DAMAI SECONDARY SCHOOL
Preliminary Examination 2020

CANDIDATE NAME				
CLASS			INDEX NUMBER	

CHEMISTRY **6092/01**

Paper 1 **15 September 2020**

Secondary 4 Express **1 hour**

Setter: Ms Goh Ai Lian 40 marks

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

There are **forty** questions in this section. Answer **all** questions.
For each question, there are four possible answers, **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is provided on page 17.

This document consists of **17** printed pages.

1 Which of the following provides the best evidence that matter is made up of tiny particles that are in constant random motion?

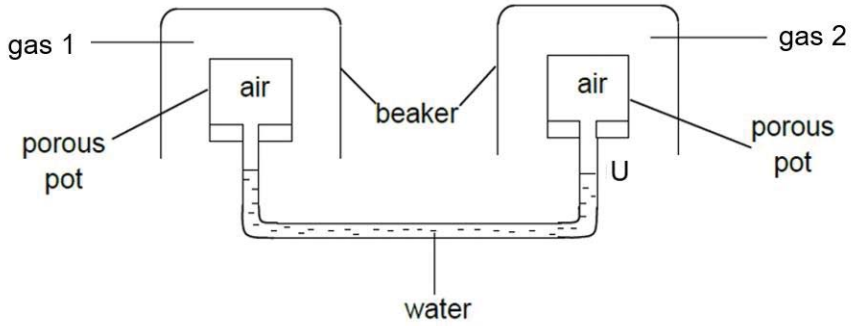
A Air can be readily compressed.

B A thin layer is formed when a drop of oil is placed on water.

C A small mass of water produces a much larger mass of steam.

D When a bottle of perfume is opened, the smell is quickly detected in all parts of the room.

2 The apparatus is set up, using different gases in the two inverted beakers.



Which pair of gases would cause an upward movement of the water level at U?

	gas 1	gas 2
A	helium	carbon monoxide
B	helium	hydrogen
C	nitrogen	carbon monoxide
D	nitrogen	hydrogen

3 An ion of element X has 23 electrons and a mass number of 56.

What is the charge on the ion if it has 30 neutrons?

A +2

B –2

C +3

D –3

4 Element X has 12 protons and 12 neutrons.
Element Y has 17 protons and 20 neutrons.

What is the molar mass of the compound formed by these two elements?

A 46 g / mol

B 61 g / mol

C 85 g / mol

D 98 g / mol

5 Some properties of four substances, P, Q, R and S. are given below.

substance	percentage composition by mass	electrical conductivity when solid	effect of heat
P	constant	yes	solid burns in air to form an oxide
Q	varies	no	liquid burns to form carbon dioxide and water
R	constant	yes	solid decomposes to form carbon dioxide
S	varies	no	solid melts

Which of the following shows the correct classification of P, Q, R and S as an element, a compound or a mixture?

	element	compound	mixture
A	P	Q and R	S
B	P	R	Q and S
C	R	Q and P	S
D	S	P	Q and R

6 Antimony oxide has the formula Sb_2O_3 while lithium phosphate has the formula Li_3PO_4.

Which is the formula of antimony phosphate?

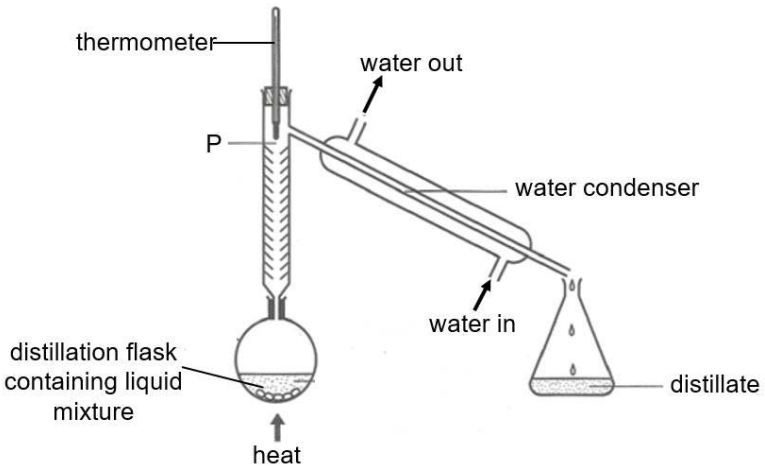
A $SbPO_4$

B Sb_2PO_4

C $Sb_2(PO_4)_3$

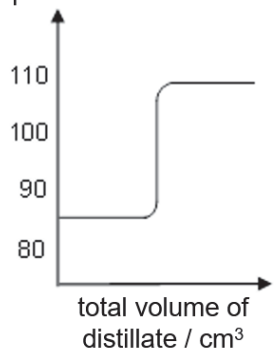
D Sb_3PO_4

7 A mixture containing two liquids with boiling points 85 °C and 110 °C is separated using the apparatus shown below.

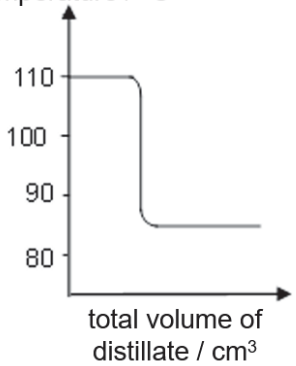


Which graph would be obtained if the temperature at point P was plotted against the total volume of distillate produced?

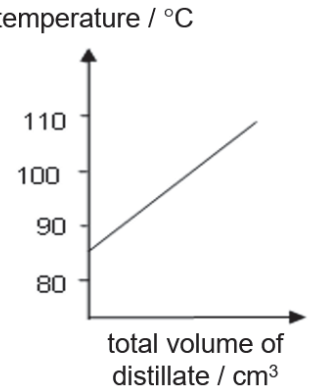
A



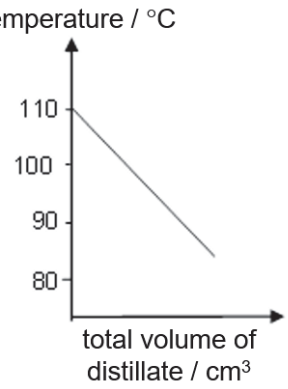
B



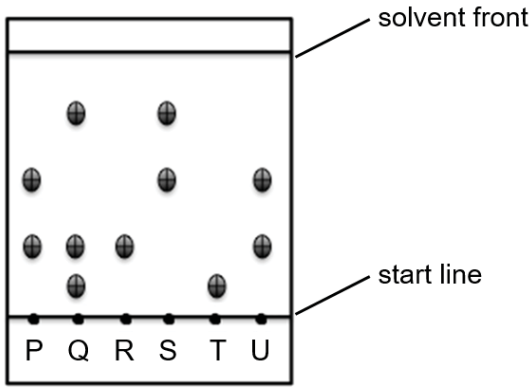
C



D



8 The chromatogram shown below was developed using ethanol as a solvent.



Which of the following statements is **not** true?

