VCE CHEMISTRY

2008

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**

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Victorian Certificate of Education 2008

STUDENT NUMBER									Letter
Figures									
Words									

CHEMISTRY

Written examination 2 (Trial)

(not to be used before Monday October 6, 2008)

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	7	7	59
			Total 79

- 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 19 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.

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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.

Question 1

When concentrated aqueous ammonia is added to a precipitate of silver chloride, the precipitate dissolves to give a clear solution. One of the reactions which occurs is

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$$

The addition of ammonia causes the silver chloride to dissolve because

A. silver chloride is more soluble in solutions of high pH.

B. hydroxide ions, $OH^-(aq)$, are formed by the $NH_3(aq)$.

C. $Ag^+(aq)$ is removed from the equilibrium $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

D. $NH_3(aq)$ forms an equilibrium with $NH_4^+(aq)$.

Question 2

Hypochlorous acid (HOCl) is the active component in household bleach. It is a weak acid and exists in equilibrium with the hypochlorous ion (OCl^-) according to the equation:

$$HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OCl^-(aq)$$

When two drops of 5.0 M HCl are added to this equilibrium mixture at constant temperature,

A. the pH of the solution increases.

B. the concentration of H_3O^+ increases.

C. the concentration of OCl^- increases.

D. the ratio $\dfrac{[OCl^-][H_3O^+]}{[HOCl][H_2O]}$ decreases.

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Questions 3 and 4 refer to the following information.

Two gases (X and Y) exist in equilibrium at 200°C according to the equation

$$2X(g) \rightleftharpoons 3Y(g) \qquad \Delta H = -100 \text{ kJ mol}^{-1}$$

The equilibrium constant at 200°C is 25 M.

Question 3
Which one of the following best describes the effect of increasing pressure and temperature on the equilibrium yield of gas Y?

A. Increasing pressure and increasing temperature both decrease the yield.

B. Increasing pressure and increasing temperature both increase the yield.

C. Increasing pressure decreases the yield and increasing temperature increases the yield.

D. Increasing pressure increases the yield and increasing temperature decreases the yield.

Question 4
The numerical value of the equilibrium constant for the reaction $6Y(g) \rightleftharpoons 4X(g)$ at 200°C is

A. $\frac{1}{625}$

B. $\frac{1}{50}$

C. $\frac{1}{25}$

D. 25

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Question 5
Which one of the following statements about the strength and concentration of acids is **always** true?

A. A strong acid is more concentrated than a weak acid.

B. An acid with a high concentration is a strong acid.

C. A strong acid and a weak acid can have solutions with the same pH.

D. Strong acids and weak acids are both completely ionised in solution.

Question 6
Propanoic acid is a weak monoprotic acid. 370 mg of propanoic acid is dissolved completely in water to form 500 mL of solution. The pH of this solution is closest to

A. 1.7

B. 3.4

C. 4.7

D. 6.8

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Question 7
Pure water ionises very slightly according to the equation
$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ $\Delta H = +57$ kJ mol^{-1}

Which one of the following statements is **always** true about this equilibrium?

A. The energy content of the products is less than the energy content of the reactants.

B. The activation energies of the forward and reverse reactions are equal.

C. The pH = 7.

D. For any temperature, $[H_3O^+(aq)] = [OH^-(aq)]$

Question 8
An increase in temperature increases the rate of a chemical reaction because this

