



SUBJECT: **Chemistry**  
 PAPER NUMBER: I  
 DATE: 26<sup>th</sup> August 2022  
 TIME: 9:00 p.m. to 11:05 p.m.

**Useful data:**

Relative atomic masses: H = 1, O = 16, Na = 23

Standard temperature and pressure (stp): 0 °C and 1 atm (760 mm Hg)

The molar volume for gases at stp = 22.4 dm<sup>3</sup>

Specific heat capacity of water = 4.2 J g<sup>-1</sup> °C<sup>-1</sup>

Faraday constant = 96500 C mol<sup>-1</sup>

Avogadro constant, L = 6.02 x 10<sup>23</sup>

$\Delta H = mc\Delta\theta$

**Directions to Candidates**

- Write your index number in the space at the top left-hand corner of this page.
- Answer **ALL** questions. Write all your answers in the spaces provided in this booklet.
- The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated in brackets.
- You are reminded of the necessity for orderly presentation in your answers.
- In calculations you are advised to show all the steps in your working, giving your answer at each stage.
- The use of electronic calculators is permitted.
- A Periodic Table is printed on the back of this booklet.

**For examiners' use only:**

Question	1	2	3	4	5	6	7	8	9	10	11	12	Total
Score													
Maximum	6	6	6	6	6	6	6	6	6	6	20	20	100

**Section A: Answer ALL questions.**

1. Objects made out of iron may develop rust on them depending on the environmental conditions.

a. Give **TWO** factors that are necessary for iron to rust.

i. Factor 1: \_\_\_\_\_ (1)

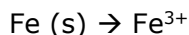
ii. Factor 2: \_\_\_\_\_ (1)

b. An iron garden gate has started to form rust. Give **TWO** ways that may be used to protect the gate from further rusting.

i. Method 1: \_\_\_\_\_ (1)

ii. Method 2: \_\_\_\_\_ (1)

c. When iron rusts the following conversion occurs:



i. What type of reaction is this?

\_\_\_\_\_ (1)

ii. Explain your answer to part (c)(i) in terms of electrons.

\_\_\_\_\_ (1)

**(Total: 6 marks)**

6

2. Use the terms below to complete the paragraph. Each term may be used only once or not at all.

solid	boils	liquid	osmosis
freezes	solvent	crops	filtration

Water is a \_\_\_\_\_ which is essential for our day to day living. One way to check if water is pure is to check if it \_\_\_\_\_ at 0 °C and \_\_\_\_\_ at 100 °C.

Water is a very good \_\_\_\_\_. Climate change is affecting our supply of water causing some countries to experience flooding while some countries do not have enough to water their \_\_\_\_\_. In Malta, drinking water is obtained from sea water by reverse \_\_\_\_\_.

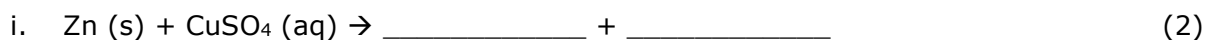
**(Total: 6 marks)**

6

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3. The reactions below are types of displacement reactions.

a. Complete the missing substances in the following equations:



b. Give **ONE** observation that can be made in reaction in part (a)(i).

\_\_\_\_\_ (1)

c. Give **ONE** observation that can be made in reaction in part (a)(ii).

\_\_\_\_\_ (1)

**(Total: 6 marks)**

6
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4. Consider atoms of sodium, sulfur, hydrogen, and nitrogen.

a. Write down the electronic configuration of:

i. Sodium, Na: \_\_\_\_\_ (1)

ii. Sulfur, S: \_\_\_\_\_ (1)

iii. Hydrogen, H: \_\_\_\_\_ (1)

iv. Nitrogen, N: \_\_\_\_\_ (1)

b. With reference to your answer to part (a), state the type of bonding that would be formed:

i. between Na and S; \_\_\_\_\_ (1)

ii. between H and N. \_\_\_\_\_ (1)

**(Total: 6 marks)**

6
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5. Boron has two isotopes, represented as  $^{10}\text{B}$  and  $^{11}\text{B}$ .

a. Define the term 'isotopes'.