A Substance R is pure.

B Substance P is the same as substance U.

C Substance S is more soluble in ethanol than substance R.

D Substance Q contains all the components found in R, S and U.

9 The element Z has three electrons in its outer shell.

What is the formula of the oxide of element Z?

A ZO_3

B Z_2O_3

C Z_2O_5

D Z_3O_2

10 Which of the following explains why graphite can be used as a lubricant but not diamond?

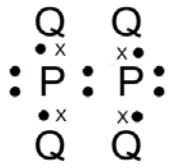
A Graphite has delocalised electrons along the layers.

B Graphite has weak forces of attraction between the layers.

C Graphite has a hexagonal arrangement of atoms in the layers.

D Graphite has weak covalent bonds between atoms in the layers.

11 The diagram below shows the arrangement of outermost electrons for element P when it reacts with element Q to form a compound.



To which groups of the Periodic Table do element P and element Q belong?

	element P	element Q
A	Group V	Group VI
B	Group V	Group VII
C	Group VI	Group I
D	Group VI	Group VII

12 Capsaicin, which is found in chilli and pepper, causes the spicy burning sensation in the mouth.

It has the molecular formula $C_{18}H_{27}NO_3$ and has a melting point of 65°C.

Which of the following statements best explains why drinking water is ineffective in removing the burning sensation caused by capsaicin?

A Capsaicin has a giant molecular structure and is soluble in water.

B Capsaicin has a giant molecular structure and is not very soluble in water.

C Capsaicin has a simple molecular structure and is soluble in water.

D Capsaicin has a simple molecular structure and is not very soluble in water.

13 Which has the same number of molecules as 80 g of bromine gas?

A 12 dm^3 of sulfur dioxide

B 24 dm^3 of carbon dioxide

C 2 g of hydrogen gas

D 28 g of nitrogen

14 The active component of tobacco, nicotine, found in cigarette smoke is thought to increase the chances of a person developing lung cancer.

The percentage composition of nicotine is 74.0% carbon, 8.7% hydrogen and 17.3% nitrogen. The relative molecular mass of nicotine is 162.

What is the molecular formula of nicotine?

A C_3H_2N

B C_5H_7N

C $C_9H_6N_3$

D $C_{10}H_{14}N_2$

15 50 cm^3 of butyene, C_4H_6, reacts with 300 cm^3 of oxygen. The equation for the reaction is shown below.

$$2C_4H_6(g) + 11O_2(g) \rightarrow 8CO_2(g) + 6H_2O(l)$$

What is total volume of gases remaining at the end of the reaction, measured at room temperature and pressure?

A 150 cm^3

B 225 cm^3

C 350 cm^3

D 375 cm^3

16 A solution containing 0.60 g sample of iodine is titrated with 0.10 mol/dm^3 sodium thiosulfate solution. The equation for the reaction is shown below.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

The average volume of sodium thiosulfate used is 26.45 cm^3.

What is the percentage purity of the iodine sample?

A 23%

B 28%

C 45%

D 56%

17 One mole of a compound P gives two moles of ions in aqueous solution. P reacts with ammonium carbonate to form a pungent gas which is highly soluble in water.

What is compound P?

A calcium hydroxide

B hydrochloric acid

C potassium hydroxide

D zinc oxide

18 Citric acid is found naturally in citrus fruits such as lemons and limes.

Which of the following statements about citric acid is **incorrect**?

A It reacts with ammonia to form ammonium citrate.

B It reacts with ammonium carbonate to form ammonia.

C It reacts with ammonium carbonate to form carbon dioxide.

D It reacts with powdered magnesium to form hydrogen.

19 Magnesium oxide is added slowly to a beaker containing hydrochloric acid until the magnesium oxide is in excess.

Which of the following statements about this reaction are true?

I Effervescence is observed.
II The pH of the mixture increases till pH 7.
III The temperature of the mixture increases.
IV The colourless solution turns green.

A I and II only

B II and III only

C I, II and III only

D I, II and IV only

20 Excess aqueous sodium hydroxide is added to 2 cm^3 of aqueous iron(II) chloride in a test tube. The reaction mixture is left to stand for 10 minutes.

Which row shows the correct observation and the ions remaining in the solution?

	observation	ions remaining in the solution
A	brown precipitate	Cl^-, Na^+, OH^-
B	brown precipitate	Na^+, OH^-
C	green precipitate	Cl^-, Na^+, OH^-
D	green precipitate	Fe^{2+}, OH^-

21 The following scheme shows the steps to prepare lead(II) chloride from lead(II) carbonate.

lead(II) carbonate $\xrightarrow{\text{reagent X}}$ lead(II) nitrate $\xrightarrow{\text{reagent Y}}$ lead(II) chloride

Identify reagents X and Y.

	reagent X	reagent Y
A	aqueous sodium nitrate	hydrochloric acid
B	aqueous sodium nitrate	silver chloride
C	nitric acid	hydrochloric acid
D	nitric acid	silver chloride

22 Which reaction does **not** involve either oxidation or reduction?

A $CuO + H_2 \rightarrow Cu + H_2O$

B $2SO_2 + O_2 \rightarrow 2SO_3$

C $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$

D $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

23 Rubidium, Rb, is a Group I element.

Which method is most likely to be used in its extraction?

A electolysis of its molten ore

B electrolysis of aqueous rubidium chloride

C heating its ore in air

D heating its ore with carbon

24 Which statement is **not** true of all metals?

A They conduct electricity.

B They are reducing agents.

C They contain mobile electrons.

D They react with sulfuric acid to form hydrogen gas.

25 The following observations were made on the reaction of metal X.

I Metal X reacts readily with steam.

II A deposit was formed when metal X was placed in copper(II) nitrate solution.

III Bubbles of colourless gas evolved at a moderately fast rate when metal X was placed into dilute nitric acid.

What is metal X likely to be?

A calcium

B lead

C magnesium

D zinc

26 Iron is extracted in the blast furnace.

Why is limestone added from the top of the furnace?

