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Tasmanian Secondary Assessment Board

CHEMISTRY

Senior Secondary 5C

Subject Code: CH856

External Assessment

2003

Criteria 2 and 7

Time: 45 minutes

On the basis of your performance in this examination, the examiners will provide results on each of the following criteria taken from the syllabus statement:

Criterion 2 Communicate ideas and information using appropriate chemical language and formats when undertaking chemical investigations.

Criterion 7 Demonstrate an understanding of the fundamental principles and theories of electrochemistry.

Questions: 5
Pages: 7

CANDIDATE INSTRUCTIONS

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NOTE: 1 litre (L) = 1000 millilitres (mL) = $1dm^3$ = 1000 cm^3.

Question 1

Chlorine is a heavy, greenish-yellow gas, with a characteristic choking smell.

(a) Chlorine can be prepared in the laboratory fume cupboard by reacting potassium permanganate with concentrated hydrochloric acid. Write a balanced equation for this reaction. (2 marks)

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(b) When solutions of potassium chlorate ($KClO_3$) and dilute hydrochloric acid are mixed, chlorine gas is produced.

(i) Write a half equation for the reduction of the chlorate ion in acidic solution to gaseous chlorine. (1 mark)

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(ii) Hence write an overall equation for the reaction between potassium chlorate and hydrochloric acid. (1 mark)

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(c) Explain why fluorine is a stronger oxidiser than chlorine. (2 marks)

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(d) Chlorine dissolves in water forming a yellow solution smelling of chlorine known as chlorine water. An equilibrium is set up:

$$Cl_{2(aq)} + H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)} + HOCl_{(aq)}$$

Explain in terms of oxidation numbers why this is an oxidation-reduction reaction. (2 marks)

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Question 1 continues over the page.

Question 1 (continued)

(e) Manganese dioxide oxidises **concentrated** hydrochloric acid to produce chlorine. Suggest why this reaction is effective even though the E^o values indicate that the reaction would not proceed. (2 marks)

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Question 2

A chemistry class conducted an experiment to investigate the voltages of several electrochemical cells. A half cell consisting of a strip of lead in a 1.00 mol L^{-1} solution of lead nitrate ($Pb(NO_3)_2$) was joined to a half cell consisting of a strip of magnesium in a 1.00 mol L^{-1} solution of magnesium nitrate ($Mg(NO_3)_2$). A salt bridge containing sodium nitrate ($NaNO_3$) was used to join the two half cells. In the external circuit, a voltmeter and a switch were added.

(a) What is the maximum cell voltage obtainable with this combination? (1 mark)

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(b) One group used sodium sulfate in their salt bridge and found that no voltage was recorded and their salt bridge 'clogged up'. Explain their observations. (2 marks)

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(c) Indicate which electrode is the anode and which is the cathode. (1 mark)

Anode: .....

Cathode: .....

(d) The magnesium half cell was replaced by a copper half cell (a strip of copper in a 1.00 mol L^{-1} solution of copper II nitrate ($Cu(NO_3)_2$). What should the students have observed about the current flow? Give reasons. (3 marks)

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Question 2 continues opposite.

Question 2 (continued)

(e) The copper half cell was then replaced by a tin half cell (a strip of tin in a 1.00 mol L^{-1} solution of Sn^{2+} ions). Very few students recorded a voltage. Should this result have been expected? Explain. (2 marks)

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(f) Why is it impossible to obtain a sodium half cell to use in this experiment? (1 mark)

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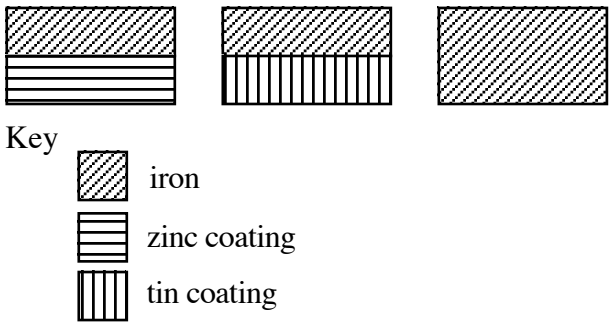
For Marker Only

Questions	Marks
1 & 2	/20

Question 3



When a piece of iron which had been partly coated with zinc (galvanised) was exposed to a corrosive environment, it was observed that the zinc slowly corroded but the iron did not rust. A piece of iron which had been partly coated with tin (tin plate) in the same environment was soon covered with patches of rust.