\_\_\_\_\_  
 \_\_\_\_\_ (2)

b. The isotopes of boron,  $^{10}\text{B}$  and  $^{11}\text{B}$ , are in the ratio 19.9 : 80.1. Use these values to calculate the atomic mass of boron.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ (4)

**(Total: 6 marks)**

6
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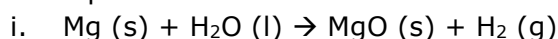
6. Magnesium and calcium are metals in Group 2 of the Periodic Table  
 a. Why are these two metals placed in Group 2 of the Periodic Table?

(1)

- b. When magnesium burns in air an intense white light is produced which can be very dangerous. Mention **ONE** use of this reaction of magnesium.

(1)

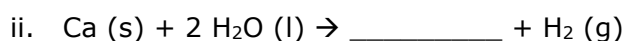
- c. Both calcium and magnesium react with water but the products are different as shown in the equations below.



Give **TWO** observations that can be made during this reaction.

Observation 1: \_\_\_\_\_ (1)

Observation 2: \_\_\_\_\_ (1)



Fill in the missing product in the above equation.

(1)

- d. Although magnesium and calcium are in the same group, calcium is more reactive. Explain why calcium is more reactive than magnesium.

(1)

(Total: 6 marks)

6

7. The table below contains various chemical substances which are used in everyday life. Complete the table to give **ONE** use of each chemical.

	Chemical	Use
a.	Washing soda / $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	
b.	Slaked lime / calcium hydroxide	
c.	Plaster of Paris / $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$	
d.	Caustic soda / sodium hydroxide	
e.	Baking soda / sodium hydrogencarbonate	
f.	Milk of magnesia / magnesium hydroxide	

(Total: 6 marks)

6

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8. Air is a mixture of gases. Gases may be obtained from air by fractional distillation.
- a. Carbon dioxide is obtained as a solid called dry ice. The dry ice will warm up and turn into gas.
- i. Give a chemical test for carbon dioxide.

\_\_\_\_\_ (1)

- ii. Why is solid carbon dioxide called 'dry ice'?

\_\_\_\_\_ (1)

- b. The water vapour present in air can be condensed to liquid water. Anhydrous copper(II) sulfate,  $\text{CuSO}_4$ , may be used to prove that a fluid contains water.
- i. Mention **ONE** observation that may be made during this chemical test.

\_\_\_\_\_ (1)

- ii. Give a balanced equation for this reaction.

\_\_\_\_\_ (2)

- c. The main gases present in air are oxygen and nitrogen. State the approximate percentage of nitrogen present in air.

\_\_\_\_\_ (1)

**(Total: 6 marks)**

6

9. Oxygen and carbon are both non-metals.

- a. Draw a dot-and-cross diagram, showing outer electrons only, to show the bonding in oxygen,  $\text{O}_2$ .

\_\_\_\_\_ (2)

- b. Carbon forms giant covalent molecules, called macromolecules. Give the name of **TWO** macromolecules of carbon.

\_\_\_\_\_ (2)

- c. With reference to the bonding present, explain why:
- i. oxygen has a low boiling point;

\_\_\_\_\_ (1)

- ii. a large amount of energy is required for solid carbon to change state.

\_\_\_\_\_ (1)

**(Total: 6 marks)**

6

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10. Acids react with bases and alkalis.

a. Complete the following sentence:

The reaction between an acid and a base is called a \_\_\_\_\_ reaction. (1)

b. What is the difference between a base and an alkali?

\_\_\_\_\_ (1)

c. Complete the following word equation:

Hydrochloric acid + zinc oxide  $\rightarrow$  \_\_\_\_\_ + \_\_\_\_\_ (2)

d. Give a balanced chemical equation for the reaction between potassium hydroxide and dilute sulfuric acid.

\_\_\_\_\_ (2)

**(Total: 6 marks)**

6

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**Section B: Answer ALL questions from this section.**

11. This question is about rates of reactions.

a. Define 'rate of reaction'.

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(2)

b. Give **THREE** factors that may affect the rates of chemical reaction **except** for temperature and surface area.

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

(3)

c. Calcium carbonate chips react with hydrochloric acid giving off carbon dioxide. In an experiment, the volume of carbon dioxide produced by this reaction is measured every 30 seconds.