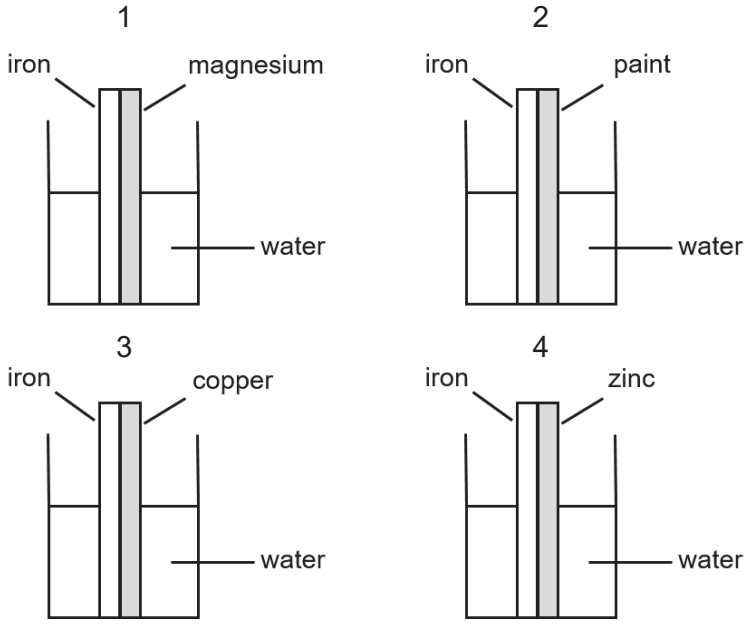
A to generate heat

B to reduce haematite

C to remove impurities

D to produce carbon monoxide

27 Four different experiments using identical iron rods are set up.



In which experiment(s) would the iron be least likely to rust after 2 days?

A 2 only

B 1 and 4 only

C 2 and 3 only

D 3 and 4 only

28 A chemical warmer bag is used to keep one warm during the cold winter.
The bag consists of powdered iron, water, salt and sawdust.

The following reaction occurs when the bag is shaken.

$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) \qquad \Delta H = -823\ kJ/mol$$

Which statement about the reaction is **not** correct?

A The temperature of the reaction mixture increases.

B The energy level of reactants is lower than that of the products.

C The energy level of products is lower than that of the reactants.

D The energy change involved in bond forming is more than that in bond breaking.

29 When solid candlewax ($C_{30}H_{62}$) burns, it is converted into carbon dioxide and water in four stages.

stage 1: $C_{30}H_{62}(s) \rightarrow C_{30}H_{62}(l)$
stage 2: $C_{30}H_{62}(l) \rightarrow C_{30}H_{62}(g)$
stage 3: $C_{30}H_{62}(g) + 45½\ O_2(g) \rightarrow 30\,CO_2(g) + 31\,H_2O(g)$
stage 4: $30\,CO_2(g) + 31\,H_2O(g) \rightarrow 30\,CO_2(g) + 31\,H_2O(l)$

Which stages are exothermic?

A 1 and 2

B 3 and 4

C 1, 3 and 4

D 2, 3 and 4

30 Which of the following pollutants is not removed by the catalytic converter in a car?

A carbon dioxide

B carbon monoxide

C nitrogen monoxide

D unburnt petrol

31 A sample of river water was boiled to drive off the oxygen. It was found to contain about 30% of oxygen.

Which of the following describes why there is an increase in percentage oxygen in river water compared to dry air?

A Carbon dixoide is more soluble in water than is oxygen.

B Nitrogen reacts with the water whereas oxygen does not react with the water.

C Noble gases are insoluble in water.

D Oxygen is more soluble in water than nitrogen.

32 A newly discovered alkali metal, L, has an atomic number greater than 37.

What is the most likely property of L?

A L floats on water.

B L has a higher melting point than sodium.

C L reacts with chlorine gas to form a yellow crystalline solid.

D L reacts with water more vigourously than potassium with water.

33 Astatine (At) is a member of the halogen group of elements.

Which statement is likely to be true of astatine?

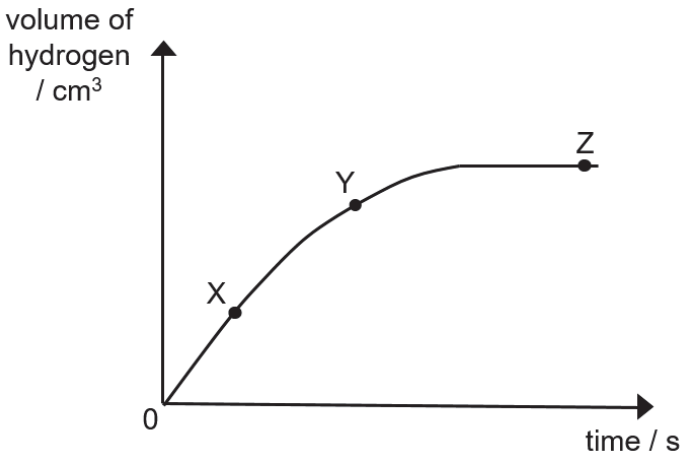
A It is a colourless, viscous liquid.

B It will dissolve in carbon tetrachloride.

C It reacts with sodium to form a compound with the formula $NaAt_2$.

D It can displace bromine from a solution of potassium bromide.

34 The graph shows how the volume of hydrogen gas produced by the reaction between 50 cm^3 of 2.0 mol / dm^3 hydrochloric acid and an excess of magnesium varied with time.



Which statement is correct?

A The reaction is faster at point Y than point X.

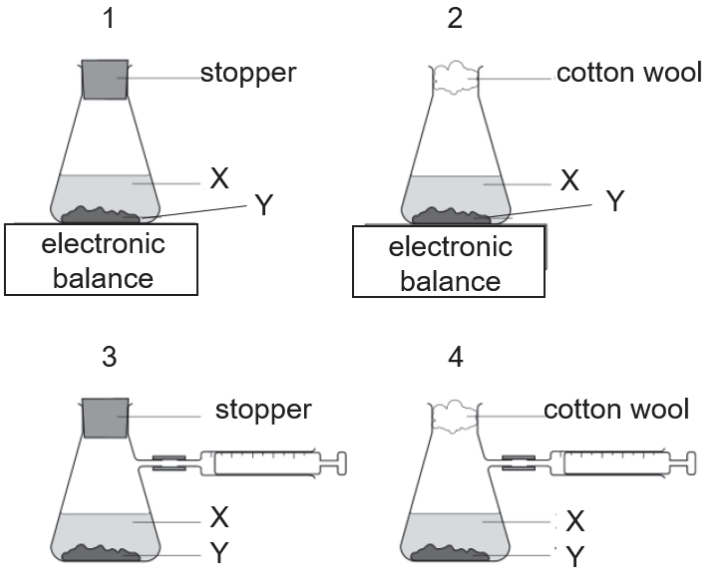
B All the magnesium has reacted at point Z.

