L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	18th May 2023
TIME:	9:00 a.m. to 11:05 a.m.

Useful data:

Relative atomic masses: H = 1, C = 12, O = 16

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. 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	7	6	6	6	6	5	7	6	5	6	20	20	100

Section A: Answer ALL questions.

1. The Table below contains some statements but **not** all are correct. Mark each statement as True (T) or False (F).

	Statement	T or F
a.	The nucleus of an atom is negatively charged.	
b.	A neutral atom has an equal number of positively charged and negatively charged particles.	
c.	Hydrogen chloride dissolves in water to form an acidic solution.	
d.	When hydrogen chloride dissolves in methylbenzene it forms ions.	
e.	Ions are always positively charged.	
f.	The chlorine in swimming pools causes the colours of swimwear to fade.	
g.	When bromine is added to KCl solution, chlorine is formed.	

(Total: 7 marks)

7

2. Concentrated sulfuric acid, H_2SO_4, is a very useful chemical in the laboratory since it can exhibit several properties.

   a. Concentrated sulfuric acid is hygroscopic.
   Explain the term 'hygroscopic'.

   ______________________________ (1)

   b. A few drops of concentrated sulfuric acid are added to some sugar in a beaker. A reaction occurs which may be represented by the following equation:

$$C_6H_{12}O_6\,(s) \xrightarrow{\text{Conc. } H_2SO_4} 6\,H_2O\,(l) + 6\,C\,(s)$$

   i. What is the function of concentrated sulfuric acid in this reaction?

   ______________________________ (1)

   ii. State **ONE** observation that can be made in this reaction.

   ______________________________ (1)

   iii. Calculate the mass of carbon that is formed in the reaction if 1 mole of sugar, $C_6H_{12}O_6$, completely reacts. Show your reasoning.

   ____

   ____

   ______________________________ (3)

(Total: 6 marks)

6

3. a. Substances may show different behaviours when an electric current is passed, or tries to pass, through them.
From the word bank below, choose the appropriate term to fill the empty spaces in the table. The terms may be used once, more than once or not at all. The first one has been filled in as an example.

electrolyte	non-electrolyte	conductor	non-conductor

	Substance	**Description**
i.	sugar solution	non-electrolyte
ii.	dilute sulfuric acid	
iii.	silver metal	
iv.	graphite	
v.	wood	

(4)

b. Dilute ethanoic acid and copper(II) sulfate solution may be electrolysed using inert electrodes. Complete the Table below by filling the missing substances as indicated.

		Name of product collected at the inert cathode (the negative electrode)
i.	dilute ethanoic acid	
ii.	dilute $CuSO_4$ solution	

(2)

(Total: 6 marks)

6

4. a. Draw dot-cross diagrams, showing outer electrons only, to show the bonding in the following compounds:

i. H_2O;

(2)

ii. NaCl.

(2)

This question continues on next page.

b. i. Give a test carried out on a sample of water to check that it is pure. How can it be determined if a sample of water is pure or not?

____ (1)

ii. From the three temperatures below, circle the value which best represents the melting point of sodium chloride.

Temperatures/ °C	40	100	800

(1)

(Total: 6 marks)

6

5. a. i. Hydrogen chloride gas, HCl, is produced when concentrated sulfuric acid reacts with solid sodium chloride, NaCl. Give a balanced equation for the reaction.

____ (2)

ii. Besides HCl gas another product is formed in the reaction in part (a)(i). Give the name of this product.

____ (1)

b. The pH value of a solution indicates whether a solution is alkaline, acidic or neutral.
For each of the following substances, indicate whether the pH value is less than 7, equal to 7, or greater than 7.

Substance	pH less than 7, equal to 7, or greater than 7
distilled water	
orange juice	
ammonia solution	

(3)

(Total: 6 marks)

6

6. The following equations represent the action of heat on some substances. Fill in the missing products.

a. $2\ NaHCO_3\ (s) \rightarrow$ ________________ $+ H_2O\ (l) + CO_2\ (g)$ (1)

b. $2\ KNO_3\ (s) \rightarrow 2$ ______________ + ________________ (2)

c. $Zn(OH)_2\ (s) \rightarrow$ ______________ + _______________ (2)

(Total: 5 marks)

5

7. Consider the following compounds of copper in the scheme below.

$$CuCO_3 \rightarrow Cu(NO_3)_2 \rightarrow CuO$$

a. i. Give the name or formula of a substance that will react with copper(II) carbonate to form copper(II) nitrate.

____ (1)

ii. Identify the gas given off during the reaction in part (a)(i). Give **ONE** use of this gas.