A. increases the number of particles with sufficient energy to react.

B. decreases the number of collisions per second.

C. increases the value of equilibrium constant.

D. decreases the concentration of the particles.

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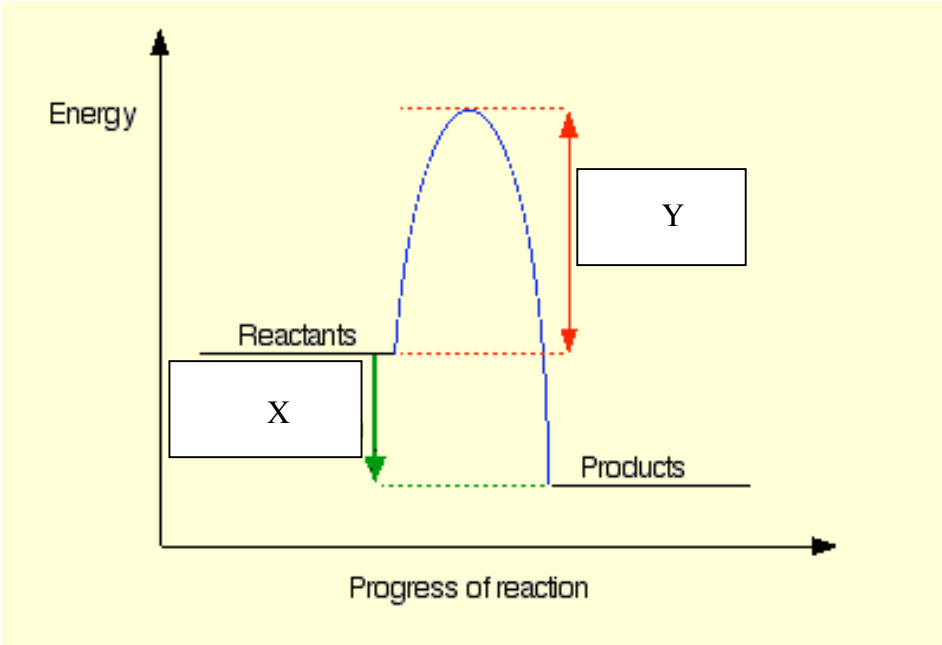
Question 9
The diagram below is the energy profile for a chemical reaction.



From the information provided above, select the correct statement.

A. **Y** is the activation energy for the forward reaction and **X** has a negative value.

B. **Y** is the activation energy for the forward reaction and **X** has a positive value.

C. **Y** is the activation energy for the reverse reaction and **X** has a negative value.

D. **Y** is the activation energy for the reverse reaction and **X** has a positive value.

Question 10
Hydrogen iodide gas exists in equilibrium with hydrogen gas and iodine gas according to the equation $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ .The equilibrium constant at temperature T is $K_c = 2.0$

1×10^{20} molecules of HI were introduced into a vessel of fixed volume at temperature T.
After some time, there were 1.4×10^{19} molecules of HI, 2.0×10^{19} molecules of H_2
and 2.0×10^{19} molecules of I_2 in the vessel. The temperature was unchanged,

Which one of the following statements about this system is correct?

A. The system is at equilibrium.

B. The system is **not** at equilibrium.

C. It is not known whether the system is at equilibrium, since the temperature is not given.

D. It is not known whether the system is at equilibrium, as K_c refers to concentrations expressed in mol L^{-1}, and the volume of the vessel is not given.

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Question 11
1500 mL of 2.5 M NaOH is mixed with 1200 mL of 2.0 M HCl.
The equation for the reaction is $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$.
57 kJ of energy is given off for each mol of NaOH(aq) reacting.

The energy released in this reaction is closest to

A. 57 kJ

B. 114 kJ

C. 137 kJ

D. 214 kJ

Questions 12 and 13 refer to the following information.

In an electrochemical cell, chemical energy is converted into electrical energy. A particular electrochemical cell is made from the two half-cells $Ag^+(aq)/Ag(s)$ and $Ni^{2+}(aq)/Ni(s)$.

Question 12
When the cell is producing energy, the cathode is

A. the positive electrode and nickel metal is deposited.

B. the negative electrode and nickel metal is deposited.

C. the positive electrode and silver metal is deposited.

D. the negative electrode and silver metal is deposited.

Question 13
The anode and cathode reactions for this electrochemical cell are respectively

	Anode reaction	**Cathode reaction**
A.	$Ag(s) \rightarrow Ag^+(aq) + e^-$	$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$
B.	$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	$Ag(s) \rightarrow Ag^+(aq) + e^-$
C.	$Ag^+(aq) + e^- \rightarrow Ag(s)$	$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$
D.	$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$	$Ag^+(aq) + e^- \rightarrow Ag(s)$

