Neap:

Trial Examination 2011

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
A Multiple-choice	20	20	20
B Short-answer	7	7	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners 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 booklet of 18 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 2011 VCE Chemistry Unit 4 Written Examination.

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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

Which of the following combination of reactants would be expected to produce the greatest extent of reaction, assuming all conditions to be standard?

A. $Zn(NO_3)_2(aq) / Sn(NO_3)_2(aq)$

B. $Fe(NO_3)_2(aq) / AgNO_3(aq)$

C. $Pb(NO_3)(aq) / Ni(s)$

D. $Cu(s) / Mn(NO_3)_2(aq)$

The following information relates to Questions 2 and 3.

It is estimated that a gas molecule may undergo 10^9 collisions every second at room temperature. Hydrogen gas and chlorine gas may react according to the equation below. For this reaction, an increase of 10ºC in the reaction temperature doubles the rate of formation of gaseous HCl.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Question 2

Which one of the following statements is incorrect?

A. An increase of 10°C in the reaction temperature must double the number of collisions of reactant molecules in the reaction.

B. Only a small proportion of the 10^9 reactant molecule collisions per second will yield products in the reaction.

C. Each type of gas molecule represented in the equation will collide with the other gas molecules shown.

D. Increasing the temperature will increase the fraction of collisions which will result in the product molecules forming.

Question 3

The reaction rate for the formation of HCl(g) is 1.9 M s^{-1} at 15°C.

If the temperature is increased to 45°C, the rate of reaction (in M s^{-1}) is likely to be

A. less than 3.8

B. 3.8

C. 5.7

D. greater than 5.7

Question 4

Ethanal (CH_3CHO) rapidly decomposes at 500°C according to the following equation.

$$CH_3CHO(g) \rightarrow CH_4(g) + CO(g)$$

The activation energy for the forward reaction is 190 kJ mol^{-1}. The activation energy for the reverse reaction is 210 kJ mol^{-1}.

The enthalpy change (in kJ mol^{-1}) of the forward reaction is

A. –400
B. –20
C. +20
D. +400

Question 5

The data below show enthalpy changes for two reactions.

$$2Cu_2O(s) + O_2(g) \rightarrow 4CuO(s) \qquad \Delta H = -288 \text{ kJ mol}^{-1}$$

$$Cu_2O(s) \rightarrow Cu(s) + CuO(s) \qquad \Delta H = +11 \text{ kJ mol}^{-1}$$

The enthalpy of formation of a compound is the energy required or released in the formation of one mole of the compound from its constituent elements.

Using the data above, the enthalpy of formation of copper(II) oxide, in kJ mol^{-1}, is

A. –133
B. –144
C. –155
D. –299

Question 6

The nuclear reaction represented in the equation shown below releases large amounts of energy.

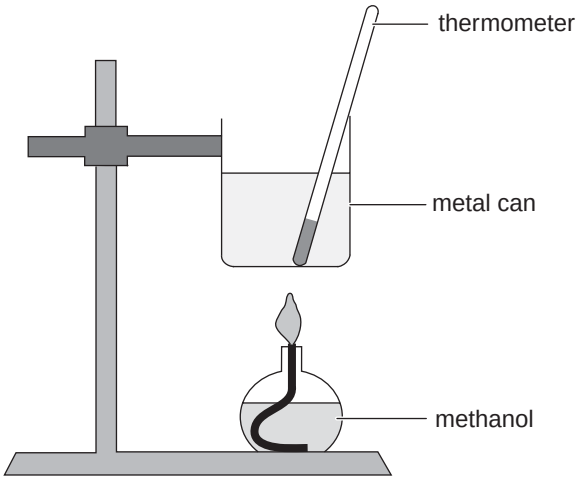
$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n$$

Which of the following statements concerning this nuclear reaction is correct?

A. This fusion reaction is not currently available as an energy source on Earth due to difficulties in obtaining the conditions required for the reaction to occur.
B. This fusion reaction is not currently available as an energy source on Earth due to the limited availability of the raw materials.
C. This fission reaction currently has limited use as an energy source on Earth due to concerns about the dangers of radioactive waste.
D. This fission reaction is not currently available as an energy source on Earth due to difficulties in containing the reaction mixture.

Question 7

An experiment was conducted to determine the heat of combustion of methanol using the equipment shown below. The metal can containing water was heated by burning a known mass of methanol and the temperature rise was measured.