____ (2)

b. Give a balanced equation to show the conversion of copper(II) nitrate to copper(II) oxide.

____ (2)

c. Copper(II) oxide reacts with dilute sulfuric acid according to the following equation:

$$CuO\ (s) + H_2SO_4\ (aq) \rightarrow CuSO_4\ (aq) + H_2O\ (l)$$

i. What type of reaction does the above equation show?

____ (1)

ii. Mention **ONE** observation that can be made in the reaction in part (c)(i).

____ (1)

(Total: 7 marks)

7

8. Ammonia and ammonium salts have many properties and uses, including their use in fertilisers, explosives, cooking, and industrial applications.

a. Ammonium sulfate, $(NH_4)_2SO_4$, has a formula mass of 132. It is often used as a fertiliser because of its nitrogen content. Calculate the percentage nitrogen by mass in ammonium sulfate.

____

____

____ (2)

This question continues on next page.

b. Food grade ammonium carbonate is used by confectioners to make crisp biscuits and crackers. Ammonium carbonate decomposes on heating according to the following equation:

$$(NH_4)_2CO_3\ (s) \rightarrow 2\ NH_3\ (g) + H_2O\ (l) + CO_2\ (g)$$

During heating, the products are immediately eliminated from the biscuit mixture and in doing so the carbon dioxide helps the mixture to rise.
Calculate the volume of carbon dioxide, measured at STP, that is produced on heating 0.5 mol of ammonium carbonate.

____

____

____ (3)

c. Give a test to confirm that the gas given off is ammonia.

____ (1)

6

(Total: 6 marks)

9. a. Diamond and graphite are the two main allotropes of carbon. Give **TWO** reasons why diamond is harder than graphite.

Reason 1: ____ (1)

Reason 2: ____ (1)

b. In an experiment, 80 cm^3 of carbon monoxide gas is added to 80 cm^3 of oxygen gas, both volumes measured at the same temperature and pressure. The two gases react according to the following equation. The final mixture contains carbon dioxide and one of the original gases that remains unreacted.

$$2\ CO\ (g) + O_2\ (g) \rightarrow 2\ CO_2\ (g)$$

i. Identify the gas that remains unreacted in the final mixture with the carbon dioxide formed.

____ (1)

ii. Give the volume of the gas in part (i).

____ (1)

iii. What volume of carbon dioxide is formed? Show your reasoning.

____

____ (1)

5

(Total: 5 marks)

10. a. When ammonia gas passes over heated copper(II) oxide the following reaction occurs:

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

This is a redox reaction.

i. What is the function of ammonia in this reaction?

____ (1)

ii. Explain your answer to part (a)(i).

____ (1)

b. Copper metal does **not** react with dilute sulfuric acid but reacts with concentrated sulfuric acid.

i. Give a balanced equation to show the reaction between copper metal and concentrated sulfuric acid.

____ (2)

ii. Give **ONE** reason why copper reacts with concentrated sulfuric acid but **not** with dilute sulfuric acid.

Reason: ____

____ (1)

iii. How can any unreacted copper in part (b)(i) be separated from the reaction mixture?

____ (1)

6

(Total: 6 marks)

Please turn the page.

Section B: Answer ALL questions.

11. a. A standard solution is used in a titration.
i. What is a 'standard solution'?

____ (1)

ii. Why is a standard solution used?

____ (1)

b. A group of students in the laboratory are asked to carry out a titration. On the bench there are various items of glassware and laboratory apparatus. These include:

conical flasks	gauze	test tubes
beaker	burette	volumetric pipette
white tile	stand and clamp	Bunsen burner

They have to decide what apparatus to use for the experiment since **not** all of these items are necessary.
Draw a labelled diagram to show how the apparatus is set up for a titration between hydrochloric acid and potassium carbonate. Any apparatus from the above that will be used for the experiment should be properly drawn and labelled.

(6)

c. Hydrochloric acid and potassium carbonate react according to the equation:

$$2HCl\ (aq) + K_2CO_3\ (aq) \rightarrow 2KCl\ (aq) + H_2O\ (l) + CO_2\ (g)$$

Write an ionic equation omitting spectator ions for this reaction.

____ (3)

d. In a titration, hydrochloric acid of concentration 0.6 mol dm^{-3} was added dropwise to 25.0 cm^3 of potassium carbonate solution, swirling carefully until complete neutralisation occurred. The titration was repeated more than once and the results in the table below were obtained.

	1st titration	2nd titration	3rd titration	4th titration
Final volume / cm^3	18.30	38.10	24.55	43.65
Initial volume /cm^3	00.00	20.05	06.40	25.55
Volume HCl used / cm^3	18.30	18.05	18.15	18.10

i. Use the values in the table to calculate the volume that was needed to reach the endpoint.

