sun		
Energy stored in plants		
Combustion of the coal in the power station furnace		
Oxidation of sulfur impurities in the coal		
Boiling water to provide steam to drive the generator		

1 + 1 + 1 + 1 + 1 = 5 marks

Total 5 marks

Question 2

A calorimeter is used to study the reaction between 100 cm^3 of 0.5M HCl(aq) and 100 cm^3 of 0.5M NaOH(aq). The calibration factor of the calorimeter and its contents is 140 J $^oC^{-1}$.
The initial temperature of the calorimeter and its contents is 25.0 ^oC . The temperature rise during the reaction is 20.0 ^oC.

a. **i.** Write a balanced molecular equation for the reaction.

_____

ii. Write a balanced ionic equation for the reaction.

_____

1 + 1 = 2 marks

b. Calculate ΔH for the reaction.

_____

_____

_____

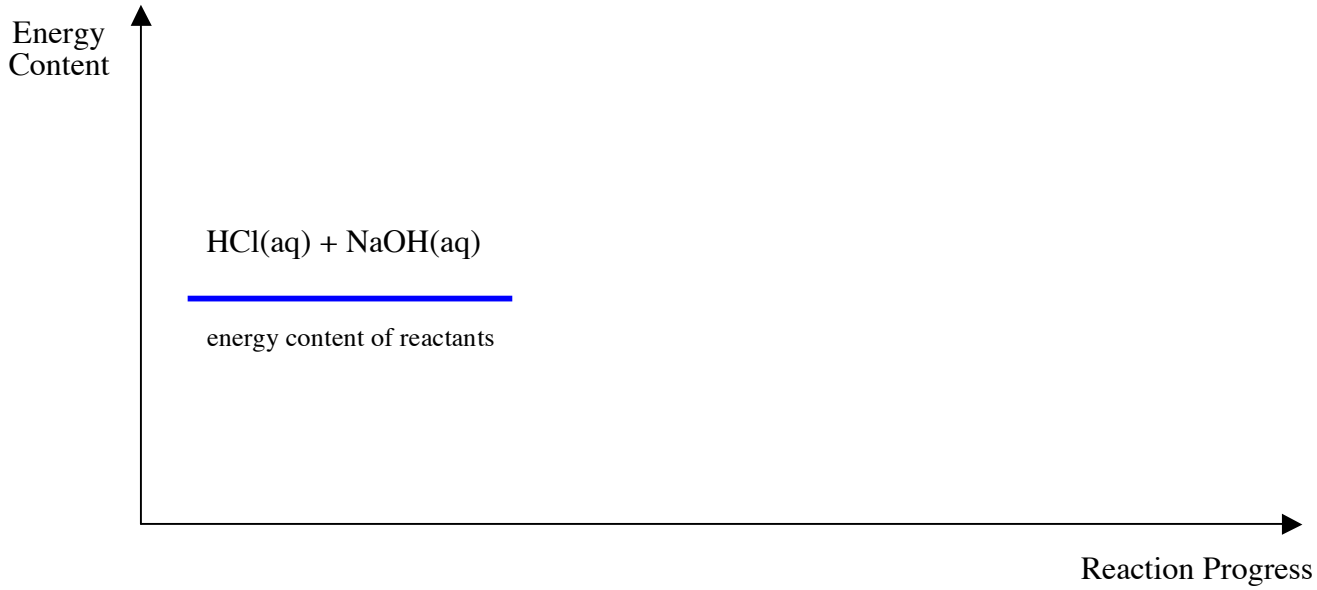
_____

2 marks

c. On the diagram below, sketch an energy profile for this reaction. Clearly mark

i. The activation energy for the forward reaction.
ii. The activation energy for the reverse reaction.
iii. The ΔH value.

1 + 1 + 1 + 1 = 4 marks



Question 2 (continued)

d. After the reaction is complete in the calorimeter, the pH of the solution is measured and found to be less than 7.

i. Explain why the pH is less than 7.

_____

_____

_____

2 marks

ii. Is the solution basic, acidic or neutral? Give a reason for your answer.

_____

_____

_____

2 marks

Total 12 marks

Question 3

The molar enthalpy of combustion of ethanol can be determined by burning a known amount of ethanol in excess oxygen in a bomb calorimeter.

a. Write a balanced equation for the molar enthalpy of combustion of ethanol.

