SINGAPORE CHINESE GIRLS' SCHOOL
Preliminary Examination
Secondary Four

CANDIDATE NAME								
CLASS	4			REGISTER NUMBER				
CENTRE NUMBER					INDEX NUMBER			

CHEMISTRY

6092/02

Paper 2 Theory

23 August 2022

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

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

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.
A copy of the Periodic Table is printed on page 21.

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

For Examiner's Use	
Section A	/50
Section B	/30
Total	/80

This question paper consists of 21 printed pages and 1 blank page.

Section A

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

The total mark for this section is 50.

A1 Use the substances in the list below to answer the following questions. Each option may be used once, more than once or not at all.

aluminium iodide	sodium chloride	ammonium chloride	zinc
chlorine	nitric acid	sodium bromide	potassium carbonate

(a) Which substance in aqueous form reacts with aqueous chlorine to form a brown solution with black crystals?

……... [1]

(b) Which substance can reduce hydrochloric acid in a redox reaction?

……... [1]

(c) Which substance, when warmed in a mixture with aqueous sodium hydroxide and aluminium, produces a gas that turns moist litmus blue?

……... [1]

(d) Which substance produces a reddish brown vapour when it conducts electricity in the molten state?

……... [1]

(e) Which salt cannot be prepared by titration method?

……... [1]

[Total 5]

A2 The table below lists some information about the elements in Period 3 in the Periodic Table.

Element	Na	Mg	Al	Si	P	S	C*l*	Ar
Number of valence electrons	1	2	3	4	5	6	7	8
Common oxidation state	+1	+2	+3	+4 / - 4	-3	-2	-1	0
Melting point /^{o}C	98	650	660	1414	317	115	-101	-189

(a) Explain the variation in oxidation state(s) across the period.

...……

...……

...……

……...

[2]

(b) Explain the large difference in melting points between silicon and chlorine.

.....

.....

.....

.....

..... [3]

(c) Sodium phosphide is a reagent that is used in the production of other chemicals and as a catalyst in polymerisation. Sodium phosphide can be produced by reacting sodium with phosphorus in the reaction shown below.

$$12Na + P_4 \rightarrow 4Na_3P$$

(i) Draw a dot and cross diagram to show the bonding in sodium phosphide. Show all the electrons in your diagram. [2]

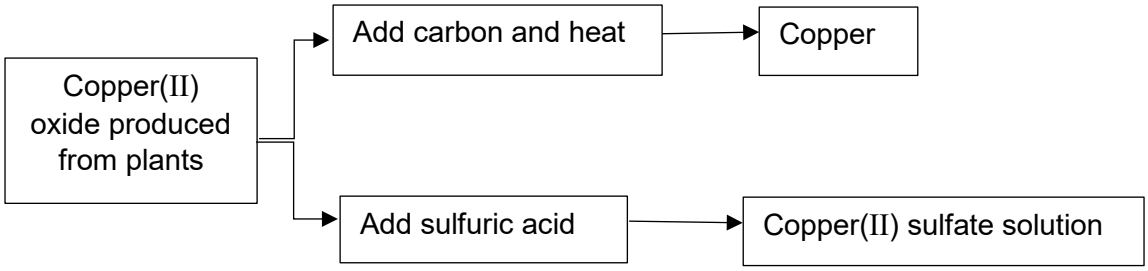
(ii) 5.75 g of sodium was reacted with 3.1 g of phosphorus.

Show by calculation which reactant is in excess and calculate the mass of sodium phosphide formed. [3]

[Total 10]

A3 To mine copper from land that contains very low percentages of copper compounds, plants may be cultivated to absorb these compounds through their roots.

These plants are then burnt to produce copper(II) oxide, which can then undergo reactions to produce copper or copper(II) sulfate solution as shown in the diagram below.



(a) Excess copper(II) oxide was reacted with carbon. Suggest how the solid copper metal can be separated from the resulting mixture.

……

…… [2]

(b) Name another non-metallic element that can be reacted with copper(II) oxide to obtain copper.

…… [1]

(c) Copper can be obtained from the copper(II) sulfate solution in two ways. One way involves reacting the copper(II) sulfate solution with iron.

(i) Write the ionic equation with state symbols for the reaction.

…… [1]

(ii) Describe two observations seen in the reaction.