____ (1)

ii. Calculate the amount of substance (in moles) of hydrochloric acid used in the experiment.

____

____

____ (3)

iii. Use the equation given in part (c) to calculate the amount of substance (in moles) of potassium carbonate used.

____

____

____ (2)

iv. From the answers above, calculate the concentration of the potassium carbonate solution.

____

____

____

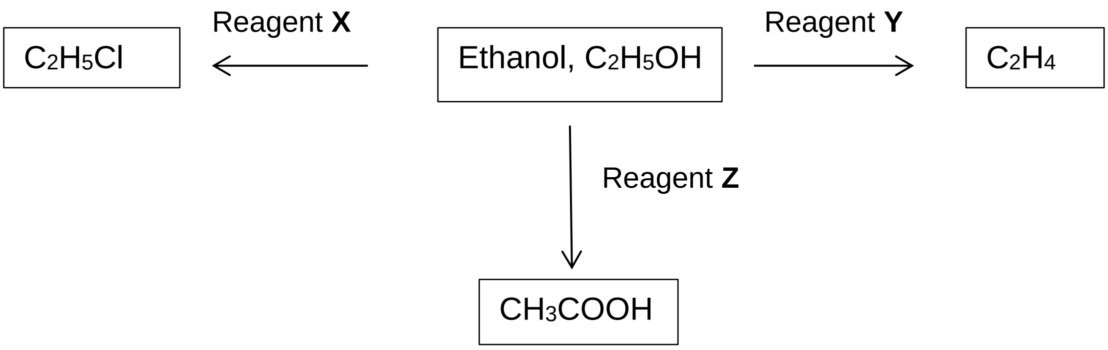
____ (3)

20

(Total: 20 marks)

Please turn the page.

12. a. The scheme below shows some reactions of ethanol, C_2H_5OH.



i. Give the name or formula of the reagents labelled **X**, **Y** and **Z**.

Reagent **X**: ______________________________ (1)

Reagent **Y**: ______________________________ (1)

Reagent **Z**: ______________________________ (1)

ii. Give a balanced equation to show how ethanol, C_2H_5OH, reacts with reagent **X** to form C_2H_5Cl.

______________________________ (2)

iii. A gas is given off in the reaction in part (a)(ii). Give a test to confirm the identity of this gas.

______________________________ (1)

iv. Why is the reaction in part (a)(ii) useful in organic chemistry?

______________________________ (1)

v. Draw the structure of ethene, C_2H_4.

(1)

vi. Draw the structure of the product formed when ethene, C_2H_4, reacts with chlorine gas.

(1)

vii. Ethanol, C_2H_5OH, reacts with ethanoic acid, CH_3COOH, in the presence of concentrated sulfuric acid. Give a balanced equation for the reaction.

______________________________ (2)

viii. State **ONE** observation that can be made during the reaction in part (a)(vi).

____ (1)

b. Draw the structure of an isomer of ethanol.

(1)

c. LPG, liquid petroleum gas, contains both propane and butane. LPG is used as a fuel both in homes and in industry.

i. Propane burns in air according to the equation:

$$C_3H_8\ (g) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (l) \qquad \Delta H = -2220.4\ kJ\ mol^{-1}$$

Calculate the mass of carbon dioxide that is produced, starting from 2 moles of propane.

____

____

____

____ (4)

ii. The volume of the carbon dioxide produced in part (c)(i) is 134.4 dm^3, measured at STP. What will the volume of the gas be, if the volume is instead measured at two atmospheres pressure keeping the same temperature?

____

____ (2)

iii. Why must LPG, like any other hydrocarbon fuel, be used in a well-ventilated place?

____ (1)

20

(Total: 20 marks)

PERIODIC TABLE

Key

Relative atomic mass — A
X
Z — Atomic Number

I	II											III	IV	V	VI	VII	VIII
1 H 1																	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

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIA
DATE:	18th May 2023
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, C = 12, O = 16

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

Section A: Answer ALL questions.

1. Hydrogen reacts with both metals and non-metals.
   a. Give the name or formula of the substance formed when magnesium reacts with sulfur.

   ______________________________ (1)

   b. Give a balanced equation for the reaction between hydrogen and chlorine.

   ______________________________ (2)

   c. i. Copper(II) oxide can be reduced by reacting it with a stream of hydrogen using a combustion tube. Draw a labelled diagram to show how this experiment can be carried out.

   (3)

   ii. Give **ONE** observation that can be seen in the combustion tube.

