SCHOOL OF SCIENCE AND TECHNOLOGY, SINGAPORE

SECONDARY 4
PRELIMINARY EXAMINATION

CHEMISTRY
Paper 2 6092/02

14 Sep 2021 (Tuesday) **1 hour 45 minutes**

CANDIDATE NAME	
CLASS	
INDEX NUMBER	

READ THESE INSTRUCTIONS FIRST
Do not turn over the page until you are told to do so.
Write your name, class, and index number in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
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 use of an approved scientific calculator is expected, where appropriate.

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

The total mark for this paper is **80**.

A copy of the Periodic Table is printed on page **18.**

FOR EXAMINERS' USE	
Paper 1	**/ 40**
Paper 2	**/ 80**
Section A	**/ 50**
Section B	**/ 30**

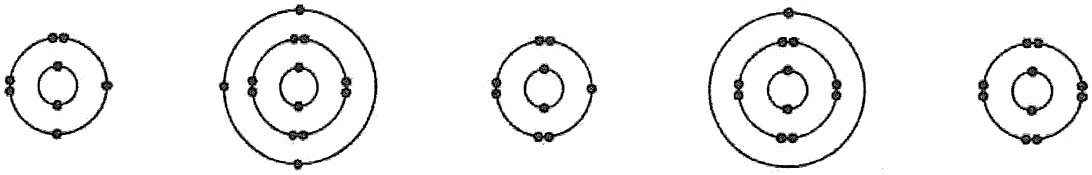
This document consists of **18** printed pages including the cover page.

[Turn over

Section A

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

1 Fig. 1.1 shows the electronic configurations of five atoms, **A**, **B**, **C**, **D** and **E**.



A **B** **C** **D** **E**

Fig 1.1

(a) Answer the following questions.

Each letter may be used once, more than once or not at all.

Give the letter of the atom, **A**, **B**, **C**, **D** and **E**, that:

(i) is in Group 1 of the Periodic Table, [1]

.....

(ii) has 11 protons, [1]

.....

(iii) is a noble gas, [1]

.....

(iv) forms a stable ion with a single negative charge. [1]

.....

(b) Complete Table 1.1. to show the number of electrons, neutrons and protons in the nitrogen atom and phosphide ion. [3]

Table 1.1

particle	number of electrons	number of neutrons	number of protons
$^{15}_{7}N$	7		
$^{32}_{15}P^{3-}$		17	

[Total: 7 marks]

[Turn over

2 Figs. 2.1 and 2.2 show diagrams of the structures of diamond and magnesium oxide.

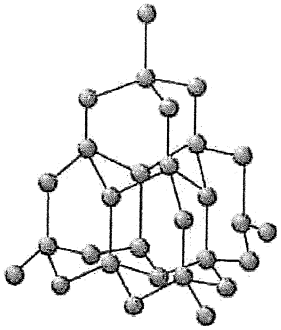


Fig. 2.1 Structure of diamond

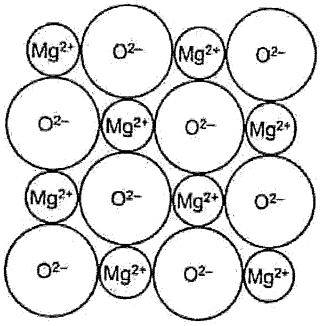


Fig. 2.2 Structure of magnesium oxide

(a) Describe one similarity and one difference in the two structures. [2]

similarity .....

.....

difference .....

.....

(b) Discuss how and why the melting points of diamond and magnesium oxide are similar. [3]

.....

.....

.....

.....

.....

.....

(c) Explain why the diagram for diamond is a more accurate representation than the diagram for magnesium oxide. [1]

.....

.....

(d) Diamond is a form of carbon. Carbon is an element.

What is meant by the term *element*? [1]

.....

.....

[Total: 7 marks]

[Turn over

3 Three students want to make a sample of pure dry iron(II) sulfate crystals, $FeSO_4 \bullet 7H_2O$. They use insoluble iron(II) carbonate as one of the reactants.

(a) State the other reactant that the students need. [1]

.....

(b) Describe the steps in their method (without details of the apparatus used). [4]

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.....

(c) The students calculated the mass of crystals they were expecting and found that the percentage yield of their process was much less than 100%.

They gave explanations for this low percentage yield.

student A The crystals are damp at the end.
student B Some iron(II) carbonate remains unreacted at the end.
student C The iron(II) sulfate has lost some of its water of crystallisation.

For each explanation, state whether it could be correct and explain your answer. [3]

student A .....

.....

.....

student B .....

.....

.....

student C .....

.....

.....

[Total: 8 marks]

[Turn over

4 A student was given a test-tube containing a small piece of sodium in oil.

(a) Why was the sodium in oil? [1]

.....

The piece of sodium was transferred from the test-tube to a beaker half-filled with water. The reaction produced a gas.

(b) Name this gas and give a test to confirm the presence of this gas. [2]

gas .....

test and observation

.....

.....

(c) Give two observations that were made when sodium reacted with the water. [2]

1. .....

2. .....

(d) Name the solution that remained in the beaker when the reaction had finished. [1]

.....

(e) A piece of litmus paper was placed in this solution. What was the colour of the litmus paper in this solution? [1]

.....

