Index Number:_____ SEC06/1.21m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	30th June 2021
TIME:	9:00 a.m. to 11:05 a.m.

Useful data:

Relative atomic masses: H = 1, O = 16, Cl = 35.5, 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^3

Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

Faraday constant = 96500 C mol^{-1}

Avogadro constant, L = 6.02 x 10^{23}

$\Delta H = mc\Delta\theta$

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**	**7**	**6**	**5**	**6**	**6**	**6**	**6**	**5**	**7**	**20**	**20**	**100**

Section A: Answer ALL questions

1. This question is about atomic structure and the Periodic Table.
   a. The element sodium, Na, is found in Group 1 of the Periodic Table. Give **ONE** reason why sodium is placed in Group 1.

_____ (1)

   b. The table below is incomplete. Fill in the missing data for the atoms of potassium and chlorine.

	Protons	**Neutrons**	**Electrons**
Potassium-39	19		19
Chlorine-35	17		

(3)

   c. State the type of bonding in the compound that is formed when potassium and chlorine react together.

_____ (1)

   d. Which particle in an atom has the smallest mass?

_____ (1)

(Total: 6 marks)

6

2. Air contains many gases which interact with substances when they are heated.
   a. When magnesium ribbon is heated in air it reacts very strongly.
      i. State **TWO** observations that can be made during this reaction.

Observation 1 _____ (1)

Observation 2 _____ (1)

      ii. Give a balanced equation to show the reaction of magnesium with the nitrogen, N_2, present in air.

_____ (2)

      iii. When heated in air, magnesium ribbon reacts with two other substances besides nitrogen gas. Give the names or formulae of these **TWO** other substances.

_____ (2)

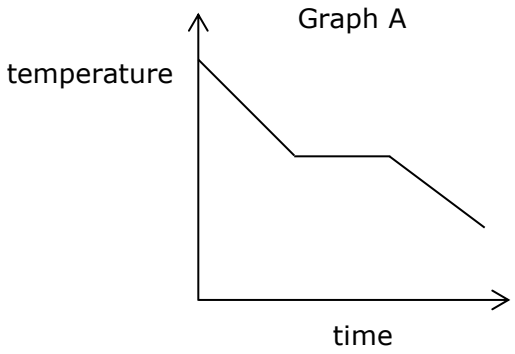
   b. Iron rusts quite easily when the right conditions are present. However, rain has no effect on an iron gate if the iron is painted. Explain.

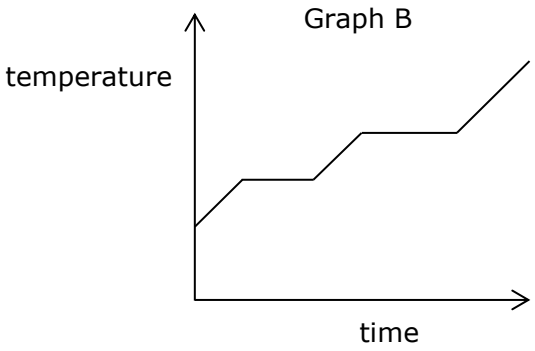
_____ (1)

(Total: 7 marks)

7

3. The graphs below are graphs of temperature against time for two different substances.





a. The following questions are about graph A.

i. What does graph A represent?

_____ (1)

ii. What does the horizontal part in graph A represent?

_____ (1)

iii. Why does graph A show a downward slope past the flat horizontal part?

_____ (1)

b. The following questions are about graph B.

i. What does graph B represent?

_____ (1)

ii. Explain why graph B shows two flat horizontal parts.

_____

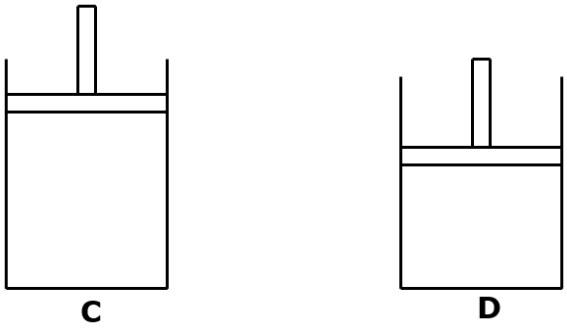
_____ (2)

(Total 6 marks)

6

Please turn the page.

4. The diagrams show two cylinders, **C** and **D**. Cylinder **C** contains 100 cm^3 of neon gas. After some time, the piston in cylinder **C** is pushed in as shown in cylinder **D**. The volume inside cylinder **D** is now 80 cm^3.



a. Show on the diagram how the particles of neon can be represented in cylinder **C** and cylinder **D**. (2)

b. In which of the two cylinders is there a higher pressure? Explain your answer.

_____

_____ (2)

c. What other factor increases momentarily when the piston is pushed in?

_____ (1)

(Total: 5 marks)

5

5. Some substances are unstable on heating forming new substances while other substances are stable to heat.

a. The table below shows some substances. Complete the table by writing stable or unstable. The first one has been done for you.

Substance	Stable or unstable on heating
sodium carbonate, Na_2CO_3 (s)	Stable
sodium hydroxide, NaOH (s)	
potassium nitrate, KNO_3 (s)	
calcium hydrogencarbonate, $Ca(HCO_3)_2$ (aq)	
sodium chloride, NaCl (s)	

(4)

b. Give a balanced equation to show the action of heat on **ONE** of the unstable substances in part (a).

_____ (2)

(Total: 6 marks)

6

6. Supermarkets often sell items that serve to remove humidity from small places like drawers or cupboards. Some of these items are in the form of small boxes that contain anhydrous calcium chloride, $CaCl_2$. When they absorb humidity the calcium chloride changes to $CaCl_2.xH_2O$. In an experiment it is found that 11.1 g of $CaCl_2$ absorbs 3.6 g of water.

   a. Calculate the number of moles of anhydrous calcium chloride used.

_____

_____ (2)

   b. Calculate the number of moles of water absorbed.

_____

_____ (2)

   c. Use your answers to part (a) and part (b) to calculate the value of x in $CaCl_2.xH_2O$.

_____

_____ (2)

(Total: 6 marks)

6

7. Ethanol and ethanoic acid are organic compounds that have been used extensively by humans for many years.

   a. Ethanol is the second member of the alcohols homologous series.

      i. Draw the structure of ethanol showing **all** bonds.

(2)

      ii. Give a balanced equation to show how ethanol may be prepared from glucose, $C_6H_{12}O_6$, by fermentation.