   ______________________________ (1)

   (Total: 7 marks)

7

2. Calcium and magnesium are two metals found in Group 2 of the Periodic Table. In an experiment, both metals were placed separately in a beaker containing water.
   a. Give a balanced equation for the reaction of magnesium with water.

   ______________________________ (2)

   b. State what is observed when calcium and magnesium react with water and explain why they react differently.

   ____

   ______________________________ (2)

   c. The same experiment was repeated using sulfuric acid instead of water. The reaction between calcium and dilute sulfuric acid stops after a short while even though the reactants were **not** completely used up. Explain this observation.

   ____

   ______________________________ (2)

   (Total: 6 marks)

6

3. There are several trends in the Periodic Table. The Table below contains some statements but some of them are **not** correct. State whether each statement is True (T) or False (F).

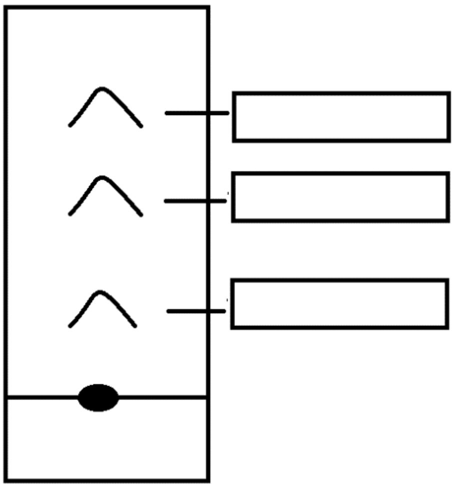
	Statement	**T or F**
a.	The elements along a period are placed according to their atomic number.	
b.	The atomic radius increases down a group.	
c.	The reactivity of the elements increases across a period.	
d.	The reactivity of group 7 elements decreases down the group.	
e.	The melting points of group 1 elements increase down the group.	
f.	The metallic character decreases across a period.	

6

(Total: 6 marks)

4. During a chromatography experiment, the black ink of a marker was tested. A student obtained the following chromatogram. The colours obtained were green, blue, and yellow. Blue was the most soluble colour whereas yellow was the least soluble colour.

a. Label the **THREE** colours, green, blue, and yellow, on the chromatogram below.



(3)

b. Why cannot glass be used instead of chromatography paper?

____

____ (1)

c. Name **ONE** precaution, other than wearing safety glasses and other protective equipment, that is required when performing chromatography.

____

____ (1)

5

(Total: 5 marks)

5. Carbon dioxide is a colourless and odourless gas.
   a. Carbon dioxide is an acidic oxide. Explain why.

   ____

   ____ (1)

   b. Carbon dioxide is formed when calcium carbonate is very strongly heated. Give a balanced equation for this reaction.

   ____ (2)

   c. Give the name or formulae of **TWO** substances that can be reacted together to prepare a pure sample of calcium carbonate.

   ____ (2)

(Total: 5 marks)

5

6. Fill in the blanks with the appropriate words.

In the petrochemical industry crude oil is separated into simpler fractions by ______________ ______________. Some of the large fractions are broken down into smaller hydrocarbons by a process known as _____________. In one such reaction, decane ($C_{10}H_{22}$) is broken down into _____________ and ethene. From this process an important fuel and an alkene are produced. Alkenes have single and _____________ _____________, so they are described as _____________. The general formula of alkenes is _____________.

(Total: 6 marks)

6

7. Polymerisation occurs when small molecules called monomers link together to form long chains. One such substance is polythene (PE) which is an example of an addition polymer.
   a. Draw the structure (showing all the atoms and bonds) of the monomer of polythene.

   (2)

   b. What particular feature in the monomer molecule makes it capable to form polymers?

   ____ (1)

   c. State **ONE** use of polythene.

   ____ (1)

d. Explain why polythene is described as an addition polymer.

____

____ (1)

e. Polythene is non-biodegradable. Explain this statement with reference to its effect on the environment.

____

____ (2)

(Total: 7 marks)

7

8. In an experiment, a small quantity of powdered zinc was placed in a beaker containing copper(II) sulfate solution.

a. Write the ionic equation, omitting spectator ions, for the reaction taking place.

____

____ (3)

b. State **TWO** observations which occur during this reaction.

____

____ (2)

c. Name this type of reaction.

____ (1)

d. With reference to the position of the metals in the reactivity series, explain briefly why the reaction occurs.

____

____ (1)

(Total: 7 marks)

7

9. Consider the following equilibrium reaction.

$$2\ X_2\ (g) + Z_2\ (g) \rightleftharpoons 2\ X_2Z\ (g) \qquad \Delta H = -248.2\ kJ$$

a. Explain the term ‘dynamic equilibrium’.

