

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

Figures

Words

Letter

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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.

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.

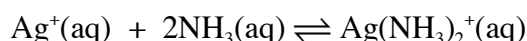
A correct answer scores 1, an incorrect answer scores 0.

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

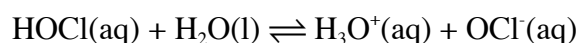


The addition of ammonia causes the silver chloride to dissolve because

- A. silver chloride is more soluble in solutions of high pH.
- B. hydroxide ions, $\text{OH}^-(\text{aq})$, are formed by the $\text{NH}_3(\text{aq})$.
- C. $\text{Ag}^+(\text{aq})$ is removed from the equilibrium $\text{AgCl}(\text{s}) \rightleftharpoons \text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- D. $\text{NH}_3(\text{aq})$ forms an equilibrium with $\text{NH}_4^+(\text{aq})$.

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:



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 $\frac{[\text{OCl}^-][\text{H}_3\text{O}^+]}{[\text{HOCl}][\text{H}_2\text{O}]}$ decreases.

Questions 3 and 4 refer to the following information.

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



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 $6\text{Y(g)} \rightleftharpoons 4\text{X(g)}$ at 200°C is

- A. $\frac{1}{625}$
- B. $\frac{1}{50}$
- C. $\frac{1}{25}$
- D. 25

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.

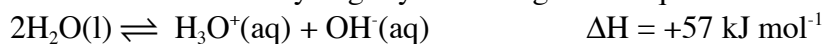
Question 6

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

Question 7

Pure water ionises very slightly according to the equation



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, $[\text{H}_3\text{O}^+(\text{aq})] = [\text{OH}^-(\text{aq})]$

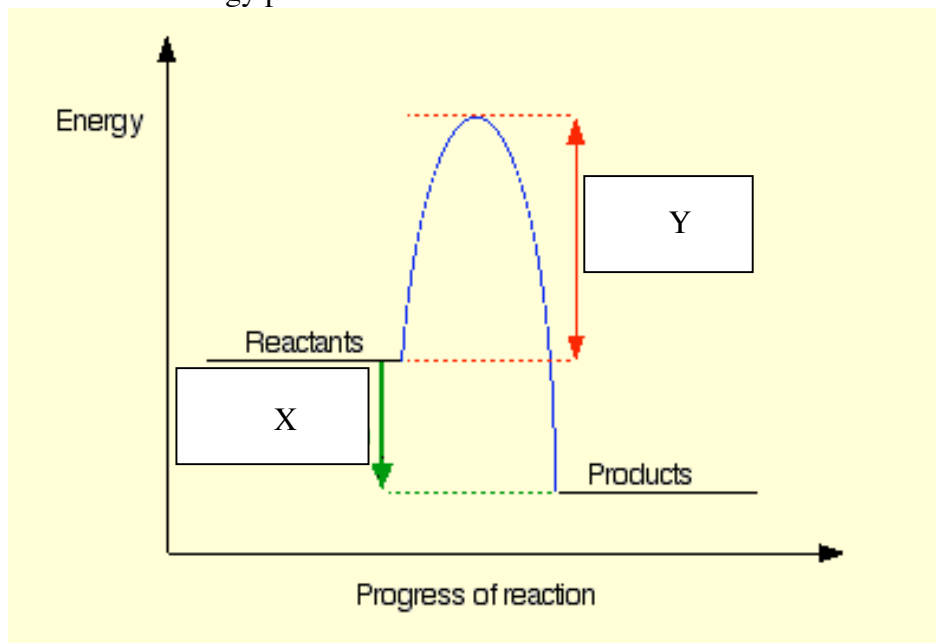
Question 8

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.

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 $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$. 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.

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 $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$.

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 $\text{Ag}^+(\text{aq})/\text{Ag(s)}$ and $\text{Ni}^{2+}(\text{aq})/\text{Ni(s)}$.

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.	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$	$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni(s)}$
B.	$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni(s)}$	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$
C.	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$	$\text{Ni(s)} \rightarrow \text{Ni}^{2+}(\text{aq}) + 2\text{e}^-$
D.	$\text{Ni(s)} \rightarrow \text{Ni}^{2+}(\text{aq}) + 2\text{e}^-$	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$

Question 14

An electrolytic cell contains 1.0 M solutions of $\text{KNO}_3(\text{aq})$ and $\text{Mg}(\text{NO}_3)_2(\text{aq})$. 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. $\text{K}(\text{s}) \rightarrow \text{K}^+(\text{aq}) + \text{e}^-$
- B. $\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$
- C. $2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$
- D. $2\text{H}_2\text{O}(\text{l}) \rightarrow \text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$