Time (s)	30	60	90	120	150
Volume CO <sub>2</sub> (cm <sup>3</sup> )	8	14	18	20	20

i. Draw a labelled diagram to show how the experiment is carried out. Include the apparatus to measure the volume of carbon dioxide produced and any other quantity required to calculate the rate.

(4)

ii. On the graph paper, plot a graph of volume of carbon dioxide on the y-axis against time on the x-axis for this reaction. Label this graph (ii). (5)

iii. On the same axes as part (b)(ii) sketch the graph that would be obtained if the same mass of powdered calcium carbonate is used instead of calcium carbonate chips. Label this graph (iii). (2)

iv. On the same axes as part (b)(ii) sketch the graph that would be obtained if warm hydrochloric acid of the same concentration was used. Label this graph (iv). (2)

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- d. If the same mass of magnesium carbonate is used rather than calcium carbonate, a larger volume of carbon dioxide is produced. Explain.

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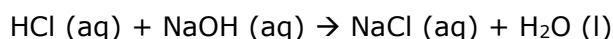
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(2)

**(Total: 20 marks)**

20

12. In a titration experiment dilute hydrochloric acid and sodium hydroxide react according to the equation:



- a. In this experiment 25.0 cm<sup>3</sup> of hydrochloric acid of concentration 0.060 mol dm<sup>-3</sup> are placed in a conical flask.
- i. Calculate the amount (in moles) of hydrochloric acid in the conical flask.

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(3)

- ii. The reaction requires 15.6 cm<sup>3</sup> of sodium hydroxide solution which is added dropwise. Use your answer in part (a)(i) to calculate the concentration of the sodium hydroxide solution used.

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(4)

- iii. Hence calculate the mass of anhydrous sodium hydroxide which was dissolved in 1000 cm<sup>3</sup> of water.

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(2)



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- b. The hydrochloric acid used has a concentration of  $0.060 \text{ mol dm}^{-3}$ . Why is this called a 'standard solution'?

(1)

- c. Why is the hydrochloric acid placed in a conical flask rather than a beaker?

(1)

- d. An acid-base indicator is used in a titration.

- i. Why is an indicator necessary?

(1)

- ii. Name a suitable indicator for this reaction.

(1)

- e. In the spaces below draw diagrams for these items of glassware that are used in a titration.

i. volumetric flask	ii. pipette	iii. burette

(3)

- f. A white tile is often used in a titration.

- i. Where is a white tile placed in a titration setup?

(1)

- ii. Why is a white tile used in a titration?

(1)

- g. State **TWO** precautions necessary in a titration.