____

____ (2)

This question continues on next page.

b. What happens when pressure is applied to this system whilst keeping temperature constant? Explain your reasoning.

____

____

____ (2)

c. A catalyst was applied to the system, but it had no effect on the position of the equilibrium. Explain why.

____

____ (1)

d. If more Z_2 is added into the container, what effect will it have on the position of equilibrium?

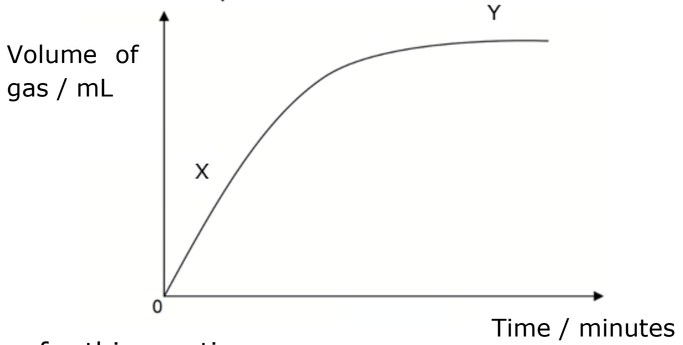
____

____ (1)

(Total: 6 marks)

6

10. The graph below shows the results of an experiment to determine the rate of decomposition of 10% hydrogen peroxide in the presence of manganese(IV) oxide.



a. Write an equation for this reaction.

____ (2)

b. Explain the shape of the graph with reference to what is happening during the reaction. Refer to points X and Y shown on the graph in your explanation.

____

____

____ (2)

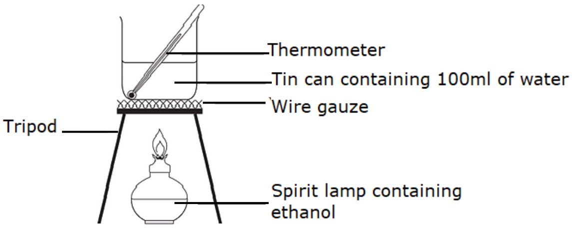
c. On the same graph sketch the curve that would be obtained if the experiment was carried out with the same mass of manganese(IV) oxide but 15% hydrogen peroxide solution. Label this graph Z. (1)

(Total: 5 marks)

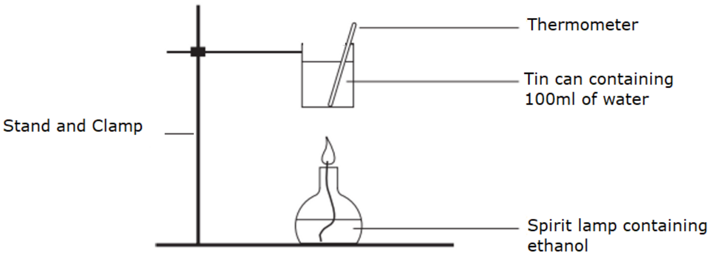
5

Section B: Answer TWO questions from this section.

11. During a chemistry lesson, the teacher asked two groups of students to draw how the experiment to find the enthalpy of combustion of ethanol can be set up. The students drew the following diagrams.



Group A



Group B

(Adapted from Barker College Chemistry Department https://andrewchoi2.wixsite.com/past-hsc-chem2)

Considering that both experiments were well lagged (insulated):

a. Give **ONE** error in the diagram of Group A. (1)

b. Explain how the experiment of Group B can be improved. (1)

The students obtained the following results from the experiment:

	Results
Mass of spirit lamp with ethanol before	29.974 g
Mass of spirit lamp with ethanol after	29.592 g
Temperature of 100 cm^3 of water before	17.1 ^oC
Temperature of 100 cm^3 of water after	41.2 ^oC

c. Assuming that all the heat that was released from the spirit burner was transferred to the water,

i. Calculate the heat energy produced from the burning of ethanol. (3)

ii. Calculate the mass of ethanol burnt during the experiment. (1)

iii. Work out the enthalpy of combustion of ethanol in kJ mol^{-1}. (5)

d. Explain why the water needs to be continuously stirred. (1)

e. The combustion of ethanol is exothermic. Explain why the reaction is exothermic by referring to bond energies. (2)

f. Draw an energy level diagram, including the activation energy, for the combustion of ethanol. (3)

g. Ethanol is a fuel made from various plants such as corn, sugarcane, and grains, collectively known as biomass.

i. Name the process by which ethanol is made from plant materials. (1)

ii. Give **ONE** advantage of using ethanol as a fuel. (1)

iii. To meet the growing demand, ethanol must be produced on a large scale and so a lot of crops are needed. Give **ONE** disadvantage of this. (1)

(Total: 20 marks)

Please turn the page.