C The volume of gas produced is doubled if 100 cm^3 of 2.0 mol / dm^3 hydrochloric acid is used.

D The time taken to reach completion decreases if 25 cm^3 of 4.0 mol / dm^3 hydrochloric acid is used.

35 Solution X reacts with solid Y to form a gas.

Four different set-ups are shown below.



Which two diagrams show suitable methods for investigating the speed of reaction?

A 1 and 3

B 1 and 4

C 2 and 3

D 2 and 4

36 The Haber Process is used in the industry to synthesise ammonia.

Which of the following statements about the Haber Process is **incorrect**?

A A catalyst of finely divided iron is used.

B Nitrogen and hydrogen are fed into the reactor in the volume ratio of 1 : 3.

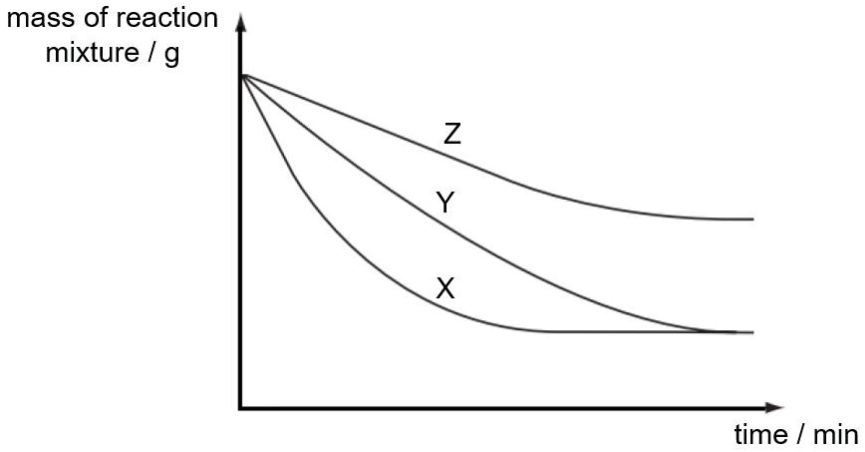
C Due to the cost of high pressure technology, the reaction is carried out at 10 atm.

D While low temperatues achieve an optimum yield of ammonia, the reaction is carried out at a higher temperature of 450 °C.

37 A student carried out two experiments under the same room temperature and pressure to investigate the speed of reaction of marble with 0.2 mol / dm^3 hydrochloric acid.

experiment 1: excess powdered marble is added to 20 cm^3 of dilute hydrochloric acid
experiment 2: excess marble chips is added to 20 cm^3 of dilute hydrochloric acid

The mass of the reaction mixture was measured at regular time intervals and plotted against time.



Which pair of curves is obtained in the two experiments?

	experiment 1	experiment 2
A	X	Y
B	X	Z
C	Y	X
D	Y	Z

38 In an electrolysis experiment, the same amount of charge deposited 3.90 g of zinc and 2.36 g of cobalt.
[A_r Co = 59; Zn = 65]

What was the charge on the cobalt ion?

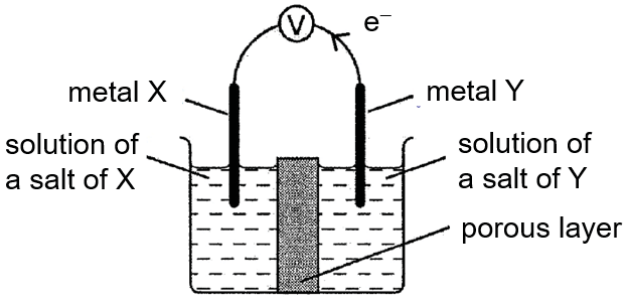
A 1+

B 2+

C 3+

D 4+

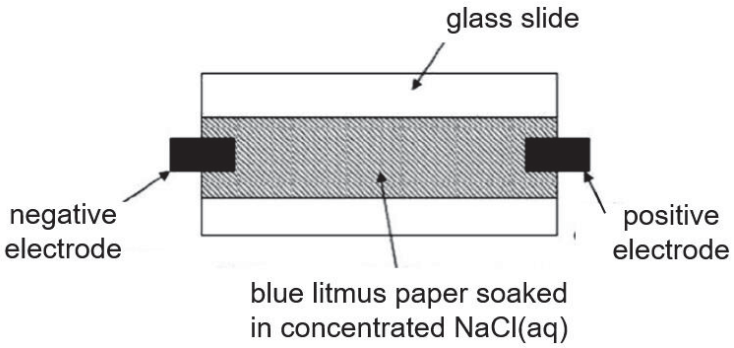
39 The direction of electrons in the simple cell shown below is from metal Y to metal X.



Which pair of metals X and Y will produce the highest voltage when used as electrodes in the simple cell?

	metal X	metal Y
A	copper	aluminium
B	iron	magnesium
C	iron	zinc
D	silver	magnesium

40 A piece of blue litmus paper is soaked in concentrated aqueous sodium chloride and supported on a glass slide. The litmus paper is connected to an electrical supply as shown in the diagram below.



Which of the following shows the correct observations near each electrode after some time?

	negative electrode	positive electrode
A	remains blue	turns red and then bleached
B	remains blue	remains blue
C	turns red	turns red and then bleached
D	turns red and then bleached	turns red

END OF PAPER

DATA SHEET
The Periodic Table of the 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 Lanthanoid series	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 Actinoid series	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 flevorium -		116 Lv livermorium -		

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
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.).

DAMAI SECONDARY SCHOOL
Preliminary Examination 2020

CANDIDATE NAME				
CLASS			INDEX NUMBER	

CHEMISTRY 6092/02

Paper 2 **15 September 2020**

Secondary 4 Express **1 hour 45 minutes**

Setter: Ms Goh Ai Lian 80 marks

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class 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, highlighters, glue or correction fluid.

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

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.

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

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

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

This document consists of **21** printed pages.