……

…… [2]

(d) Another method to obtain copper from the copper(II) sulfate solution involves the electrolysis of copper(II) sulfate solution using carbon electrodes.
State an advantage of obtaining copper from copper(II) sulfate by the addition of iron compared to electrolysis.

……

…… [1]

(e) Suggest a reason why copper should be recycled.

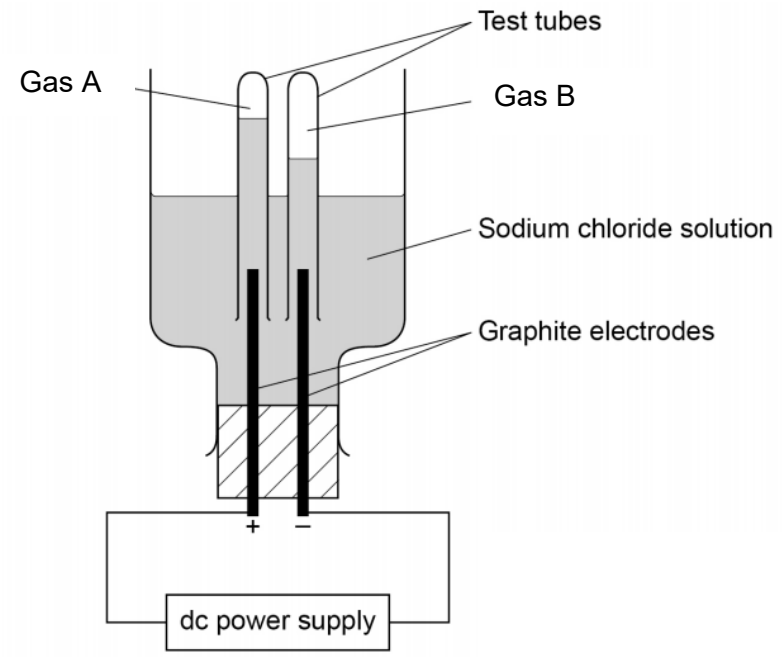
……

……

…… [1]

[Total 8]

A4 A student carried out electrolysis on a solution of sodium chloride using the apparatus shown.



(a) Write the half equation for the formation of

(i) gas A: ……..

(ii) gas B: ……..……. [2]

(b) Describe a test to confirm the identity of gas A.

……

…… [1]

(c) Explain why the ratio of gas A to gas B is 1:2.

……

……

…… [1]

(d) The student carried out a second experiment using a different solution of sodium chloride and the gases she obtained were in the ratio of 1:1. The gas collected at the positive electrode turned moist litmus blue and bleached it.

(i) How is the sodium chloride solution used in the second experiment different from that in the first experiment?

……

…… [1]

(ii) Describe and explain the changes in the electrolyte as the electrolysis progressed in the second experiment.

...

...

...

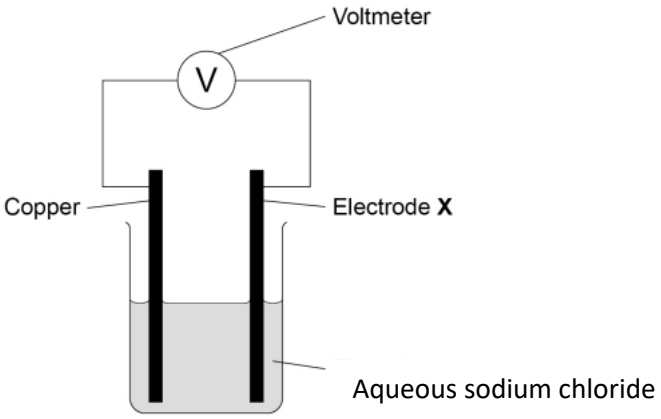
……[2]

(e) What must the student do if she wants to obtain sodium by electrolysis from sodium chloride?

……... [1]

[Total 8]

A5 A student investigated the voltage produced by different chemical cells.
The apparatus used is shown below.



The student measured the voltage obtained using different metals as electrode **X**.
The table below shows the results obtained.

Electrode **X**	Voltage / V
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	-0.46
tin	+0.48

(a) List the six metals used for electrode **X** in decreasing order of reactivity.