12. This question is about substances **A**, **B** and **C**. Use the information in the Table to answer the questions below.

	Melting point (°C)	Boiling point (°C)	Electrical conductivity as solid	Electrical conductivity as liquid	Electrical conductivity as aqueous solution
A	615	876	Poor	Good	Good
B	-105	-45	Poor	Poor	Good
C	3777	4332	Good	Not applicable	Not applicable

a. State whether each of **A**, **B** and **C** is a solid, liquid or gas at room temperature. (3)
b. Classify substances **A**, **B** and **C** as having ionic, simple covalent, giant covalent, or metallic bonding by looking at their properties. (3)
c. State what type of bonding is present in:
   i. KCl; (1)
   ii. between the atoms in CO_2 gas; (1)
   iii. a block of Fe; (1)
   iv. between the molecules in liquid N_2. (1)
d. Explain the following statements:
   i. Giant covalent structures do **not** conduct, apart from graphite. (3)
   ii. Copper(II) chloride does **not** conduct electricity when solid. However, when dissolved in water it does conduct electricity. (2)
   iii. Chlorine has a low boiling point. (2)
e. Draw the structure of solid iodine. Label the bonds and forces present. (3)

(Total: 20 marks)

13. This question is about two unknown substances **P** and **S**.
a. Solid **P** is an insoluble white powder. When heated strongly, a colourless, odourless gas **Q** evolved, and a yellow residue **R** remained in the test tube. Residue **R** turned white upon cooling and gas **Q** turned lime water milky.
   i. Identify compounds **P**, **Q**, and **R**. (3)
   ii. Write an equation for the thermal decomposition of compound **P**. Include state symbols. (3)
   iii. Compound **R** reacts with both acids and bases. What name best describes such a compound? (1)
   iv. Is compound **P** soluble or insoluble? (1)
   v. Name the salt produced when compound **P** reacts with hydrochloric acid. (1)
b. A green solution forms when a crystalline powder **S** is dissolved in water. On adding a few drops of sodium hydroxide, a green precipitate **T** forms, which remains insoluble when an excess of the hydroxide is added. Moreover, a brown precipitate **U** forms when the test tube is left exposed to air for some time. When a few drops of acidified silver nitrate solution were added to solution of **S**, a white precipitate **V** was produced.
   i. Identify substances **S**, **T**, **U**, and **V**. (4)
   ii. Write an ionic equation for the reaction of solution **S** with sodium hydroxide solution. (3)
   iii. Explain why the green substance **T** turns brown on exposure to air. (1)
   iv. What is the significance of the negative test with barium chloride solution? (2)
   v. Name the anion which would have been present if precipitate **V** had been yellow instead of white. (1)

(Total: 20 marks)

14. Read the following excerpt and then answer the questions that follow.

As Iraqi forces pulled out of Kuwait in 1991, they set more than 700 oilwells ablaze. These were put out within months, but insidious pollution still mars [harms] the desert. For 10 months in Kuwait, everything was upside down. Daytime was full of darkness from the thick smoke, and nights were bright from the distant glow of burning oilwells.

The oilwells burned uncontrollably. The smoke plume [cloud] above them initially stretched for 800 miles. A staggering 11 million barrels of crude oil poured into the Persian Gulf, creating a slick nine miles long. Nearly 300 oil lakes formed on the surface of the desert, polluting the soils.

An international coalition of firefighters battled the fires for months until the last well was finally capped on 6 November 1991 and Kuwait celebrated under clear skies.

(*The Guardian. December 2021*)

a. Explain the meaning of the term 'pollution'. (1)

b. Name the fractions from crude oil which are used:
   i. for waterproofing and road construction; (1)
   ii. as aircraft fuel. (1)

c. i. The article mentions the burning of 700 oilwells. Such an activity produces large amounts of carbon dioxide (besides other products). Name and explain the environmental effect of excessive amounts of this gas in the atmosphere. (3)
   ii. Name the substance that is responsible for the thick black smoke described in the article. (1)

d. The uncontrolled burning of unrefined crude oil as described in the article is also responsible for acid rain.
   i. Explain how the gas which causes acid rain forms. (2)
   ii. Write a chemical equation for the reaction of the gas mentioned in (d)(i) and rainwater. (2)
   iii. State **ONE** harmful effect of acid rain. (1)

e. Combustion of fossil fuels such as butane in a closed room leads to the production of another dangerous gas.
   i. Draw the structures of butane and its isomer. (2)
   ii. Write an equation for the incomplete combustion of butane. (2)
   iii. Name the dangerous gas produced. (1)

f. In order to reduce pollution, cars are fitted with a device on their exhaust systems which converts NO and CO into less harmful gases.
   i. Name this device. (1)
   ii. State the names or formulae of the gases released from this device. (2)