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Question 14
An electrolytic cell contains 1.0 M solutions of $KNO_3(aq)$ and $Mg(NO_3)_2(aq)$. There are two inert platinum electrodes in the cell. When an electric current is passed through the cell, the reaction at the **negative electrode** would be

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

B. $Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$

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

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

Question 15
0.5 mol of $Cu^{2+}(aq)$ and 1.0 mol of $Ag^+(aq)$ are added to a beaker of water and an electrolytic cell is constructed. The quantity of electricity required to deposit **all** of the copper and silver on the cathode of this electrolytic cell is

A. $\frac{1}{3} \times 96500 \text{ C}$

B. $\frac{1}{2} \times 96500 \text{ C}$

C. $\frac{3}{2} \times 96500 \text{ C}$

D. $2 \times 96500 \text{ C}$

Question 16
A steady current is passed for a fixed time through three cells connected in series containing respectively the solutions 1.0 M $Pb(NO_3)_2(aq)$, 1.0 M $AgNO_3(aq)$ and 1.0 M $Al(NO_3)_3(aq)$. Each of the cells has two platinum electrodes. The molar ratio n(Pb) : n(Ag) : n(Al) of metal deposited at the negative electrode in each cell is

A. 2 : 1 : 0

B. 2 : 1 : 3

C. 2 : 3 : 1

D. 1 : 2 : 0

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Question 17
A student carries out experiments with three metals, P, Q, R. their solutions, $P(NO_3)_2(aq)$, $Q(NO_3)_2(aq)$, $R(NO_3)_2(aq)$ and HCl(aq). Metal P does not react with dilute HCl(aq). Metal R will reduce solutions of both $P(NO_3)_2(aq)$ and $Q(NO_3)_2(aq)$ to the respective metals P and Q.

A **possible** order of standard electrode potentials, E^0, (from most positive to most negative) is

A. $H_2 > P > Q > R$

B. $Q > R > P > H_2$

C. $P > H_2 > R > Q$

D. $P > Q > R > H_2$

Question 18
According to the electrochemical series in the Data Book, it is predicted that 1.0 M nickel sulfate solutions would be reduced by the metals

A. silver and copper.

B. copper and iron.

C. silver, copper, iron and zinc.

D. zinc and iron.

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Question 19
It is found that one of the metals predicted to react with nickel sulfate in **Question 18** shows no observable reaction. A possible explanation for this is

A. the concentration of nickel sulfate is too low.

B. the rate of reaction is too slow.

C. too small a quantity of the metal has been used.

D. the equilibrium has shifted to the left.

Question 20
A cell is set up using Zn(s) in 1.0 M $ZnSO_4$(aq) as one half-cell and Ni(s) in 1.0 M $NiSO_4$(aq) as the other half-cell. The cell potential under standard conditions would be closest to (in volts)

A. 0.23

B. 0.53

C. 0.76

D. 0.99

END OF SECTION A
VCE CHEMISTRY 2008 TRIAL WRITTEN EXAMINATION 2

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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

Catalysts are commonly used in the production of industrial chemicals such as ammonia, nitric acid, sulfuric acid and ethene.

a. Give the chemical formula of **one** of the above and name the catalyst used in the industrial production of this chemical. If no catalyst is used, write "none".

Chemical formula_____

Catalyst_____

1 + 1 = 2 marks

b. In terms of collision theory, explain the function of a catalyst in a chemical reaction.

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

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Question 1 (continued)

c. Potassium dichromate, ($K_2Cr_2O_7$), in acid solution, oxidises iron(II) ions (Fe^{2+}) to iron(III) ions (Fe^{3+}). The orange solution containing the dichromate(VI) ions ($Cr_2O_7^{2-}$) turns green as chromium(III) ions (Cr^{3+}) are formed. As the reaction proceeds the temperature increases.

i. Write the half equations for this reaction.