Question 15

0.5 mol of $\text{Cu}^{2+}(\text{aq})$ and 1.0 mol of $\text{Ag}^+(\text{aq})$ 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 $\text{Pb}(\text{NO}_3)_2(\text{aq})$, 1.0 M $\text{AgNO}_3(\text{aq})$ and 1.0 M $\text{Al}(\text{NO}_3)_3(\text{aq})$. Each of the cells has two platinum electrodes. The molar ratio $n(\text{Pb}) : n(\text{Ag}) : n(\text{Al})$ 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

Question 17

A student carries out experiments with three metals, P, Q, R. their solutions, $\text{P}(\text{NO}_3)_2(\text{aq})$, $\text{Q}(\text{NO}_3)_2(\text{aq})$, $\text{R}(\text{NO}_3)_2(\text{aq})$ and $\text{HCl}(\text{aq})$. Metal P does not react with dilute $\text{HCl}(\text{aq})$. Metal R will reduce solutions of both $\text{P}(\text{NO}_3)_2(\text{aq})$ and $\text{Q}(\text{NO}_3)_2(\text{aq})$ to the respective metals P and Q.

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

- A. $\text{H}_2 > \text{P} > \text{Q} > \text{R}$
- B. $\text{Q} > \text{R} > \text{P} > \text{H}_2$
- C. $\text{P} > \text{H}_2 > \text{R} > \text{Q}$
- D. $\text{P} > \text{Q} > \text{R} > \text{H}_2$

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.

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 ZnSO₄(aq) as one half-cell and Ni(s) in 1.0 M NiSO₄(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 $\text{H}_2(\text{g})$; $\text{NaCl}(\text{s})$.

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

Question 1 (continued)

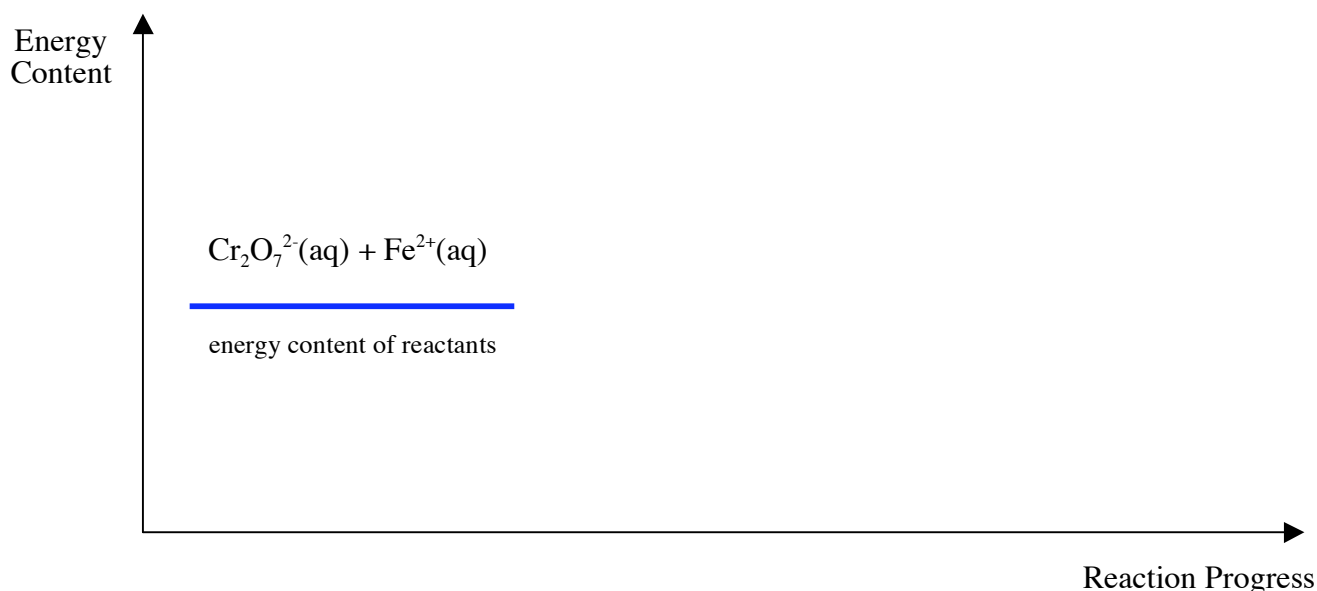
- c. Potassium dichromate, ($\text{K}_2\text{Cr}_2\text{O}_7$), in acid solution, oxidises iron(II) ions (Fe^{2+}) to iron(III) ions (Fe^{3+}). The orange solution containing the dichromate(VI) ions ($\text{Cr}_2\text{O}_7^{2-}$) turns green as chromium(III) ions (Cr^{3+}) are formed. As the reaction 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.