(f) Write an equation for the reaction between sodium and water. [1]

.....

[Total: 8 marks]

[Turn over

5 Fig. 5.1 below shows the apparatus that can be used to investigate the rate of reaction between calcium carbonate and various acids.

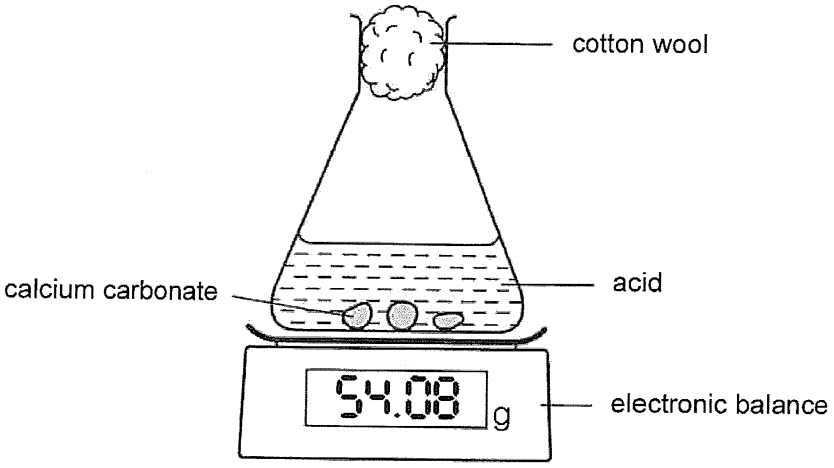
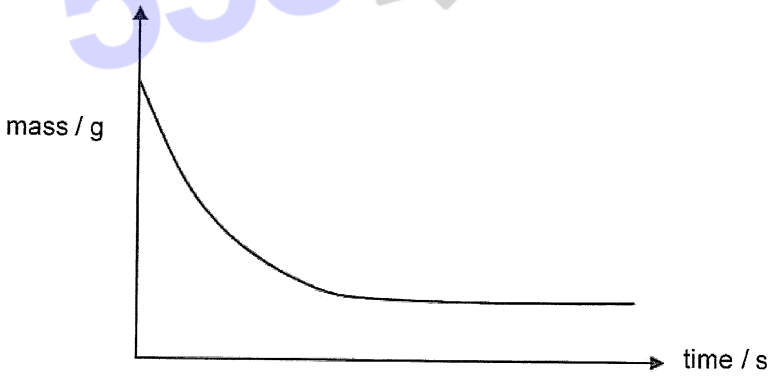


Fig. 5.1

(a) Write the balanced equation, including state symbols, for the reaction between calcium carbonate and hydrochloric acid. [2]

.....

(b) The graph shows the change in mass that occurs during the reaction between 50 g of calcium carbonate and 200 cm^3 of 1.0 mol/dm^3 hydrochloric acid.



(i) Explain why the mass decreases during the course of the reaction. [1]

.....

.....

(ii) Exactly the same experiment was repeated with 200 cm^3 of 1.0 mol/dm^3 ethanoic acid.

Sketch on the graph the expected results. [2]

[Turn over

(c) Explain why hydrochloric acid reacts much faster with calcium carbonate powder than with lumps of calcium carbonate. [2]

.....

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.....

(d) Calcium carbonate is added to excess sulfuric acid. Explain why the reaction stops after a while even when the calcium carbonate is not completely used up. [2]

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.....

.....

[Total: 9 marks]

[Turn over

6 Bromide ions are present in seawater. A key reaction in the manufacture of bromine from seawater is the reaction of bromide ions with chlorine gas. The chlorine is made on site by electrolysis of brine.

(a) **(i)** Write an ionic equation for the reaction of bromide ions with chlorine. [1]

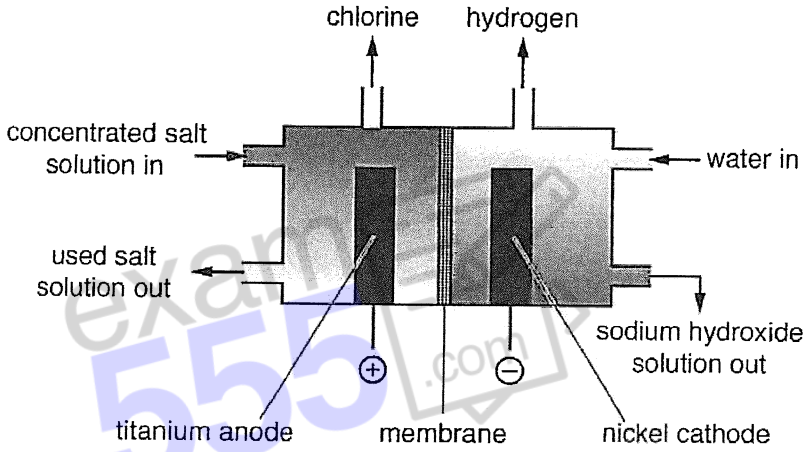
.....

(ii) What information does the reaction in **(i)** give about the relative reactivities of the two halogens involved? Give your answer in terms of electrons. [1]

.....

.....

(b) Chlorine is usually manufactured from sodium chloride using a membrane cell.