The calculated heat of combustion from the experiment was approximately fifty per cent below the accepted value.

Which of the following changes to the experiment could be made in order to produce a more accurate result?

I using a glass beaker in place of the metal can

II loosely wrapping the assembled equipment in aluminium foil

III placing a lid on the vessel containing the water

A. I or II only
B. I or III only
C. II or III only
D. I, II or III

Question 8

A solution of limewater, $Ca(OH)_2$, at 25°C contains $Ca(OH)_2$ at a concentration of 3.50×10^{-3} M.

The pH of the solution is

A. 2.15
B. 2.46
C. 11.5
D. 11.8

Question 9

5.00 mol of HI(g) was admitted to an evacuated 2.00 L reaction vessel and allowed to reach equilibrium at a constant temperature, according to the following equation.

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

At equilibrium, 0.250 mol of I_2 had formed.

The equilibrium concentration of HI(g) at the temperature of the reaction is

A. 2.25 M
B. 2.38 M
C. 4.50 M
D. 4.75 M

Question 10

20.0 mL of a 0.10 M solution of hypochlorous acid (HOCl), a weak acid, is diluted with distilled water to a total volume of 200.0 mL.

The effect of this dilution on the pH of the solution would be to

A. decrease the pH by 1.0
B. increase the pH by 1.0
C. increase the pH by less than 1.0
D. decrease the pH by less than 1.0

Question 11

Cadmium metal is used to electroplate metal items to give them a lustrous coating which is resistant to corrosion. The item to be electroplated is placed into an electrolytic cell with a cadmium electrode and a solution of cadmium ions which is stirred constantly.

In the course of the electrolytic process

A. electrons will travel from cathode to anode.
B. the mass of the anode will increase.
C. the concentration of cadmium ions in the electrolyte will decrease.
D. cadmium ions will move towards the cathode.

Question 12

At a particular temperature, the equilibrium constant for the following reaction is 49.

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

At the same temperature, the equilibrium constant for the reaction shown below is

$$HI(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$$

A. 2.0×10^{-2}
B. 0.14
C. 3.5
D. 4.9

Question 13

A 1.0 M K_2SO_4 solution is electrolysed using inert electrodes. The following standard reduction potentials are provided in addition to those in the Data Booklet.

$S_2O_8^{2-}(aq) + 2e^- \rightleftharpoons 2SO_4^{2-}(aq)$ $\quad E^0 = +2.01$ V

$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons SO_2(aq) + 2H_2O(l)$ $\quad E^0 = +0.16$ V

In the electrolysis of a dilute solution of K_2SO_4, the sulfate ions are

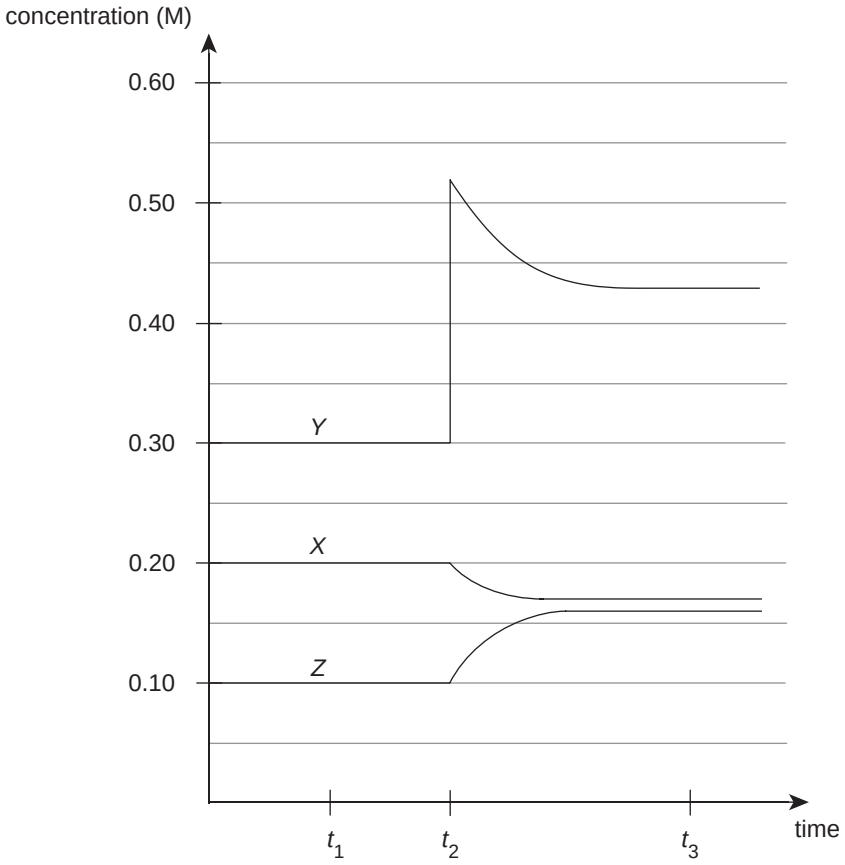
A. attracted to the anode where they are oxidised.
B. attracted to the cathode where they are reduced.
C. not attracted to either electrode as they are spectator ions only.
D. attracted to the anode where they are neither reduced nor oxidised.

