OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

Tasmanian Certificate of Education
External Assessment 2017

PLACE YOUR CANDIDATE LABEL HERE

CHEMISTRY

(CHM415115)

PART 1

Time: 45 minutes

Pages:	12
Questions:	6
Attachments:	Information Sheet

Candidate Instructions

1. You **MUST** make sure that your responses to the questions in this examination paper will show your achievement in the criterion being assessed.
2. Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.
3. You should make sure you answer all parts within each question so that the criterion can be assessed.
4. This examination is 3 hours in length. It is recommended that you spend approximately 45 minutes in total answering the questions in this booklet.
5. The 2017 External Examination Information Sheet for Chemistry can be used throughout the examination. No other written material is allowed into the examination.
6. A TASC approved calculator can be used throughout the examination.
7. All written responses must be in English.

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

Criterion 5 Identify and apply fundamental principles and theories of electrochemistry.

Section Total: /40

Additional Instructions for Candidates

In calculations no credit can be given for incorrect answers unless they are accompanied by details of the working. Some credit will be given for unsimplified answers. Appropriate units must be included.

Note:

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Question 1

For Marker Use Only

(a) Determine the oxidation state of nitrogen in:

(i) nitric oxide, NO.....

(ii) nitrate ion, NO_3^-.....

(iii) nitrogen, N_2.....

(iv) ammonia, NH_3.....

(2 marks)

(b) A nitric acid solution, $HNO_{3(aq)}$, will react with copper metal to produce aqueous copper(II) ions and nitric oxide gas, $NO_{(g)}$.

(i) Write a balanced half-equation to represent the conversion of the aqueous acidified nitrate ion to nitric oxide gas, and classify the reaction as either oxidation or reduction. (2 marks)

Equation:.....

Classification:.....

(ii) Write a balanced half-equation to represent the conversion of copper metal to aqueous copper(II) ions. (1 mark)

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(iii) Write a balanced net ionic equation to represent the reaction occurring between copper metal and the nitric acid solution. (2 marks)

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/7

Question 2

For Marker Use Only

Is a strong oxidiser also a weak reducer under normal laboratory conditions?

Explain using an appropriate example to support your answer. (2 marks)

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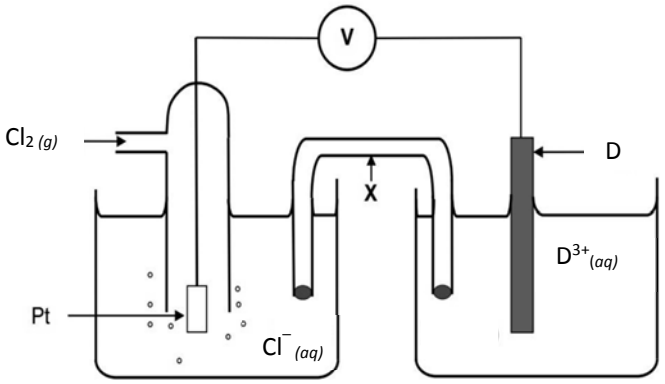
Question 3

An electrochemical cell was made using two half-cells. The first contains a rod of an unknown metal, D, partially immersed in a solution containing $D^{3+}_{(aq)}$ ions. A $Cl_{2(g)}|Cl^{-}_{(aq)}|Pt$ half-cell completed the cell. All solutions have a concentration of 1 mol L^{-1}.



The chemical reaction occurring when the cell is operating can be represented by the following equation:

$$6Cl^{-}_{(aq)} + 2D^{3+}_{(aq)} \longrightarrow 3Cl_{2(g)} + 2D_{(s)}$$

(a) (i) Identify the cathode. (1 mark)

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(ii) What occurs at this electrode in terms of electron transfer? (1 mark)

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Question 3 continues.

Question 3 (continued)

For Marker Use Only

(b) Explain the purpose of the part of the cell labelled X. (1 mark)

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(c) Write the half-reaction occurring at the anode. (1 mark)

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The initial reading on the voltmeter was 0.14 V.

(d) Calculate the standard reduction potential for the $D^{3+}_{(aq)}|D_{(s)}$ electrode and **hence** identify metal D. (2 marks)

Calculation: .....

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Identity of D: .....

/6

Question 4

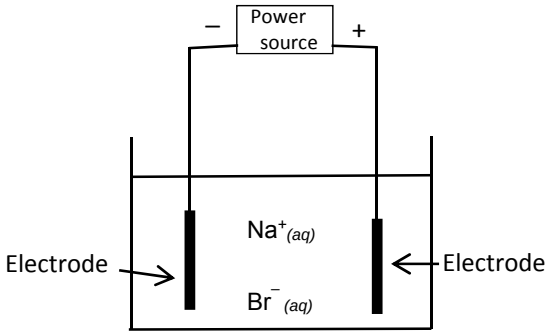
For Marker Use Only

Two students each constructed an electrolytic cell to electrolyse a solution of sodium bromide, $NaBr_{(aq)}$, of concentration 1.0 mol L^{-1} at 25°C.

Each student had to choose **one pair** of electrodes for their cell from the three pairs available.

The options for the electrodes were:

- A pair of carbon electrodes, OR
- A pair of iron electrodes, OR
- A pair of copper electrodes.



(a) Label the anode **and** the direction of ion flow in the cell. (1 mark)

(b) One student used carbon electrodes when electrolysing the sodium bromide solution.

(i) For each electrode:

- predict the products
- write the half-equation
- state the observation for each electrode reaction. (4 marks)

Cathode: .....

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Anode: .....

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Question 4 continues.

(ii) After the first observations were made the student diluted the sodium bromide solution so that its concentration was adjusted to 0.010 mol L^{-1}.

Would this affect the electrolysis products? Explain. (2 marks)

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(c) The other student set up an electrolytic cell using a different pair of electrodes from those available. The solution gradually turned blue as the electrolysis proceeded.

(i) Explain this observation. (1 mark)

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(ii) If this cell operated for an extended period of time, would there be any change to the products? Explain. (3 marks)

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Question 5

For Marker Use Only

The chemical properties of 3 metals, labelled X, Y and Z, were investigated so that their relative strength as reducers could be compared. The associated aqueous ions of the metals are X^+, Y^{2+}, and Z^{3+} respectively.