_____ (2)

   b. Ethanoic acid is a weak acid. Similar to other acids, ethanoic acid can react to form salts. Give a balanced equation to show the reaction of ethanoic acid with sodium carbonate.

_____ (2)

(Total: 6 marks)

6

8. Hydrogen is a light gas that is a clean fuel since it produces only water when burnt.
   a. Hydrogen may be prepared in the laboratory by adding dilute hydrochloric acid, HCl, to iron filings, Fe.
      i. Give a balanced equation for this reaction.

_____ (2)

      ii. Give **ONE** observation that may be made during this reaction.

_____ (1)

      iii. How is the hydrogen gas produced collected?

_____ (1)

   b. The reaction in part (a) is a redox reaction. Give the name or formula of the reducing agent in this reaction. Give a reason for your answer.

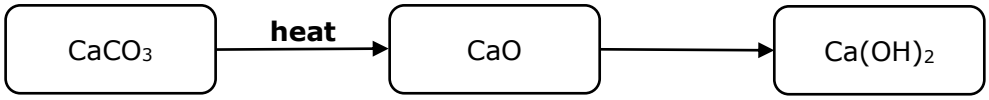
Reducing agent: _____ (1)

Reason: _____ (1)

6

(Total: 6 marks)

9. Consider the following scheme:



   a. How is calcium oxide, CaO, converted into calcium hydroxide, $Ca(OH)_2$?

_____ (1)

   b. The reaction in part (a) must be carried out carefully. Explain.

_____ (1)

   c. Why is calcium oxide used when ammonia gas is prepared?

_____ (1)

   d. Sometimes farmers add calcium oxide to the soil in their fields. Explain.

_____ (1)

   e. The common name for calcium carbonate, $CaCO_3$, is limestone. Malta and Gozo's magnificent Stone Age temples and the impressive fortifications were constructed using local limestone. Nowadays, one of the biggest enemies of these structures is acid rain, which leads to corrosion of the limestone. Give the name or formula of a substance which causes acid rain.

_____ (1)

5

(Total: 5 marks)

10. This question is about bonding.

a. Draw dot-cross diagrams, showing outer electrons only, to represent the bonding in:

i. magnesium oxide, MgO;

(2)

ii. ammonia, NH_3.

(2)

b. Which of the two compounds, magnesium oxide or ammonia has the lower boiling point? Explain your answer by considering both magnesium oxide and ammonia.

_____

_____

_____

_____

_____ (3)

(Total: 7 marks)

7

Please turn the page.

Section B: Answer ALL questions

11. One of the problems that chemists face is when impurities need to be removed. Consider the situations given below.

    a. Given a mixture of sugar and sand, state the processes, in the correct order, that need to be carried out so as to obtain sugar crystals from the mixture.

_____

_____

_____ (3)

    b. Ethanol has a boiling point of around 78 °C at atmospheric pressure. It is in a mixture with another liquid of boiling point 110 °C. These liquids are miscible.

        i. Name the process by which pure ethanol may be separated from the mixture.

_____ (1)

        ii. Draw a labelled diagram of the apparatus that can be set up to carry out the process in part (b) (i). Your diagram must show how the ethanol is collected as a liquid.

(7)

c. A group of students need to separate engine oil from a mixture of engine oil and water. Draw a labelled diagram of the apparatus used to separate the two liquids indicating the end result.

(7)

d. Give a suitable separation technique to separate the following mixtures:

i. ammonium chloride and sand; _____ (1)

ii. the pigments in a purple flower. _____ (1)

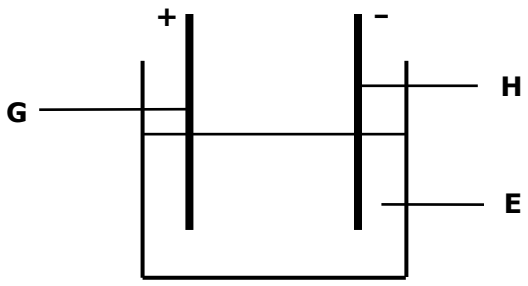
(Total: 20 marks)

20

Please turn the page.

12. Impure copper can be purified using electrolysis.

a. The diagram shows a simple sketch of the experimental setup used to purify impure copper by an electrolytic method. **G** and **H** are the electrodes while **E** is the electrolyte. The polarities of the respective electrodes are as indicated.



i. Name the positive electrode, **G**.

_____ (1)

ii. State the material which the positive electrode, **G** is made of.

_____ (1)

iii. Name the negative electrode, **H**.

_____ (1)

iv. State the material which the negative electrode, **H** is made of.

_____ (1)

v. Give the name or formula of substance **E.**

_____ (1)

vi. Several ions are present in the electrolyte solution. Give the symbols of **all** the ions present.

_____ (3)

vii. Give the balanced half equation for the reaction at the positive electrode.

_____ (2)

viii. Give the balanced half equation for the reaction at the negative electrode.

_____ (2)

ix. State **TWO** observations that can be made during the purification process.

_____

_____ (2)

b. Copper displaces silver from a solution of its ions.

i. Give a balanced ionic equation, including state symbols and omitting spectator ions, for the reaction that happens when a copper rod is placed in silver nitrate, $AgNO_3$, solution.

_____

_____

_____ (3)

ii. The reaction in part (b) (i) is a redox reaction. Give the name or formula of the substance being oxidised. Explain your answer in terms of oxidation states.

Name: _____ (1)

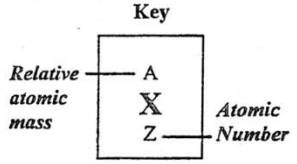
Explanation: _____

_____ (2)

(Total: 20 marks)

20

PERIODIC TABLE



I	II											III	IV	V	VI	VII	VIII
																	4 He 2
7 Li 3	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	59 Co 27	59 Ni 28	63.5 Cu 29	65 Zn 30	70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
85 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
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	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

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

Index Number:_____ SEC06/2A.21m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIA
DATE:	1st July 2021
TIME:	9:00 a.m. to 11:05 a.m.

Useful data:

Relative atomic masses: H = 1, C = 12, N = 14, O = 16, Na = 23, Mg = 24, Cl = 35.5, Zn = 65

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

The molar volume for gases at stp = 22.4 dm^3

Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

Faraday constant = 96500 C mol^{-1}

Avogadro constant, L = 6.02×10^{23}

$\Delta H = mc\Delta\theta$

Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
- Answer **ALL** questions from Section A. Write all your answers for Section A in the spaces provided in this booklet.
- Answer **TWO** questions from Section B. Write all your answers for Section B 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**	**13**	**14**	**Total**
Score															
Maximum	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**20**	**20**	**20**	**20**	**100**

Section A: Answer ALL questions.