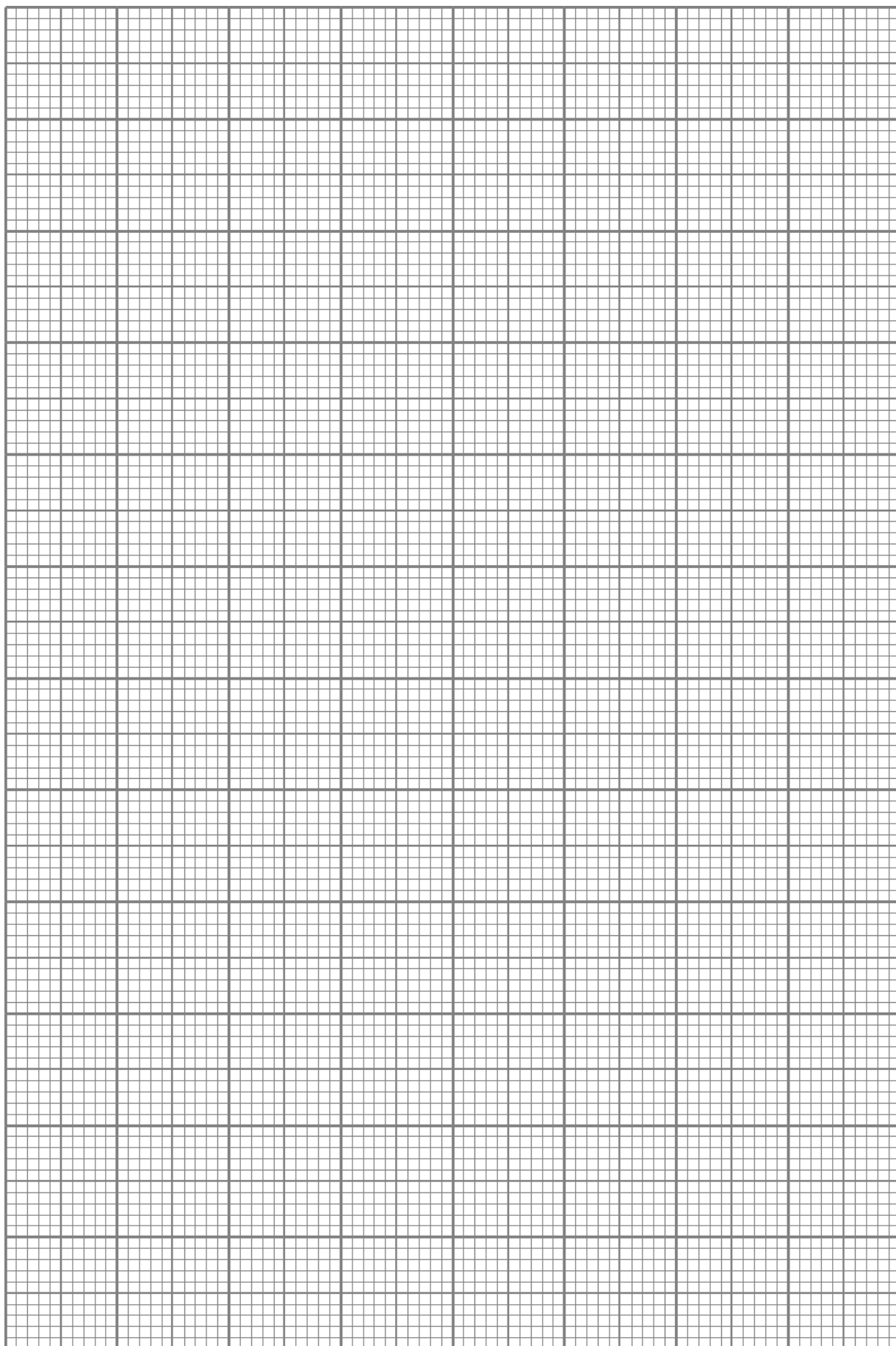
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20

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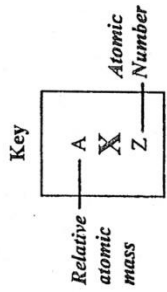
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PERIODIC TABLE

I	II	III	IV	V	VI	VII	VIII
1 H 1	9 Be 4	11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
23 Na 11	24 Mg 12	27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
39 K 19	40 Ca 20	45 Sc 21	48 Ti 22	51 V 23	52 Cr 24	55 Mn 25	56 Fe 26
85 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44
133 Cs 55	137 Ba 56	139 La 57	178.5 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76
223 Fr 87	226 Ra 88	227 Ac 89	204 Th 81	207 Pa 82	209 U 83	210 Np 84	222 Pu 86
			65 Zn 30	63.5 Cu 29	59 Ni 28	59 Co 27	65 Zn 30
			115 In 49	108 Ag 47	106 Pd 46	103 Rh 45	112 Cd 48
			204 Tl 81	197 Au 79	195 Pt 78	192 Ir 77	201 Hg 80
			70 Ga 31	73 Ge 32	75 As 33	79 Se 34	84 Kr 36
			119 Sn 50	122 Sb 51	127 Te 52	128 I 53	131 Xe 54
			209 Bi 83	209 Po 84	210 At 85	210 Rn 86	222 Fr 87



140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	252 Es 99	257 Fm 100	258 Md 101	259 No 102	260 Lr 103




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SUBJECT:	<b>Chemistry</b>
PAPER NUMBER:	IIB
DATE:	26 <sup>th</sup> August 2022
TIME:	4:00 p.m. to 6:05 p.m.