(Total: 20 marks)

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PERIODIC TABLE

Key

Relative atomic mass — A
X
Z — Atomic Number

I	II											III	IV	V	VI	VII	VIII
1 **H** 1																	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

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2023 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIB
DATE:	18th May 2023
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, C = 12, O = 16

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

Section A: Answer ALL questions.

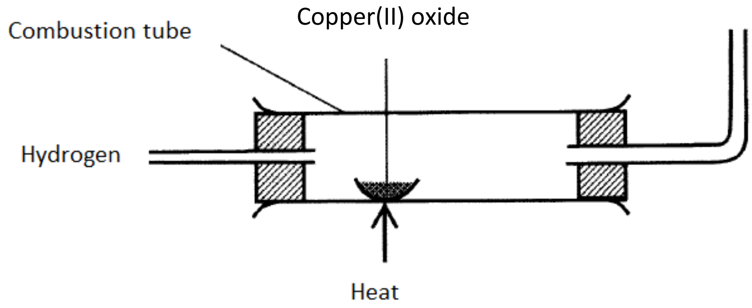
1. Hydrogen reacts with both metals and non-metals.
   a. Give the name or formula of the substance formed when magnesium reacts with sulfur.

   ______________________________ (1)

   b. Give a balanced equation for the reaction between hydrogen and chlorine.

   ______________________________ (2)

   c. Copper(II) oxide can be reduced by reacting it with a stream of hydrogen using the apparatus below.



Adapted from Atika School (www.atikaschool.org)

   i. Complete the reaction taking place

   CuO (s)+ H_2 (g) → _______ (s) + ______ (g) (2)

   ii. Give **ONE** observation that can be seen in the combustion tube.

   ______________________________ (1)

(Total: 6 marks)

6

2. Calcium and magnesium are two metals found in Group 2 of the Periodic Table. In an experiment, both metals were placed separately in a beaker containing water.
   a. Which of the metals, calcium or magnesium, is the most reactive?

   ______________________________ (1)

   b. Give a balanced equation for the reaction of magnesium with water.

   ______________________________ (2)

   c. Magnesium reacts with dilute hydrochloric acid. Give the name or formula of the two products.

   ______________________________ (2)

   d. Gold will **not** react with dilute hydrochloric acid. Explain with reference to the reactivity series.

   ____

   ______________________________ (1)

(Total: 6 marks)

6

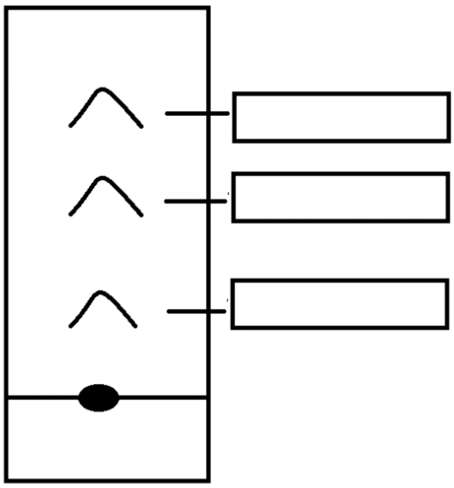
3. There are several trends in the Periodic Table. The table below contains some statements but some of them are **not** correct. State whether each statement is True (T) or False (F).

	Statement	**T or F**
a.	The Periodic Table has groups and periods.	
b.	The atomic radius increases down a group.	
c.	In Group 1, potassium (K) is more reactive than caesium (Cs).	
d.	Aluminium (Al) is found in Period 2.	
e.	Noble gases are found in Group 1.	
f.	The metallic character decreases across a period.	

(Total: 6 marks) 6

4. During a chromatography experiment of the black ink of a marker, a student obtained the following chromatogram. The colours obtained were green, blue, and yellow. Blue was the most soluble colour whereas yellow was the least soluble colour.

   a. Label the **THREE** colours, green, blue, and yellow on the chromatogram below.



(3)

   b. A pencil is used to draw the line on the chromatography paper. Explain why the line cannot be drawn in ink.

____

____ (1)

   c. Which of the following materials is suitable as a chromatogram for this chromatography experiment: glass, aluminium, filter paper?