1. Pure water can be distinguished from a solution of salt and water through a number of tests.
   a. How can water be distinguished from a salt solution using the freezing point and the boiling point?

_____

_____ (2)

   b. Can anhydrous copper(II) sulfate be used to distinguish between the two? Explain why.

_____

_____ (2)

   c. An electrical current does **not** go through pure water easily. However, an electric current can easily go through a solution of salt and water. Explain why there is a difference in the conduction of electricity between pure water and a solution of salt and water.

_____

_____ (2)

(Total: 6 marks)

6

2. Two students set up a simple cell to investigate how electrical energy can be obtained from chemical reactions. They used a copper electrode, a zinc electrode, a beaker half filled with sodium chloride solution and a filament lamp.
   a. Which of the two metals mentioned is the most reactive metal?

_____ (1)

   b. Write an ionic half equation for the most reactive metal in this simple cell.

_____ (2)

   c. Draw a labelled diagram of the simple cell used by these students.

(2)

   d. Indicate the flow of electrons by means of arrows on the diagram in part (c). (1)

(Total: 6 marks)

6

3. Most water hardness in Malta is caused by calcium hydrogencarbonate.
   a. Calcium carbonate does **not** make water hard. Explain.

_____ (1)

   b. How can a soap solution be used to distinguish between hard water and soft water?

_____

_____ (2)

   c. Give **ONE** disadvantage of hard water besides its reaction with soap.

_____ (1)

   d. Calcium hydrogencarbonate can be removed by boiling water. Write a chemical equation to show this change.

_____ (2)

(Total: 6 marks)

6

4. A spirit lamp containing ethanol was used to heat 250 cm^3 of water in a glass beaker. The temperature of the water increased from 20.0 °C to 62.5 °C. The mass of the spirit lamp decreased by 1.50 g. The density of water is 1 g cm^{-3}. Calculate:
   a. the heat energy (in J) released by the reaction;

_____

_____

_____ (3)

   b. the standard enthalpy of combustion of ethanol.

_____

_____

_____

_____

_____

_____ (3)

(Total: 6 marks)

6

5. Both copper and iron are transition metals.

An aqueous solution of an iron salt forms a green precipitate, **A**, when mixed with dilute sodium hydroxide solution. Substance **A** eventually turns brown as it is oxidised to substance **B** on exposure to air.

Copper darkens slowly on exposure to air to form a black substance **C** which in the presence of carbon dioxide forms a green substance **D**.

a. Identify the compounds **A** to **D**.

A: _____ **B**: _____

C: _____ **D**: _____ (4)

b. Give **TWO** reasons why iron and copper are transition metals.

_____

_____ (2)

(Total: 6 marks)

6

6. Chlorine gas is bubbled through a solution of potassium bromide.

a. Give **ONE** observation for this reaction.

_____ (1)

b. Give a balanced ionic equation, omitting spectator ions, for the reaction between chlorine and aqueous potassium bromide.

_____

_____

_____ (2)

c. This experiment shows that chlorine is more reactive than bromine. Explain this statement.

_____

_____

_____

_____ (3)

(Total: 6 marks)

6

7. The equation for the reduction of copper(II) oxide with ammonia is given below:

$$3CuO(s) + 2NH_3(g) \rightarrow 3Cu(s) + 3H_2O(g) + N_2(g)$$

a. What is the volume of nitrogen collected at the end of the experiment if 5.0 dm^3 of ammonia are passed through the reaction chamber? All volumes are measured at standard temperature and pressure and CuO is present in excess.

_____

_____ (1)

b. At what temperature, in °C, would the volume of nitrogen produced in part (a) be halved if the pressure in the reaction vessel is increased to 4 atmospheres?

_____

_____

_____

_____

_____ (5)

6

(Total: 6 marks)

8. In a titration experiment, 24.0 cm^3 of hydrochloric acid of unknown concentration required 18.0 cm^3 of 0.670 mol dm^{-3} sodium carbonate solution for complete neutralisation.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

a. Name an indicator that is used in acid-base titrations.

_____ (1)

b. Calculate the concentration of the hydrochloric acid.

_____

_____

_____ (3)

c. If half the amount of hydrochloric acid is added, a different salt is formed. Identify this salt.

_____ (1)

d. The same volume of an unknown acid of the same concentration required twice the volume of the same sodium carbonate solution to be neutralised. What does this show about this acid?

_____ (1)

6

(Total: 6 marks)

9. An experiment is carried out to find the composition of some common substances: a fertiliser, an antioxidant, and chalk.

X is white and dissolves in water. There is no visible change on addition of alkali to a solution of **X**. In a flame test, a lilac colour is imparted to the flame. On addition of barium chloride solution to a solution of **X**, a white precipitate forms which dissolves in hydrochloric acid.

Y is a white powder soluble in water. On adding alkali to its solution, a gas is released which turns moist red litmus paper blue. The solution is heated slowly, and more alkali is added until no further gas is released. On addition of aluminium turnings and heating the solution, the same gas starts being released again.

Z is white and insoluble in water. **Z** dissolves in hydrochloric acid to release a colourless gas. This gas produces a white precipitate when bubbled through lime water. If sodium hydroxide is added to the solution of **Z** in hydrochloric acid, a white precipitate is formed. This precipitate does not dissolve on addition of excess sodium hydroxide. A solution of **Z** imparts a brick red colour in a flame test.

Link each of the substances **X**, **Y**, and **Z** with:

- their chemical name; (3)
- their common use. (3)

Unknown substance	Chemical name	Common use
X	Ammonium nitrate	Fertiliser
Y	Calcium carbonate	Antioxidant
Z	Potassium sulfite	Chalk

(Total: 6 marks)

6

10. Hydrocarbons may be saturated or unsaturated.

a. Define the following terms:

i. hydrocarbons;

_____ (1)

ii. unsaturated.

_____ (1)

b. Draw the structural formula showing **all** bonds of:

i. ethene;

(1)

ii. ethyne.

(1)

c. Write a balanced chemical equation to show the conversion of ethene to ethane.

_____ (2)

(Total: 6 marks)

6

Section B: Answer TWO questions from this section.

