	Class	Register Number
Name		

6092/02
CHEMISTRY

20/4PE/6092/2

PAPER 2

Wednesday **2 September 2020** **1 hour 45 minutes**

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Deductions	
Presentation	
Significant Figures	
Units	

The use of an approved scientific calculator is expected, where appropriate.

A copy of Periodic Table is printed on **page 20**.

Setters: F. Yeo & Ong L.B.

This question paper consists of 20 printed pages, including the cover page.

[Turn Over

Section A (50 marks)

Answer all the questions in this section in the spaces provided.

A1 Choose from the following list of substances to answer the questions below.

calcium chloride	**lead(II) chloride**	**copper(II) chloride**
graphite	**hydrochloric acid**	**platinum**
copper	**sodium**	**lead**

Each substance can be used once, more than once, or not at all.

(a) Which molecule has a giant structure?

.....[1]

(b) Which substance only conducts electricity in its molten state?

.....[1]

(c) Which substances produce gases at both electrodes when they are electrolysed in their aqueous states with inert electrodes?

.....[1]

(d) Which substances show changes in pH when their concentrated solutions are electrolysed with inert electrodes?

.....[1]

(e) What is the observation of the electrolyte when aqueous copper(II) chloride is electrolysed using copper electrodes?

.....[1]

(f) Fill in the blanks below with one substance each for inert and reactive electrodes.

inert electrode	reactive electrode

[1]

[Total: 6]

A2 Silver dichromate, $Ag_2Cr_2O_7$, is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution as shown by the equation below.

$$2AgNO_3 + (NH_4)_2Cr_2O_7 \rightarrow 2NH_4NO_3 + Ag_2Cr_2O_7$$

(a) Describe how you can obtain pure and dry solid silver dichromate after mixing silver nitrate solution and ammonium dichromate solution.

.....

.....

.....[2]

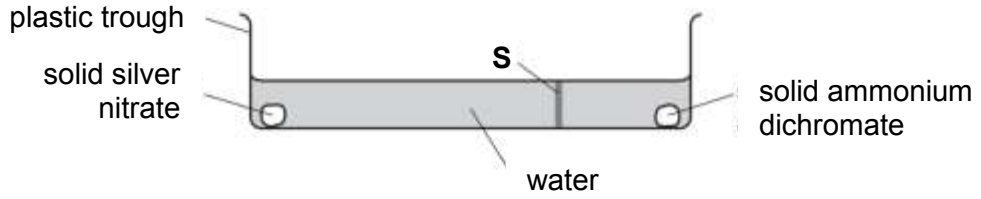
(b) **(i)** Deduce the oxidation state of chromium in $Ag_2Cr_2O_7$.

.....[1]

(ii) Write the ionic equation with state symbols for the formation of silver dichromate in this reaction.

[2]

(c) The apparatus shown below is set up.



After five minutes, a red solid appeared at the position marked **S** on the diagram.

(i) Explain why a red solid appeared at the position marked **S**.

.....

.....

.....[2]

(ii) The experiment is then repeated at a higher temperature.

What effect, if any, would this have on the time taken for the red solid to appear?

Explain your answer.

.....

.....[1]

[Total: 8]

A3 Flerovium, F*l* (atomic number: 114) was first made in research laboratories in 1998.

(a) Flerovium was made by bombarding atoms of plutonium, Pu (atomic number: 94), with atoms of element **Z**.

- The nucleus of one atom of plutonium combined with the nucleus of one atom of element **Z**.
- This formed the nucleus of one atom of flerovium.

Suggest the identity of element **Z**.

.....[1]

(b) Fill in the missing information about an atom of flerovium.

number of electron shells	number of outer shell electrons

[1]

(c) Two isotopes of flerovium are ^{286}F*l* and ^{289}F*l*.

State a similarity and difference between the nuclei of the two isotopes.

.....

.....

.....[2]

(d) Only a relatively small number of atoms of flerovium has been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium behaves like a typical metal.

(i) Draw a labelled diagram to show the type of bonding in flerovium.

[2]

(ii) State a physical property of flerovium.