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Use the list of substances to answer the questions.

ammonia
ammonium sulfate
barium sulfate
coke
hydrogen
lead(II) nitrate
limestone

(a) Which substance liberates a colourless gas when added to sulfuric acid?

……..…….. [1]

(b) Which substance can be prepared by reacting an acid with an alkali?

……..…….. [1]

(c) Which substance is displaced from its salts in alkaline conditions?

……..…….. [1]

(d) Which substance is added to remove impurities during the extraction of iron in the blast furnace?

……..…….. [1]

(e) Which substance can be used to detect the presence of chloride ions in an aqueous solution?

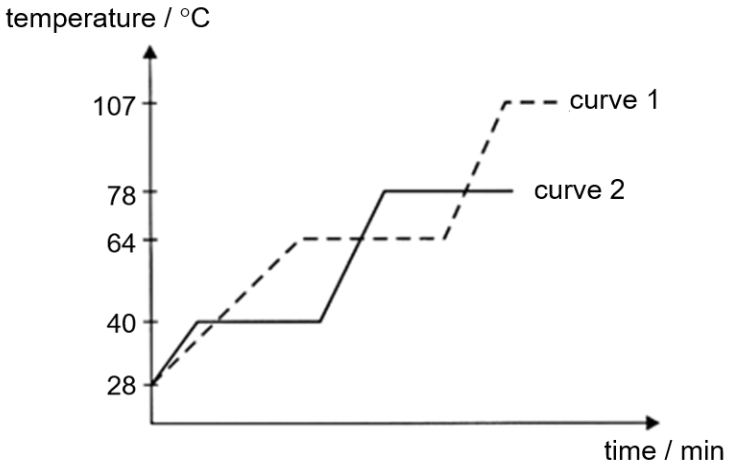
……..…….. [1]

(f) Which substance is used to extract zinc from zinc oxide?

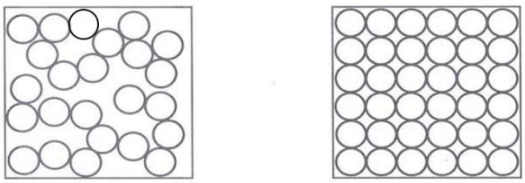
……..…….. [1]

[Total: 6]

A2 The heating curves of two pure solids M and N are shown below.



The arrangements of particles in M and N at 50 °C are shown below.



M N

(a) State the melting point and boiling point for M.

melting point …….. boiling point …….. [2]

(b) Explain why the temperature remains constant during melting and boiling of a pure substance.

……...…….

……...…… [1]

(c) Describe how the arrangement and movement of particles in M change as the temperature rises from 60 °C to 80 °C.

……...…….

……...…….

……...…….

……...…….

……...…….

……...…… [2]

[Total: 5]

A3 The table shows the names and symbols of some isotopes of common elements.

isotope name	isotope symbol
fluorine–19	$^{19}_{9}\mathrm{F}$
carbon–12	$^{12}_{6}\mathrm{C}$
iodine–131	$^{131}_{52}\mathrm{I}$
strontium–90	$^{90}_{38}\mathrm{Sr}$
neon–20	$^{20}_{10}\mathrm{Ne}$
carbon–14	$^{14}_{6}\mathrm{C}$
magnesium–24	$^{24}_{12}\mathrm{Mg}$

Use the isotopes in the table to answer the following questions.

(a) Give the names of **two** isotopes that contain the same number of protons in each of their atoms.

…… and …… [1]

(b) Give the names of **two** isotopes that contain seven electrons in the outer shell of each of their atoms.

…… and …… [1]

(c) Give the names of **two** isotopes that contain the same number of neutrons in each of their atoms.

…… and …… [1]

(d) Give the names of **two** isotopes which form stable compounds that contain ions with a charge of +2.

…… and …… [1]

(e) Give the name of **one** isotope that can displace chlorine from sodium chloride solution.

…… [1]

[Total: 5]

A4 Sulfur is the fifth most common element on Earth. It occurs mostly as sulfide and sulfate minerals.

(a) Sulfur forms sulfides with both carbon and silicon.

The properties of carbon disulfide, CS_2, and silicon disulfide, SiS_2, are shown below.

compound	**carbon disulfide, CS_2**	**silicon disulfide, SiS_2**
appearance	colourless liquid	white solid
melting point / °C	−111	1090

(i) Draw a 'dot-and-cross' diagram to show the bonding in carbon disulfide. Show only the outer shell electrons.

[2]

(ii) With reference to structure and bonding, explain the difference in the melting points of carbon disulfide and silicon disulfide.

……...…….

……...…….

……...…….

……...…….

……...…….

……...…….

……...…… [3]

(b) Sulfur also reacts with magnesium to form magnesium sulfide.

(i) Write the electronic configurations for the elements, magnesium and sulfur.

magnesium ……...

sulfur ……...……... [1]

(ii) Draw a ‘dot-and-cross’ diagram to show the bonding in magnesium sulfide.

[2]

(iii) Using your understanding of bonding and structure, which of these statements would you predict to be true and which would you predict to be false about magnesium sulfide?

Put a tick (✓) in one box in each row.

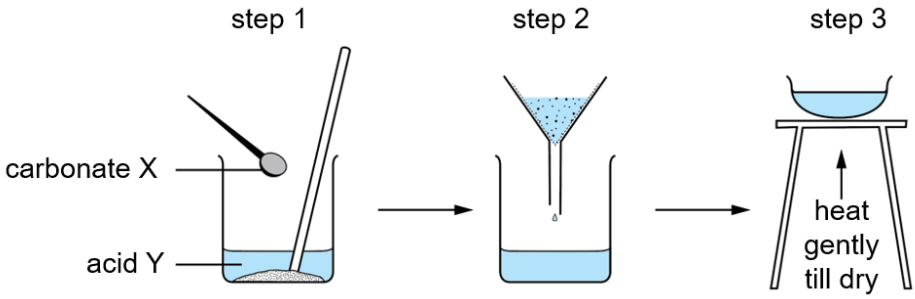
	true	**false**
Magnesium sulfide is a crystalline solid at room temperature.		
Magnesium sulfide has a low melting point.		
Magnesium sulfide conducts electricity when molten.		
Magnesium sulfide is moderately soluble in water.		

[2]

[Total: 10]

A5 Different salts were made by reacting an excess of a carbonate X with an acid Y. Unreacted solids were separated by filtration and the salt was recovered from the filtrate by evaporation to dryness.

The diagram below shows the first three steps used to prepare these salts.