11. When a mixture of sulfur and iron is heated, a black solid, **E**, is obtained. When dilute hydrochloric acid is added to **E**, a pale green solution, **F**, and a gas with a pungent smell, **G**, are obtained. When chlorine gas is bubbled into **F**, the solution changes colour to a brown solution, **H**. When chlorine gas is added to gas **G**, a redox reaction takes place giving a yellow powder, **I**, and an acidic gas, **J**.
    a. Write a balanced chemical equation for the reaction between:
        i. sulfur and iron to produce **E**; (2)
        ii. **E** and hydrochloric acid; (2)
        iii. **F** and chlorine gas; (2)
        iv. gas **G** and chlorine gas. (2)
    b. Give the name for each of substances **H**, **I**, and **J**. (3)
    c. Draw a labelled diagram of the apparatus that should be used to safely dissolve gas **J** in water. (2)

    When sulfur and iron are heated, some of the sulfur reacts with oxygen to produce gas **K**.
    d. Identify gas **K**. (1)
    e. Give **TWO** properties of gas **K**. (2)
    f. Give the test to confirm the identity of gas **K** and its result. (2)
    g. Give **TWO** other ways of producing gas **K**. (2)

(Total: 20 marks)

12. Mixtures of metals require chemical techniques to separate one metal from another.
    a. Impurities of zinc are removed from its mixture with copper by adding moderately concentrated hydrochloric acid. Zinc dissolves in the acid to form zinc chloride while copper does not.
        i. Why does zinc dissolve in acid but **not** copper? (1)
        ii. Name **ONE** other metal that does **not** react with hydrochloric acid. (1)
        iii. Why is moderately concentrated hydrochloric acid, rather than moderately concentrated nitric acid, used in this experiment? (2)
        iv. What separation technique is used to obtain copper from this mixture after the acid has been added and all zinc reacted? (1)
    b. The solution of zinc chloride obtained in part (a) is transferred to a test tube. Any excess hydrochloric acid is removed by passing the solution of zinc chloride over calcium oxide. A solution containing two chlorides is obtained.
        i. Name the other soluble substance that is now present in the mixture. (1)
        ii. Calcium oxide is used rather than sodium hydroxide to neutralise the acid because sodium hydroxide would otherwise react with zinc chloride. Give a chemical reaction for this side reaction that would otherwise occur. (2)
    c. 3.0 g of magnesium are added to the solution obtained in part (b). A chemical reaction occurs where the magnesium ribbon dissolves and a metallic precipitate forms.
        i. Why does magnesium react with only one of the chlorides mentioned in part (b)? (1)
        ii. Would the reaction occur if magnesium is replaced with:
            - aluminium? (1)
            - lead? (1)
        iii. Write an ionic equation, including state symbols, for the reaction that occurs between magnesium and one of the soluble chlorides mentioned in part (b). (3)
        iv. Calculate the mass of the metallic precipitate if the 3.0 g of magnesium react completely. (3)
    d. In reality, the metallic precipitate is mixed with a trace quantity of white precipitate that forms because of a side reaction of magnesium with the solvent.
        i. Identify this impurity. (1)
        ii. Write a chemical equation for this side reaction. (2)

(Total: 20 marks)

13. Ammonia is produced in industry through the Haber process. This involves the mixing of hydrogen and nitrogen gases which produce ammonia. The equation is given using a reversible reaction sign (⇌). The change in heat for the formation of ammonia from nitrogen and hydrogen is equal to -92 kJ mol^{-1}.
    a. Write a balanced chemical equation, including state symbols, for this reaction. (3)
    b. How does the equilibrium position of this reaction change by:
        i. increasing the temperature? (1)
        ii. increasing the pressure? (1)
        iii. removing ammonia? (1)
    c. Name the principle used to reply to the questions in part (b). (1)
    d. How is ammonia removed from the equilibrium mixture? (1)

e. In industry, conditions of temperature and pressure along with a suitable catalyst are used to obtain good yields and lower the cost. State and discuss the conditions used in the industrial production of ammonia. (6)

f. When ammonia is mixed with hydrogen chloride, ammonium chloride is formed.

$$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$$

i. If 44.8 dm^3 of ammonia are mixed with an equal volume of hydrogen chloride at standard temperature and pressure, calculate the mass of ammonium chloride produced. (5)

ii. This reaction is reversible. State the condition that is necessary for the backward reaction that produces ammonia and hydrogen chloride to occur. (1)

(Total: 20 marks)

14. The decomposition of hydrogen peroxide is dependent on the presence of light.

$$2H_2O_2(aq) \xrightarrow{light} 2H_2O(l) + O_2(g)$$

In an experiment, two clear containers, labelled **P** and **Q**, each containing hydrogen peroxide, are allowed to stand in different light intensities. A sample from each container is taken every 3 hours and the concentration of hydrogen peroxide measured by means of a titration. The results are displayed in the table below.

	Time (hours)	**0**	**3**	**6**	**9**	**12**	**15**	**18**
Concentration of H_2O_2 (mol dm^{-3})	**P**	0.52	0.40	0.32	0.28	0.26	0.25	0.24
	Q	0.52	0.32	0.22	0.18	0.15	0.13	0.13

a. What does rate of reaction mean? (2)

b. Give **TWO** precautions that should be taken during this experiment to ensure fair results. (2)

c. Name **TWO** other factors that affect the rate of decomposition of hydrogen peroxide. (2)

d. Give **ONE** example of another chemical reaction whose rate is affected by light. (1)

e. On the same graph paper, plot graphs of concentration (in mol dm^{-3} H_2O_2) on the y-axis against time (in hours) on the x-axis for both **P** and **Q**. Label the curves as **P** and **Q** accordingly. (6)