(i) Write the ionic half-equation for the reaction happening at the respective electrodes. [2]

anode: .....

cathode: .....

(ii) The membrane allows some ions in the salt solution to move through but not others.

Identify an ion that can move through the membrane. Explain your reasoning. [2]

.....

.....

.....

.....

[Turn over

(iii) 20 kg of hydrogen gas is produced by a membrane cell.

Calculate the volume of chlorine gas (measured at room temperature and pressure) that will be produced at the same time. [3]

(c) Bromine can be produced in a laboratory by reacting Br^- and BrO_3^- ions.

$$5Br^- + 6H^+ + BrO_3^- \rightarrow 3Br_2 + 3H_2O$$

Identify the reducing agent in this reaction. Explain your answer in terms of changes in oxidation state. [2]

.....

.....

.....

[Total: 11 marks]

[Turn over

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.

7 Read the information about solutions.

Definition of a Solution

In general, a solution is formed when one substance disperses uniformly throughout another. Each substance in a solution is called a *component* of the solution. The *solvent* is normally the component present in the greatest amount, and all the other components are called *solutes*.

When we think of solutions, we usually think of liquids, such as a solution of a salt in water, like seawater. Solutions, however, can also be solids or gases. For example, the air we breathe is a gaseous solution, as it is a homogeneous mixture of several gases.

Solubility and Saturated Solutions

Solubility is a measurement of the maximum quantity of a substance which will dissolve in a given amount of solvent at a particular temperature. When a solute's concentration is equal to its solubility, the solution is said to be *saturated* with the solute. If the concentration is less than its solubility, the solution is said to be *unsaturated*.

Solubility Curves

A solubility curve is a graph of solubility against temperature. Figs 7.1 and 7.2 show the solubility curves of different substances in water.