The first investigation involved placing each of the metals in separate test tubes containing hydrochloric acid solution of concentration 2 mol L^{-1}.

Only metals Y and Z reacted, each producing hydrogen gas.

(a) Compare the reducing ability of **each** of the metals with that of hydrogen. As part of your answer write the balanced net ionic equation to represent Z reacting with the acid. (2 marks)

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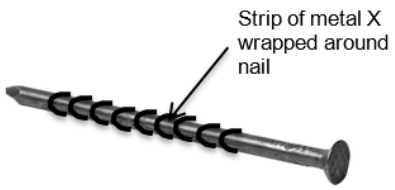
In the second investigation iron nails were individually wrapped with thin strips of the metals. Each nail had a different metal wrapped around it. The three nails were then exposed to moist air.



The iron nails wrapped in strips of X and Z both showed significant rusting, whilst the nail wrapped in Y remained rust-free.

(b) Suggest the role of metal Y in this observation. Support your answer with suitable balanced half-equations. (3 marks)

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Question 5 continues.

Question 5 (continued)

The third investigation involved making an electrochemical cell using metals Y and X, along with their associated nitrate salts.

The shorthand notation for the electrochemical cell set up is given by:

$$Y_{(s)} \mid Y^{2+}_{(aq)} \parallel X^{+}_{(aq)} \mid X_{(s)}$$

(c) (i) Identify both the anode and the oxidiser. (1 mark)

Anode: .....

Oxidiser: .....

(ii) Write a balanced net ionic equation to represent the reaction occurring in the electrochemical cell. (1 mark)

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(d) List the following elements in order of decreasing reducing strength: X, Y, Z, Fe and H_2. (2 marks)

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Question 6

For Marker Use Only

Rusting of a steel shipping container can be prevented by applying an EMF of 1.25 V.

(a) Draw a diagram to represent how the EMF is applied. (1 mark)

(b) Use electrochemistry to explain how the applied EMF prevents the shipping container from rusting.

Relevant balanced chemical equations or half-equations and discussion of the value of the EMF are expected as part of your answer. (4 marks)

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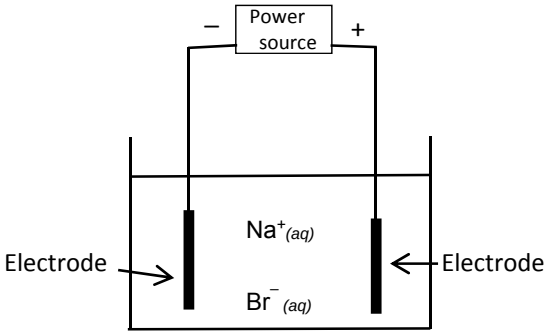
SPARE DIAGRAM

Question 4



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CHEMISTRY

(CHM415115)

PART 2

Time: 45 minutes

Pages:	16
Questions:	7
Attachments:	Information Sheet

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7. All written responses must be in English.

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

Criterion 6 Identify and apply principles and theories of thermochemistry, kinetics and equilibrium.

Section Total: /40

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Additional Instructions for Candidates

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A spare set of diagrams has been provided in the back of the answer booklet for you to use if required. If you use the spare diagrams, you **MUST** indicate you have done so in your answer to that question.

Question 7

For Marker Use Only

Consider the following chemical equation that represents the reaction occurring between methane and steam to produce carbon monoxide and hydrogen.

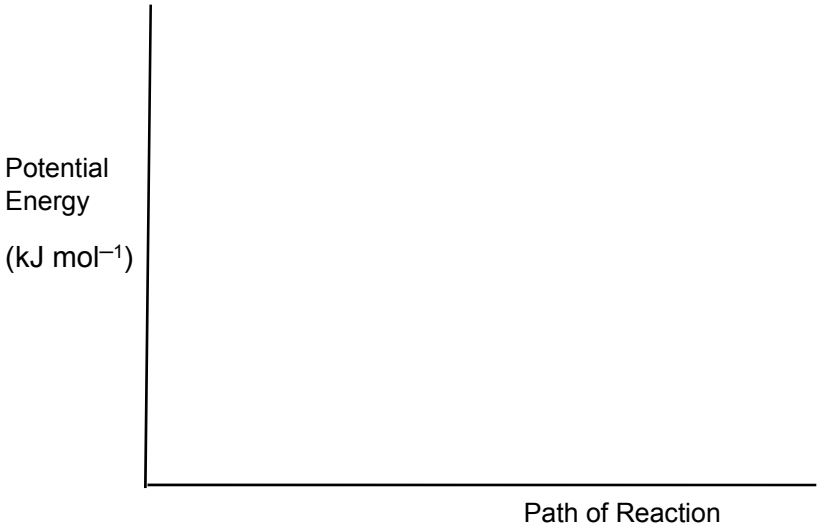
$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$$

$K_c = 4.68 \times 10^{-2}$ at 1000°C

$\Delta H = 206$ kJ mol^{-1}

$E_a = 250$ kJ mol^{-1}

(a) Construct a potential energy diagram for the chemical reaction between methane and steam. (2 marks)



(b) What information does the value of K_c indicate about the relative concentrations of each of the chemicals in the equilibrium mixture? (1 mark)

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Question 7 continues.

Question 7 (continued)

For Marker Use Only

(c) Consider the values of K_c, ΔH and E_a.

(i) Which, if any, will change if the temperature is increased. Explain your answer. (2 marks)

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(ii) Which, if any, will change when a catalyst is used. Explain your answer. (2 marks)

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(d) Use the table below to calculate a value for the bond energy in carbon monoxide. (The relevant information about the reaction has been reproduced to assist in the calculation.) (4 marks)

$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ $\Delta H = 206$ kJ mol^{-1}

Bond	C – H	O – H	H – H
Bond enthalpy (kJ mol^{-1})	413	464	436

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Question 8

For Marker Use Only

Consider the equilibrium between colourless dinitrogen tetroxide gas, $N_2O_{4(g)}$, and brown nitrogen dioxide gas, $NO_{2(g)}$ represented by the following chemical equation:

$$\underset{\text{colourless}}{N_2O_{4(g)}} \rightleftharpoons \underset{\text{brown}}{2NO_{2(g)}}$$

(a) A sample of gas containing nitrogen dioxide and dinitrogen tetroxide was collected in a gas syringe then sealed.