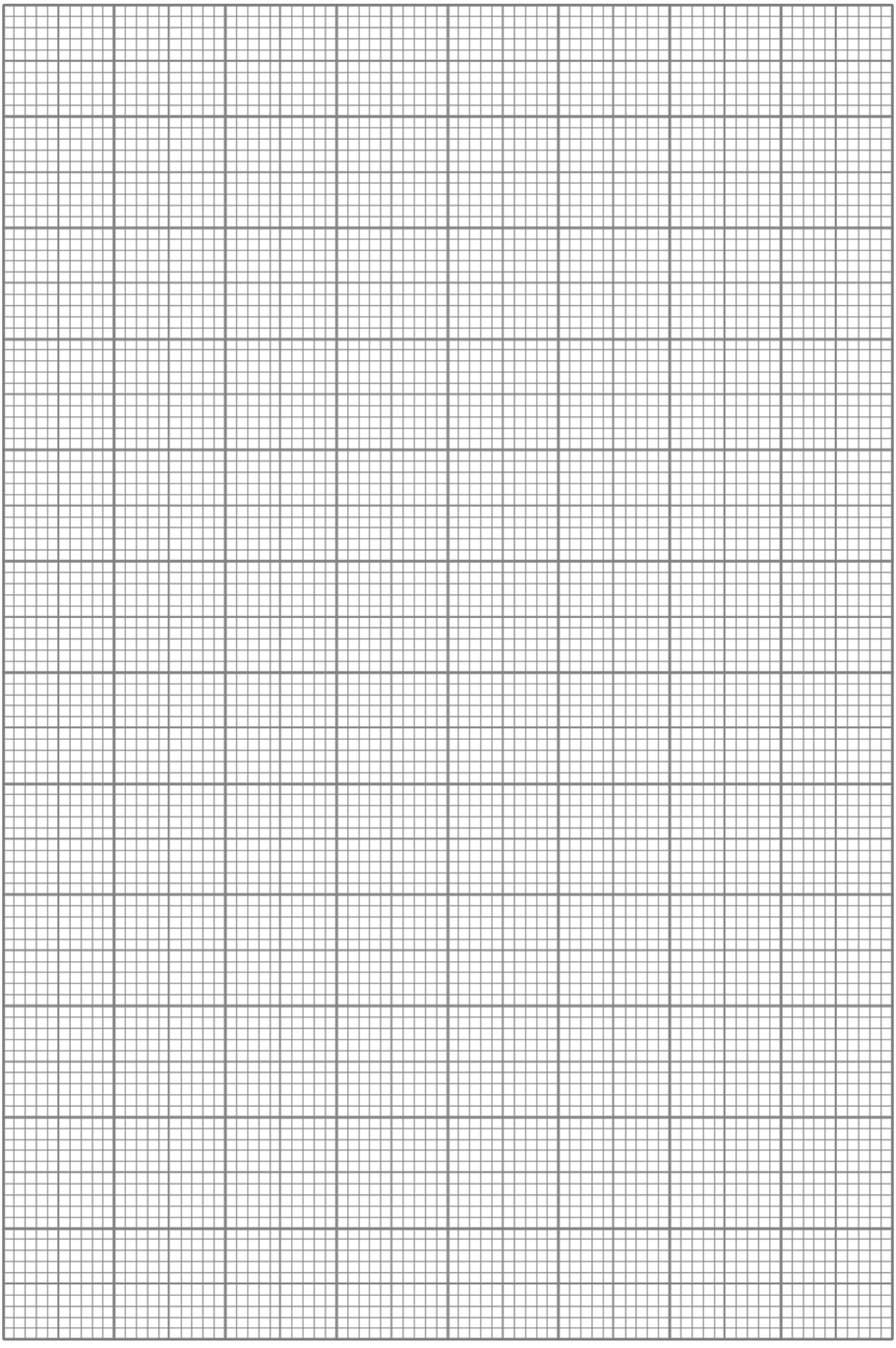
f. Which of the containers, **P** or **Q**, is exposed to the highest light intensity? Explain with reference to the graph. (2)

g. The rate of this reaction can be monitored by measuring the volume of oxygen produced.

i. Draw a labelled diagram of the apparatus used for this experiment. (3)

ii. Sketch a graph of volume of O_2 produced on the y-axis against time on the x-axis for both **P** and **Q**. Do **not** use the graph paper. (2)

(Total: 20 marks)



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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 He 2
7 Li 3	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	59 Co 27	59 Ni 28	63.5 Cu 29	65 Zn 30	70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
85 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
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	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

Key

Relative atomic mass — A
X
Z — *Atomic Number*

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

Index Number:_____ SEC06/2B.21m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2021 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIB
DATE:	1st July 2021
TIME:	9:00 a.m. to 11:05 a.m.

Useful data:

Relative atomic masses: H = 1, C = 12, 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^3

Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

Faraday constant = 96500 C mol^{-1}

Avogadro constant, L = 6.02 x 10^{23}

$\Delta H = mc\Delta\theta$

Directions to Candidates

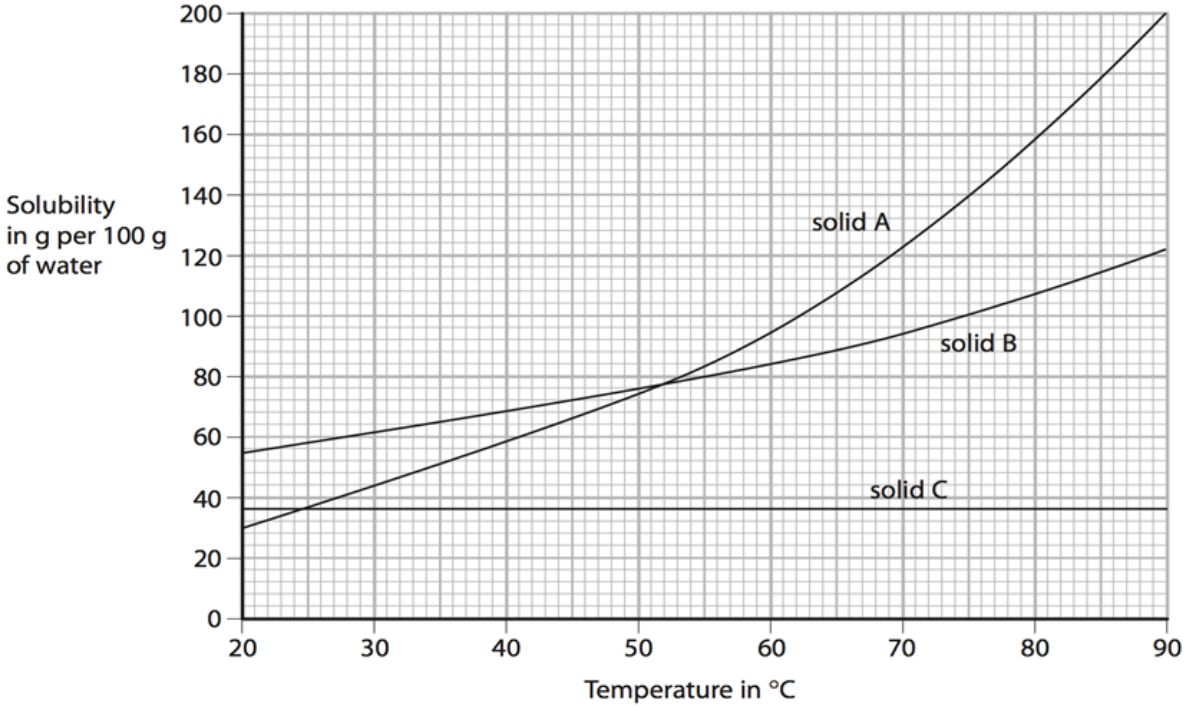
- Write your index number in the space at the top left-hand corner of this page.
- Answer **ALL** questions from Section A. Write all your answers for Section A in the spaces provided in this booklet.
- Answer **TWO** questions from Section B. Write all your answers for Section B in the spaces provided 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	13	14	Total
Score															
Maximum	6	6	6	6	6	6	6	6	6	6	20	20	20	20	100

Section A: Answer ALL questions.