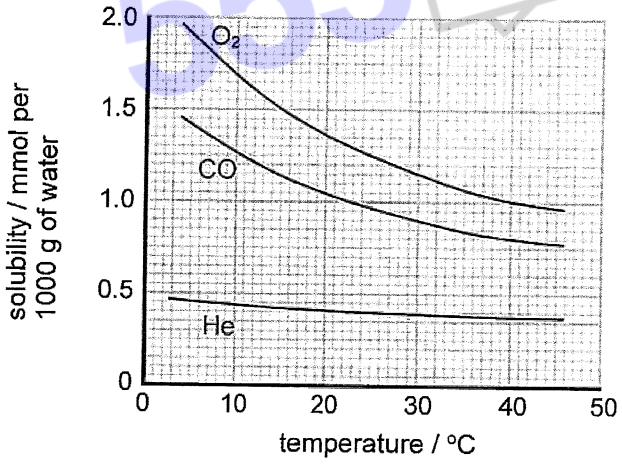


Fig. 7.1

[Turn over

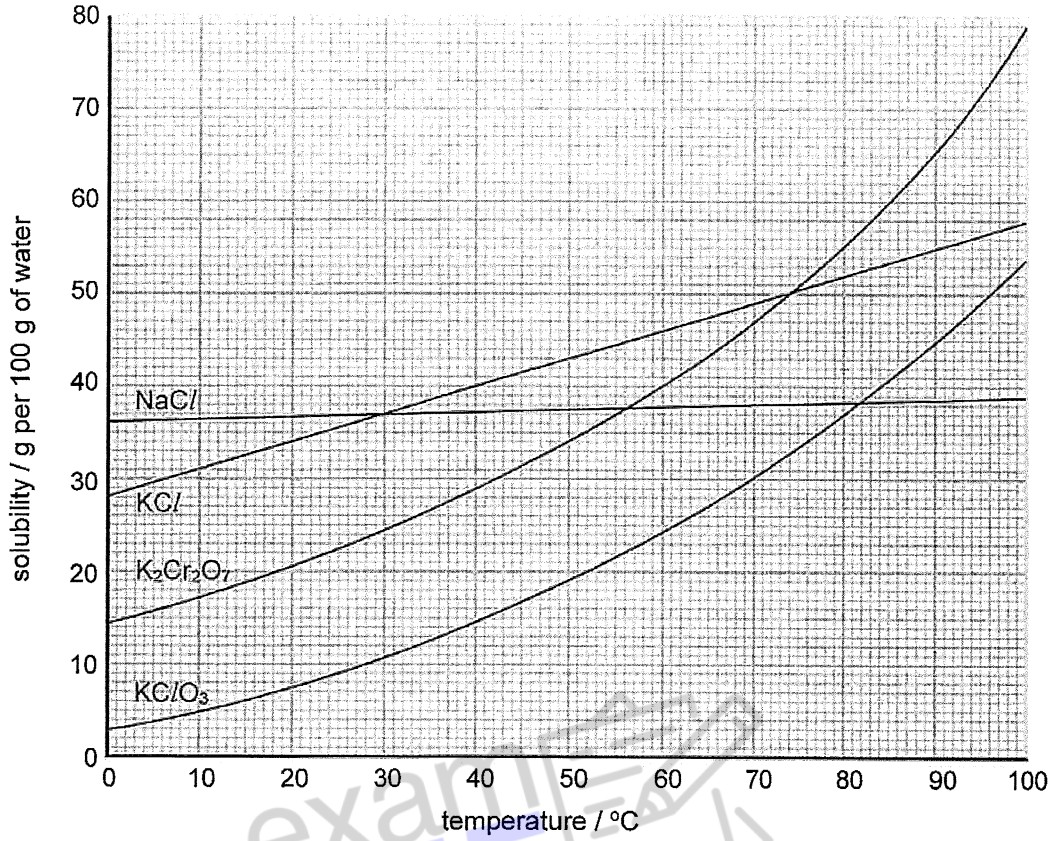


Fig. 7.2

Supersaturated Solutions

A solution that contains more than the maximum amount of solute that is required to saturate it is known as a *supersaturated* solution. A supersaturated solution is unstable and the excess dissolved solute will crash out of the solution until the solution becomes saturated, i.e., the solute's concentration is equal to its solubility.

(a) Air is a gaseous solution.

Identify the solvent in air and explain your answer. [1]

.....

.....

(b) Use the data to calculate the maximum mass of oxygen that can be dissolved into 100 g of water at 30 °C. [2]

(c) Why do bubbles form on the inside wall of a cooking pot when water is heated on the stove, even though the water temperature is well below the boiling point of water? [2]

.....

.....

.....

(d) What is a similarity and a difference in the solubilities of KC*l* and KC*l*O_3? [2]

similarity .....

.....

difference .....

.....

(e) Why does the x-axis of the graph in Fig 7.2 not go below 0 °C or above 100 °C? [1]

.....

.....

[Turn over

(f) At what temperature would 3 g of $KClO_3$ saturate 10 g of water? [1]

.....

(g) On cooling a saturated solution of KCl containing 50 g of water from 60 °C to a lower temperature, 6 g of solid were deposited. Determine the temperature to which the solution was cooled. Show all your working. [3]

[Total: 12 marks]

[Turn over

8 Photosynthesis is a reaction that takes place in the chloroplasts of plants.

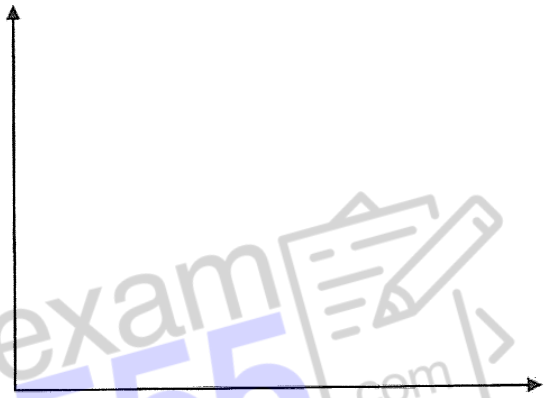
The overall reaction involves the conversion of carbon dioxide and water into glucose and oxygen.

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

The reaction is endothermic and is catalysed by enzymes (chlorophyll).

(a) Draw an energy profile diagram for photosynthesis using the axes shown.

Label
- the axes,
- the enthalpy change and activation energy,
- the reactants and products. [3]



(b) Describe how a catalyst, such as an enzyme, speeds up a chemical reaction. [2]

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.....

.....

(c) Photosynthesis, combustion and respiration are important processes in the carbon cycle.

Describe how the carbon cycle regulates the amount of carbon dioxide in the atmosphere. [3]

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[Total: 8 marks]

[Turn over

EITHER

9 Zinc is an important metal and it is extracted from its ore called zinc blende, ZnS.

(a) Zinc blende is first roasted in air to obtain zinc oxide.

Name the **other** product formed in this reaction. [1]

.....

(b) Zinc oxide is then converted into impure zinc by heating with coke.

Give two reasons why coke is needed. [2]

1. .....

2. .....

(c) The major impurity in the impure zinc is cadmium. The boiling point of zinc is 907 °C and that of cadmium is 767 °C.

Name a technique which could be used to separate these two metals. [1]

.....

(d) In common with most metals, zinc is a good conductor of electricity.

Describe the metallic bonding in zinc and explain why it is a good conductor of electricity. [4]

.....

.....

.....

.....

.....

(e) Steel articles can be plated with zinc to prevent rusting.

When the zinc layer is damaged exposing the underlying steel, it does not rust. Explain. [2]

.....

.....

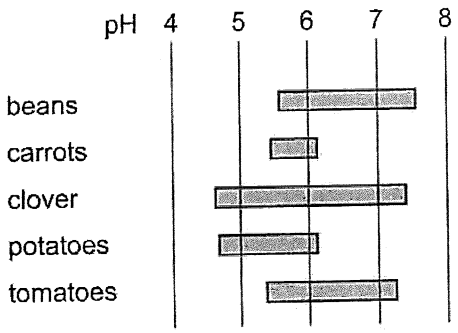
.....

[Total: 10 marks]

[Turn over

OR

9 The diagram shows the best pH ranges for growing different plants.



(a) Which **two** plants grow best in acidic conditions **only**? [1]

.....

(b) Explain why lime is added to acidic soils. [2]

.....

.....

Farmers fertilise soil by adding compounds containing ammonium salts.

(c) Explain why adding lime to fertilised soil may cause a loss of nitrogen from the soil. [2]

.....

.....

(d) Draw a 'dot-and-cross' diagram to show the bonding in an ammonium ion.