A student noticed that the colour of the gas mixture in the syringe **initially** became lighter **followed by** no further change in colour.

Explain these observations. (2 marks)

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(b) The volume of the gas syringe was altered to change the pressure of the equilibrium mixture. The temperature was kept constant during the process and the gas mixture was **darker when equilibrium was re-established.**

Has the volume been increased or decreased? Explain your answer. (2 marks)

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Question 8 continues.

Question 8 (continued)

For Marker Use Only

(c) 0.920 mol of $N_2O_{4(g)}$ was sealed in a 2.00 L container and left to come to equilibrium at a given temperature. There were 0.710 mol of $N_2O_{4(g)}$ present once the equilibrium was established.

Calculate the value of the equilibrium constant, K_c, for this equilibrium at this temperature. (3 marks)

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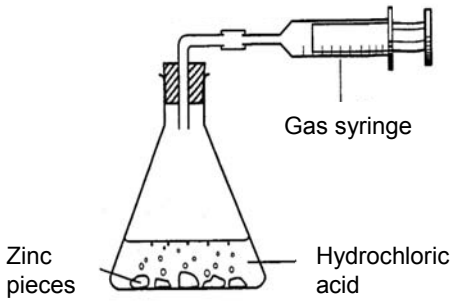
Question 9

For Marker Use Only

Zinc reacts with hydrochloric acid solution according to the following chemical equation:

$Zn_{(s)} + 2H^+_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

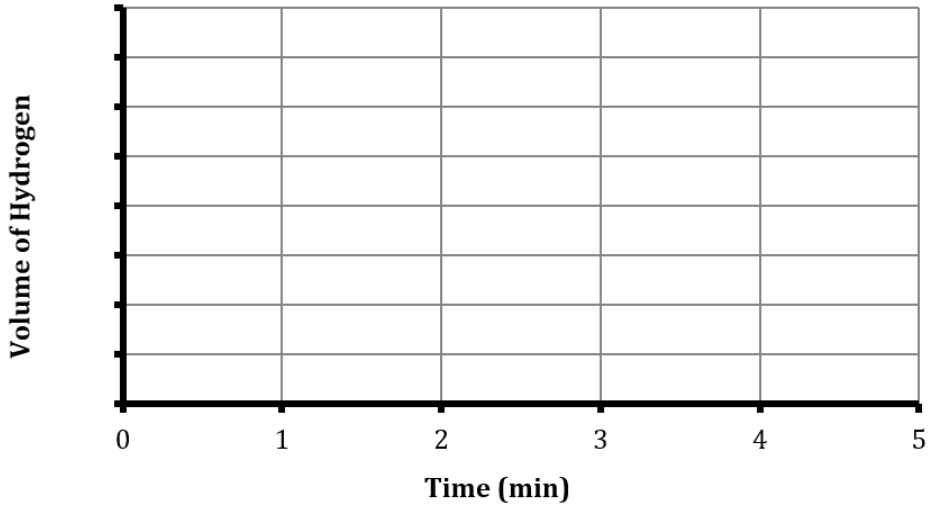


0.0500 mol of zinc pieces reacted with excess acid and the gas evolved was collected in a gas syringe under standard laboratory conditions.

The volume of gas collected was measured at regular intervals for 5 minutes.

After 4 minutes there was no further change in the volume of hydrogen collected. Assume that the reaction went to completion.

(a) Sketch a graph on the axes below to show how the volume of hydrogen changes during 5 minutes of data collection. (1 mark)



(b) Calculate the average rate of reaction under the experimental conditions used. (1 mark)

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Question 9 continues.

Question 9 (continued)

(c) When the same quantity of zinc powder is used instead of zinc pieces, the rate of reaction changes.

Explain this observation. (2 marks)

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Question 10

Consider the two chemical reactions summarised by the following equations:

Equation A $Zn_{(s)} + 2H^+_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)}$ $\Delta H < 0$

Equation B $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ $\Delta H = 57.2$ KJ.

Why does the chemical reaction between zinc and hydrochloric acid (as summarised in equation A) go to completion, yet the reaction summarised in equation B does not?

(2 marks)

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Question 11

For Marker Use Only

Methanoic acid, HCOOH, is a weak acid with a K_a value of 1.8×10^{-4}.

The expression for K_a is:

$$K_a = \frac{\left[H^+(aq)\right]\left[HCOO^-(aq)\right]}{\left[HCOOH(aq)\right]}$$

(a) Write a chemical equation to show that methanoic acid is a weak acid. (1 mark)

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(b) Calculate the concentration of each of the following ions, if present, in a solution of methanoic acid of concentration 0.10 mol L^{-1} at 25°C. (4 marks)

- hydrogen ions, $H^+_{(aq)}$
- hydroxide ions, $OH^-_{(aq)}$

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(c) Since methanoic acid is a weak acid, it is suggested that sufficient dilution with distilled water would neutralise the 0.10 mol L^{-1} acid. Is this possible? Explain your answer. (2 marks)