The following information relates to Questions 14 and 15.

The gases *X*, *Y* and *Z* were placed in an evacuated vessel and allowed to reach equilibrium according to the equation

$$X(g) + yY(g) \rightleftharpoons zZ(g)$$

At time t_2, a change was made, and the effect on the concentration of the gases was graphed, as shown below. The temperature remained constant throughout the experiment.



Question 14

Which one of the following statements can be correctly deduced from the given information?

A. Decreasing the volume of the equilibrium mixture would yield more of gas *Z*.

B. At time t_2, the volume of the reaction vessel was decreased.

C. Using a suitable catalyst would increase all of the gas concentrations at time t_3.

D. Immediately after time t_2, the rate of the forward reaction is less than that of the backward reaction.

Question 15

The numerical value of the equilibrium constant, *K*, for the forward reaction at time t_1 is

A. 1.7

B. 1.9

C. 6.2

D. 93

Question 16

Three half-cells were set up under standard conditions.

Half-cell number	Electrode	Electrolyte
1	Graphite	$P^{2+}(aq)$ and $P^{3+}(aq)$
2	Metal Q	$Q^{2+}(aq)$
3	Metal R	$R^{2+}(aq)$

Two galvanic cells were constructed using combinations of these half-cells. The results obtained are shown in the table below.

Half-cells used	Result
1 and 2	Half reaction at cathode: $Q^{2+}(aq) + 2e^- \rightarrow Q(s)$
1 and 3	Half reaction at anode: $R(s) \rightarrow R^{2+}(aq) + 2e^-$

Based on the results of the experiment, which of the following is the strongest reductant?

A. $P^{2+}(aq)$
B. $P^{3+}(aq)$
C. $R(s)$
D. $Q(s)$

Question 17

Which of the following fuel samples would be expected to release the least amount of energy, assuming each undergoes complete combustion?

A. 5.9 mL of ethanol (density 0.785 g mL^{-1}).
B. 0.10 mol of pentane.
C. 24.5 L of hydrogen gas at a pressure of 101.3 kPa and a temperature of 25°C.
D. 5.8 g of butane.

Question 18

At a particular temperature, pure water has a pH of 6.5.

Which of these statements are accurate?

I The concentration of hydroxide ions is $10^{-7.5}$ M.

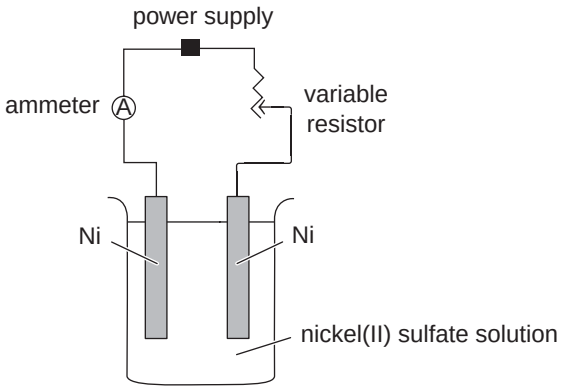
II The water is acidic as the pH is less than 7.0.