Show outer electrons only. [2]

(e) A fertilizer contains 28.2% nitrogen, 8.1% hydrogen, 20.8% phosphorus and 42.9% oxygen.

(i) How does this prove that the fertiliser contains only the four elements? [1]

.....

(ii) Use the above percentages to calculate the empirical formula of the fertiiliser. [2]

[Total: 10 marks]

[Turn over

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											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 –		

Key: proton (atomic) number; atomic symbol; name; relative atomic mass

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.)

2021 O-level Chemistry P2 Suggested Marking Scheme

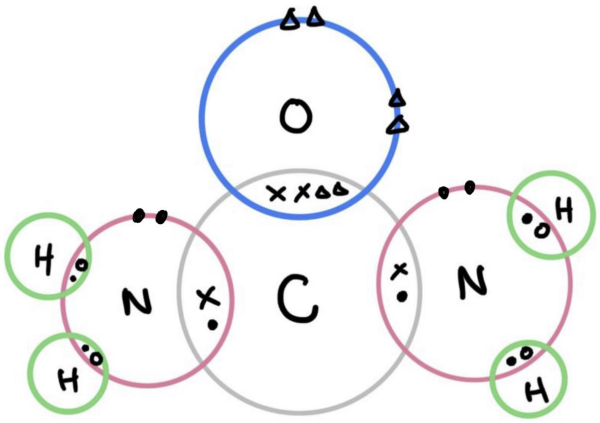
Se00ction A

Qn	Suggested Answer	Marks	Guidance
A1a(i)	Potassium and chlorine	1	Students need to note: students selected the most and least reactive metal. (i.e. potassium and copper)
A1a(ii)	chlorine	1	
A1a(iii)	copper	1	
A1a(iv)	aluminium	1	Note: since the question asked for **element**, you should only state aluminium and **not aluminium oxide**
A1a(v)	Potassium and chlorine	1	Students need to note: students selected lithium or magnesium (which will form ions of 2 and 2.8 electronic configuration respectively)
A1b	• The most unreactive group contains only non-metals. [True] • Melting point increases across period 2. [False] • Atoms lose electrons more easily down Group I. [True] • The strongest non-metal oxidising agent is at the top of the group. [True]	3	
A2(a)	Fractional distillation occurs by separating propane and octane through their **differences in boiling point**.Columns at the top have lower temperatures than columns at the bottom with higher temperatures Octane has a **larger molecular size/larger relative molecular mass** as compared to propane. With a	1 1	[R] Both octane and propane have different boiling points. This is not good enough. You need to relate to the chemical formula to determine which hydrocarbon has a higher bp and thus how will it affect the which part of the fractionating column does it leave from.

	larger molecular size, more energy is absorbed to overcome a more extensive intermolecular forces of attraction in octane as compared to propane. Hence, octane has a **higher boiling point** as compared to propane. Propane with a lower boiling point will be **distilled in the higher fractions containing propane and butane**, octane with a higher boiling point **will be distilled at a lower column**	1	
A2b	Both propane and butane has **similar molecular sizes with similar boiling points**. Hence, they will leave the column in the same fraction.	1	What is the principle behind the separation of substances that take place in the fractionating column? It will be varying boiling points, not viscosity.
A2c	<table><tr><td></td><td>Molecular formula</td><td>Empirical formula</td></tr><tr><td>propane</td><td>C_3H_8</td><td>C_3H_8</td></tr><tr><td>octane</td><td>C_8H_{18}</td><td>C_4H_9</td></tr></table>	2	Recall: empirical formula is the **simplest** whole number ratio of a substance. Hence, the molecular formula of octane can be further simplified. Students need to note: empirical formula written as $(C_4H_9)_2$.
A2d(i)	Octane has a **higher number of carbon and hydrogen atoms** as compared to butane. Hence, octane has a larger number of C-C and C-H bonds as compared to butane. The enthalpy change of combustion of octane is more negative than butane as **more energy is given out in the bond formation of carbon dioxide and water in the combustion of octane than energy absorbed to break bonds in octane and oxygen.**		$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ Students need to note: - "More energy needed to form bonds" without specifying reactants and products.
A2d(ii)	No. mol of octane combusted = 50 x 1000 / [(12x8) + (18 x 1)] = 438.596 mol Energy released in combustion of octane	1	

	= 438.596 x 5470 = 2399122.81 kJ No. of mol of butane combusted with the same amount of energy = 2399122.81 / 2880 = 833.028 mol Mass of butane combusted = 833.028 x [(12x4) + (10x1)] = 48315.624 g = **48.3 kg (3 s.f.)**	1 1	
A3a	RED CAT AN OX expt | (-) electrode | (+) electrode | electrolyte | (-) electrode | (+) electrode 1 | C | C | Dilute NaCl(aq) | $H_2(g)$ | $O_2(g)$ and $H_2O(l)$ 2 | C | C | Conc NaCl(aq) | $H_2(g)$ | $Cl_2(g)$ 3 | Ag | Ag | Dilute $CuSO_4(aq)$ | copper | oxygen 4 | Cu | Cu | Dilute $CuSO_4(aq)$ | Copper solid /deposits | copper(II) ions	2	Students need to note: in expt 4: copper as product for both (-) and (+) electrodes, thus indicate the state at which it is formed.
A3b	Inert electrodes are **unreactive electrodes which do not participate in the reactions of the cell**. Examples of inert electrodes from the table are **carbon and silver electrodes**. **Non-inert electrodes are reactive and participate in the reactions of the cell**. Examples of non-inert electrodes is **copper electrodes.**	1 1	Students need to note: students did not read the requirements of the question properly and gave examples which are **not** in the table. Note that in this question, silver is to be inferred as inert electrodes based on the products formed (given by question)
A3ci	Observations should be stated. **Reddish brown deposits** formed on the surface of the negative electrode.	1	