Explain these observations and compare them with a piece of untreated iron which was in the same environment for the same time. (4 marks)

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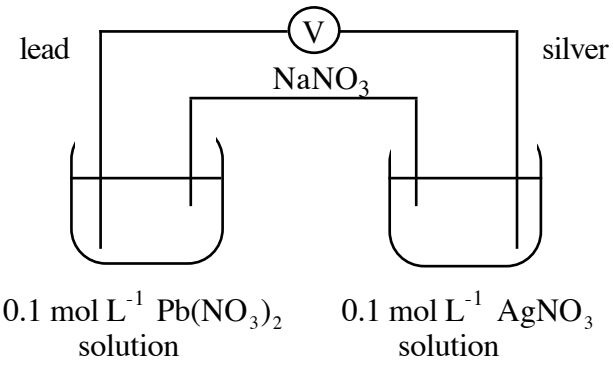
Question 4

Below is a diagram of an electrochemical cell.



(a) Write the anode half equation. (1 mark)

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(b) What happens to the concentration of $Pb^{2+}_{(aq)}$ as the electrochemical cell operates? Explain. (2 marks)

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(c) To which electrode do the sodium ions in the salt bridge move towards? (1 mark)

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(d) Explain why the voltage decreases with time. (1 mark)

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Question 5

A dilute solution of sodium chloride is to be electrolysed to produce hydrogen and oxygen.

(a) Estimate the minimum voltage needed. Show all equations used. (3 marks)

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Question 5 continues opposite.

Question 5 (continued)

(b) What time would it take to electrolyse 10 g of water if a current of 1.50 A was used? (3 marks)

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(c) The experiment was repeated using dilute hydrochloric acid instead of dilute sodium chloride.

(i) How does this affect the reactions at the electrodes? (2 marks)

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(ii) How might this affect the minimum voltage required? (2 marks)

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(iii) Indicate suitable electrodes. (1 mark)

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For Marker Only

Questions	Marks
3, 4, & 5	/20

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Tasmanian Secondary Assessment Board

CHEMISTRY

Senior Secondary 5C

Subject Code: CH856

External Assessment

2003

Criteria 2 and 8

Time: 45 minutes

On the basis of your performance in this examination, the examiners will provide results on each of the following criteria taken from the syllabus statement:

Criterion 2 Communicate ideas and information using appropriate chemical language and formats when undertaking chemical investigations.

Criterion 8 Demonstrate an understanding of the principles and theories of thermochemistry, rate of reaction and equilibrium.

Questions: 7
Pages: 10

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CANDIDATE INSTRUCTIONS

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NOTE: 1 litre (L) = 1000 millilitres (mL) = $1dm^3$ = 1000 cm^3.

Question 6

(a) Are the following processes endothermic or exothermic? Give reasons.

(i) Evaporation of ethanol: (2 marks)

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(ii) Formation of the fluoride ion, (F^-) as in the equation $F_{(g)} + e^- \rightarrow F^-_{(g)}$. (1 mark)

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(b) Explain, in terms of energy, why two hydrogen atoms bond together to form H_2 molecules but two helium atoms do not. (2 marks)

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(c) How is energy stored in a gaseous molecule such as ammonia, NH_3? (2 marks)

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Question 7

Great care must be taken when diluting concentrated nitric and concentrated sulfuric acids as large amounts of heat are liberated. For example the heat of dilution of nitric acid is 30 kJ per mole of HNO_3.