.....[1]

(iii) Suggest a chemical property of flerovium oxide.

.....[1]

[Total: 8]

A4 The Alhambra is a beautiful monument in Granada, Spain. It comprises of buildings made of limestone, $CaCO_3$, with a river filled with aquatic life near it.

The life of this monument can be preserved by treatment with an aqueous mixture of barium hydroxide and urea, $CO(NH_2)_2$. As this aqueous mixture soaks into the porous limestone structures, the urea slowly reacts with water to form ammonia and carbon dioxide. The carbon dioxide that is released reacts with aqueous barium hydroxide, forming barium carbonate.

The solubility of the sulfates and carbonates of calcium and barium are shown below.

substance	$CaCO_3$	$CaSO_4$	$BaCO_3$	$BaSO_4$
solubility in water / mol dm^{-3}	1.5×10^{-4}	4.6×10^{-2}	9.0×10^{-5}	9.4×10^{-6}

(a) (i) Use information from the table to explain why having a layer of barium carbonate on the monument will help to preserve the life of the limestone monument.

.....

.....[1]

(ii) The layer of barium carbonate on the surface of the treated monument can react with sulfur dioxide in the air to form a layer of barium sulfate and carbon dioxide.

Will the above reaction speed up or slow down corrosion of the monument?

Use information from the table to explain your answer.

.....

.....[2]

(b) Urea reacts with water to form ammonia and carbon dioxide.

(i) Write the equation for this reaction.

[1]

(ii) Environmentalists are concerned when ammonia and carbon dioxide are produced near the river.

Explain why.

.....

.....

.....

.....

.....[3]

(c) Over time, the Alhambra monument is still corroded despite the preservation method used.

Suggest why.

……

……[1]

[Total: 8]

A5 Paracetamol, the active drug ingredient in Panadol, is commonly used to reduce fever and relief pain. Based on recommended dosages, an adult should not take more than 4 g of paracetamol daily.

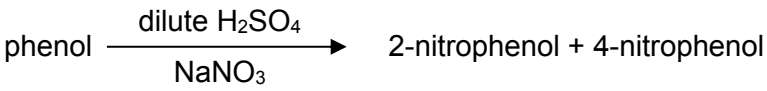
(a) A sample of paracetamol was found to contain 63.6% of carbon, 5.9% of hydrogen, 9.3% of nitrogen and 21.2% of oxygen by mass.

Show, by means of calculation, that the empirical formula of paracetamol is $C_8H_9NO_2$.

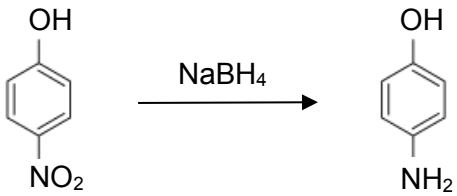
[2]

(b) Paracetamol can be synthesized in the laboratory via a three-step process.

Step 1:



Step 2:



4-nitrophenol ($C_6H_5NO_3$) 4-aminophenol (C_6H_7NO)

Step 3: $C_6H_7NO + C_4H_6O_3 \rightarrow C_8H_9NO_2 + C_2H_4O_2$

4-aminophenol paracetamol ethanoic acid

(i) Suggest why the yield of paracetamol in the laboratory is less than 50%.

.....

.....[1]

(ii) Explain why $NaBH_4$ acts as a reducing agent in step 2.

.....

.....[1]

(iii) One Panadol tablet contains 500 mg of the active ingredient paracetamol.

Calculate the mass of 4-aminophenol required to synthesize 8 Panadol tablets.

[3]

(iv) How can the purity of the synthesized paracetamol be tested?

.....

.....[1]

(v) Explain, in terms of bonding, why paracetamol is a solid but ethanoic acid is a liquid at room temperature and pressure.

.....

.....

.....