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**Useful data:**

Relative atomic masses: O = 16, Ca = 40

Standard temperature and pressure (stp): 0 °C and 1 atm (760 mm Hg)

 The molar volume for gases at stp = 22.4 dm<sup>3</sup>

 Specific heat capacity of water = 4.2 J g<sup>-1</sup> °C<sup>-1</sup>

 Faraday constant = 96500 C mol<sup>-1</sup>

 Avogadro constant, L = 6.02 x 10<sup>23</sup>
 $\Delta H = mC\Delta\theta$ 


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**Directions to Candidates**

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- Answer **ALL** questions from Section A. Write all your answers for Section A in the spaces provided in this booklet.
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Score															
Maximum	6	6	6	6	5	6	6	5	7	7	20	20	20	20	100

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**Section A: Answer ALL questions.**

1. Most salts form crystals. Some salts form crystals that contain water of crystallisation.
- a. What is water of crystallisation?

\_\_\_\_\_ (1)

- b. Name a salt that forms crystals that do **not** have water of crystallisation.

\_\_\_\_\_ (1)

- c. Salts that contain water of crystallisation can be deliquescent, efflorescent, or hygroscopic. Define the terms:

i. deliquescent;

\_\_\_\_\_ (1)

ii. efflorescent;

\_\_\_\_\_ (1)

iii. hygroscopic.

\_\_\_\_\_ (1)

- d. Write the chemical formula of hydrated cobalt(II) chloride hexahydrate.

\_\_\_\_\_ (1)

**(Total: 6 marks)**

6

2. When substances are mixed with water, some dissolve to form solutions while others react with water to form new substances.
- a. Identify what happens to sodium chloride, sulfur dioxide, oxygen, and nitrogen when they are mixed with water. Place these substances in the table below accordingly.

Chemical Change	Physical Change

(4)

- b. Write a balanced chemical equation for the reaction of sodium with water.

\_\_\_\_\_ (2)

**(Total: 6 marks)**

6

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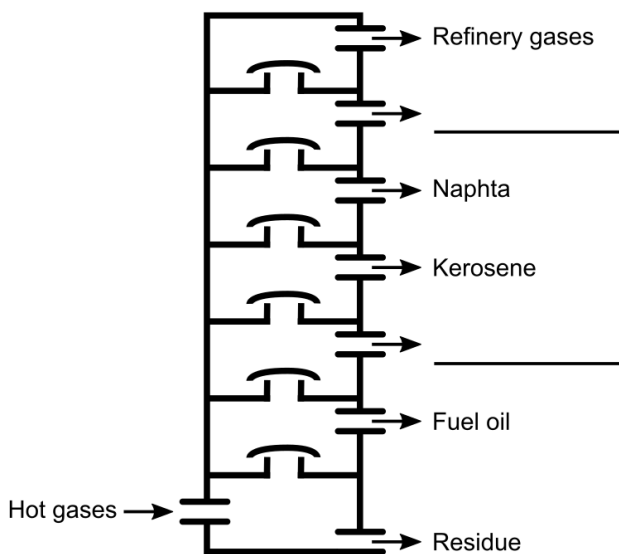
3. Use the letter next to each gas to match the gases with their corresponding test and result.

	Gas		Test and Result
a.	Oxygen		Produces dense white smoke with ammonia gas.
b.	Carbon dioxide		Brown gas that turns litmus paper blue to red.
c.	Ammonia		Turns acidified $K_2Cr_2O_7$ solution from orange to green.
d.	Nitrogen dioxide		Extinguishes a burning splint.
e.	Hydrogen chloride		Relights a glowing splint.
f.	Sulfur dioxide		Turns litmus paper from red to blue.

6

(Total: 6 marks)

4. The diagram below shows a fractionating tower that is used to separate the fractions in crude oil.



- a. Fill in the missing fractions in the spaces provided. (2)
- b. Indicate (b) on the diagram where the temperature of the tower is the coolest. (1)
- c. Large hydrocarbons are often cracked to form smaller more useful hydrocarbons.
  - i. Write a balanced chemical equation for the cracking of decane ( $C_{10}H_{22}$ ).

(2)

ii. Specify **ONE** condition that is required for the reaction in part (c)(i) to happen.

(1)

6

(Total: 6 marks)

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5. In an experiment to determine the chemical formula of calcium oxide, 5.0 g of calcium were heated in a plentiful supply of air. The final mass of the product was 7.0 g.

a. Calculate the mass of oxygen that reacted with calcium.