Outline a safe method for diluting these concentrated acids, explaining why it is safe. (3 marks)

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Question 8

When solid potassium hydroxide, (KOH) is dissolved in water the reaction is exothermic whereas when solid sodium thiosulfate, ($Na_2S_2O_3$) is dissolved in water the reaction is endothermic. Explain these observations in terms of the bonding involved in the dissolving of ionic compounds. (4 marks)

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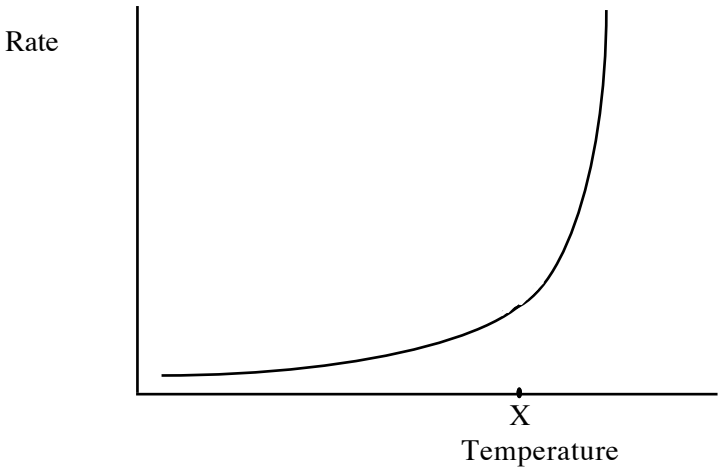
Question 9

Aqueous solutions of hydrogen peroxide are increasingly being used in industry for bleaching rather than chlorine or chlorine oxides. Hydrogen peroxide decomposes according to the reaction:

$$2H_2O_{2(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$

The reaction is exothermic and the rate of decomposition varies with temperature as follows:



(a) Why does the rate increase with an increase in temperature? (2 marks)

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Question 9 continues over the page.

Question 9 (continued)

(b) What happens to the rate of the reaction when the temperature is greater than X? Explain. (2 marks)

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(c) Sunlight (or UV light) will increase the rate of the reaction. Explain. (2 marks)

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For Marker Only

Questions	Marks
6, 7, 8 & 9	/20

Question 10

Sufficient hydrogen chloride gas and oxygen are introduced into a container and the temperature held constant at 450°C, and the pressure adjusted to 101.3 kPa until equilibrium is attained, according to the reaction:

$$4HCl_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Cl_{2(g)} \; ; \; \Delta H = -117.6 \text{ kJ}$$

(a) Write an expression for the equilibrium constant, K_c. (1 mark)

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(b) How will the equilibrium constant at 550°C compare with the value at 450°C, (the pressure remaining constant at 101.3 kPa)? Explain. (3 marks)

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Question 10 continues opposite.

Question 10 (continued)

(c) The volume is expanded at constant temperature so that the pressure is decreased. The system allowed to resettle to equilibrium. How will the concentrations of the reactant gases and product gases at this new equilibrium compare with their concentrations at the initial equilibrium? Give reasons. (3 marks)

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(d) Compare K_c at this new equilibrium to the initial value. (1 mark)

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(e) For the similar equilibrium between hydrogen bromide gas and oxygen:

$$4HBr_{(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(g)} + 2Br_{2(g)}$$

What property of the system could you make use of in order to determine any change in the position of the equilibrium? (1 mark)