.....[2]

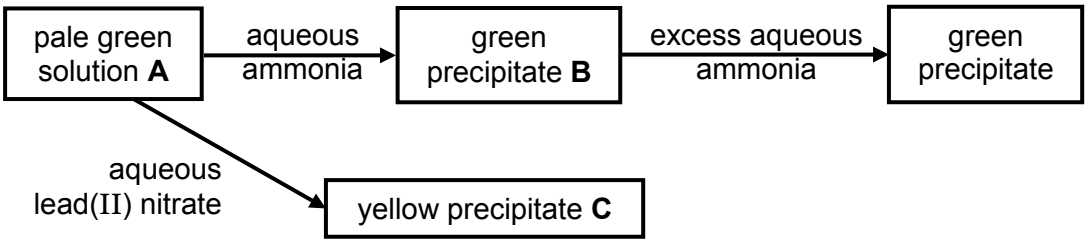
(c) The correct dosage of paracetamol for children varies according to a child's weight. However, a child weighing 10 kg should only consume a maximum of 600 mg of paracetamol in a day.

Given that a bottle of Panadol syrup contains 120 mg of paracetamol per 5 ml of syrup, calculate the correct dose of Panadol syrup (in ml) that should be given every 6 hours for a 10 kg child.

[2]

[Total: 12]

A6 Study the reaction scheme below and answer the questions that follow.



(a) Identify the unknown substances **A**, **B** and **C**.

A: ……

B: ……

C: …… [3]

(b) Describe what will be observed when green precipitate **B** is left to stand.

…….....…….. [1]

(c) Chlorine gas is bubbled into two solutions, solution **A** and aqueous hydrogen peroxide.

(i) Describe and explain what will be observed when chlorine gas is bubbled into solution **A**.

...……

...……

...……[2]

(ii) The reaction between chlorine gas and hydrogen peroxide is shown below.

$$Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$$

Explain, in terms of oxidation states, why this is a redox reaction.

...……

...……

...……[2]

[Total: 8]

Section B (30 marks)

Answer all three questions in this section.

The last question is in the form of an either / or and only one of the alternatives should be attempted.

B7 Hydrogen Halides

Hydrogen halides are diatomic covalent molecules with the formula H**X**, where **X** is one of the halogens: fluorine, chlorine, bromine or iodine. Hydrogen halides are colourless gases that dissolve in water to form acids which are commonly known as hydrohalic acids.

$$H\mathbf{X} \rightleftharpoons H^+ + \mathbf{X}^-$$

Strength of Acids

A strong acid usually records a low pH of about 0 to 3. However, this is not always the case as pH is simply a measure of the concentration of hydrogen ions in solution, not the strength of an acid. Hence, even a strong acid can have a pH value near 7 if its concentration is very low. For instance, a 1.00×10^{-6} mol dm^{-3} solution of dilute hydrochloric acid has a pH of 6. The lower the concentration of hydrogen ions in the solution, the higher the pH and vice versa.

pH can be calculated using the formula below:

$$pH = -\log_{10}[H^+]$$

where $[H^+]$ = concentration of hydrogen ions in mol dm^{-3}

Acid Dissociation Constant, K_a

The measure of the strength of an acid can be quantified using the acid dissociation constant, K_a. The larger the K_a value, the greater the extent of the dissociation of the acid molecules in solution and hence the stronger the acid. Weak acids typically have K_a values below 1 while strong acids have K_a values above 1.

The K_a of a monobasic acid, HX, can be calculated using the following formula:

$$K_a = \frac{[H^+][X^-]}{[HX]} = \frac{[H^+]^2}{[HX]}$$

where $[H^+]$ = concentration of hydrogen ions in mol dm^{-3}
$[\mathbf{X}^-]$ = concentration of halide ions in mol dm^{-3}
$[H\mathbf{X}]$ = concentration of hydrohalic acid in mol dm^{-3}

pK_a can be calculated in the same way as pH which is shown below:

$$pK_a = -\log_{10}K_a$$

Table 1 below shows the acid dissociation constants of some hydrohalic acids.

Table 1

substance	K_a / mol dm^{-3}	pK_a
hydrofluoric acid, HF	6.8×10^{-4}	3.2
hydrochloric acid, HC*l*	1.3×10^{6}	-6.1
hydrobromic acid, HBr		
hydroiodic acid, HI	3.2×10^{9}	-9.5

Data extracted from: https://depts.washington.edu/eooptic/links/acidstrength.html

Bond Energy

Bond energy is a measure of the strength of a covalent bond. It is defined as the amount of energy required to break apart one mole of molecules into its constituent atoms.