\_\_\_\_\_ (1)

b. Calculate the number of moles present in:

i. calcium;

\_\_\_\_\_ (1)

ii. oxygen.

\_\_\_\_\_ (1)

c. Using your answers to part (b), determine the formula of calcium oxide.

\_\_\_\_\_  
\_\_\_\_\_ (2)

**(Total: 5 marks)**

5

6. Different separation techniques are used to separate different types of mixtures.

a. What kind of mixture is separated when using:

i. filtration; \_\_\_\_\_ (1)

ii. simple distillation; \_\_\_\_\_ (1)

iii. fractional distillation. \_\_\_\_\_ (1)

b. Draw a labelled diagram for a simple distillation setup.

(3)

**(Total: 6 marks)**

6



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7. Carboxylic acids, also known as organic acids, are a homologous series of organic compounds.
- a. Draw the displayed formula of pentanoic acid.

(2)

- b. Draw a circle around the functional group on the displayed formula in part (a). (1)

- c. Sodium reacts with ethanoic acid.

- i. Write a balanced chemical equation for this reaction.

(2)

- ii. Give the name of the salt formed.

(1)

**(Total: 6 marks)**

6

8. One of the tests chemists use to identify unknown substances is the flame test.

- a. Describe how a flame test is performed using a clean nichrome wire.

(2)

- b. The following table shows the flame test colours obtained from testing three different substances. Fill in the ion that may be present in these substances:

Flame test colour	Ion present
Blue green	
Yellow	
Lilac	

(3)

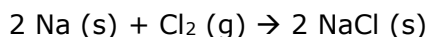
**(Total: 5 marks)**

5

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9. When sodium reacts with chlorine, sodium chloride is produced according to the following equation:



- a. Give the oxidation number of:
- sodium atoms; \_\_\_\_\_ (1)
  - chlorine molecules; \_\_\_\_\_ (1)
  - sodium ions; \_\_\_\_\_ (1)
  - chloride ions. \_\_\_\_\_ (1)
- b. Which substance was oxidised? Explain your answer in terms of gain/loss of electrons.

\_\_\_\_\_ (2)

- c. Which substance is the oxidising agent? \_\_\_\_\_ (1)

**(Total: 7 marks)**

7

10. Copper is a metal that has been known since antiquity. Most copper is extracted from copper(II) carbonate.

- a. Describe the **TWO** steps required to produce copper from copper(II) carbonate.

\_\_\_\_\_ (2)

- b. Write a balanced chemical equation including state symbols to represent **ONE** of the reactions in part (a).

\_\_\_\_\_ (3)

- c. Copper is a particularly useful metal. State the property on which **each** of the following uses depends:

- i. professional kitchen cookware; \_\_\_\_\_ (1)

- ii. electrical wiring. \_\_\_\_\_ (1)

**(Total: 7 marks)**

7

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**Section B: Answer TWO questions from this section.**

11. Hydrogen gas may be prepared in the laboratory using zinc powder, dilute hydrochloric acid, and a simple apparatus.
- a. Give a balanced chemical equation for the laboratory preparation of hydrogen using zinc powder and dilute hydrochloric acid. Include **all** state symbols. (3)
- b. Explain why the following substances are **not** suitable for this reaction:
- concentrated nitric acid;
  - copper. (2)
- c. The following apparatus is used in the laboratory to collect a pure dry sample of hydrogen. Draw a diagram to show how this apparatus is set up.
- Zinc granules
  - Dilute hydrochloric acid
  - Calcium chloride
  - Thistle funnel
  - Conical flask
  - U-tube
  - Gas jar
  - Stoppers and tubing (3)
- d. A student who tried to prepare hydrogen reacted some magnesium ribbon with some hydrochloric acid and managed to collect  $3.6 \text{ dm}^3$  of hydrogen measured at stp.
- Calculate the amount (in moles) of hydrogen produced. (1)
  - Calculate the mass of magnesium reacted completely during the reaction. (2)
  - Calculate the volume of  $2.0 \text{ mol dm}^{-3}$  hydrochloric acid that was used. (3)
- e. The student tests for hydrogen using a lighted splint.
- What will the student observe if hydrogen is present? (1)
  - Give the equation for the reaction that takes place during the test for hydrogen. (2)
- f. Hydrogen is being used as a fuel much more frequently in recent years. Give **ONE** advantage and **ONE** disadvantage of using hydrogen as a fuel. (2)
- g. Give **ONE** other use of hydrogen (besides as a fuel). (1)