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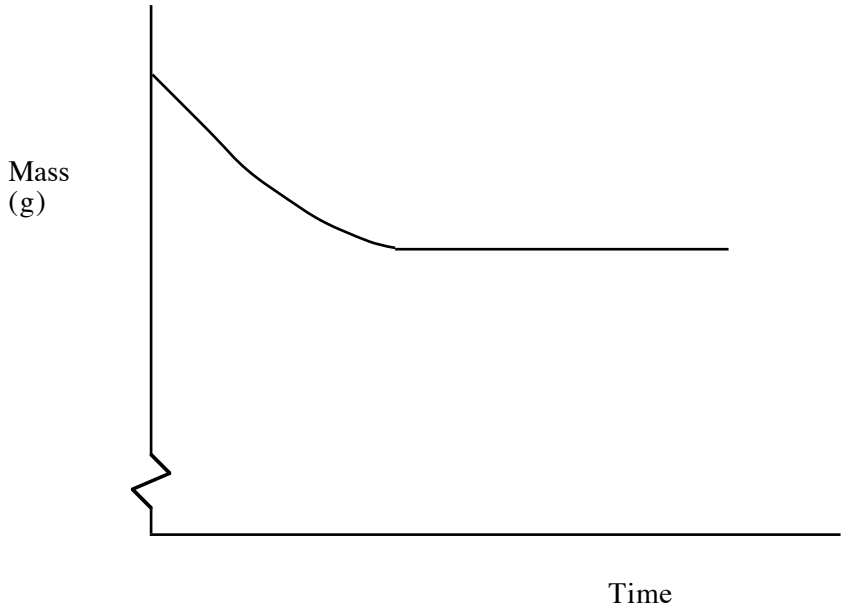
Question 11

10.0 g of scrap copper water pipe was dissolved in a beaker containing 500 mL of 2.00 mol L^{-1} nitric acid according to the following equation:

$$3Cu_{(s)} + 8HNO_{3(aq)} \longrightarrow 3Cu(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$$

The changing mass of the mixture was observed against time, and the following graph obtained.



(a) On the graph above sketch the expected curve if 500 mL of 1.00 mol L^{-1} nitric acid had been used instead. Label you new graph line.

Explain the difference in shape. (2 marks)

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(b) Show on the graph above the expected line if the 10.0 g of scrap copper had previously been ground up in a hammer mill. Label this graph line. Explain. (2 marks)

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Question 12

A

B
extra solid silver ethanoate added

C
sodium ethanoate added

D
extra water added

Four beakers each containing 100 mL of a solution containing solid silver ethanoate is in equilibrium with silver ions and ethanoate ions.

$$AgCH_3COO_{(s)} \rightleftharpoons Ag^+_{(aq)} + CH_3COO^-_{(aq)}$$

(a) Write an expression for the equilibrium constant. (1 mark)

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(b) Extra solid silver ethanoate is added to beaker B. What would happen to the concentration of the ions in solution in beaker B? Give reason. (2 marks)

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(c) Some solid **sodium** ethanoate is added to beaker C and dissolved. Explain what would happen to the concentration of silver ions in solution in beaker C. (2 marks)

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(d) 100 mL of water is added to beaker D. How would the total amount of silver ions in solution in beaker D compare with the total amount of silver ions in solution in beaker A? Explain. (2 marks)

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For Marker Only

Questions	Marks
10, 11, & 12	/20

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Tasmanian Secondary Assessment Board

CHEMISTRY

Senior Secondary 5C

Subject Code: CH856

External Assessment

2003

Criteria 2 and 9

Time: 45 minutes

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Criterion 2 Communicate ideas and information using appropriate chemical language and formats when undertaking chemical investigations.

Criterion 9 Demonstrate an understanding of properties and reactions of inorganic and organic matter.

Questions: 8
Pages: 7

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Question 13

A straight chain alkanal (aldehyde) has the molecular formula C_4H_8O.

(a) Draw a structural formula for this compound and name it. (2 marks)

Name: .....

(b) Draw and name a straight chain structural formula of an isomer of C_4H_8O which is a alkanone (ketone). (2 marks)

Name: .....

(c) Is it possible to obtain a straight chain saturated alcohol with this molecular formula? Explain. (2 marks)

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Question 14

(a) Ethyl methanoate is hydrolysed with water. Write an equation to represent this reaction. (1 mark)

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(b) Animal fats and vegetable oils are esters of glycerol with long chain carboxylic acids. These acids are called 'fatty acids'.