_____

1 mark

b. Ethanol also undergoes oxidation in the body with this same chemical reaction.
A certain light beer is 2.9% ethanol by mass. Calculate the energy produced from 500 g of this beer, assuming that ethanol is the only source of energy in the beer.

_____

_____

_____

_____

_____

2 marks

Total 3 marks

Question 4

Lactic acid (also known as, 2-hydroxypropanoic acid) is a weak monoprotic acid which ionises in aqueous solution.

a. Write a balanced chemical equation for the partial ionisation of lactic acid.

_____

1 mark

b. Calculate the pH of a 0.001M solution of lactic acid.

_____

_____

_____

_____

_____

_____

_____

2 marks

c. Sodium lactate is added to an equilibrium solution of lactic acid.
Will the pH of the solution increase or decrease? Explain your answer.

_____

_____

_____

_____

2 marks

Total 5 marks

Question 5

Methanol, CH_3OH, is produced on a large scale from a mixture of carbon monoxide gas and hydrogen gas in the presence of a mixture of Cu, ZnO, and Al_2O_3. Typical conditions of large scale methanol production are a pressure of 7 MPa and a temperature of 250°C.

Equilibrium is reached according to the equation:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \text{ ; } \Delta H \text{ is negative}$$

At temperature *T*, the equilibrium concentrations of $CH_3OH(g)$, $H_2(g)$ and $CO(g)$ in the reaction vessel were: $[CH_3OH]_e = 4.00$ M ; $[H_2]_e = 0.20$ M ; $[CO]_e = 0.10$ M.

a. Calculate the equilibrium constant for the formation of methanol.

_____

_____

_____

_____

2 marks

b. In a new and separate equilibrium mixture of these three gases, still at temperature *T*, the equilibrium concentrations of CO and H_2 were each 0.20 M. Calculate the equilibrium concentration of methanol in this new mixture.

_____

_____

_____

_____

2 marks

c. What is the purpose of the mixture of Cu, ZnO, and Al_2O_3in the reaction vessel?

_____

_____

1 mark

Question 5 (continued)

d. Give a reason for using a pressure of 7 MPa in the production of methanol.

_____

_____

_____

_____

1 mark

e. 250°C is a **compromise temperature** for the large scale production of methanol.
Explain the meaning of "**compromise temperature**".

_____

_____

_____

_____

1 mark

Total 7 marks

Question 6
In the production of industrial chemicals ammonia, ethene, nitric acid and sulfuric acid, equilibrium considerations play an important part.

a. Choose **one** of these chemicals. Write a balanced chemical equation for an equilibrium reaction that occurs during its production and state whether it is exothermic or endothermic.

Chemical	Equilibrium Reaction	Exothermic or endothermic
Ammonia		
Ethene		
Nitric acid		
Sulfuric acid		

2 marks

b. For the equilibrium equation that you have written, write down the oxidation numbers of **all** the elements in **both** the reactants and the products.

Reactant(s)		Product(s)	
Element	Oxidation number	Element	Oxidation number

2 marks

c. For the chemical you have chosen,

i. give one use.

_____

1 mark

ii. give the chemical formula of one useful product formed from the chemical.

_____

1 mark

iii. name one possible pollutant from the manufacturing process.

_____

1 mark

Total 7 marks

Question 7

$MgCl_2$ and $CuCl_2$ are dissolved in water so that the concentration of Mg^{2+} and Cu^{2+} are each 1.0 M. An electric current is passed between two inert carbon electrodes placed in the solution. A constant current is then passed through the solution for a long time.

a. Describe, giving appropriate half-reactions, what you would observe happening **first** at each of the carbon electrodes.

Cathode

Observation

_____

_____

_____

Half-reaction

_____

1 + 1 = 2 marks

Anode

Observation

_____

_____

_____

Half-reaction

_____

1 + 1 = 2 marks

Question 7 (continued)

b. The current is passed through the electrolysis cell for a long time. Describe the sequence of events you would expect to find at each of the carbon electrodes.