Four experiments were carried out using different combinations of X and Y to prepare salts. The percentage yield of each experiment is given in the table below.

experiment	X	Y	salt prepared	percentage yield of salt / %
1	$CuCO_3$	H_2SO_4	$CuSO_4$	95
2	$ZnCO_3$	HNO_3	$Zn(NO_3)_2$	92
3	$CaCO_3$	H_2SO_4	$CaSO_4$	18
4	Ag_2CO_3	HCl	AgCl	< 1

(a) The copper(II) sulfate obtained in experiment 1 was white in colour.

When experiment 1 was modified in the last step by recovering copper(II) sulfate by crystallisation instead of by evaporation to dryness, the percentage yield became 140%.

Explain why the percentage yield increased when the salt was recovered by crystallisation.

……

……

…… [1]

(b) **(i)** Explain why the yields were low in experiments 3 and 4.

……

……

……

…… [2]

(ii) Suggest another pair of reagents that could be used in experiment 4 to obtain a higher yield of the salt.

……..…… [1]

(c) A student added excess zinc carbonate to 100 cm^3 of 0.5 mol / dm^3 of nitric acid in experiment 2.

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

……..…… [2]

(ii) Calculate the mass of zinc nitrate that was obtained at the end of the reaction.

[3]

[Total: 9]

A6 Chromium is a transition element and is often added to steel to make stainless steel. The iron in the stainless steel does not rust due to the formation of a thin layer of chromium(III) oxide that forms over the steel object over time.

A student investigated the reactivity of three metals, zinc, chromium and copper by placing a small amount of each metal into the aqueous nitrate solutions of the other two metals. The results are shown in the table below.

	aqueous zinc nitrate	**aqueous chromium(III) nitrate**	**aqueous copper(II) nitrate**
zinc		green solution turned colourless and grey metal coated with silvery solid	blue solution turned colourless and grey metal coated with reddish brown solid
chromium			
copper		no visible reaction	

(a) **(i)** Complete the table by writing the results of the remaining three reactions. [2]

(ii) Write an ionic equation for the reaction that occurs when zinc is placed in aqueous chromium(III) nitrate.

……..…….. [2]

(iii) Hence, arrange chromium, copper, iron and zinc in increasing order of chemical reactivity.

Explain the reasoning for chromium's position in your answer.

……..

……..

……..

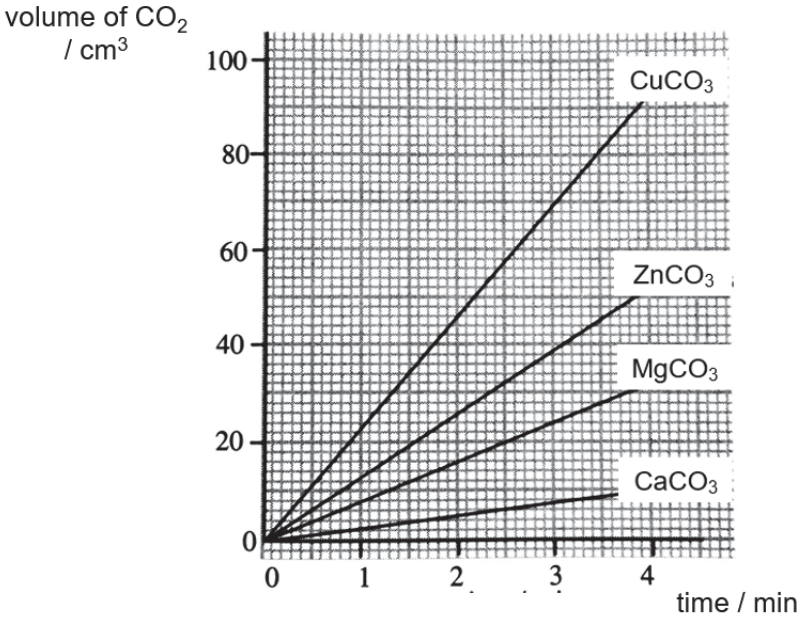
……..

……..

……..…….. [3]

(b) The graph below shows the rate of decomposition of four different carbonates.

In each experiment, 0.010 moles of the metal carbonate was heated to the same temperature. The volume of carbon dioxide gas produced was measured every minute.



(i) How could you tell from the graph that the decomposition of the carbonates was not completed?

……..

……..…….. [1]

(ii) Which carbonate decomposed at the slowest rate?

……..…….. [1]

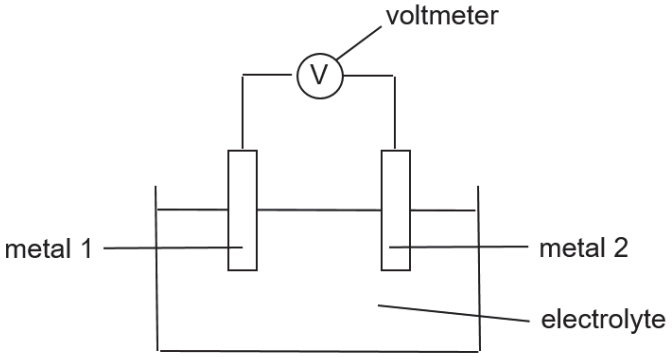
(iii) Suggest the trend between the reactivity of the metals and the rate of thermal decomposition of their carbonates.

……..

……..…….. [1]

[Total: 10]

A7 Two metal electrodes and an electrolyte can be used to produce electrical energy.



The table shows the voltage produced by some cells when different metals are used.

cell	metal 1	metal 2	voltage / V
1	copper	zinc	1.10
2	copper	magnesium	2.72
3	silver	zinc	1.56
4	silver	iron	1.25

(a) In which direction will the electrons flow in the external wire of cell 3?

…… [1]

(b) In terms of the reactions that take place in the cells, explain why the voltage of cell 2 is higher than cell 1.

……..

……..

……..

……..

…… [2]

(c) Suggest the voltages that will be produced when the following metals are used.

metal 1	metal 2	predicted voltage / V
copper	iron	
silver	magnesium	

[2]

[Total: 5]

END OF SECTION A

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 The Straits Times reported on 8 October 2019 that Singapore generated 52.5 million tonnes of greenhouse gases in 2017. This works out to about 0.11% of global emissions.

Carbon emissions make up 97% of the total greenhouse gas emissions. These carbon emissions lead to climate change and can make our weather hotter and raises the sea level around us. As a low-lying island city state, Singapore is particularly vulnerable to the impacts of climate change.