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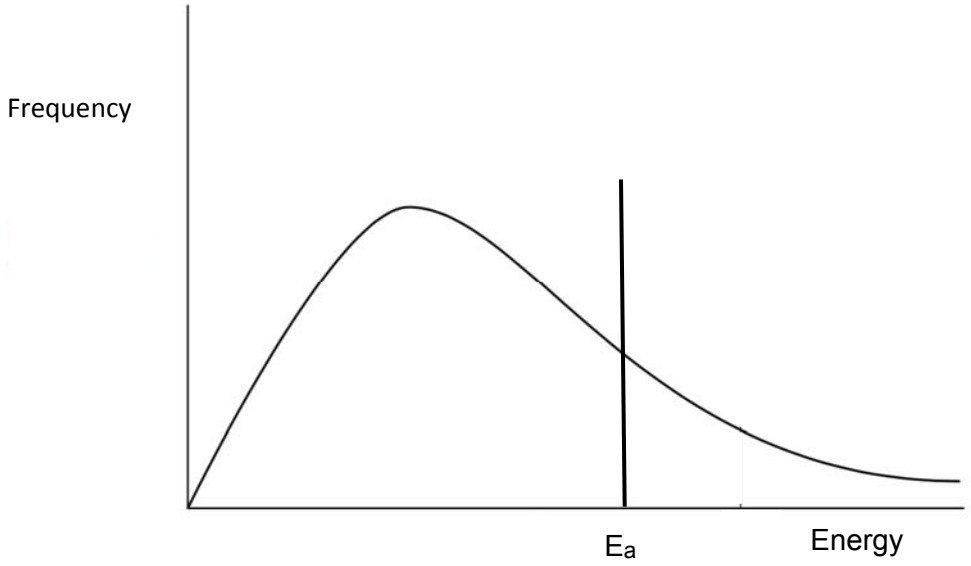
Question 12

For Marker Use Only

The graph below shows the Maxwell–Boltzmann distribution of molecular energies in a sample of the reacting gases at **temperature *T***.



(a) On the diagram above, draw a distribution of molecular energies in this sample of gas at a **higher** temperature. (1 mark)

(b) Using the diagram, explain why increasing the temperature increases the rate of a reaction. (2 marks)

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Question 13

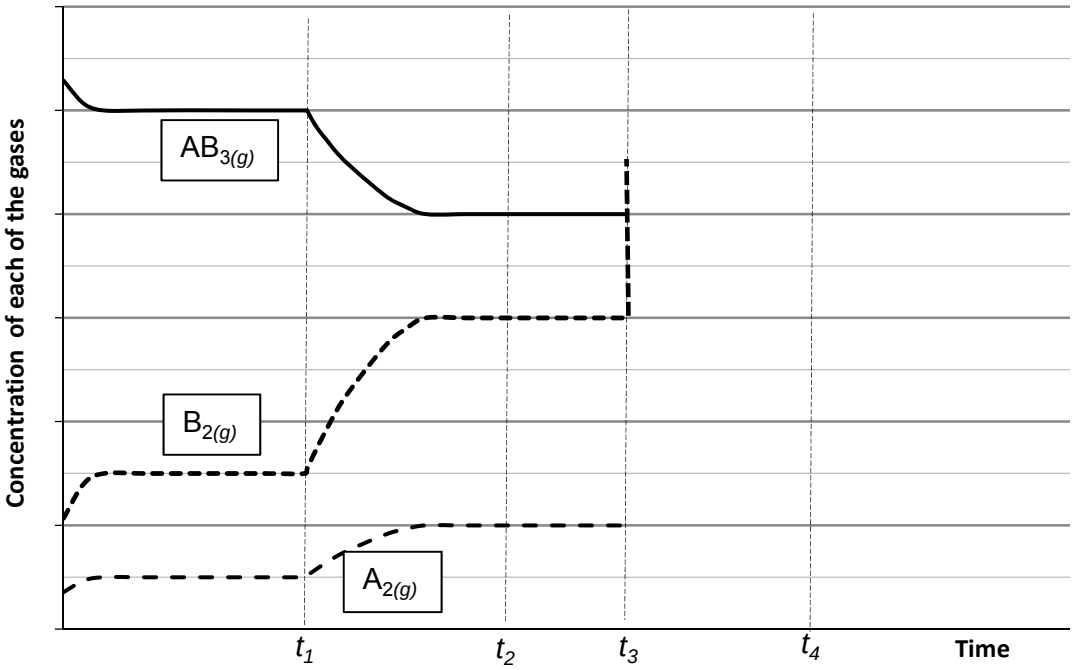
For Marker Use Only

Gases A_2 and B_2 react according to the following chemical equation:

$$A_{2(g)} + 3B_{2(g)} \rightleftharpoons 2AB_{3(g)} \qquad \Delta H < 0$$

Changes are made to the chemical system at times t_1, t_2 and t_3.

The effect of two of the changes made on the concentration of each of the chemicals $A_{2(g)}$, $B_{2(g)}$ and $AB_{3(g)}$ are shown in the diagram below.



(a) A change was made to the system at time t_1. Identify the change and explain your choice. (2 marks)

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(b) A change was made to the system at time t_2. Identify the change and explain your choice. (2 marks)

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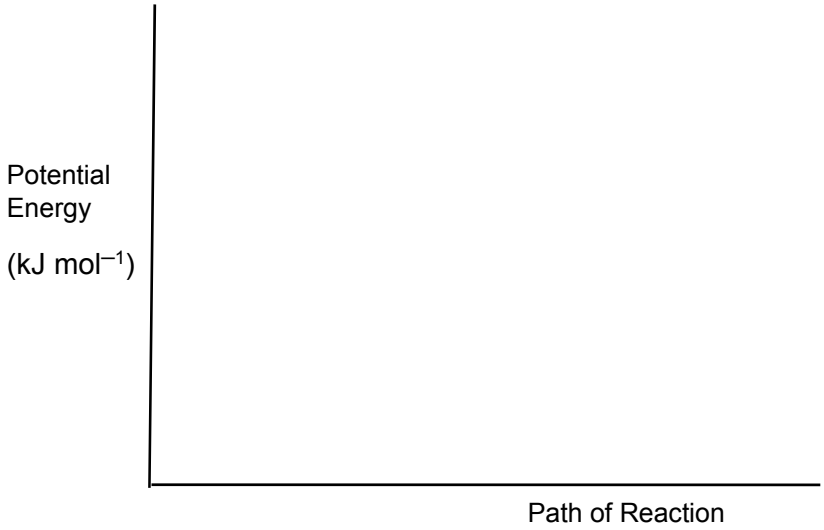
(c) The third change occurred at time t_3. On the diagram above sketch lines to show the effect of this change on the concentration of each of the reactants. The system attained a state of equilibrium at time t_4. (2 marks)