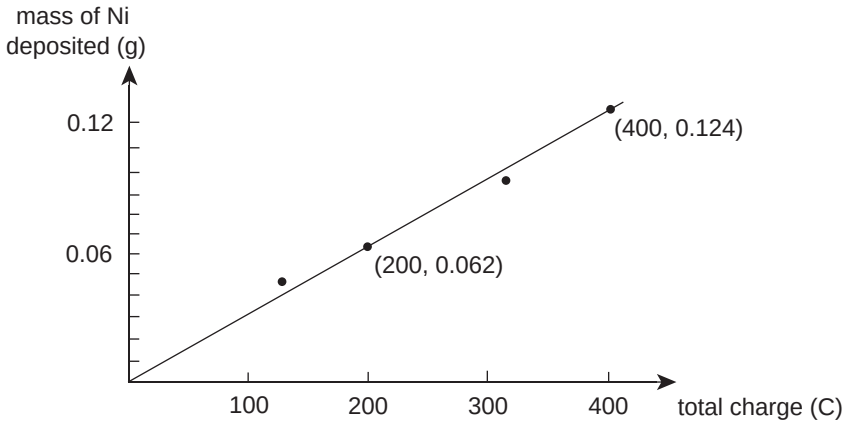
III The value of K_w would be unchanged if the water temperature increased.

A. I and III only
B. II and III only
C. I, II and III
D. neither I, II nor III

The following information relates to Questions 19 and 20.

A group of students investigated the relationship between the amount of charge that passed through an electrolytic cell and the mass of metal produced at one electrode of the cell. The cell voltage was adjusted to allow for the deposition of nickel at the negative electrode. A series of tests were conducted in which different currents were passed through the cell for different lengths of time. In each case the electrode was carefully dried and weighed to determine the mass of nickel deposited. The apparatus used, and the results obtained are shown in the diagram and graph below.





Question 19

Based on the data obtained in this experiment, the charge on one mole of electrons would be calculated to be

A. 1.89×10^4 C

B. 9.47×10^4 C

C. 9.65×10^4 C

D. 9.72×10^4 C

Question 20

The calculated value for the charge on one mole of electrons differs from the theoretical value.

The calculated value is

A. greater than the theoretical value possibly because the nickel solution used was contaminated with copper(II) ions.

B. less than the theoretical value possibly because the nickel solution used was contaminated with copper(II) ions.

C. greater than the theoretical value possibly because the nickel solution used was contaminated with zinc ions.

D. less than the theoretical value possibly because the nickel solution used was contaminated with zinc ions.

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

In a bomb calorimeter, the reaction vessel is surrounded by water. Since the amount of water may vary from one experiment to the next, the mass of water used is measured in each experiment. The calibration factor of the calorimeter is therefore broken into two parts: the water and the calorimeter components.

a. The calibration factor for one calorimeter containing 1.00 kg of water is 9.56 $kJ°C^{-1}$.

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

_____

_____

_____

2 marks

b. In a separate experiment, the bomb calorimeter used in **part a** is filled with 1058 g of water. The initial temperature of the calorimeter contents is 22.8°C. A 3.05 g sample of 2-propanol undergoes complete combustion in the calorimeter.

i. Calculate the energy released during the combustion reaction.

_____

_____

_____

ii. Calculate the final temperature reached by the calorimeter contents.

_____

_____

_____

_____

_____

_____

2 + 3 = 5 marks

Total 7 marks

Question 2

a. Lactic acid ($HC_3H_5O_3$) is a product of anaerobic respiration in muscle cells. It accumulates in muscle tissue during exertion, causing pain. In a 0.15 M solution of lactic acid, the acid is 3.0% ionised.

i. Write an expression for the acidity constant, K_a, for lactic acid.

ii. Determine the concentration of the $C_3H_5O_3^-$ anion in a 0.15 M aqueous solution of lactic acid.

_____

_____

_____

_____

iii. Hence show that the value of the acidity constant, K_a, for lactic acid is 1.4×10^{-4}.

_____

_____

_____

_____

1 + 2 + 2 = 5 marks

b. Phosphoric acid (H_3PO_4) is a weak triprotic acid. The acidity constants for the successive ionisation of H_3PO_4 are represented as K_{a1}, K_{a2} and K_{a3}.

$K_{a1} = 7.5 \times 10^{-3}$

i. Write an expression for the second acidity constant, K_{a2}, for phosphoric acid.

ii. Would you expect the value of K_{a2} to be greater than, or less than, 7.5×10^{-3}?

_____

1 + 1 = 2 marks
Total 7 marks

Question 3

Methanol (CH_3OH) is produced in large quantities industrially for use as a fuel and as a raw material for the production of other chemicals.