1. The following graph shows the solubility curves of three substances A, B, and C.



Source: edexcel-igcse-chemistry.blogspot.com

Use the graph above to answer the following questions.

a. Which is the most soluble substance at 80 °C?

_____ (1)

b. Which substance has a constant rate of solubility in water?

_____ (1)

c. A hot solution of solid B can hold _____ of solute at 90 °C while it will hold 61 g of solute at _____ °C. (2)

d. Which **TWO** substances have the same solubility at 24.6 °C?

_____ (2)

(Total: 6 marks)

6

2. Fill in the blanks in the following table by giving the names of the substances that are discharged when an electric current is passed through the following substances.

Electrolyte	Substance discharged at the graphite cathode	Substance discharged at the graphite anode
Sulfuric acid	Hydrogen	
Molten lead(II) iodide		Iodine
Copper(II) sulfate solution using inert electrodes	Copper	
Sugar solution	No substance discharged	
Ethanoic acid		Oxygen
Sodium chloride solution (concentrated)	Hydrogen	

6

(Total: 6 marks)

3. Stalactites and stalagmites can be found in limestone caves.

   a. Give the chemical name for limestone. _____ (1)

   b. Name the main substance that makes up stalactites and stalagmites.

_____ (1)

   c. Explain briefly how stalactites and stalagmites form.

_____

_____

_____

_____ (2)

   d. A similar deposit is formed when tap water is boiled in a kettle. However, this is not a very desirable process. Give **TWO** disadvantages that result from the formation of this substance when tap water is boiled.

Disadvantage 1:_____

_____

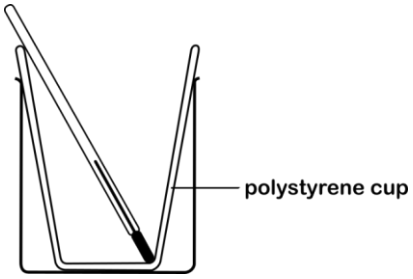
Disadvantage 2:_____

_____ (2)

6

(Total: 6 marks)

4. The following apparatus is used in the laboratory to determine the heat of neutralisation.



a. Name **TWO** substances used in this experiment.

_____ (2)

b. When 100 cm^3 of an acid neutralised 100 cm^3 of an alkali, the temperature change recorded was 7 °C. Calculate the quantity of heat energy released during this experiment. Assume that the density of the resulting solution (a very dilute solution of water) is 1 g cm^{-3}.

_____

_____ (2)

c. Define change in heat of neutralisation.

_____

_____ (1)

d. Given that the amount of water produced during the neutralisation reaction was 0.1 mol, calculate the heat of neutralisation for this experiment.

_____ (1)

(Total: 6 marks)

6

5. This question is about transition metals and their reactions.

a. Name the substances formed when iron is reacted with:

i. chlorine; _____ (1)

ii. hydrochloric acid. _____ (1)

b. What is the colour of the substance that is formed when iron is reacted with:

i. chlorine; _____ (1)

ii. hydrochloric acid. _____ (1)

c. Iron is a transition metal. Give **TWO** properties of transition metals that are shown in part (a) and part (b)?

Property 1: _____ (1)

Property 2: _____ (1)

(Total: 6 marks)

6

6. Sodium hydrogen carbonate is used in baking powder to make cakes rise. It decomposes on heating according to the equation below:

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

a. Calculate the volume of carbon dioxide produced at standard temperature and pressure if 2.0 g of sodium hydrogen carbonate decompose completely.

_____

_____

_____ (4)

b. The temperature changes from standard temperature (273 K) to 573 K. Calculate the volume by which the cake should rise at this temperature due to the production of carbon dioxide alone and assuming no carbon dioxide escapes the cake.

_____

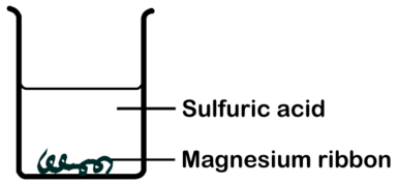
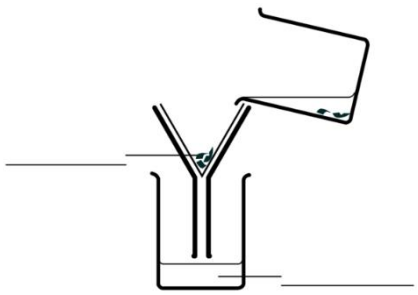
_____ (2)

(Total: 6 marks)

6

7. The preparation of magnesium sulfate crystals in the laboratory is performed in three steps.

a. Label the diagram in Step 2 and draw the diagram including labels for Step 3.

Step 1	Step 2	Step 3
		

(3)

b. Write an equation for the reaction to prepare magnesium sulfate in the laboratory.