Industries, power stations and motor vehicles are the main sources of carbon emissions. Fig. 8.1 shows the projected carbon emissions in 2020 at 77.2 million tonnes if measures are not taken to reduce carbon emissions.

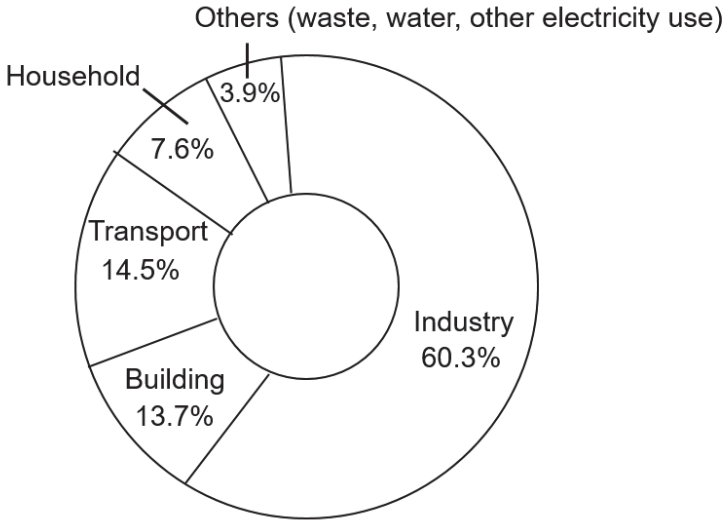


Fig. 8.1

https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapore%27s-emissions-profile

In 2010, Singapore has pledged to reduce her greenhouse emissions by 16% below the 2020 projected level and has taken many measures to reduce emissions.

One of the measures includes power stations switching from using fuel oil to natural gas to generate electricity. Natural gas is a fossil fuel and is mostly made up of methane, CH_4, and emits 40% less carbon dioxide than fuel oil for every unit of electricity generated. About 95 per cent of Singapore's electricity is generated using natural gas.

Singapore also uses nature-based solutions such as tree planting and conserving green spaces such as parks, gardens, swamps, and forests. These green spaces act as a carbon sink to help keep the environment cooler.

A typical motor car that runs on petrol, which is a mixture consisting mainly of octane (C_8H_{18}), produces 252 g of carbon dioxide per kilometre travelled. It is estimated that 2.34 kg of carbon dioxide is emitted per litre of petrol being burnt. To reduce carbon emissions from transportation, cycling and using the public transport are encouraged.

Companies and research institutes are also looking into fuel cell technology to power vehicles and to generate electricity. Fuel cells produce electrical energy from the reaction between a fuel and oxygen. Hydrogen, which can be obtained by electrolysing water, is a possible fuel for use in fuel cells.

Table 8.1 gives some data about these hydrogen and octane fuels.

Table 8.1

fuel	melting point / °C	boiling point / °C	energy change of combustion (kJ / mol)
hydrogen	−259	−252	256
octane	−57	126	5480

Adapted from
https://www.straitstimes.com/politics/singapore-generated-011-of-global-emissions-in-2017
https://www.mewr.gov.sg/topic/carbon-emissions

(a) **(i)** Explain why excessive carbon emissions can lead to climate change.

……..

…… [1]

(ii) Explain how trees and green spaces can act as a carbon sink.

……..

…… [1]

(iii) Calculate the mass of carbon dioxide generated in a year by a motorist who drives an average of 60 km each day.

Leave your answer to the nearest kilogram.

[2]

(b) **(i)** Households generate carbon emissions as electricity is consumed.
Use Fig. 8.1 to calculate the projected amount of carbon dioxide generated, in million tonnes, by households in 2020.

[1]

(ii) While natural gas is considered to be a cleaner source of fuel than coal and fuel oil, it nevertheless still contributes to carbon emissions when used in the power stations.

Write an equation to show how natural gas contributes towards carbon emission.

…… [1]

(c) **(i)** Write an equation to show the combustion of hydrogen in a fuel cell.

…… [1]

(ii) Use information provided in Table 8.1 to calculate the energy output, in kJ, for 1 g of each fuel, hydrogen and octane.

[2]

(iii) Using the equation written in **(c)(i)** and the values calculated in **(c)(ii)**, discuss the advantages of using hydrogen as an alternate fuel.

……..

……..

……..

……..

…… [2]

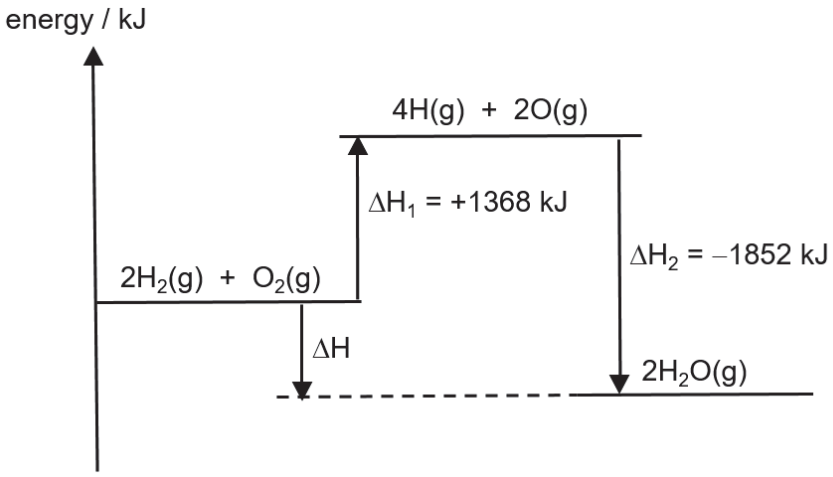
(iv) Suggest a reason why the cost of using the hydrogen fuel cell is high.

……..

…… [1]

[Total: 12]

B9 A hydrogen fuel cell uses hydrogen and oxygen to produce electricity, heat and water. The energy level diagram for the reaction is shown below.



(a) **(i)** State a process by which hydrogen can be obtained.

……..…… [1]

(ii) Name the process by which oxygen can be obtained from air.

……..…… [1]

(b) Calculate the enthalpy change, ΔH, for the reaction that occurs in the fuel cell.

[2]

(c) The bond energies of some bonds are given below.

bond	bond energy (kJ / mol)
O – O	150
O = O	496
O – H	460

(i) Use ideas about breaking and forming of bonds to explain why the enthalpy change, ΔH_1, is a positive value while the enthalpy change, ΔH_2, is a negative value.

……...…….