…….. [1]

(b) If **X** is zinc,

(i) write a half equation for the reaction at the copper electrode. Is this reaction oxidation or reduction? Explain your answer.

…….

……. [2]

(ii) describe what would be observed at electrode **X**.

..... [1]

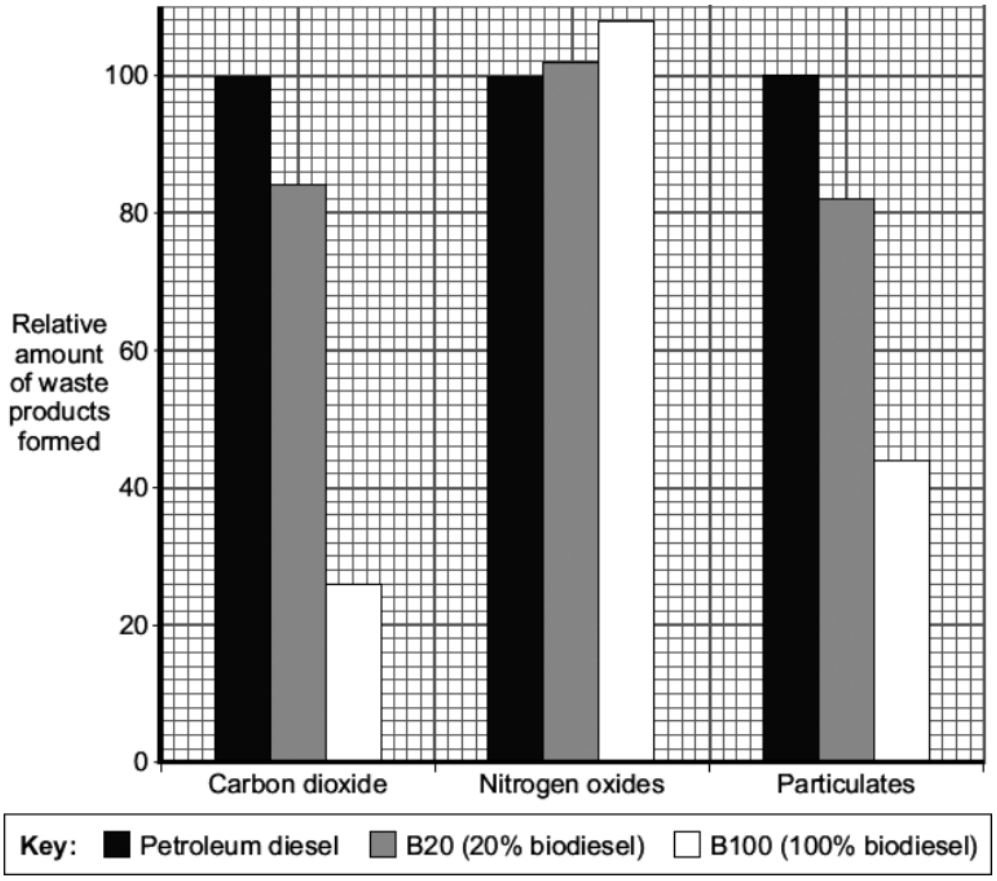
(c) Hydrogen fuel cells are chemical cells that can be used to power different forms of transport. Some diesel trains are being converted to run on hydrogen fuel cells. A newspaper article referred to the converted trains as the new ‘steam trains’. Suggest why.

……

……. [1]
[Total 5]

A6 There are two main types of diesel fuel used for cars:
- biodiesel, made from vegetable oils,
- petroleum diesel, made from crude oil.

(a) Biodiesel can be mixed with petroleum diesel (e.g. B20) to make a fuel for cars. In a car engine, the fuel burns in air. The waste products leave the car engine through the car exhaust system. The bar chart compares the relative amounts of waste products made when three different types of diesel fuel burn in a car engine.



(i) Mary studied the data in the graph and concluded that B100 is the best fuel to use as it causes the least pollution when used. Do you agree with her statement? Justify your answer by referring to data from the graph.

……

……

……

……[2]

(ii) What is the percentage reduction in particulates when B20 is used instead of petroleum diesel?

…… [1]

(iii) A carbon neutral fuel does not add extra carbon dioxide to the atmosphere. Is biodiesel (B100) a carbon neutral fuel? Use the data and your knowledge to explain your answer.