Table 2 below shows the bond energy of hydrogen halides, H**X**.

Table 2

bond	bond energy / kJ mol^{-1}
H-F	562
H-C*l*	431
H-Br	366
H-I	299

(a) Explain why weak acids typically have K_a values below 1.

……

……[1]

(b) Hydrofluoric acid is a weak acid.

(i) Calculate the concentration of H^+ ions in a 0.100 mol dm^{-3} solution of dilute hydrofluoric acid.

[1]

(ii) Hence, calculate the pH of a 0.100 mol dm^{-3} solution of dilute hydrofluoric acid.

[1]

(c) **(i)** Using Table 1, state the relationship between K_a and pK_a.

……[1]

(ii) Hence, predict the pK_a value for hydrobromic acid, HBr.

……[1]

(d) **(i)** Using Table 1, describe the trend in the strength of the hydrohalic acids down Group VII.

……

……[1]

(ii) Using the bond energies in Table 2, explain your answer in **(d)(i)**.

……

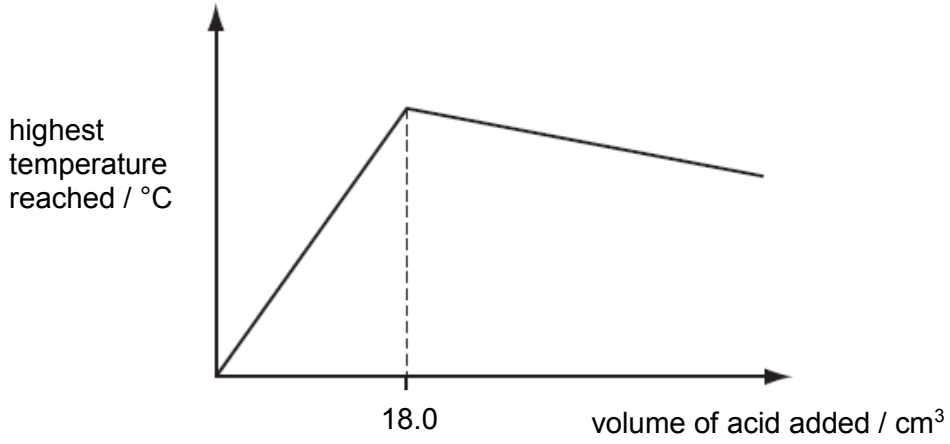
……

……

……[2]

(e) A solution of aqueous sodium hydroxide was placed in a beaker and the temperature of the solution was measured. 1.00 cm^3 portions of dilute hydroiodic acid were added successively into the beaker, with the highest temperature of the mixture reached measured after each addition.

The graph below shows the results of the experiment.



(i) Explain the shape of the graph above, stating clearly the significance of the volume "18.0 cm^3" in your answer.

.....

.....

.....

.....

.....

.....[3]

(ii) The experiment was repeated using dilute hydrochloric acid instead of hydroiodic acid, with all the other conditions kept constant. The same results were obtained.

Suggest why the temperature rise measured is the same for both experiments.

.....

.....[1]

[Total: 12]

B8 Zinc is used to make alloys and in the construction of dry cells (batteries).

Zinc can be obtained from zinc oxide in a two-step process as shown below.

Step 1: aqueous zinc sulfate is made from zinc oxide

Step 2: aqueous zinc sulfate is electrolysed with carbon electrodes to obtain zinc

(a) Name the reagent which reacts with zinc oxide to form zinc sulfate.

.....[1]

(b) Complete the following for the electrolysis of aqueous zinc sulfate.

(i) Write the ionic equation happening at the anode.

[1]

(ii) What is the resulting electrolyte formed?

.....[1]

(iii) Besides electrolysis, suggest another method to extract zinc from zinc oxide.