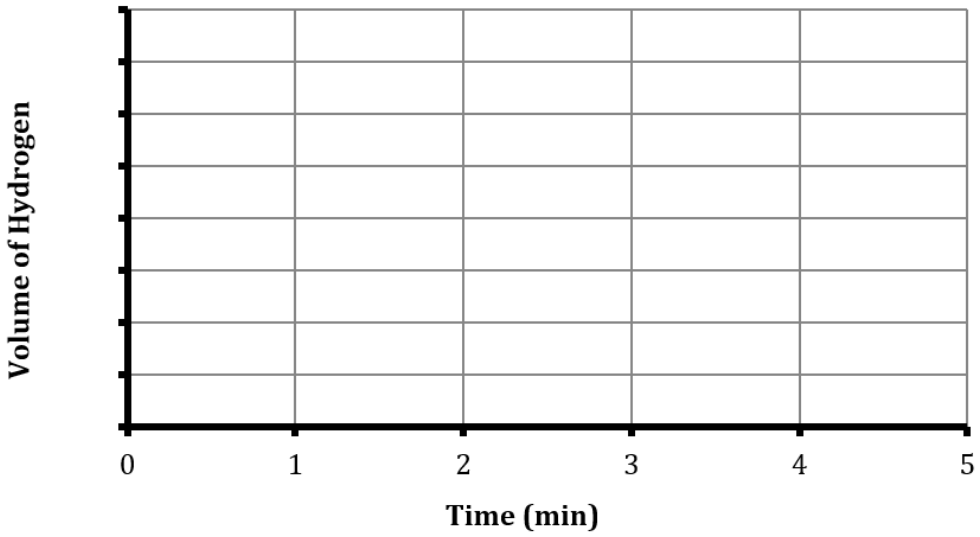
/6

SPARE DIAGRAMS

Question 7 (a)

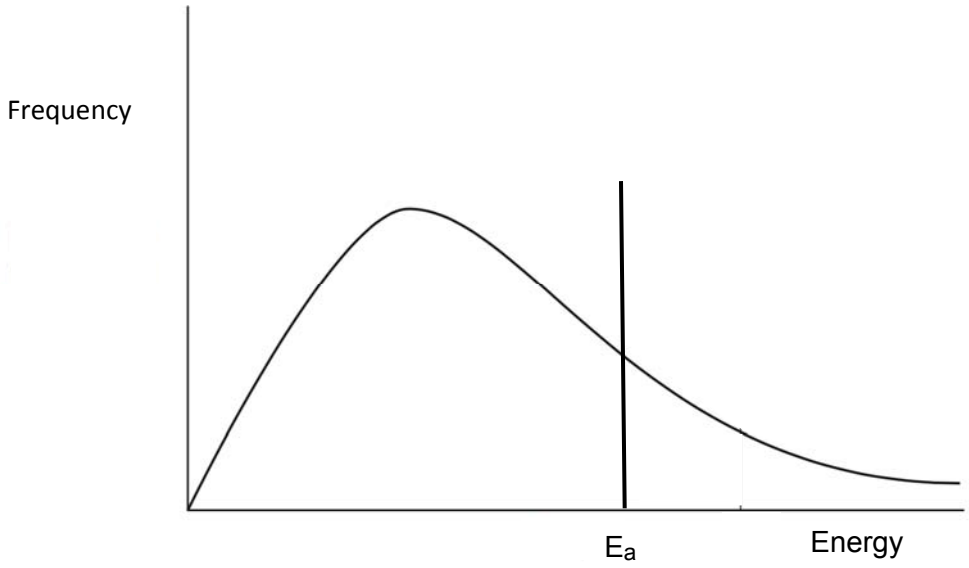


Question 9 (a)

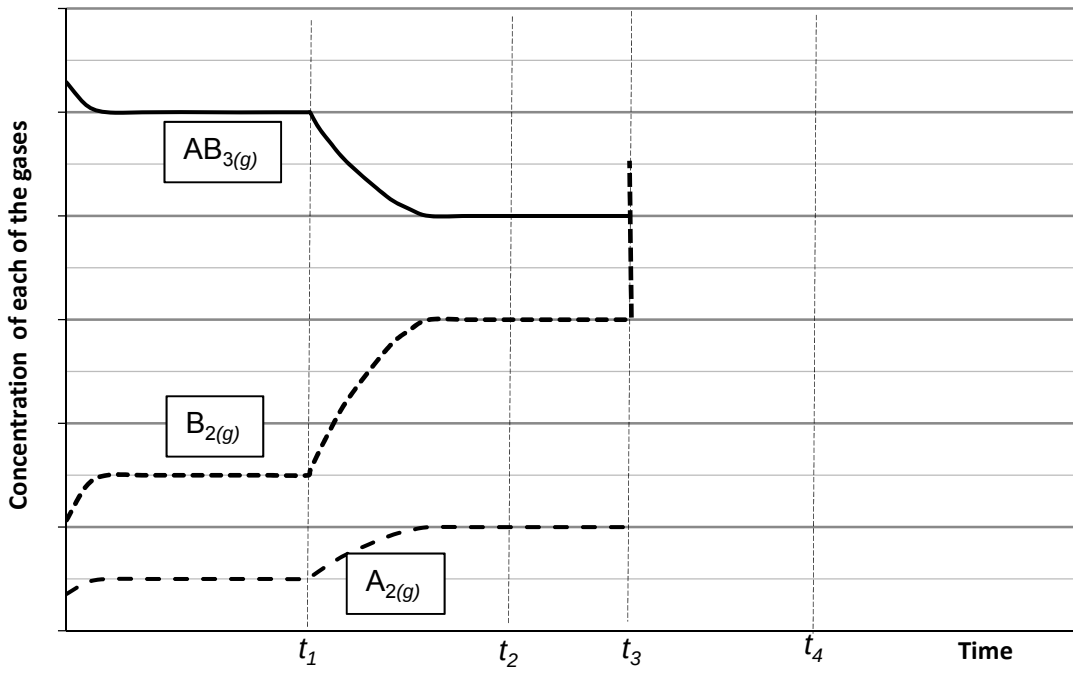


SPARE DIAGRAMS

Question 12



Question 13



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CHEMISTRY

(CHM415115)

PART 3

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Criterion 7 Demonstrate knowledge and understanding of properties and reactions of organic and inorganic matter.