_____

_____

_____

_____

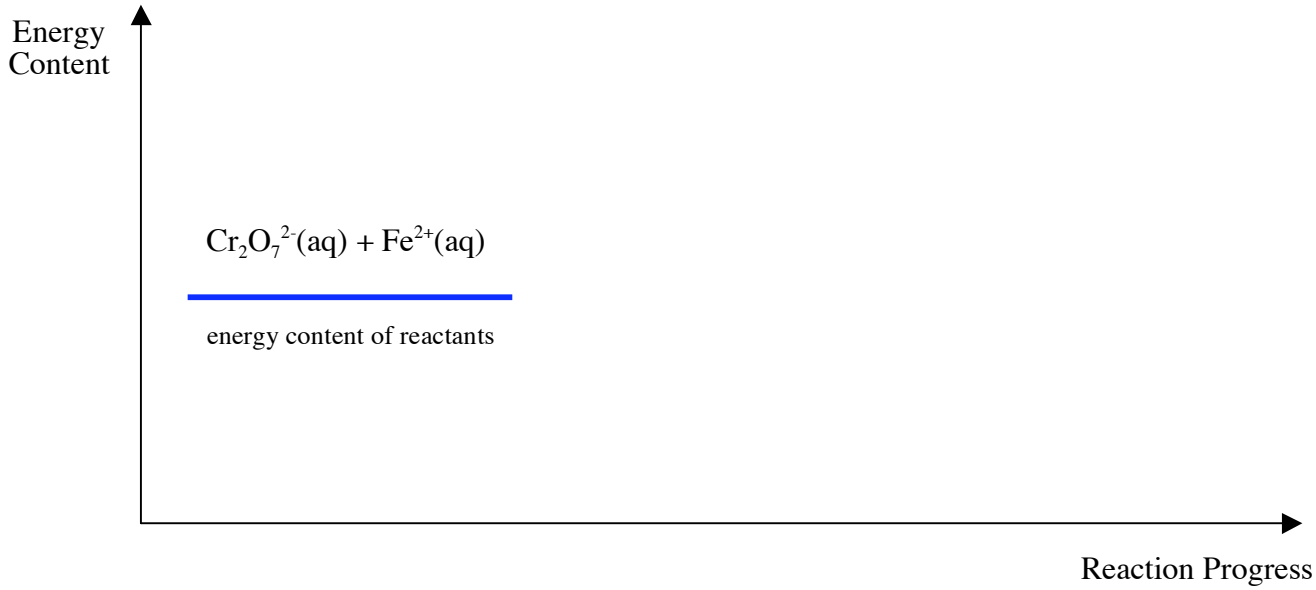
ii. Write an overall equation for this reaction.

_____

_____

2 + 1 = 3 marks

d. **i.** On the diagram below, sketch an energy profile for this reaction.



ii. On the diagram above, sketch an energy profile for this reaction **when a catalyst is used**. Use the word "catalyst" and an "arrow" to indicate clearly any change in the energy profile.

2 + 2 = 4 marks

Total 11 marks

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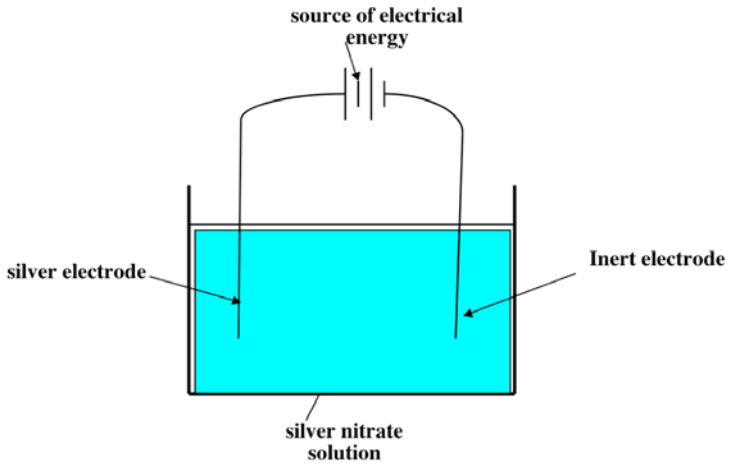
Question 2

An electrolytic cell is set up as shown below. One electrode is inert. The other electrode is pure silver metal. The electrolyte is a 1.0 M aqueous solution of silver nitrate. One of the electrodes has a total surface area 20.0 cm^2 and is to be covered **all over** with a coating of silver 0.200 mm thick. The electrode is suspended by a conducting wire into a large volume of an aqueous solution containing the ion $Ag^+(aq)$.



a. Write the balanced chemical equation for the reduction reaction in this electrolysis.