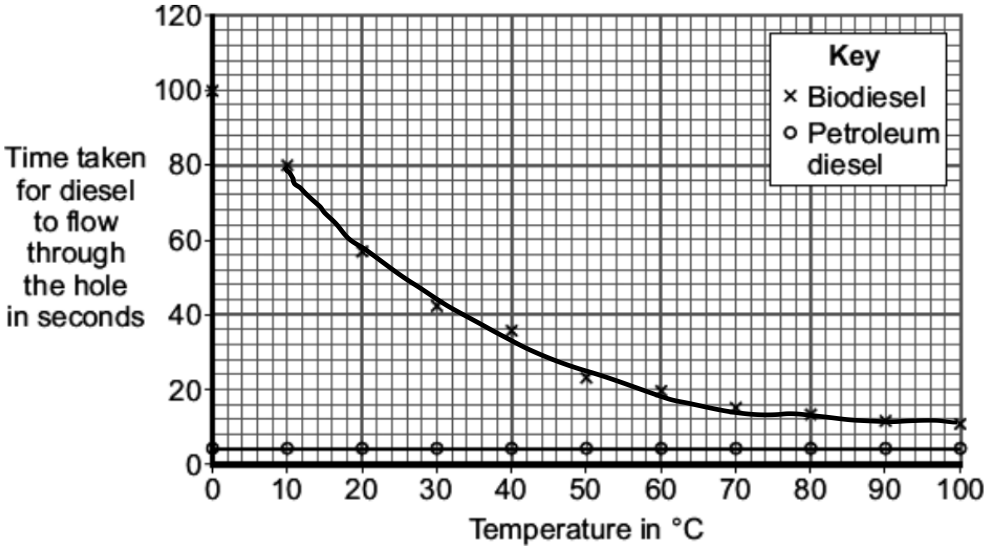
……

……

……

……[2]

(b) A scientist compared the viscosity of biodiesel with petroleum diesel at different temperatures. The scientist measured the time for the same volume of diesel to flow through a small hole in a cup. The scientist's results are plotted on the grid.



(i) What conclusions can the scientist make about the viscosity of biodiesel compared with the viscosity of petroleum diesel at different temperatures?

.....

.....

.....

.....[2]

(ii) Besides the difference in output of the products when used as a fuel, suggest another advantage of biodiesel over petroleum diesel.

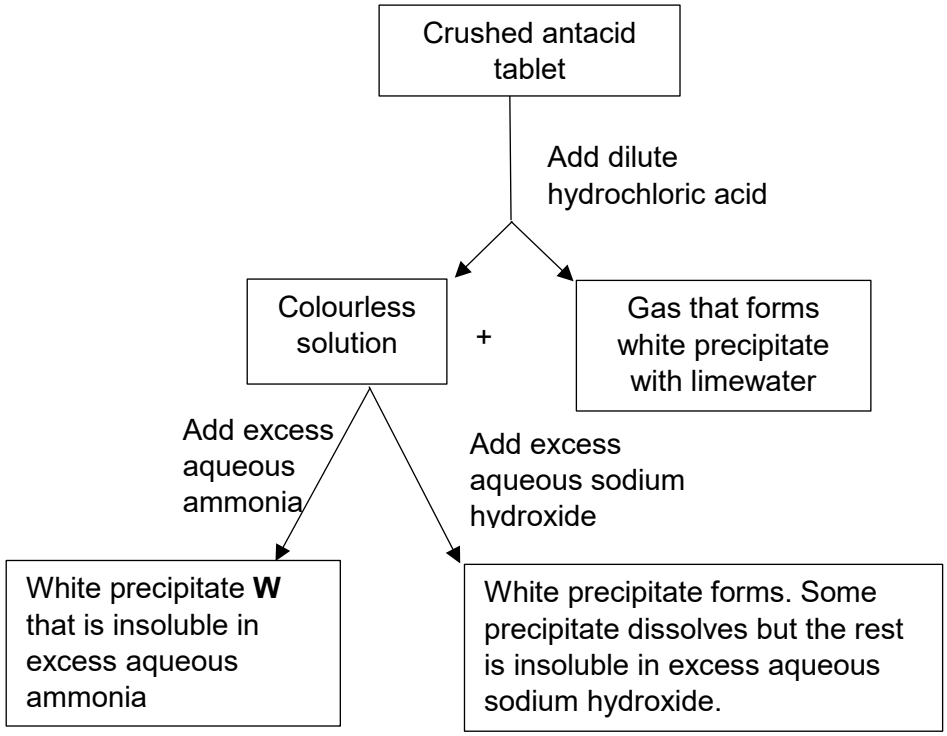
……

……

…….....…….... [1]