(i) What is the essential difference between a saturated fat or oil and a polyunsaturated fat or oil? (1 mark)

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Question 14 continues over the page.

Question 14 (continued)

(ii) How could you experimentally distinguish between a saturated vegetable oil and a polyunsaturated vegetable oil? (2 marks)

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Question 15

A class was given an organic liquid to identify. They were told that it was a straight chain compound that contained carbon, hydrogen and oxygen only.

(a) A colourless gas was evolved when they reacted the liquid with sodium. What two functional groups does this indicate could be in the compound and what is the gas evolved? (2 marks)

Functional Groups: .....

Gas Evolved: .....

(b) They tested the pH of the solution of the liquid in water and found it to be approximately 3, so they decided to titrate it against a sodium hydroxide solution. They measured out 0.360 g of the acid, added about 20 mL of water and phenolphthalein indicator, and found that they needed 30.4 mL of 0.160 mol L^{-1} sodium hydroxide solution to reach the end point.

Calculate the molar mass of the compound, assuming as the class did, that the compound and NaOH reacted in the ratio of 1:1 (3 marks)

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(c) Identify the compound from the information in (b). (2 marks)

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Question 16

Benzene, C_6H_6, is a colourless liquid.

(a) Describe the structure of benzene and draw its structural formula. (2 marks)

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(b) Benzene, like all hydrocarbons, burns readily. Write an equation for the combustion of benzene assuming that the carbon is converted to equal amounts of CO and CO_2. (1 mark)

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For Marker Only

Questions	Marks
13, 14, 15 & 16	/20

Question 17

(a) Give the electron configuration of the calcium **ion**. (1 mark)

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(b) Explain why calcium is more reactive than magnesium. (2 marks)

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(c) Compare the following expected properties of strontium to those of magnesium.

(i) atomic radius (1 mark)

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(ii) strength as a reducing agent (1 mark)

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(d) (i) Predict the formula of a compound between strontium and astatine. (1 mark)

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(ii) Write an equation for the reaction between strontium oxide and water. (1 mark)

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Question 18

(a) Account for the apparent contradiction in the following two statements: Oxygen is collected over water because it is insoluble in water. Oxygen dissolved in water is necessary for the respiration of aquatic plants and animals. (2 marks)

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(b) Three students were given two unlabelled gas jars which could contain one of oxygen, nitrogen and carbon dioxide.

Outline how the students could experimentally identify the gases. (3 marks)

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Question 19

Sulfuric acid is one of the most important industrial chemicals. It is used as an acid, an oxidising agent, a catalyst or as a dehydrating agent.

(a) In the following situations explain, with the aid of appropriate equations, how is it being used.

(i) When added to a flask which contains ethanoic acid and methanol. (3 marks)

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(ii) Production of ammonium sulfate fertiliser by reacting sulfuric acid with ammonia gas. (1 mark)

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Question 19 continues opposite.

Question 19 (continued)

(b) It is also used in car batteries. What purpose does it fulfil in this case? (1 mark)

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Question 20

(a) The concentration of argon in the atmosphere is about 30 times greater than the concentration of carbon dioxide, yet it was not discovered until about 300 years after carbon dioxide. Suggest a reason for this. (1 mark)

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(b) Some compounds of radon, xenon and krypton have been made with fluorine or oxygen. However, so far no compounds have been made with helium or neon. Explain why it is more difficult to make compounds of helium and neon than compounds of radon, xenon and krypton. (2 marks)

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For Marker Only

Questions	Marks
17, 18, 19 & 20	**/20**

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Tasmanian Secondary Assessment Board

CHEMISTRY

Senior Secondary 5C

Subject Code: CH856

External Assessment

2003

Criteria 2 and 10

Time: 45 minutes

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Criterion 2 Communicate ideas and information using appropriate chemical language and formats when undertaking chemical investigations.

Criterion 10 Apply logical processes to solve quantitative chemical problems.