.....[1]

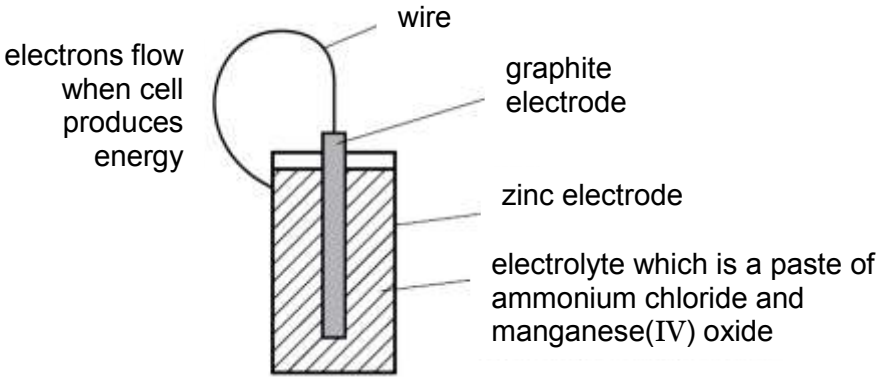
(c) A dry cell (battery) has a central rod, usually made of graphite.

This is the positive electrode which is surrounded by the electrolyte, typically a paste of ammonium chloride and manganese(IV) oxide, all of which are in a zinc container which is the negative electrode.

The following ionic equations occur at the electrodes in a dry cell.

positive electrode: $2NH_4^+(aq) + 2MnO_2(s) + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$

negative electrode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$



(i) Draw an arrow on the diagram to indicate the direction of electron flow. [1]

(ii) Suggest why the electrolyte is a paste instead of solid.

.....

.....[1]

(iii) Suggest why is there no gas built up in the dry cell.

.....

.....[1]

(iv) Give the overall equation for the reaction.

[1]

[Total: 8]

EITHER

B9 Standard electrode potentials (E°) are also known as reduction potentials. They measure how easily a substance gains electrons, or how easily a substance is reduced.

The E° values for some substances are shown below:

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	E° = − 2.38 V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	E° = − 0.76 V
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	E° = 0.00 V
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	E° = + 0.34 V
$Ba^{2+}(aq) + 2e^- \rightleftharpoons Ba(s)$	E° = − 2.90 V
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	E° = − 0.28 V

The more positive the E° value, the more likely the forward reaction takes place and the more easily the substance is reduced.

Conversely, the more negative the E° value, the more likely the reverse reaction takes place and the more easily the substance is oxidised.

(a) Deduce the relationship between the E° value and reactivity of metals.

……..…….. [1]

(b) A piece of zinc metal was added to a colourless solution of barium nitrate in test tube **A** while a piece of zinc metal was added to a pink solution of cobalt(II) nitrate in test tube **B**.

By writing relevant equation(s), describe what will be observed in the two test tubes.

……..……

……..……

……..……

…….[3]

(c) Will barium carbonate require a higher or a lower temperature than cobalt(II) carbonate to decompose?

Explain your answer.

……..……

……..……

…….[2]

(d) The reactions of two unknown metals **X** and **Y** are given in the table below.

metal **X**	No visible reaction observed between metal **X** and acid. Metal **X** displaces copper from its salt solution.
metal **Y**	Metal **Y** reacts with both cold water and steam. Magnesium displaces metal **Y** from its salt solution.

Use the information above to predict the E° values of metal **X** and metal **Y**.

metal **X**: ……

metal **Y**: …… [2]

(e) Complete the 'dot-and-cross' diagram to represent the bonding in zinc hydride.

The zinc ion has already been drawn for you.

$$\left[\ Zn\ \right]^{2+}$$

[2]

[Total: 10]

OR

B9 Three test tubes contain the following acid solutions:

Test tube **A**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute nitric acid

Test tube **B**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute ethanoic acid