[Total 8]

A7 Gastric pain is often caused by hyperacidity due to excess hydrochloric acid in the stomach. Antacid tablets contain active ingredients that react and neutralise the acid.
An antacid tablet was crushed and tested as shown in the flow chart below.



(a) Give the formulae of three ions present in the active ingredient of the antacid.

..... [3]

(b) Write the ionic equation for the formation of white precipitate **W**.

…… [1]

(c) Magnesium hydroxide is another active ingredient that can be found in other antacids. Magnesium hydroxide is insoluble in water.

Describe how a pure dry sample of magnesium hydroxide can be made, starting from suitable common reagents in the laboratory.

.....

……

.....

……

.....

……

…….. [2]

[Total 6]

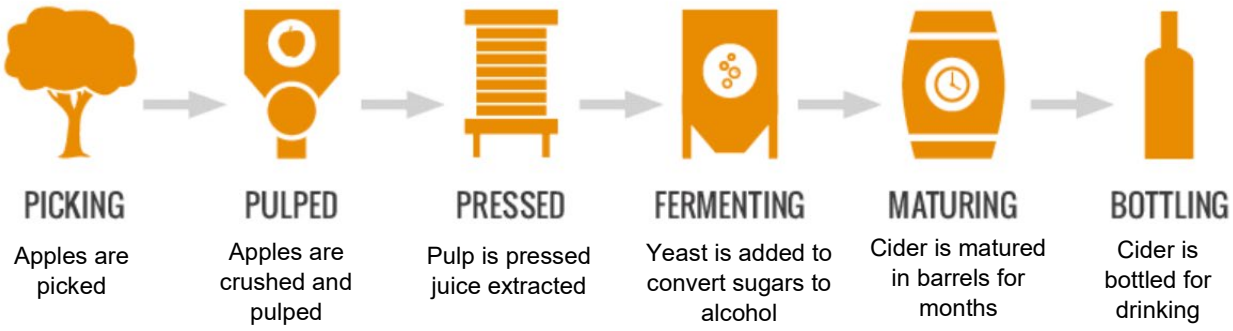
Section B

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.

B8 Read the following information on the chemistry of cider production.

Cider is made from apples in a process that involves the following steps.

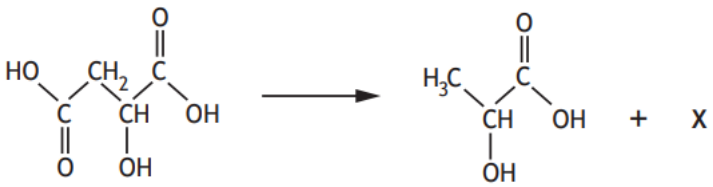


During the fermenting stage, yeast is added to convert the sugars in the apple juice into alcohol and carbon dioxide.

The percentage mass of alcohol in cider can be calculated using the formula

$$\text{Percentage mass of alcohol} = \frac{\text{mass of alcohol}}{\text{mass of cider}} \times 100\ \%$$

During the maturing process, malic acid in apple juice is converted to lactic acid and a gas **X**.

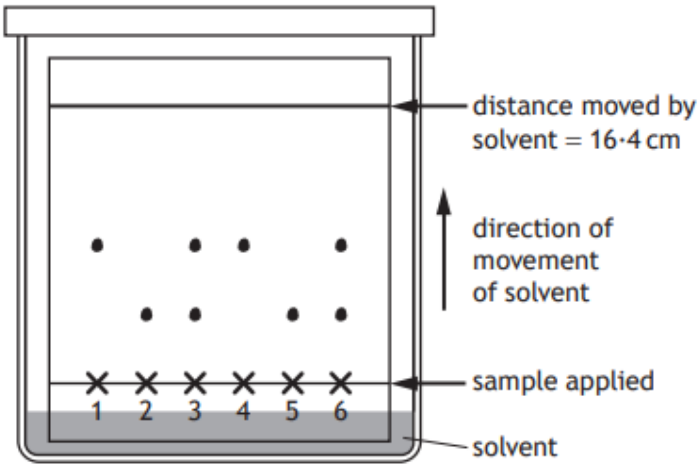


malic acid lactic acid

The maturing process can monitored using chromatography using thin layer chromatography.