Section Total: /40

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Question 14

For Marker Use Only

Consider period 3 of the Periodic Table.

(a) State and explain the trend in electronegativity from silicon to chlorine. (2 marks)

Trend: .....

Explanation: .....

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(b) For period 3 elements, write the ground state electron configuration for the stable ions. (2 marks)

Cations: .....

.....

Anions: .....

.....

(c) Give the formula of the largest stable ion in period 3. Explain your choice. (2 marks)

Formula of ion: .....

Explanation: .....

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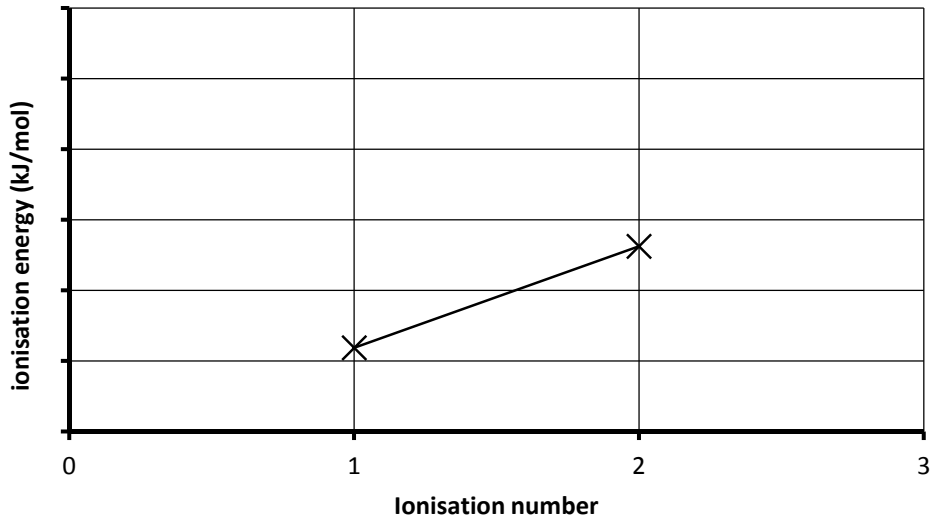
Question 15

For Marker Use Only

The successive ionisation energies for helium are represented on the diagram below.



(a) Why is the second ionisation energy of helium greater than the first ionisation energy? (1 mark)

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(b) Write a balanced equation to represent the first ionisation for lithium. (1 mark)

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(c) On the diagram above represent the first **two ionisation energies** for lithium using those of helium as a reference. Exact values are not expected.

Explain the relative position of your points with respect to those of helium. (3 marks)

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Question 16

For Marker Use Only

This is a diagram of the Periodic Table published in 1869 by Mendeleev.

I	II	III	IV	V	VI	VII	VIII		
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 196
Au 197	Hg 201	Tl 204	Pb 207	Bi 209					
			Th 237		U 238				

Helium is not included on this table.

(a) Why was helium isolated much later than many other elements? (1 mark)

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Astronomers analysing the absorption spectrum of the sun's light made the discovery of helium.

(b) The absorption spectrum of helium (as presented) shows absorption at only some wavelengths of light. Explain why. (2 marks)

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(c) Once helium had been discovered, and based on the general structure of the Periodic Table, suggest why researchers thought there would be other gaseous elements yet to be discovered. (2 marks)

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Question 17

For Marker Use Only

(a) Draw the structural formula and name the product formed from the oxidation of ethanol when heated in the presence of a copper catalyst. (1 mark)

Name: .....

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(b) Write a balanced equation for the reaction of ethanol with sodium metal. (1 mark)

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(c) Write a balanced equation for the dehydration of ethanol in the presence of concentrated sulfuric acid. (1 mark)

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/3

Question 18

Consider the following three isomers with molecular formula $C_3H_6O_2$.

CH_3CH_2COOH
CH_3COOCH_3
CH_3COCH_2OH

(a) Draw the structural formula of the organic product formed by the complete oxidation of CH_3COCH_2OH with acidified potassium permanganate. (1 mark)

(b) CH_3COOCH_3 will undergo hydrolysis using a suitable catalyst. Write a balanced chemical equation to represent the reaction occurring. (1 mark)

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Question 18 continues.

Question 18 (continued)

For Marker Use Only

The solubility of two of these isomers in water is significantly greater than that of the third isomer.

(c) Predict which of the isomers is the least soluble in water. Justify your choice. (2 marks)

Prediction: .....

Justification: .....

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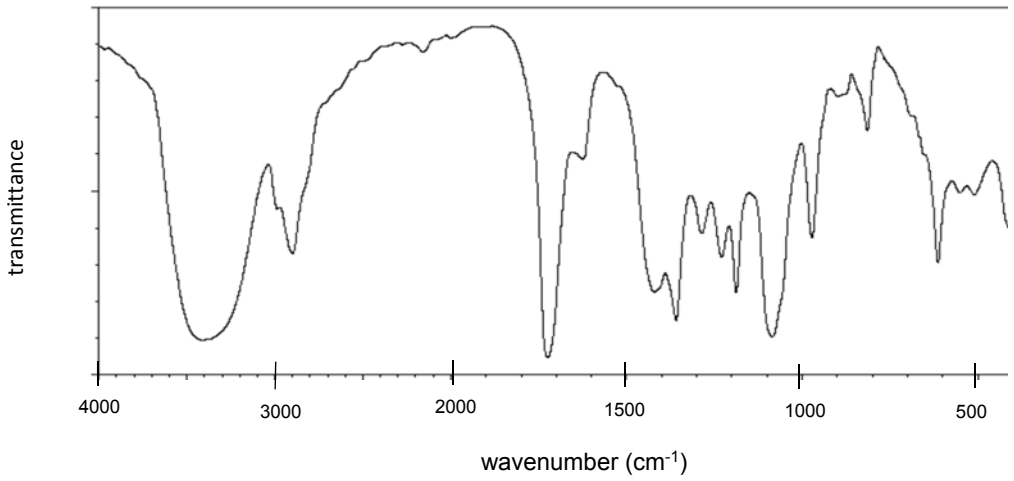
The infrared spectrum of one of the three isomers is given below.