The two main reactions which occur in sequence, in separate reaction vessels, in methanol synthesis are:

I. $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206 \text{ kJ mol}^{-1}$

II. $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H = -91 \text{ kJ mol}^{-1}$

The conditions used for these reactions are shown in the table below.

Reaction	Temperature (°C)	Pressure (kPa)	Catalyst
I	850	400	Ni
II	250	900	Cu/ZnO/alumina

a. In a particular methanol manufacturing industry, the preheated reactant gases for Reaction I are passed through a series of 19 elongated reaction tubes containing the Ni catalyst.

Suggest a reason for this arrangement.

_____

_____

_____

1 mark

b. Explain the use of the **moderate** pressure in the conditions for Reaction I.

_____

_____

_____

_____

_____

_____

3 marks

c. Account for the much lower temperature being used for Reaction II.

_____

_____

_____

_____

_____

_____

3 marks

d. The products from Reaction I are fed into the methanol synthesis reactor where Reaction II takes place. Carbon dioxide gas may also be injected into this reactor, enabling the following reaction to occur.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

Suggest why this injection of carbon dioxide gas will improve the efficiency of the overall synthesis of methanol.

_____

_____

_____

_____

2 marks

e. The properties of methanol include:

- toxic to humans
- burns with an invisible flame
- can be absorbed into the body by inhaling
- dissolves in water in all proportions
- passes through the skin into the bloodstream

Describe a specific safety procedure which would be used to protect workers in the manufacture, storage or distribution of methanol.

_____

_____

1 mark

f. During this semester you have studied the industrial production of a chemical of importance. Answer the following questions for your chosen chemical.

Circle the chemical you have chosen.

ammonia nitric acid sulfuric acid ethene

i. State the source of one raw material required for the production of your chosen chemical.

_____

_____

_____

ii. State one way in which the waste materials from the production of your chosen chemical are managed so as to limit their impact on the environment.

_____

_____

_____

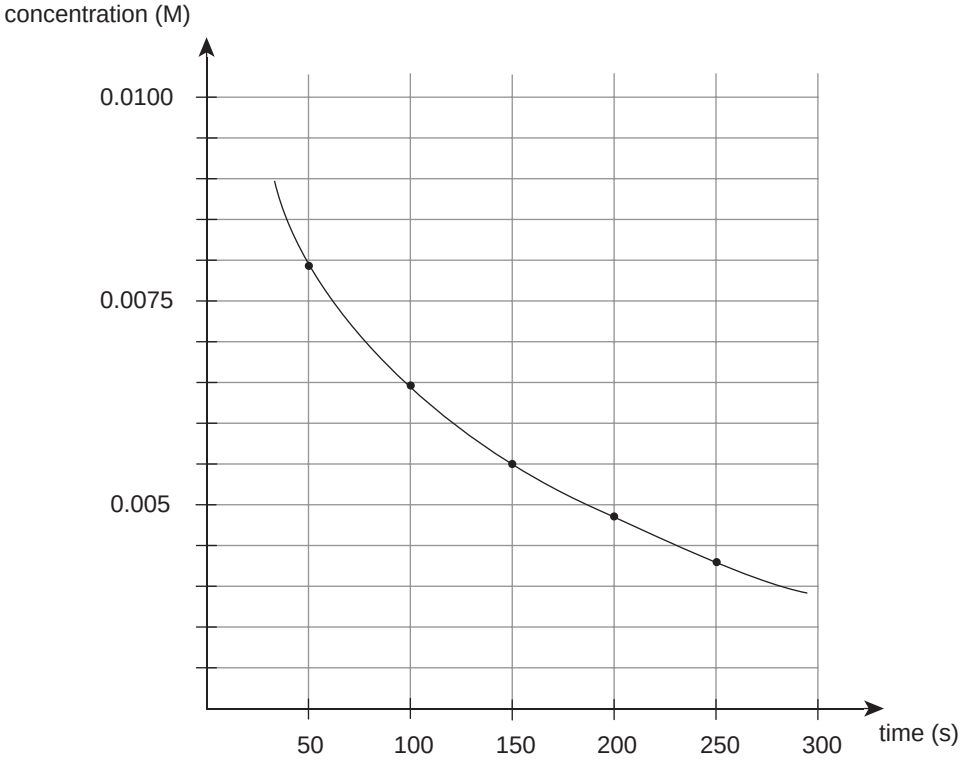
1 + 1 = 2 marks
Total 12 marks

Question 4

Nitrogen dioxide is a brown gas which contributes to the colour of photochemical smog. Nitrogen dioxide decomposes according to the following equation.

$$2NO_2(g) \rightarrow 2NO(g) + O_2(g)$$

The decomposition of nitrogen dioxide in a flask held at a constant temperature of 300°C is monitored over a period of time. The results, graphed below, show the concentration of the NO_2 in the flask over a 5 minute time period.



a. Suggest a method that could be used to monitor the NO_2 concentration in the flask.