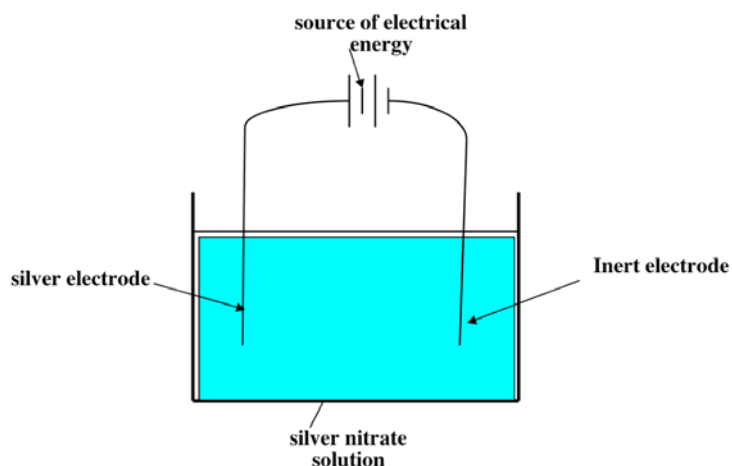
- ii. On the diagram above, sketch an energy profile for this reaction **when a catalyst is used**. Use the word “catalyst” and an “arrow” to indicate clearly any change in the energy profile.

2 + 2 = 4 marks

Total 11 marks

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 $\text{Ag}^+(\text{aq})$.



- 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

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 $\text{H}_2\text{SO}_4(\text{aq})$ was mixed with 400 mL of 0.2M $\text{KOH}(\text{aq})$ 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 $\text{H}_2\text{SO}_4(\text{aq})$ is mixed with 800 mL of 0.2M KOH .

2 marks

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: $\text{HCN}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CN}^-(\text{aq})$.

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

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

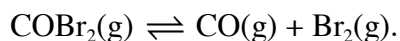
- d. The temperature of the equilibrium system $\text{HCN(aq)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{CN}^-(\text{aq})$ is increased to 70°C. How could the experimental measurement of the pH of the solution be used to determine whether or not the forward reaction is exothermic?

2 marks

Total 8 marks

Question 5

Carbonyl bromide is one of the decomposition products from the fire retardant Halon 1211: Bromochlorodifluoromethane (CBrClF₂). Carbonyl bromide, COBr₂(g), dissociates at 75°C according to the equation:



4.00 mol of carbonyl bromide was placed in a 2.00 L container at 75°C 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 75°C.

3 marks

- b.** The volume of the container was decreased to 0.5 L at a constant temperature of 75°C 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

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 $\text{Br}_2(\text{g})$?
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

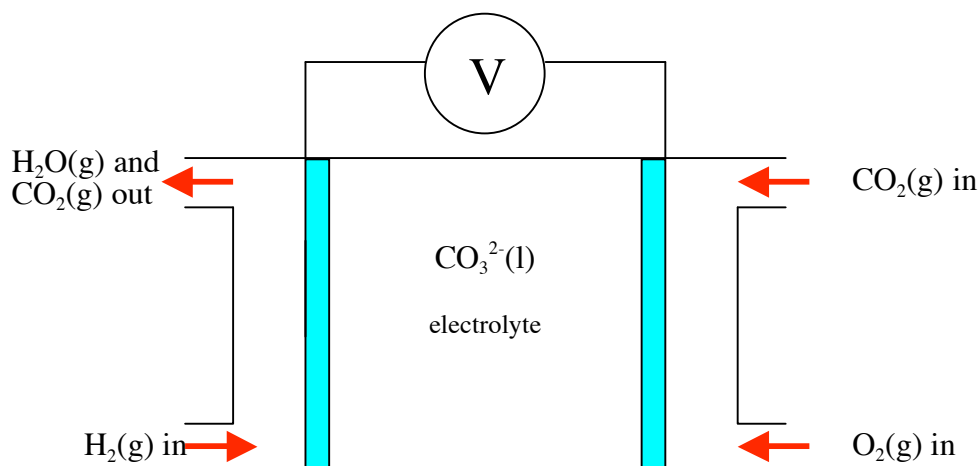
- d. Methyl orange is used as an indicator for the titration of a strong acid with a weak base but phenolphthalein is used as an indicator for the titration of a strong base with a weak acid.

1 mark

Total 4 marks

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 $\text{O}_2(\text{g}) + 2\text{CO}_2(\text{g}) + 4\text{e}^- \rightarrow 2\text{CO}_3^{2-}(\text{l})$.



- 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

- the cathode and its polarity.
- the direction of electron flow.

1 + 1 = 2 marks

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

2008 VCE CHEMISTRY TRIAL WRITTEN EXAMINATION 2

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