Questions: 9
Pages: 7

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Question 21

(a) An atom of a metal element X has a mass of 3.99×10^{-23} g. What is the molar mass of this isotope of X? (1 mark)

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(b) A sample of copper contains two isotopes, ^{63}Cu and ^{65}Cu. Analysis showed that 71.5% of the copper atoms were the lighter isotope. Calculate the relative atomic mass of this sample of copper. (2 marks)

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(c) Calculate the molar mass of a gas if 2.02 g occupies 1.56 L at a temperature of 25°C and a pressure of 101.3 kPa. (3 marks)

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(d) A gas occupies 574 mL at S.T.P. What volume will it occupy at standard pressure and –3°C? Assume the gas is ideal. (2 marks)

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Question 22

An organic compound is found to contain 52.0% by mass of carbon, 13.0% of hydrogen and 35.0% of oxygen. What is its empirical formula? (2 marks)

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Question 23

A solution of magnesium sulfate on treatment with excess barium nitrate solution gave a precipitate of barium sulfate. The precipitate was filtered, washed and dried: it weighed 1.37 g.

$$MgSO_{4(aq)} + Ba(NO_3)_{2(aq)} \longrightarrow BaSO_{4(s)} + Mg(NO_3)_{2(aq)}$$

What was the mass of magnesium sulfate in the solution? (3 marks)

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Question 24

10.0 g of scrap aluminium was dissolved in a 6.00 mol L^{-1} solution of hydrochloric acid.

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

(a) Calculate the minimum volume of hydrochloric acid that would be required. (3 marks)

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(b) What is the pH of the 6.00 mol L^{-1} hydrochloric acid solution? (1 mark)

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Question 25

What mass of aluminium could be deposited during the electrolysis of molten aluminium chloride with a current of 10.0 A for 3.00 hours? (3 marks)

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For Marker Only

Questions	Marks
21, 22, 23, 24 & 25	/20

Question 26

Hydrogen is an efficient fuel.

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}; \quad \Delta H = -484 \text{ kJ}$$

(a) What mass of hydrogen gas must be burnt to produce 1000 kJ of energy? (3 marks)

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Question 26 continues over the page.

Question 26 (continued)

(b) What volume would this mass of hydrogen gas occupy at 0°C and 101.3 kPa pressure? (Assume that hydrogen is obeying the gas laws at these conditions) (3 marks)

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Question 27

Given the following three reactions:

$C_{(s)} + 2H_{2(g)} \longrightarrow CH_{4(g)}$; $\Delta H = -74.8$ kJ

$C_{(s)} \longrightarrow C_{(g)}$; $\Delta H = +716.7$ kJ

$H_{2(g)} \longrightarrow 2H_{(g)}$; $\Delta H = +436.0$ kJ

(a) Calculate the value of ΔH for the reaction:

$$CH_{4(g)} \longrightarrow C_{(g)} + 4H_{(g)}$$

(4 marks)

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(b) Calculate the energy required to break one C-H bond? (1 mark)

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Question 28

In a titration 35.7 mL of 0.063 mol L^{-1} sulfuric acid (H_2SO_4) solution reacts with 25.0 mL of sodium hydroxide (NaOH) solution.

What is the concentration of the sodium hydroxide solution? (4 marks)

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Question 29

41.7 g of an iron (II) salt were dissolved in water to make 250 mL aqueous solution. 25 mL of this solution was oxidised by 20.8 mL of 0.12 mol L^{-1} potassium dichromate solution.

$$Cr_2O_7^{2-}{}_{(aq)} + 6Fe^{2+}{}_{(aq)} + 14H^{+}{}_{(aq)} \longrightarrow 2Cr^{3+}{}_{(aq)} + 6Fe^{3+}{}_{(aq)} + 7H_2O_{(l)}$$

(a) Calculate the mass of Fe^{2+} ions in the 25 mL solution. (3 marks)

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(b) Hence calculate the percentage of iron (II) in the original salt? (2 marks)

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For Marker Only

Questions	Marks
26, 27, 28 & 29	/20