_____

1 mark

b. Write the balanced chemical equation for the oxidation reaction in this electrolysis.

_____

1 mark

c. Identify the anode in this cell. (choose one of *inert electrode*, *silver electrode*)

_____

1 mark

d. Does any change occur in the concentration of silver ions in the solution during the electrolysis? Explain your answer.

_____

_____

_____

_____

2 marks

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Question 2 (continued)

e. Calculate the current needed to deposit a coating of silver 0.200 mm thick over a total surface area of 20.0 cm^2 when a steady current is passed through the cell for 10 minutes. The density of silver is 10.5 g cm^{-3}.

_____

_____

_____

_____

_____

_____

_____

_____

3 marks

Total 8 marks

Question 3

When sulfuric acid and potassium hydroxide are mixed an exothermic reaction occurs.
In one experiment, 400 mL of 0.2M $H_2SO_4(aq)$ was mixed with 400 mL of 0.2M KOH(aq) in a fully insulated calorimeter and the energy released was measured as 4.56 kJ.

a. Calculate the energy released when 400 mL of 0.2M $H_2SO_4(aq)$ is mixed with 800 mL of 0.2M KOH.

_____

_____

_____

_____

_____

_____

_____

_____

_____

2 marks

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Question 3 (continued)

b. Write a balanced ionic equation for this reaction.

_____

_____

1 mark

c. Calculate the ΔH value for this equation. You must show your working.

_____

_____

_____

2 marks

d. Calculate the temperature rise that would occur in **a.**

_____

_____

_____

_____

_____

_____

_____

2 marks

Total 7 marks

Question 4

Hydrocyanic acid is a weak acid which ionises slightly in aqueous solution according to the equilibrium: $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$.

A 0.01 M solution of hydrocyanic acid is prepared at a constant temperature of 25°C.

a. Write the expression for the acidity constant of hydrocyanic acid.

1 mark

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Question 4 (continued)

b. Calculate the pH of a 0.01M solution of hydrocyanic acid.

_____

_____

_____

_____

_____

_____

3 marks

c. Sodium cyanide is added to this equilibrium mixture at 25°C.
Will the pH of the solution increase or decrease? Explain your answer.

_____

_____

_____

_____

2 marks

d. The temperature of the equilibrium system $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$ is increased to 70°C. How could the experimental measurement of the pH of the solution be used to determine whether or not the forward reaction is exothermic?

_____

_____

_____

_____

_____

_____

2 marks

Total 8 marks

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Question 5

Carbonyl bromide is one of the decomposition products from the fire retardant Halon 1211: Bromochlorodifluoromethane ($CBrClF_2$). Carbonyl bromide, $COBr_2(g)$, dissociates at 75ºC according to the equation:

$$COBr_2(g) \rightleftharpoons CO(g) + Br_2(g).$$

4.00 mol of carbonyl bromide was placed in a 2.00 L container at 75ºC and, after a period of time at this temperature, the amount of carbonyl bromide in the container was constant at 2.56 mol.

a. Determine the value of the equilibrium constant for the equation at 75ºC.

_____

_____

_____

_____

_____

_____

3 marks

b. The volume of the container was decreased to 0.5 L at a constant temperature of 75ºC and the system allowed to reach a new equilibrium position.
Describe the changes that have occurred at the new equilibrium position by completing the following table.