Samples of lactic acid, malic acid and the cider are spotted on a silica plate and a solvent is allowed to travel up the plate.

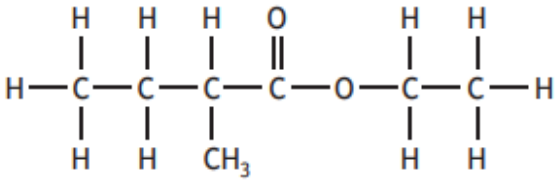
The diagram below shows a chromatogram obtained when ciders A, B, C and D from different barrels of cider are monitored for maturity by chromatography.



Number	Sample applied	Distance moved by spot(s) /cm
1	Lactic acid	8.2
2	Malic acid	4.1
3	Cider A	4.1, 8.2
4	Cider B	8.2
5	Cider C	4.1
6	Cider D	4.1, 8.2

The maturing process is complete when all the malic acid is converted to lactic acid.

Cider contains many naturally occurring substances that can affect its taste and aroma
Cider's characteristic aroma comes from ethyl 2-methylbutanoate.



ethyl 2-methylbutanoate

Ethanol in cider can be oxidised by microorganisms when left exposed to the atmosphere, spoiling the aroma.

(a) State 2 conditions required for the conversion of sugars in the apple juice to alcohol, other than the addition of yeast.

……

…… [2]

(b) 50 cm^3 of a sample of cider was found to contain 3.05 g of alcohol. 1 cm^3 of the cider weighs 1.36 g.
Calculate the percentage mass of alcohol in the cider. [1]

(c) Name the gas **X** that is formed in the maturing process.

…… [1]

(d) The retention factor or R_f value is a useful way to identify a substance from a chromatogram.

With reference to the chromatogram,

(i) calculate the R_f value of malic acid. [1]

(ii) state which cider is ready for bottling.

…… [1]

(e) **(i)** Draw the structures of two organic compounds that can be reacted to synthesise ethyl 2-methylbutanoate in the laboratory. [2]

(ii) State the conditions required for the reaction in **(e)(i)**.

…….. [1]

(iii) Name the substance formed that spoils the aroma of the cider when ethanol is oxidised.

……..…… [1]
[Total 10]

B9 Hydrogen peroxide is unstable and decomposes to form oxygen gas and water.
At room temperature, the reaction can be very slow but the reaction can be speeded up by heating the mixture.

(a) Explain, in terms of colliding particles, the effect of increasing temperature on the rate of decomposition of hydrogen peroxide.

.....

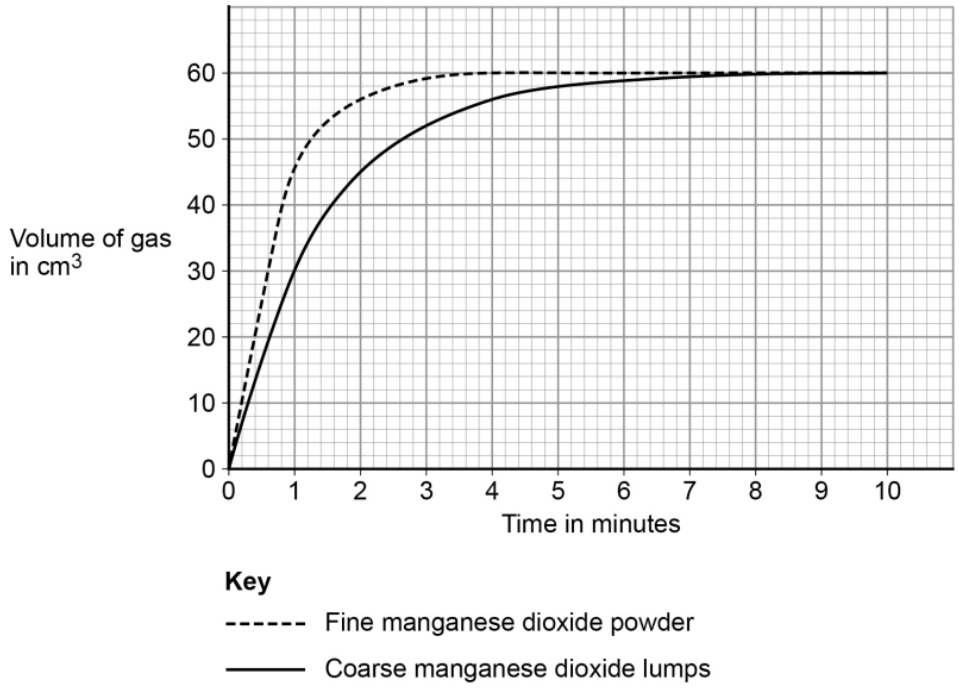
.....