(d) Which of the isomers corresponds with the infrared spectrum? Justify your choice. (2 marks)

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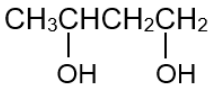
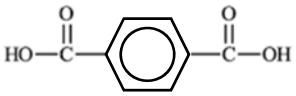
Question 19

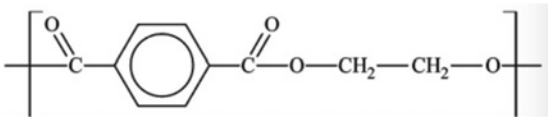
For Marker Use Only

Consider the following four organic compounds, labelled Compound A, B, C and D.

Compound	Structure	Name
A		
B	$CH_3CH(NH_2)CH_3$	
C		
D	$CH_2=CHCOOH$	

(a) Name compounds A and B in the spaces provided on the table above. (2 marks)

(b) Compound C will undergo condensation polymerisation to form the polyester whose structure is given below:



Show the structure of the other reactant. (1 mark)

(c) Draw the structure to represent the addition polymer formed from compound D. (1 mark)

Question 19 continues.

Question 19 (continued)

For Marker Use Only

(d) Simple chemical tests were performed in a school laboratory on the four compounds (A, B, C and D) to help identify them.

(i) Use the tabulated results of each test below to determine the identity of each compound. (2 marks)

Addition of bromine solution	Addition of sodium	pH test	Identity of Compound (A, B, C or D)
Red colouration	Gas evolved	neutral	
Colourless	Gas evolved	acidic	
Red colouration	No reaction	basic	
Red colouration	Gas evolved	acidic	

(ii) Explain the main points used to identify the chemicals. (4 marks)

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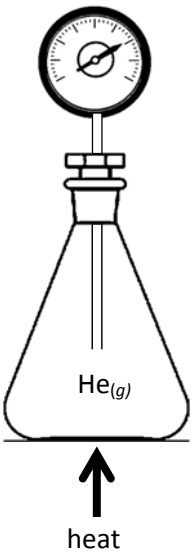
Question 20

For Marker Use Only

When a sealed flask of helium gas is heated the pressure changes.



(a) Helium most resembles an **ideal gas**. What is meant by an ideal gas? (1 mark)

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(b) Use the kinetic theory of gases to explain the change in pressure that occurs as the helium is being heated. (2 marks)

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(c) State the mathematical relationship that describes the change in pressure as the temperature of helium changes at constant volume, assuming helium behaves as an ideal gas.

Comment on the unit(s) to be used as part of your answer. (2 marks)

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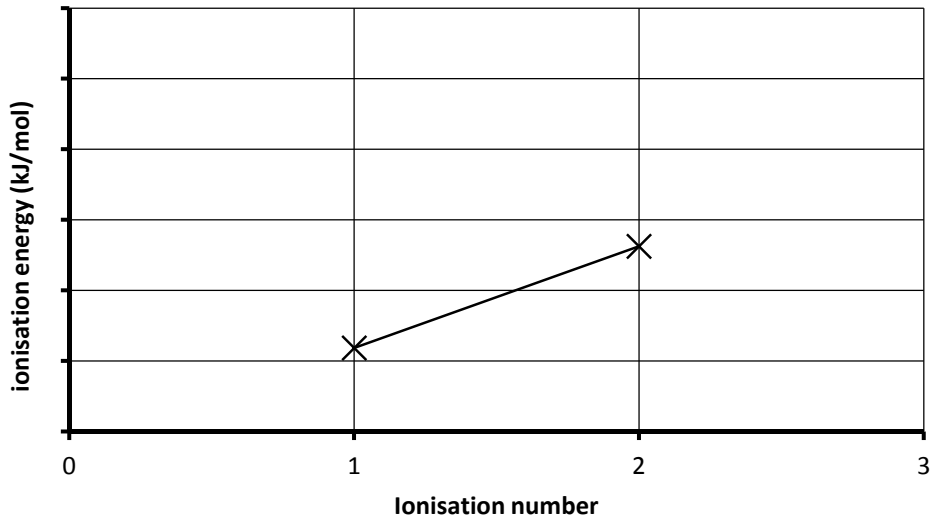
SPARE DIAGRAM

Question 15



OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

Tasmanian Certificate of Education
External Assessment 2017

PLACE YOUR CANDIDATE LABEL HERE

CHEMISTRY

(CHM415115)

PART 4

Time: 45 minutes

Pages:	12
Questions:	9
Attachments:	Information Sheet

Candidate Instructions

1. You **MUST** make sure that your responses to the questions in this examination paper will show your achievement in the criterion being assessed.
2. Answer **ALL** questions. Answers must be written in the spaces provided on the examination paper.
3. You should make sure you answer all parts within each question so that the criterion can be assessed.
4. This examination is 3 hours in length. It is recommended that you spend approximately 45 minutes in total answering the questions in this booklet.
5. The 2017 External Examination Information Sheet for Chemistry can be used throughout the examination. No other written material is allowed into the examination.
6. A TASC approved calculator can be used throughout the examination.
7. All written responses must be in English.

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

Criterion 8 Apply logical processes to solve quantitative chemical problems.

Section Total: /40

Additional Instructions for Candidates

In calculations no credit can be given for incorrect answers unless they are accompanied by details of the working. Some credit will be given for unsimplified answers. Appropriate units must be included.

Note:

When candidates are asked to ‘show that’:

- a candidate should calculate their own answer to the appropriate number of significant figures and **use this subsequently**.
- a candidate who is unable to determine the required value should use the value given by the examiner in subsequent questions.

Question 21

For Marker Use Only

(a) A sample of phosphoric acid is analysed using titration techniques.