At the new equilibrium position	Circle the answer	Give a reason for your answer
The numerical value of the equilibrium constant, K_c, has	increased decreased not changed	
The equilibrium **mass** of Br_2 has	increased decreased not changed	
The equilibrium **concentration** of $COBr_2$ has	increased decreased not changed	
The equilibrium **concentration** of Br_2 has	increased decreased not changed	

2 + 2 + 2 + 2 = 8 marks

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Question 5 (continued)

c. After the new equilibrium position has been reached, 2 mol of helium gas, He(g), is introduced into the container at 75°C and the total pressure in the container increases.
What effect, if any, is there on the equilibrium mass of $Br_2(g)$?
Give a reason for your answer.

_____

_____

_____

2 marks

Total 13 marks

Question 6

Give concise explanations for each of the following.

a. A bomb calorimeter gives a more accurate reading for the enthalpy of a chemical reaction than a simple laboratory calorimeter made from a copper can with polystyrene insulation.

_____

_____

1 mark

b. The electrolysis of a concentrated aqueous solution of sodium chloride, NaCl(aq), produces chlorine gas at the anode.

_____

_____

1 mark

c. Hydrogen has a smaller molar enthalpy of combustion than octane but is preferred to octane as a fuel when weight is an important consideration. (For example, in space rockets).

_____

_____

1 mark

d. Methyl orange is used as an indicator for the titration of a strong acid with a weak base but phenolphthalein is used as an indicator for the titration of a strong base with a weak acid.

_____

_____

1 mark

Total 4 marks

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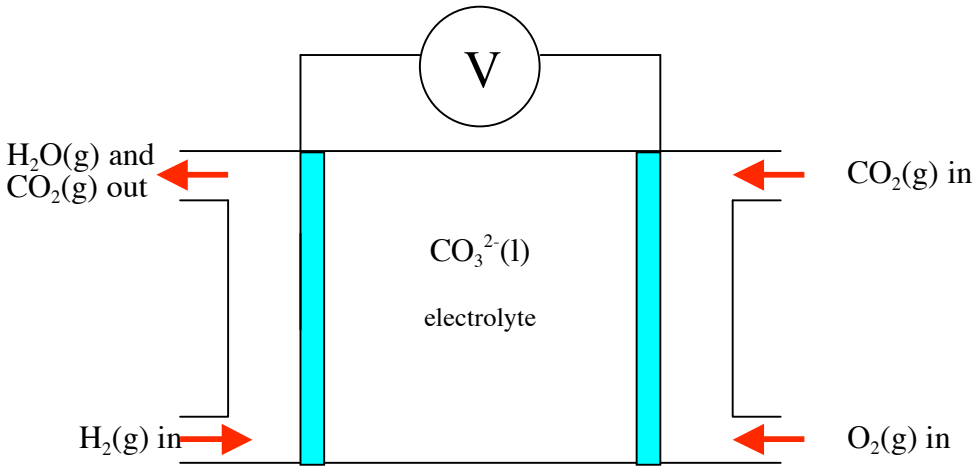
Question 7

A molten carbonate fuel cell (MCFC) uses a molten mixture of lithium carbonate, Li_2CO_3 and potassium carbonate, K_2CO_3 as the electrolyte. Hydrogen gas is passed over one electrode and a combination of oxygen gas and carbon dioxide gas is passed over the other electrode, as shown in the diagram below. The reaction at the cathode is $O_2(g) + 2CO_2(g) + 4e^- \rightarrow 2CO_3^{2-}(l)$.



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

_____

1 mark

b. The product at the anode reacts with carbonate ions at the electrode.
Write a balanced equation for this reaction.

_____

1 mark

c. Write a balanced half equation for the overall reaction occurring at the anode

_____

1 mark

d. Write a balanced equation for the overall cell reaction.

_____

1 mark

e. On the diagram above, label

i. the cathode and its polarity.

ii. the direction of electron flow.

1 + 1 = 2 marks

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Question 7 (continued)

f. Does the molten carbonate fuel cell produce any net carbon dioxide emissions? Justify your answer.

_____

_____

_____

_____

2 marks

Total 8 marks

END OF QUESTION AND ANSWER BOOKLET

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