_____ (2)

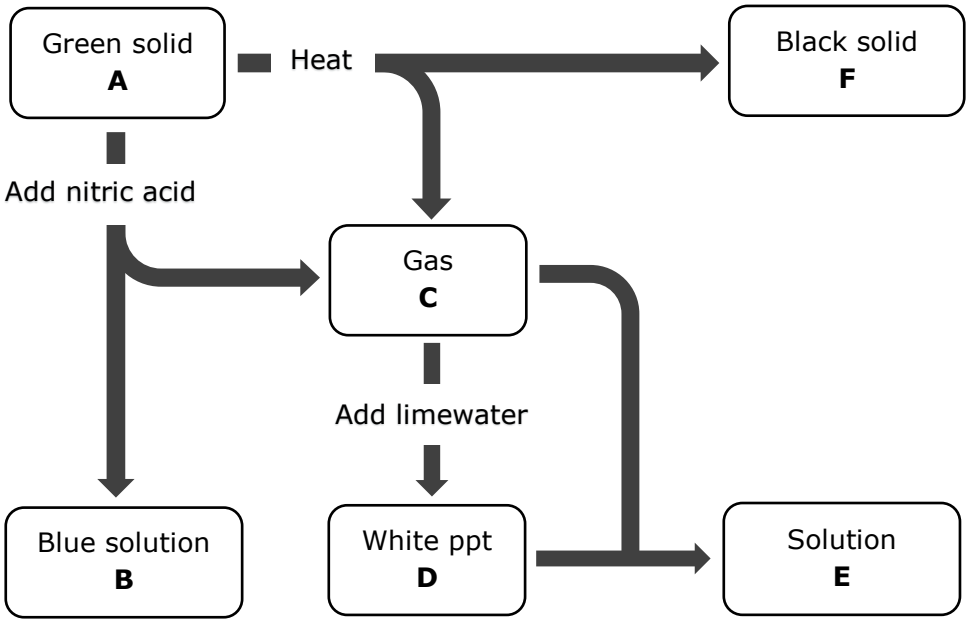
c. Give the name or formula of the substance added to sodium sulfate to obtain a sample of lead(II) sulfate?

_____ (1)

(Total: 6 marks)

6

8. A green solid **A** reacts with dilute nitric acid to give a blue solution of **B** and a gas **C**. When **C** is bubbled through lime water, a white precipitate **D** is formed. On further addition of gas **C** to the suspension, **D** will suddenly disappear to form a transparent solution of **E**. When solid **A** is heated a black solid **F** is formed and gas **C** is liberated.
The following chemical pathway illustrates the above description.



Give the name or formula of each unknown substance.

Unknown substance	Name or Formula
A	
B	
C	
D	
E	
F	

6

(Total: 6 marks)

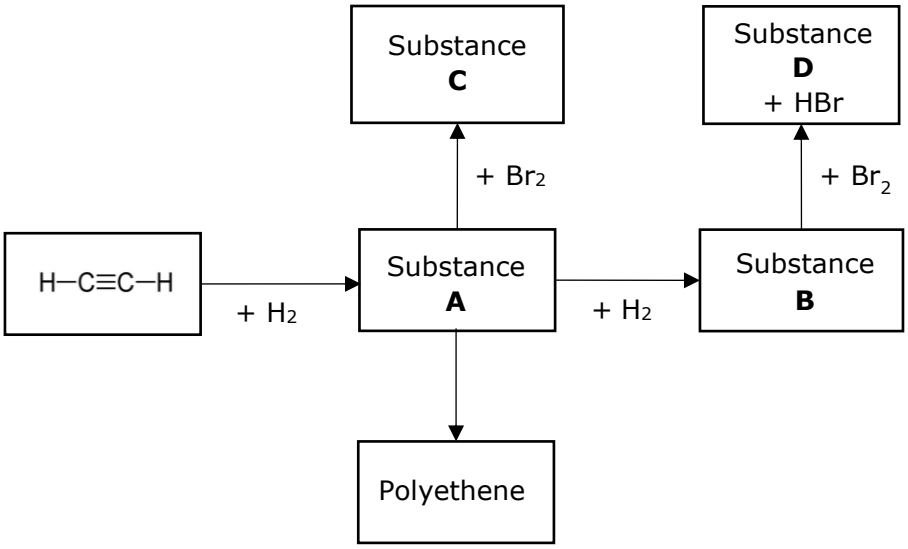
9. Fill in the blanks in the following paragraph.

Chlorine, bromine, and iodine all have _____ electrons in their outer shell. These elements therefore react by _____ one electron. Out of these three elements, chlorine is the _____ reactive. Chlorine reacts _____ with methane in the presence of sunlight to form _____ and _____.

6

(Total: 6 marks)

10. Study the following diagram and answer the questions below.



a. Give the structural formula for substance **A**.

_____ (1)

b. Name substance **B**.

_____ (1)

c. What type of reaction changes substance **A** to polyethene?

_____ (1)

d. Draw the structural formulae of substances **C** and **D** showing all bonds. (2)

Structural formula of substance C	**Structural formula of substance D**

e. How can the reaction of substance **A** and substance **B** with bromine be used to distinguish between the two substances?

_____

_____ (1)

(Total: 6 marks)

6

Section B: Answer TWO questions from this section.

11. This question is about metals and their reactivity.
    a. Sodium, potassium, magnesium, and calcium are very reactive metals.
        i. Put these metals in order of their chemical reactivity. (4)
        ii. From your list, explain why the first two metals are more reactive than the other two metals. (2)

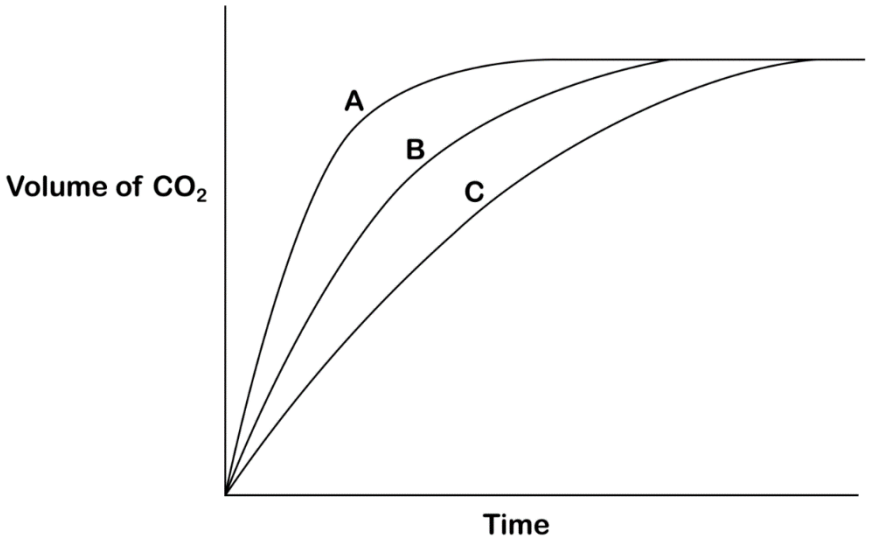
    b. Aluminium displaces iron from its oxide.
        i. Give an equation for the reaction between aluminium and iron(III) oxide. Include state symbols. (3)
        ii. Give **ONE** precaution taken when carrying out this reaction. Explain why. (2)
        iii. What type of reaction happens between aluminium and iron(III) oxide? Explain why. (3)

    c. It is claimed that a divalent metal X, can be found between aluminium and iron in the activity series. Describe an experiment you would carry out in the laboratory to show its correct position in the series. Your explanation must include a labelled diagram, an equation for the reaction that takes place and any observations made. (6)