A3cii	$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$	1	Check if your equation is balanced! Common error of missing electrons.
A3ciii	**Blue copper(II) sulfate solution decolourises/changed to light blue then colourless over time**. This is due to the **discharge of copper(II) ions to form solid copper.**, hence concentration of copper(II) ions decreases	1 1	
A4a	calcium silicate $CaSiO_3$	1	
(b)(i)	$2Fe_2O_3 \rightarrow 4Fe + 3O_2$ number of mols of Fe_2O_3 = 14 000 x 10^6 / (56x2 + 16 x 3) = 8.75 x 10^7 moles number of mols of Fe = 2 x 8.75 x 10^4 =1.75 x 10^7 moles mass of Fe = 1.75 x 10^7 x 56 = 9.8 x 10^9 g = 9800 tonnes	 1 1 1	Note on the conversion from tonnes to grams. 1 tonne = 1 x 10^3 kg = 1 x 10^6 g Note that the formula of iron(III) oxide contains two iron atoms. Ensure working and units are shown clearly.
(b) (ii)	The iron ore contains iron(III) oxide, and are other **impurities such as silicon dioxide present within the 14000 tonnes.** It could be possible for some of the iron to be **oxidised** again, since it is in contact with the oxygen and heat, **forming iron(III) oxide**, reducing the yield.		

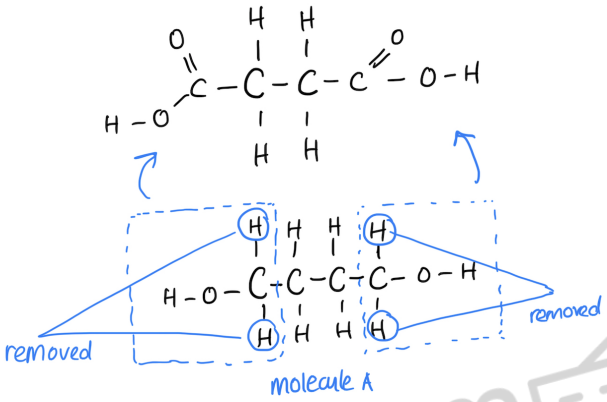
(c)	Nitrogen: The hot air blasted into the furnace contains about **78% of nitrogen**. carbon dioxide: Carbon(coke) reacting with oxygen in the blast furnace to form carbon dioxide. Carbon dioxide is also a **product of the decomposition of calcium carbonate** which is added into the blast furnace. Carbon monoxide **reduces iron(III) oxide to form molten iron and carbon dioxide gas.** carbon monoxide: **carbon dioxide reacts with excess coke (carbon)** to form carbon monoxide.		Ensure the answers are related to the question, i.e. not a general answer such that nitrogen obtained from fractional distillation or carbon dioxide is from the combustion of fuel.
(d)	Pure iron is too soft, thus carbon is added to **increase its strength**. There is a need to add the amount of carbon carefully as higher percentage of carbon added will form high-carbon steel while a low percentage of carbon added will form a low carbon steel. **High-carbon steel is harder but more brittle, less malleable than low-carbon steel.**	1 1	Show the differentiation between high and low carbon steel.
A5(a)		3	Tips: Determine the type of bonding present based on the metallic/non-metallic nature of the elements. Draw the displayed structural formula. Place the element with the most number of bonds in the centre. You may use symbols as shown.
(b)(i)	From equation 1, it is shown that a total of **3 moles of gases such as ammonia and carbon dioxide** are produced. Since **gases occupy a larger volume**		Since instruction mentions “use equation 1”, ensure reference is made.

	than liquid and the engine is hot, there is a likelihood that these gas particles will have an **increase in kinetic energy and move further apart, increasing the pressure in the tank, leading to an explosion.**	1	Do note that the explosion does not occur due to reasons such as the explosive or flammable nature of ammonia or carbon dioxide.
(ii)	Only gases such as **nitrogen and water vapour are released into the atmosphere**. These have **no adverse effects on the environment.** **Oxides of nitrogen** are completely removed, thus there will be no chance of these gases being released into the atmosphere to form **acid rain and causing damage to living things and buildings**.	1 1	Ensure reference is made to both the reactants and products of equations 2 and 3. Explanation on the effect of the pollutants must be explained.
(iii)	**Carbon dioxide, a greenhouse gas**, is still released into the atmosphere. It continues to cause an i**ncrease in the earth's temperature that will result in effects caused by global warming such as melting of ice caps.**	1 1	Ensure environmental issue is explained.
(iv)	$(NH_2)_2CO + H_2O \rightarrow 2NH_3 + CO_2$ – *eqn 1 x 4* $4(NH_2)_2CO + \cancel{4H_2O} \rightarrow \cancel{8NH_3} + 4CO_2$ $\cancel{8NH_3} + 6NO_2 \rightarrow 7N_2 + \cancel{12}H_2O$ – *eqn 3* (8) $4(NH_2)_2CO + 6NO_2 \rightarrow 7N_2 + 8H_2O + 4CO_2$	2	Answer is to be derived by cancelling species which appear on both sides of the equations.
(c)	No. of moles of urea = 160/ [14x2 + 4 + 12 + 16] = 2.66667 mol Concentration = 2.66667 / 0.5 =5.33 mol/dm^3 (3 sf)	1 1	