Cathode

Sequence of events

_____

_____

_____

2 marks

Anode

Sequence of events

_____

_____

_____

2 marks

Total 8 marks

Question 8

a. Galvanic cells and electrolytic cells both have oxidation and reduction reactions and electric charge flowing through the cell. However, in a galvanic cell, the anode is negative while in an electrolytic cell, the cathode is negative. Explain why this is the case.

_____

_____

_____

_____

_____

2 marks

b. In an electrolytic cell for the production of aluminium from Al_2O_3, aluminium metal was produced at the rate of 1.5 kg per hour. Calculate the average electric current through the cell.

_____

_____

_____

_____

_____

2 marks

c. When $Fe^{3+}(aq)$ was used as an oxidant in a galvanic cell, the cell produced 5179 coulomb of electricity for each gram of $Fe^{3+}(aq)$ consumed. Calculate the final oxidation number of the iron in the reaction.

_____

_____

_____

_____

_____

_____

_____

3 marks

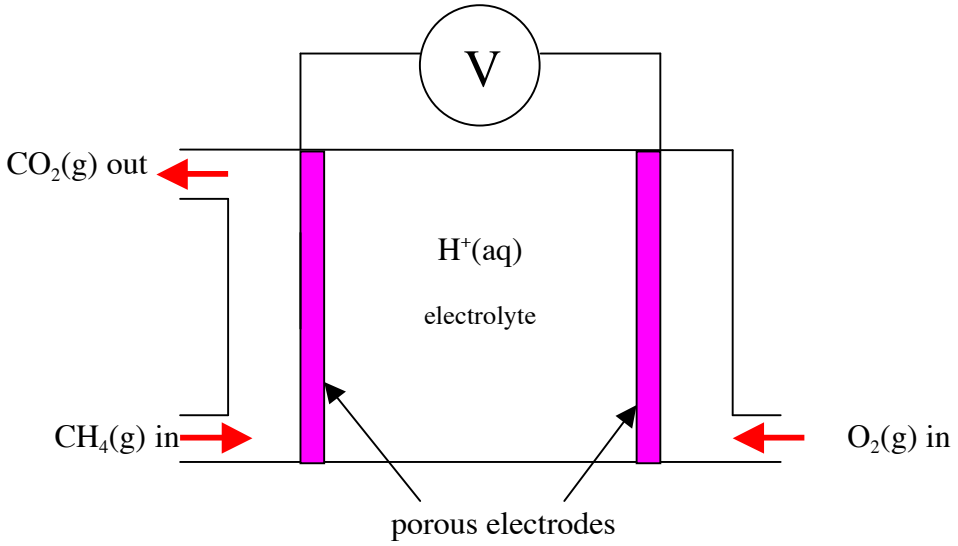
Total 7 marks

Question 9

Australia exports huge quantities of Liquid Natural Gas (LNG) to the world. LNG is methane gas that has been cooled to a liquid. Some of this methane is used as a fuel to produce electricity in conventional power stations which are relatively inefficient. In the future, society may obtain electricity directly (and, therefore, more efficiently) from fuel cells which consume methane and oxygen and use an acidic electrolyte. The overall equation for the reaction occurring in the power stations **and** the fuel cell is the same.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

Below is a simplified diagram of a methane-oxygen fuel cell.



a. On the diagram above, label

i. the anode and its polarity.

ii. the direction of electron flow.

1 + 1 = 2 marks

b. Write a half equation for the reaction at the anode.

_____

1 mark

c. Write a half equation for the reaction at the cathode.

_____

1 mark

Question 9 (continued)

d. The current drawn by a family home connected to this fuel cell averages 10.0 A. What volume of methane under SLC is consumed by the cell each day, if the fuel cell is 75% efficient? That is, 75% of the total energy produced by the cell is converted into electricity.

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

Total 6 marks

END OF QUESTION AND ANSWER BOOKLET

2009 VCE CHEMISTRY TRIAL WRITTEN EXAMINATION 2

KILBAHA MULTIMEDIA PUBLISHING **PO BOX 2227** **KEW VIC 3101** **AUSTRALIA**	**TEL: (03) 9817 5374** **FAX: (03) 9817 4334** **Email: kilbaha@gmail.com** **Internet: http://kilbaha.googlepages.com**