..... [2]

(b) Manganese dioxide can be used as a catalyst for the decomposition of hydrogen peroxide.

A student investigated the effect of the particle size of manganese dioxide on the rate of the reaction. She added 2 g of fine manganese dioxide powder to 25 cm^3 of 0.2 mol/dm^3 hydrogen peroxide solution in a conical flask and measured the volume of gas produced every minute for 10 minutes. She then repeated the experiment with 2 g of coarse manganese dioxide granules.

The graph below shows the results she obtained.



(i) Explain the difference in the shapes of the two graphs obtained.

.....

.....

.....

.....

..... [2]

(ii) If 25 cm^3 of 0.1 mol/dm^3 hydrogen peroxide was decomposed using 2 g of coarse manganese dioxide granules as catalyst, the reaction was completed at 4 min.

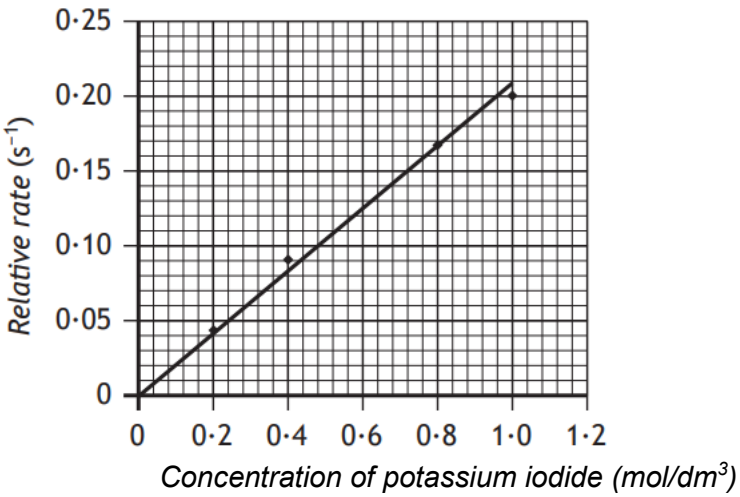
Sketch the expected graph on the grid on page 14. [2]

(c) The concentration of hydrogen peroxide is often described as volume strength. This relates to the volume of oxygen that can be produced from a hydrogen peroxide solution.

volume of oxygen produced	=	volume strength	×	volume of hydrogen peroxide solution

In an experiment, 74 cm^3 of oxygen was produced from 20 cm^3 of hydrogen peroxide solution. Calculate the volume strength of the hydrogen peroxide. [1]

(d) Hydrogen peroxide can react with potassium iodide to produce water and iodine.
A student carried out an experiment to investigate the effect of changing the concentration of potassium iodide on the reaction rate. The results are shown below.



(i) Calculate the time taken, in s, for the reaction when the concentration of potassium iodide used was 0.6 mol/dm^3. [1]

(ii) Explain, in terms of oxidation states, if hydrogen peroxide is acting as an oxidising or reducing agent in this reaction.

……

……

…….. [1]

(iii) Describe what would be observed when hydrogen peroxide is added to potassium iodide.