_____

_____

1 mark

b. How could the graph be used to determine the rate of the decomposition reaction at a particular time?

_____

_____

1 mark

c. Determine the average rate of reaction of the NO_2 (in M s^{-1}) for the time interval 50 – 100 s.

_____

_____

1 mark

d. Determine the average rate of production of the O_2 (in M s^{-1}) for the time interval 50 – 100 s.

_____

1 mark

e. Use collision theory to explain why the average rate of reaction of the NO_2 for the time interval 250 – 300 s is less than the value calculated in **part c**.

_____

_____

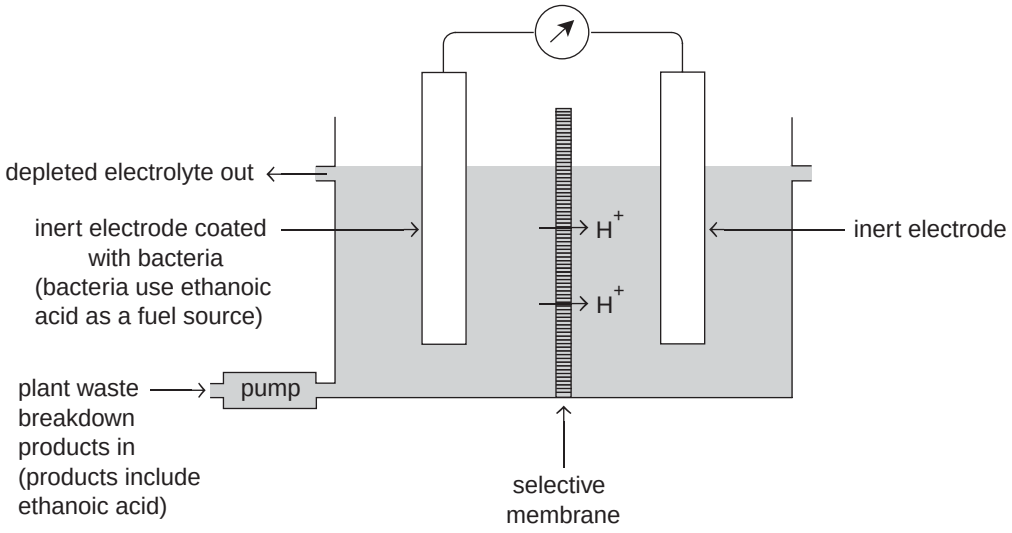
_____

_____

2 marks
Total 6 marks

Question 5

The Microbial Fuel Cell (MFC) produces an electric current from the breakdown of organic compounds by microorganisms. Plant waste materials, water containing organic contaminants and other organic waste can be used as fuel in the MFC. A simplified structure of the MFC is shown below.



a. **i.** Write the half equation showing the complete oxidation of ethanoic acid to carbon dioxide in aqueous acidic conditions.

_____

ii. If ethanoic acid is used as the fuel source, the MFC can produce a potential of 0.30 V.

How much energy, in joules, is produced by the cell for every mole of ethanoic acid consumed?

_____

_____

_____

1 + 2 = 3 marks

b. Research chemists have found that by supplying a voltage to the MFC using an external power source, an electrolytic cell is produced which can generate hydrogen gas at the cathode. This is known as the Microbial Electrolysis Cell (MEC).

i. If platinum is used as the cathode material, the voltage which needs to be supplied to produce hydrogen gas is quite low.

Suggest a possible reason for this.

_____

_____

ii. Write a half-equation showing this production of hydrogen gas at the cathode in aqueous acidic conditions.