**(Total: 20 marks)**

***Please turn the page.***

12. Some aqueous solutions, such as those of copper(II) nitrate and sodium chloride, are found to conduct electricity.
- a. Describe the electrolysis of copper(II) nitrate solution using graphite electrodes. The description should include:
- a clearly labelled diagram; (3)
  - the observation made at the cathode; (1)
  - the observation made at the anode; (1)
  - how the colour of the solution changes, if at all, during the experiment; (1)
  - balanced ionic half equations for the reaction at **each** electrode. (4)
- b. The experiment in part (a) is repeated using copper electrodes. Give:
- the observation made at the cathode; (1)
  - the observation made at the anode; (1)
  - how the colour of the solution changes, if at all, during the experiment; (1)
  - a balanced ionic half equation for the reaction at the anode. (2)
- c. Consider the electrolysis of a solution of sodium chloride:
- What substance is formed at the cathode? (1)
  - What substance is formed at the anode? (1)
  - State what will happen to red litmus paper if it is used to test:
    - the solution at the end of the reaction;
    - the substance formed at the cathode;
    - the substance formed at the anode. (3)

**(Total: 20 marks)**

13. Ammonium sulfate is used extensively as a fertilizer. It may be manufactured by reacting ammonia with sulfuric acid.
- a. In the industrial process of ammonia, hydrogen is reacted with nitrogen. Describe this process. Your answer should include:
- where nitrogen gas is obtained from; (1)
  - the balanced chemical equation for the reaction; (2)
  - the conditions (temperature, pressure and catalyst) for the reaction; (3)
  - how **each** of the conditions in part (a)(iii) affects the yield of ammonia. (3)
- b. In the production of sulfuric acid, sulfur and oxygen are first converted to sulfur trioxide through two reactions.
- Give the balanced chemical equation for the reaction between sulfur and oxygen. (2)
  - Give the balanced chemical equation for the reaction between the product to part (b)(i) and further oxygen. (2)
  - State the conditions (temperature, pressure, catalyst) used in the reaction in part (b)(ii). (3)
  - Why is sulfur trioxide **not** added directly to water to form sulfuric acid? (1)
  - Explain how sulfur trioxide is converted to sulfuric acid. (2)
- c. Why do agricultural companies prefer to store ammonium sulfate rather than ammonium nitrate as a fertilizer? (1)

**(Total: 20 marks)**

14. This question is about reversible reactions and chemical equilibrium.
- a. What is a reversible reaction? (1)
- b. What does it mean when a reversible reaction reaches equilibrium? (1)
- c. State Le Chatelier's Principle. (2)
- d. The equation for the reversible reaction between ethanol and ethanoic acid is:  
$$\text{C}_2\text{H}_5\text{OH} + \text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$$
- i. What roles does sulfuric acid play in the reaction shown above? (2)
- ii. What would happen to this reaction if more water is added to the products? (1)
- iii. What is the name of the compound  $\text{CH}_3\text{COOC}_2\text{H}_5$ ? (1)
- iv. To which homologous series does  $\text{CH}_3\text{COOC}_2\text{H}_5$  belong? (1)
- e. Methanol is produced by this reaction:  
$$\text{CO}(\text{g}) + 2 \text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}) \quad \Delta\text{H} = -92 \text{ kJ mol}^{-1}$$
- Explain what happens to the reaction when:
- i. the temperature is increased; (2)
- ii. the pressure is increased; (2)
- iii. a suitable catalyst is used. (2)
- f. The equilibrium between nitrogen dioxide and nitrogen tetroxide is often used in the laboratory to demonstrate the effect of pressure on chemical equilibrium. This is because the colour of both compounds makes it easy to see changes.  
$$2 \text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$$
  
brown      yellow
- Explain how this is done. Your answer should include:
- i. a labelled diagram for the experiment; (2)
- ii. how pressure is increased/decreased; (1)
- iii. any observations made when pressure is increased and decreased. (2)

**(Total: 20 marks)**

***Please turn the page.***