Section B

Qn	Suggested Answer	Marks	Guidance
6(a)(i)	**Hydrochloric acid is a monobasic acid** which contain a **single-charged negative ion** such as Cl^-, thus having the general formula HA. **Sulfuric acid is a dibasic acid**, with an **anion of double charge, SO_4^{2-}**, thus the formula will be H_2A.	1 1	Change in question: Suggest whether hydrochloric acid and sulfuric acid fit the general formula HA.
(ii)	$2HA + M_2CO_3 \rightarrow 2MA + CO_2 + H_2O$	1	
(iii)	$2CH_3COOH + Ca \rightarrow (CH_3COO)_2Ca + H_2$ From the above equation, it is shown that the charge of the metal, Ca, +2, corresponds to the general equation 2. The co-efficient of CH_3COOH is 2; while that of hydrogen is $\frac{2}{2}$= 1 and the chemical formula of calcium ethanoate corresponds to MA_x.	1 1	Note the chemical formulae of salts of organic acids. Make reference to information from data such as to x and general equation.
(b)(i)	The relationship suggests that the pH is **inversely proportional** to the initial concentration of the acid. If the above is true, the **product of the pH and the initial concentration of the acid has to be a constant.**		

	Using HCl(aq) as an example, the product of the two values are not shown to be a constant. i.e. which are 0.02, 0.1 and 0.14 respectively.		
(ii)	pH is determined by the concentration of hydrogen ions in the solution. The **factors that affect of the pH of an acid are concentration of acid, basicity of the acid and strength of the acid.** For HCl(aq), as its **concentration increases** from 0.01 to 0.2 mol/dm^3, **pH decreases** from 2.0 to 0.7 This trend is the same for all the other acids as well. The second factor which affects the pH is the **basicity of the acid**. If an acid is monobasic, the concentration of hydrogen ions is the same as that of its concentration. However, if the **acid is dibasic like sulfuric acid, the concentration of hydrogen ions is double that of its concentration**, which decreases the pH of the acid. Comparing 0.01 mol/dm^3, of monobasic hydrochloric acid and 0.01mol/dm^3 sulfuric acid, hydrochloric acid has a higher pH of 2.0 compared to 1.7 of sulfuric acid. The third factor is the **strength of the acids**. Weak acids such as ethanoic acid **ionises partially** to form hydrogen ions as compared to **strong acids** such as hydrochloric acid and sulfuric acid which **ionises completely to form hydrogen ions in water**. Comparing 0.1 mol/dm^3 of weak ethanoic acid and 0.1mol/dm^3 strong hydrochloric acid, ethanoic acid has a higher pH of 3.4 compared to 2.0 of hydrochloric acid.	1 1 1	1 mark for identifying each factor and explanation, will be good to quote data.
(iii)	0.04, 1.4 0.10, 1.0		Concentration of hydrogen ions = concentration of hydrochloric acid (monobasic acid) Concentration of hydrogen ions in sulfuric acid will be double of its concentration (dibasic)

			Use data to determine the pH of acid based on the concentration of hydrogen ions.
B7(a)(i)	Relative molecular mass of repeating unit = 16 + (12+2)(4) + 16 + 12+ 16 + [(12)6 + 4] + 12 + 16 + 16 = 220  		Note the oxidation of diol to to form dicarboxylic acid. No units for relative molecular mass. Show working clearly.
(b)(i)	It has many ester linkages (-COO-)		
(ii)	Similarity: Both processes involve **joining together a large number of small molecules/monomers to form a macromolecule/polymer.** At least 2: Differences: In addition polymerisation, there is **no loss of atoms/no side product formed/only 1 product is formed** when monomers are joined together. However, in condensation polymerisation, **a small molecule is removed/side products formed** as two monomers joined together. In addition polymerisation, monomers are **unsaturated C=C** (double covalent bond present between carbon atoms)**/alkenes**. However, in c**ondensation**	1 1 1	