_____

1 + 1 = 2 marks

c. Hydrogen gas has been proposed by some experts as 'the fuel of the future' as it is renewable and easily extracted, and its use as a fuel does not damage the environment. Some methods by which hydrogen gas could be used as a fuel include:

I the energy source in a hydrogen/oxygen fuel cell

II burnt in order to provide heat for the production of steam for electricity generation

III an alternative to fossil fuels in modified transport vehicles

i. In two separate experiments, an equivalent mass of hydrogen gas was used to generate electricity using methods I and II above.

Which of these methods will produce the greater amount of electrical energy? Explain your choice.

_____

_____

_____

_____

_____

ii. State one disadvantage of using hydrogen gas as an energy source in a suitably modified vehicle compared to using petrol.

_____

_____

2 + 1 = 3 marks
Total 8 marks

Question 6

a. In an experiment to determine the charge on gold ions, an aqueous solution of a salt of gold was electrolysed. When the electrolysis was performed using a current of 2.00 A for 6.75 minutes, a mass of 0.551 g of gold was deposited.

i. Calculate the number of mole of electrons passing through the cell during the electrolysis.

_____

_____

ii. Calculate the number of mole of gold deposited during the electrolysis.

_____

_____

iii. Determine the charge on the gold ions in this experiment.

_____

_____

1 + 1 + 2 = 4 marks

b. In a second experiment, a solution of 0.50 M $MgCl_2(aq)$ was electrolysed using graphite electrodes for 6.75 minutes with a current of 2.00 A. No magnesium metal was deposited at the cathode, but gases evolved at both electrodes.

i. Calculate the volume of the dried gas produced at the anode if it was collected at 100 kPa and 20°C.

_____

_____

_____

_____

_____

ii. Which of the following changes to the experiment could produce a different gas at the anode in this experiment? (Indicate your responses by ticking one or more of the boxes in the table below.)

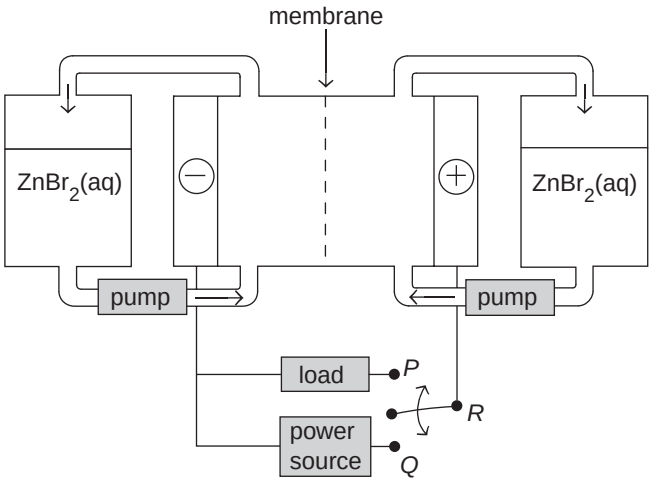
Changing the electrode surface area	
Increasing the concentration of the electrolyte	
Decreasing the duration of the electrolysis	
Using platinum electrodes instead of graphite	

3 + 1 = 4 marks
Total 8 marks

Question 7

In remote locations without connection to the electricity grid, the use of energy storage batteries which are recharged by a renewable energy source may provide a sustainable solution to the problem of electricity supply.

The simplified diagram below shows the important features of the zinc-bromine flow battery, which makes use of the reaction between Zn(s) and Br_2(l).



The electrodes are made from inert, electrically conductive material, and a special membrane separates the electrode chambers. When the switch connects *P* to *R*, the battery produces electricity. By connecting *Q* to *R*, an external power source will recharge the battery.

a. Write the half-equation for the reaction occurring at the cathode when the battery is discharging.

_____

1 mark

b. In what way does the anode change as the battery is discharging?

_____

_____

1 mark

c. An important feature of the battery is the special membrane.

i. What role does the membrane have in the operation of the battery during discharge?

_____

_____

_____

ii. Bromine cannot pass through the membrane.

Explain the importance of this restriction when the battery is being recharged.

_____

_____

_____

1 + 1 = 2 marks

d. The zinc-bromine flow battery produces a voltage of 1.67 volts per cell. This is below the predicted value from the electrochemical series.

Suggest one possible reason for this lower than expected value.

_____

_____

1 mark

e. A useful feature of the battery is its ability to be recharged using renewable energy sources.

Outline how the battery could be recharged using solar energy.

_____

_____

_____

_____

_____

2 marks
Total 7 marks

END OF QUESTION AND ANSWER BOOKLET