(Total: 20 marks)

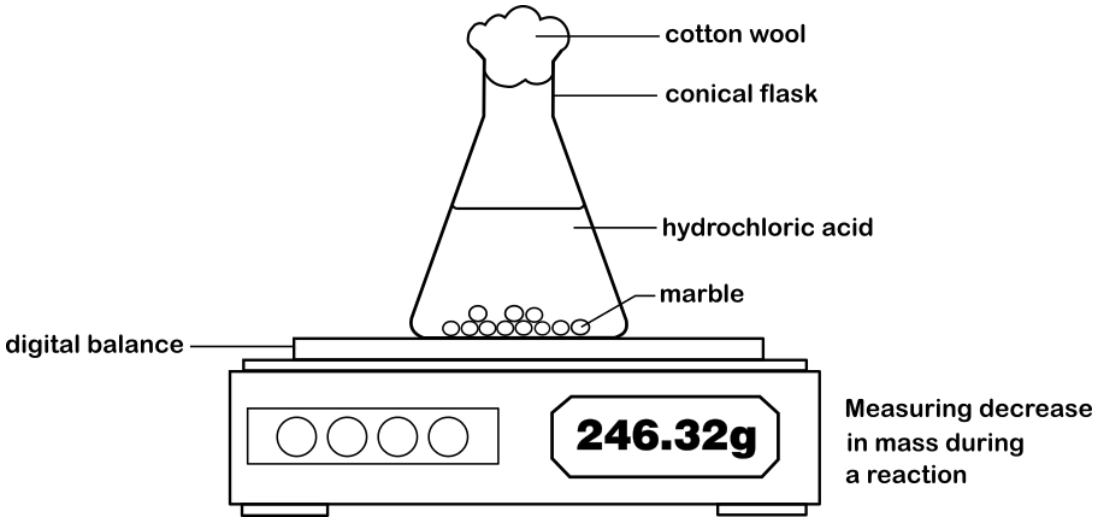
12. A student reacted three 2.5 g samples of marble chips with each of the following solutions:
    - 100 cm^3 of 0.5 mol dm^{-3} hydrochloric acid;
    - 100 cm^3 of 1.0 mol dm^{-3} hydrochloric acid;
    - 100 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

    The student measured the volume of carbon dioxide released every 10 seconds and plotted the following graphs.



    a. Which graph would be obtained for the reaction of:
        i. 2.5 g of marble chips with 100 cm^3 of 0.5 mol dm^{-3} of hydrochloric acid? (1)
        ii. 2.5 g of marble chips with 100 cm^3 of 1.0 mol dm^{-3} hydrochloric acid? (1)
        iii. 2.5 g of marble chips with 100 cm^3 of 2.0 mol dm^{-3} of hydrochloric acid? (1)
    b. Draw a labelled diagram of the apparatus used to carry out this experiment in order to obtain the graphs shown above. (3)
    c. How can this experiment be changed so that a student may investigate the effect of temperature on the rate of this reaction? (2)

Another student repeated the same experiment but instead used the following experimental setup and noted how the mass of the apparatus changed every 10 seconds.



d. Sketch the graphs obtained when using this experimental setup. Your answer should include labelled axes and each curve should be labelled with the concentration of the acid used. (5)

e. The same student repeated the experiment using 100 cm^3 of 0.5 mol dm^{-3} hydrochloric acid with 2.5 g of large marble chips and then with 2.5 g of small marble chips.
   i. Sketch the graphs for this experiment. Your answer should include labelled axes and the appropriate label for each curve. (4)
   ii. What conclusion may be made from the experiments in part (e)? (1)

f. State **TWO** other factors that are **not** mentioned in this question which may influence the rate of a chemical reaction. (2)

(Total: 20 marks)

13. This question is about the chemistry of sulfur.

a. Sulfur reacts with iron to form iron(II) sulfide. Later, iron(II) sulfide reacts with dilute hydrochloric acid.
   i. Name **TWO** conditions for sulfur to react effectively with iron. (2)
   ii. Name the products produced when iron(II) sulfide reacts with dilute hydrochloric acid. (2)

b. Sulfur dioxide is used on an industrial scale to manufacture sulfuric acid. Explain briefly how this is achieved. Your answer must include equations for every chemical reaction that takes place as well as any conditions required. (8)

c. Copper and concentrated sulfuric acid may be used to prepare sulfur dioxide in the laboratory as shown in the equation below:

$$Cu(s) + 2H_2SO_4(l) \rightarrow CuSO_4(aq) + 2H_2O(l) + SO_2(g)$$

This reaction is a redox reaction.
   i. Identify the chemical substance that is acting as the oxidising agent. (1)
   ii. State the oxidation number of copper before and after this reaction. (2)
   iii. State whether copper has been reduced or oxidised. (1)

d. Draw and name the **TWO** allotropes of sulfur. (4)

(Total: 20 marks)

14. This question is about reversible reactions and equilibria.

a. The following equation shows a reversible reaction which may reach equilibrium if it is carried out in a closed vessel.

$$N_2O_4 \rightleftharpoons 2NO_2 \quad \Delta H = +57.2 \text{ kJ mol}^{-1}$$

i. What is a reversible reaction? (1)

ii. When would this reaction reach a state of equilibrium? (1)

iii. What condition (in terms of heat energy) may be applied to favour the forward reaction? (1)

iv. A student is provided with two closed gas jars that contain dinitrogen tetroxide (N_2O_4). What experiment can be carried out to prove your answer to part (a) (iii)? Your answer should include how to carry out the experiment and any observations made during the experiment. (4)

v. The same student is also provided with a sealed syringe full of nitrogen dioxide (NO_2). Describe an experiment to show how pressure affects the position of equilibrium in this reaction. Your answer should include a description of how the experiment is carried out and any observations made. (4)

b. Ammonia is manufactured according to the following reaction:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

Explain why in industry to produce ammonia more efficiently:

i. a high pressure of 200 atmospheres is used; (2)

ii. a temperature of 450 ^{o}C is used. (3)

c. Catalysts are sometimes used in equilibrium reactions.

i. What are catalysts? (2)

ii. Why are catalysts used in some equilibrium reactions? (1)

iii. Give the catalyst used in the manufacture of ammonia. (1)

(Total: 20 marks)

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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 **He** 2
7 **Li** 3	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	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
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	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

Relative atomic mass — A; X; Z — *Atomic Number*

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