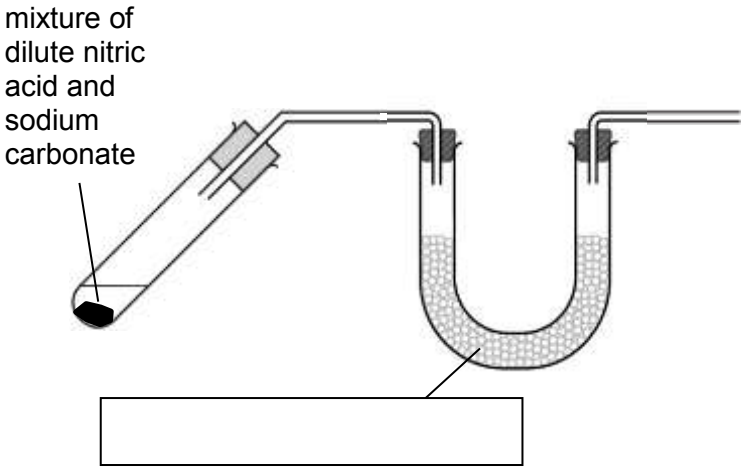
Test tube **C**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute sulfuric acid

Excess powdered sodium carbonate was added to each test tube and the volume of carbon dioxide gas produced was measured over time.

(a) What observation shows that powdered sodium carbonate was added in excess?

……..…….. [1]

(b) **(i)** Complete the diagram below to show the chemical and apparatus required to collect and measure a dry sample of the gas produced in test tube **A**.



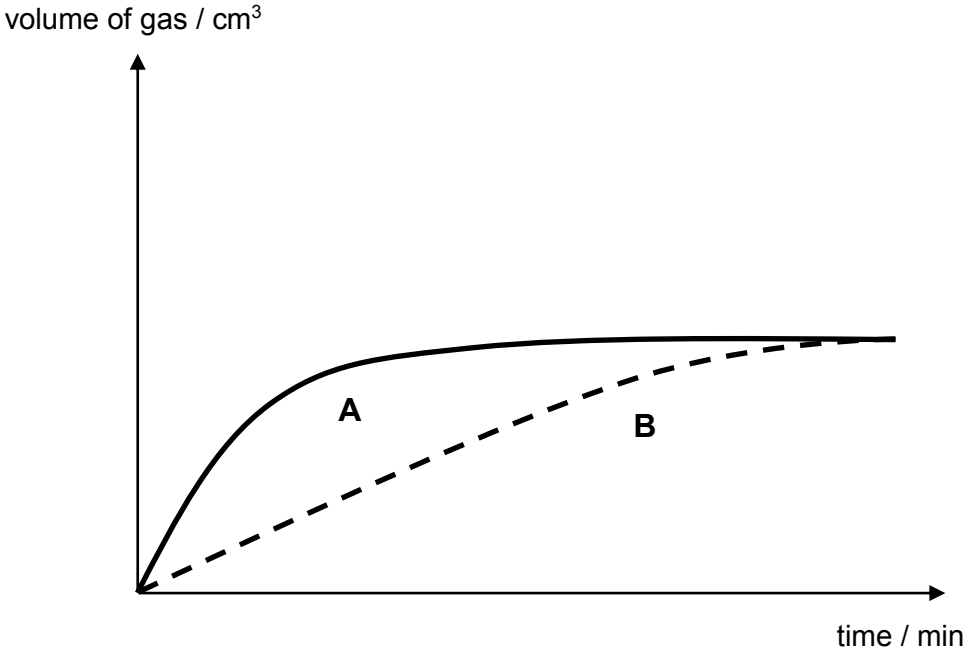
[2]

(ii) Describe a test to confirm the identity of the gas produced.

...……..……

...……[1]

(c) The graph below shows the results obtained with test tube **A** and test tube **B**.



(i) Explain why the volume of gas produced is the same for test tubes **A** and **B**.

.....

.....

.....[2]

(ii) Using collision theory, explain the difference in results for test tubes **A** and **B**.

.....

.....

.....

.....

.....[2]

(d) In the graph in **(c)**, sketch the results obtained with test tube **C**. Label the graph **C.** [1]

(e) An experiment was conducted with 3.00 cm^3 of 1.00 mol dm^{-3} warm dilute nitric acid and an excess of powdered sodium carbonate.

In the graph in **(c)**, sketch the results obtained in this experiment. Label the graph **W**. [1]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).