	polymerisation, monomers either have hydroxyl or carboxyl groups/ reactants are diol or diacid) In addition polymerisation, the polymers have the same molecular mass as the monomers. In condensation polymerisation, the polymers have different molecular masses from the monomers.		
Either B8a	The relative reactivity: **Aluminium is the most reactive of the three elements and silicon is the least reactive of the three elements. Carbon is more reactive than silicon.** **Carbon cannot reduce aluminium from aluminium oxide to form aluminium metal as aluminium oxide remains in the silicon.** Hence, carbon is less reactive than aluminium. From the equation, **carbon reduced silicon from silicon dioxide to form silicon element.** Hence, carbon is more reactive than silicon.	1 1	Students need to note: students discussed about ease of extraction instead of reduction.
Either B8b	NOTE: since this is a 5m question, examiners will EXPECT AT LEAST 5 KEY POINTS. Question requirement: " use ideas of bonding and structure". Hence, you should explain BOTH for each oxide. Carbon monoxide is a **simple covalent substance** made up of **simple, discrete molecules. A low amount of energy is absorbed to overcome the weak intermolecular forces of attraction**. Hence, carbon monoxide has a **low melting point of -205 °C and a boiling point of -192 °C.** Silicon dioxide has a **giant covalent lattice structure** made up of silicon and oxygen atoms. **A large amount of energy is absorbed to overcome the strong covalent bonds between silicon and oxygen ATOMS**. Hence,	5 1 1	Students need to note: - Students did not mention both bonding and structure - Carbon monoxide was explained as a simple molecule - "Strong forces between molecules""

	silicon dioxide has a **high melting point of 1600 °C and a boiling point of 2230 °C.** Aluminium oxide has a **giant ionic lattice structure** made up of aluminium and oxide ions. **A large amount of energy is absorbed to overcome the strong electrostatic forces of attraction between aluminium and oxide ions.** Hence, aluminium oxide has a **high melting point of 2000 °C and a boiling point of 2980 °C.** Both carbon monoxide and silicon dioxide were unable to conduct electricity in any state as CO is a simple covalent substance and SiO_2 is a giant covalent substance which both **do not have any free-moving mobile electrons and ions to conduct electricity.** Aluminium oxide is able to conduct electricity in molten state as there are **free-moving ions not held in fixed positions which an conduct electricity.** **Carbon monoxide is a gas at r.t.p hence has low density, while silicon dioxide and aluminium oxide are solid at r.t.p hence has high density.**	1 1 1	
Either 8c	Mass of aluminium in a 100g of alloy = 2.8 x 27 = 75.6g Maximum possible percentage by mass of silicon in alloy = 100% – 75.6% – 6% = 18.4% Minimum possible percentage by mass of silicon in alloy = 100% – 75.6% – 8% = 16.4% Hence, alloy Y has the closest percentage by mass of silicon between 16% – 19%.	1 1 1	
Or 8a	Experiment 2 is used as a control.	1 1	

	There is **only one factor changed in each of the other experiments**.		
Or 8b	You should make clear comparisons and explain collision theory clearly between the different experiments with reference to the control experiment 2. Also cite data! Comparing experiment 1 and 2, the **concentration of iodide ions used is 0.1 mol/dm^3, half that of the experiment 2 at 0.2 mol/dm^3**. Hence, with half the concentration, the **number of reactant particles (iodide ions) per unit volume decreases. Hence, this decreases the frequency of collisions and frequency of effective collisions decreased. Hence, time taken for blue-black colour to appear increased from 27s to 50s. Rate of reaction decreased.** Comparing experiments 2 and 3, the **temperature has doubled from 20°C to 40 °C.** When temperature increased, this **increases the kinetic energy of iodide ions. This increases the frequency of collisions. Hence, the number of particles with energy equal to or greater than activation energy increased. Hence, this increases the frequency of effective collisions. Hence, time taken for blue-black colour to appear decreased from 27s to 15s. Rate of reaction increased.** Comparing experiments 2 and 4, the presence of catalysts Cu^{2+} ions in experiment 4 will speed up the rate of reaction unlike the absence of catalyst in experiment 2. Hence, the catalysts **provide an alternative pathway of lower activation energy for the reaction to occur. A higher number of particles have energy equal to or greater than activation energy. Hence, frequency of effective collisions increases. Hence, time taken for blue-black colour to appear decreased from 27s to 20s. Rate of reaction increased.**	5 2 2 1	Students need to note: - More concentrated solution was not described was more iodide ions **per unit volume** - More collisions instead of **increased frequency of collisions** - [R] More number of collisions -
Or 8c	No. of moles of hydrogen peroxide used = 30/1000 x 0.05		

	= 0.0015 mol No. of moles of iodide ions used (for expt 2, 3, 4) = 10/1000 x 0.2 = 0.002 mol Mol ratio of I^-: H_2O_2 = 2: 1 **For 0.002 mol of iodide ions used, 0.001 mol of hydrogen peroxide is required for reaction. However, there is 0.0015 mol of H_2O_2 and there is excess 0.0005 mol of H_2O_2.** Hence, iodide ions is the limiting reagent for experiments 2, 3 and 4. OR **For 0.0015 mol of hydrogen peroxide used, 0.003 mol of iodide ions is required for the reaction. However, there is only 0.002 mol of iodide ions and there is insufficient iodide ions for the reaction.** Hence, iodide ions is the limiting reagent for experiments 2, 3 and 4. AND No. of moles of iodide ions used (for expt 1) = 10/1000 x 0.1 = 0.001 mol Mol ratio of I^-: H_2O_2 = 2: 1 **For 0.001 mol of iodide ions used, 0.0005 mol of hydrogen peroxide is required for reaction. However, there is 0.0015 mol of H_2O_2 and there is excess 0.001 mol of H_2O_2.** Hence, iodide ions is the limiting reagent for experiments 1	1 1 1	