……...…….

……...…….

……...…… [2]

(ii) Calculate the bond energy, in kJ / mol, of H – H bonds.

[2]

[Total: 8]

EITHER

B10 The Contact Process is the modern industrial method of producing sulfuric acid which involves a reversible reaction. There are two stages in the Contact Process.

stage 1: Sulfur is burnt in air to form sulfur dioxide.

$$S(l) + O_2(g) \rightarrow SO_2(g)$$

stage 2: Sulfur dioxide is passed over a hot catalyst of vanadium(V) oxide, V_2O_5, at 450 °C and 2 atmospheres where it reacts with more oxygen to form sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(a) Sulfur dioxide should not be released into the atmosphere as it is an air pollutant.

Describe one environmental problem of sulfur dioxide.

……

…… [1]

(b) Use oxidation states to determine whether the reaction that occurs in stage 2 is a redox reaction.

……

……

…… [2]

(c) **(i)** Using collision theory, explain why a higher pressure increases the rate of reaction that occurs in stage 2.

……

……

……

……

…… [2]

(ii) Suggest a reason why industries do not use a pressure that is higher than 2 atmospheres to increase the rate of production of sulfur dioxide in stage 2.

……

…… [1]

(d) Using activation energy, explain how vanadium(IV) oxide increases the rate of reaction in stage 2.

……

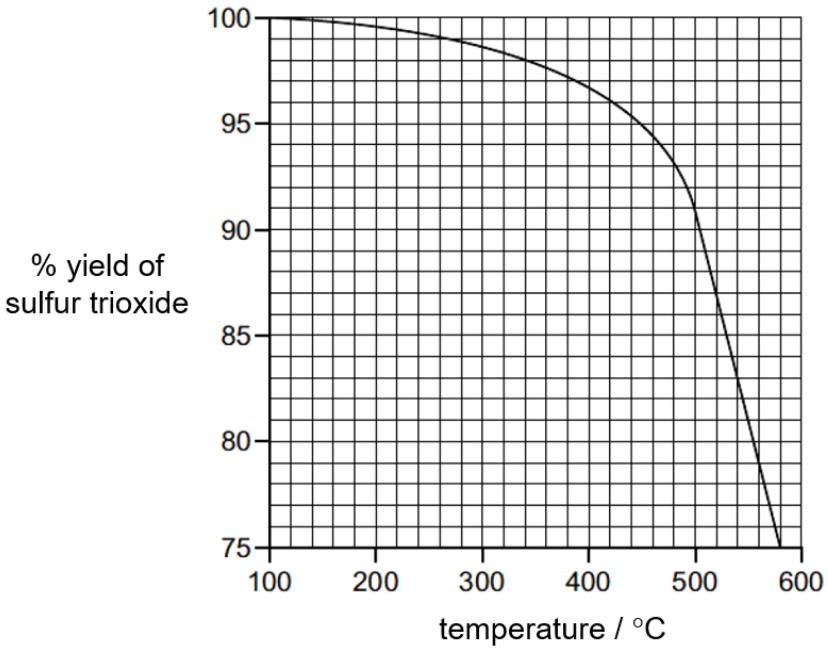
……

……

……

…… [2]

(e) The graph below shows how the percentage yield of sulfur trioxide changes with temperature when the pressure is kept constant.



(i) Describe how the percentage yield of sulfur trioxide changes with temperature.

……

…… [1]

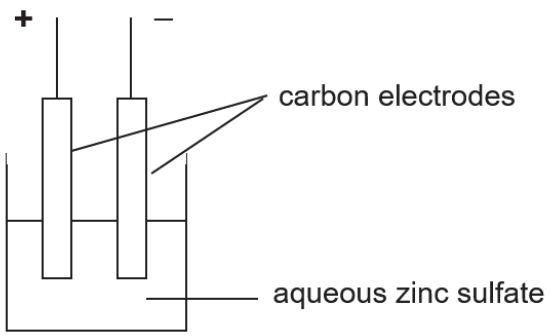
(ii) Determine the percentage yield of sulfur dioxide at 480 °C.

…… [1]

[Total: 10]

OR

B10 A student sets up the following apparatus to investigate the amount of zinc that forms on the negative electrode during the electrolysis of aqueous zinc sulfate.



(a) Write half-equations, with state symbols, for the reactions that happen at each of the electrodes.

positive electrode ……...

negative electrode ……..... [2]

(b) Describe what would be observed at the electrodes.

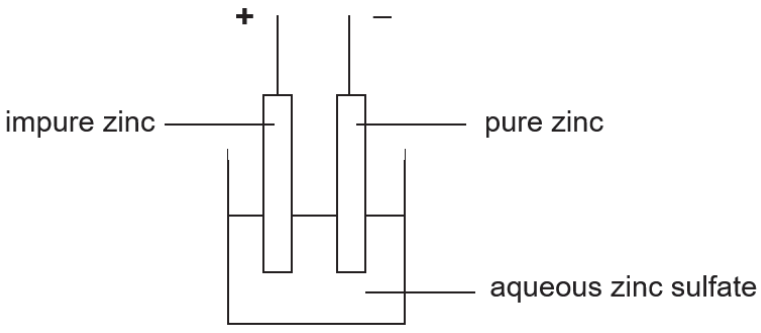
positive electrode ……...

……...……

negative electrode ……...……...

……..…… [2]

(c) In another experiment, the student sets up the following apparatus to refine zinc.



The impure zinc electrode contains mainly copper as the impurity.

Before starting the experiment, the student measures the mass of each electrode. At the end of the experiment, the electrodes are dried and their masses are measured.

(i) Write half-equations, with state symbols, for the reactions that happen at each of the electrodes.

positive electrode …….

negative electrode ……..……. [2]

(ii) How does the concentration of the aqueous zinc sulfate change during the experiment?

Explain your answer.

……...…….

……...……. [1]

(iii) At the end of the experiment, the positive electrode decreases in mass by 4.8 g while the negative electrode increases in mass by 4.5 g.

Calculate the percentage purity of the impure zinc electrode.

[1]

(iv) At the end of the experiment, the student observes that some reddish-brown solid is formed just below the impure zinc electrode.

Identify this solid and explain why it is formed under the impure zinc electrode.

……...…….

……...…….

……...……. [2]

[Total: 10]

END OF PAPER

DATA SHEET
The Periodic Table of the 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 Lanthanoid series	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 Actinoid series	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 flevorium -		116 Lv livermorium -		

			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
			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.).