……

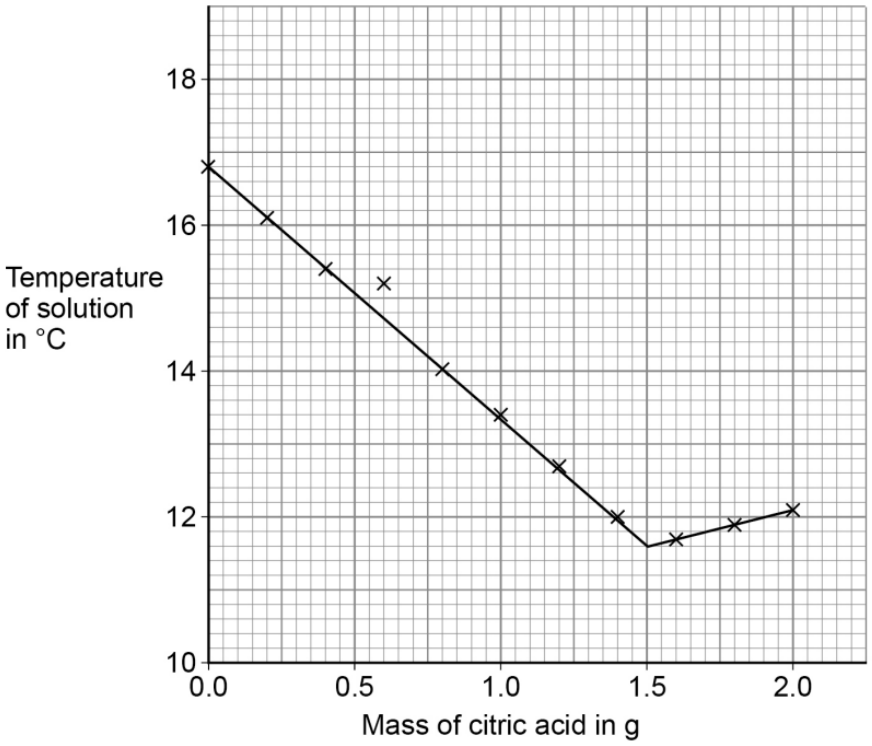
…….. [1]

[Total 10]

B10 Either

Citric acid is a solid. A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution. This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.20 g of citric acid to the polystyrene cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added. The student plotted the results on a graph.



(a) Explain the shape of the graph in terms of the energy transfers taking place.

……

……

……

……

…… [3]

(b) Is this reaction exothermic or endothermic? Explain your answer in terms of bond breaking and bond forming.

……

……

…… [2]

(c) The equation for the reaction between citric acid and sodium hydrogencarbonate is shown below:

$H_3C_6H_5O_7 + 3NaHCO_3 \rightarrow Na_3C_6H_5O_7 + 3CO_2 + 3H_2O$

Use the data from the graph to calculate the concentration of the sodium hydrogencarbonate used in the reaction. [2]

(d) Draw the energy profile diagram for the reaction between citric acid and sodium hydrogencarbonate. Label the activation energy and the enthalpy change clearly. [2]

(e) A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were of the same size and shape. The initial temperature of the solution was also the same.

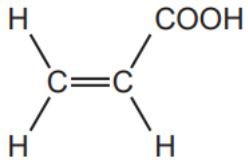
Sketch a line on the grid on Page 17 to show the second student's results.

Your line needs only show the expected results up to 1.00 g of citric acid added. [1]

[Total 10]

B10 Or

Propenoic acid (C_2H_3COOH) is an unsaturated carboxylic acid. The structural formula of propenoic acid is given below.



(a) Describe a chemical test to distinguish propenoic acid from propanoic acid.

.....

……

……..… [2]

(b) State how propenoic acid can be converted to propanoic acid. Give the conditions needed.

……

…….. [1]

(c) Write the chemical equation for the reaction of propenoic acid with calcium carbonate.

…… [1]

(d) Draw the possible structure of the organic compound formed when steam is reacted with propenoic acid. [1]

(e) An organic compound has a molecular formula $C_6H_8O_4$. It is an unsaturated carboxylic acid.

(i) Explain the term *molecular formula*.

.....

..... [1]

(ii) What is the empirical formula of this acid?

…..... [1]

(iii) One mole of this carboxylic acid reacts with two moles of sodium hydroxide. How many moles of –COOH groups are there in one mole of this compound?

..... [1]

(iv) Identify the other functional group in this compound.

…..... [1]

(v) Deduce a structural formula of this compound. [1]

[Total 10]

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.).

blank page