A 25.00 mL sample of the acid is needed to neutralise 21.2 mL of 0.500 mol L^{-1} sodium hydroxide. The chemical equation representing the reaction occurring is:

$$H_3PO_{4(aq)} + 3NaOH_{(aq)} \rightarrow Na_3PO_{4(aq)} + 3H_2O_{(l)}$$

Show that the concentration of the sample of phosphoric acid is about 0.15 mol L^{-1}.

(3 marks)

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(b) Diphosphorus pentoxide, P_4O_{10}, is added to water to make phosphoric acid. The reaction occurring is represented by the following chemical equation:

$$P_4O_{10(s)} + 6H_2O_{(l)} \rightarrow 4H_3PO_{4(aq)} \qquad \Delta H = -177 \text{ kJ}$$

(i) Calculate the mass of diphosphorus pentoxide that must be added to water to produce 2.00 x 10^4 L of phosphoric acid of the concentration calculated in part (a), assuming a complete reaction.

(M_r (P_4O_{10}) = 283.9) (2 marks)

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(ii) Calculate the theoretical heat evolved when diphosphorus pentoxide and water react to produce 2.00 x 10^4 L of phosphoric acid. (1 mark)

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Question 22

For Marker Use Only

If 0.248 g of solid sodium chloride, $NaCl_{(s)}$, is added to 50.00 mL of a 0.0225 mol L^{-1} solution of barium chloride, $BaCl_{2(aq)}$, calculate the concentration of chloride ions, $Cl^{-}_{(aq)}$, in the resulting solution.

Give your answer to the correct number of significant figures. (4 marks)

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Question 23

Bauxite is the ore from which aluminium is extracted.

To analyse the ore for its aluminium content, a 1.125 g sample of bauxite underwent a series of chemical procedures in order to convert all the aluminium in the ore to pure aluminium oxide, Al_2O_3.

If the mass of aluminium oxide obtained was 0.3587 g, determine the percentage by mass of aluminium in the bauxite ore.

($M_r(Al_20_3)$ = 101.96) (3 marks)

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Question 24

For Marker Use Only

Copper(II) sulfate exists as an anhydrous salt, $CuSO_{4(s)}$, and as a hydrated salt, $CuSO_4.5H_2O_{(s)}$. Both are readily soluble in water.

(a) When 6.25 g of copper(II) sulfate-5-water was dissolved in 50.0 mL of water, the temperature decreased by 1.30°C.

Show that the heat of reaction, ΔH, for copper(II) sulfate-5-water dissolving in water is about +11 kJ mol^{-1}. (4 marks)

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(b) The following equations represent the dissolving of the two solids in water.

$CuSO_4.5H_2O_{(s)} + nH_2O_{(l)} \rightarrow CuSO_{4(aq)}$ (n>>1)

$CuSO_{4(s)} + (n + 5)H_2O_{(l)} \rightarrow CuSO_{4(aq)}$ (n>>1) $\Delta H = -66.5$ kJ mol^{-1}

Apply Hess's Law by using these two equations and your answer from part (a) to calculate the heat of reaction for the reaction given below:

$$CuSO_{4(s)} + 5H_2O_{(l)} \rightarrow CuSO_4.5H_2O_{(s)}$$

(2 marks)

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Question 25

For Marker Use Only

The composition of seawater has changed over time.

(a) The pre-industrial concentration of carbonate ions, $CO_3^{2-}{}_{(aq)}$ is quoted as 239 µmol/kg sea water. If the density of seawater is taken as 1.03 kg L^{-1}, determine the concentration in mol L^{-1}. (2 marks)

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(b) Historically, the pH of seawater is accepted as 8.2.

Recently, a scientist measured the hydrogen ion concentration, $[H^+_{(aq)}]$, and reported it is now 8.31 x 10^{-9} mol L^{-1}. The scientist then claimed that the oceans had increased in acidity by about 30% of the historic value.

Use suitable calculations to determine if the claim of about a 30% increase in acidity is correct. (3 marks)

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Question 26

For Marker Use Only

A metal of unknown atomic mass exists as a trivalent ion, Z^{3+}. When a solution of a salt of this metal is electrolysed using a current of 367 mA for 186 minutes, 0.736 g of the metal was deposited on the cathode.

Calculate the atomic mass of the metal **and hence** identify the metal deposited. (3 marks)

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Identity of metal: .....

Question 27

At a certain temperature, K_c = 0.398 for the equilibrium

$$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$$

A mixture of carbon monoxide, $CO_{(g)}$, hydrogen, $H_{2(g)}$ and methanol, $CH_3OH_{(g)}$, was placed in a 10 L vessel and allowed to come to equilibrium. At equilibrium there was hydrogen present in the reaction vessel, as well as 2.61×10^{-2} mol of methanol and 1.05 mol of carbon monoxide.

Calculate the amount, in mol, of hydrogen present in the equilibrium mixture. (3 marks)

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Question 28

For Marker Use Only

The reaction between ammonia, $NH_{3(g)}$, and oxygen, $O_{2(g)}$, is represented by the following balanced chemical equation:

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

(a) In one reaction 16.0 L of ammonia reacts with 20.0 L of oxygen.

Calculate the change in volume that occurs. Assume all measurements are taken at the same temperature and pressure and the reaction goes to completion. (2 marks)

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(b) In another reaction 6.50 g of ammonia is combined with 18.0 g of oxygen, producing 9.17 g of nitric oxide, NO.

What is the percentage yield? (4 marks)

Useful information: $M_r(NH_3) = 17.03$
$M_r(O_2) = 32.0$
$M_r(NO) = 30.01$

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Question 29

For Marker Use Only

An early Chemistry researcher investigated a number of metals, which, when reacted with acid, formed hydrogen and a divalent ion, $X^{2+}_{(aq)}$.

The reaction occurring in each case can be represented by the chemical equation below:

$$X_{(s)} + 2H^{+}_{(aq)} \rightarrow X^{2+}_{(aq)} + H_{2(g)}$$

The researcher reported that one ounce (28.35 g) of zinc gave off 356 *'measures'* of hydrogen. The gas was collected at 755 mm Hg and 20°C.

Calculate the volume that one *'measure'* represents by first calculating the volume of hydrogen evolved when one ounce (28.35 g) of zinc reacts with excess acid. (4 marks)

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