____ (1)

(Total: 5 marks) 5

5. Carbon dioxide (CO_2) is a colourless and odourless gas.

a. State whether carbon dioxide is acidic, basic, amphoteric, or neutral.

____ (1)

b. Carbon dioxide is formed when calcium carbonate is very strongly heated. Complete the reaction below:

$CaCO_3$ (s) → ____________ (s) + ____________ (g) (2)

c. Give the test to confirm the presence of carbon dioxide.

____

____ (1)

d. Calcium carbonate is insoluble. Give the name or formula of a suitable substance that can be reacted with calcium nitrate in the lab to produce calcium carbonate.

____ (1)

e. State **ONE** use of calcium carbonate.

____ (1)

6

(Total: 6 marks)

6. Fill in the blanks by choosing the appropriate words from below. Each term may be used once or not at all.

double	fractional	triple	general
octane	cracking	unsaturated	reduction

In the petrochemical industry crude oil is separated into simpler fractions by ______________ distillation. Some of the large fractions are broken down into smaller hydrocarbons by a process known as ______________. In one such reaction decane ($C_{10}H_{22}$) is broken down into ______________ and ethene. Alkenes have single and ______________ bonds, so they are described as ______________. Their ______________ formula is C_nH_{2n}.

6

(Total: 6 marks)

7. Polymerisation occurs when small molecules called monomers link together to form long chains. One such substance is polythene (PE) which is the addition polymer of ethene.

a. Draw the structure (showing all the atoms and bonds) of the monomer ethene.

(2)

b. Why are alkenes suitable to form polymers?

____

____ (1)

c. State **ONE** use of polythene.

____ (1)

d. Which statement best describes the term 'addition polymer'. Underline the correct statement.

Statement 1: There is the loss of a simple molecule when the monomer molecules join together.

Or

Statement 2: The monomer molecules join together without the loss of a simple molecule.

(1)

e. Polythene is very unreactive and remains unchanged for a long period of time as it is **not** decomposed by natural organisms. What is the name given to such substances?

____ (1)

6

(Total: 6 marks)

8. In an experiment a small quantity of powdered zinc was placed in a beaker containing copper(II) sulfate solution.

a. Complete the ionic equation for the reaction taking place.

$$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow \_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_$$ (2)

b. State **TWO** observations which occur during this reaction.

____

____ (2)

c. Give the oxidation number of Zn in this reaction.

____ (1)

d. State which of the two metals, zinc or copper, is higher in the reactivity series.

____ (1)

6

(Total: 6 marks)

9. Consider the following equilibrium reaction which took place in a closed reaction vessel.

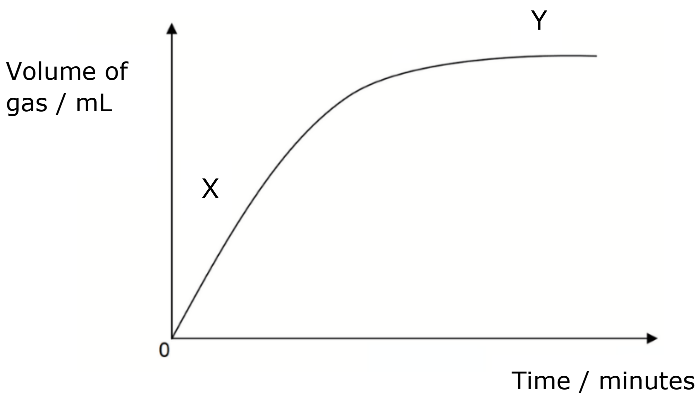
$$2\ SO_2\ (g) + O_2\ (g) \leftrightharpoons 2\ SO_3\ (g) \qquad \Delta H = -196\ kJ/mol$$

The table below contains some statements about equilibrium but some of them are **not** correct. State whether each statement is True (T) or False (F).

	Statement	**T or F**
a.	For equilibrium to be established the reaction container must be closed.	
b.	In a dynamic equilibrium the rate of the forward reaction must be equal to the rate of the backward reaction.	
c.	When pressure is increased there will be **no** change in the equilibrium position.	
d.	A catalyst will shift the equilibrium position.	
e.	In this reaction the backward reaction is endothermic.	
f.	If the product SO_3 is removed from the container, the reaction will stop.	
g.	When the temperature is increased, there will be **no** change in the equilibrium position.	

(Total: 7 marks) 7

10. The graph below shows the results of an experiment to determine the rate of decomposition of 10% hydrogen peroxide in the presence of manganese(IV) oxide.



a. Hydrogen peroxide decomposes to give water and oxygen gas. Write an equation for this reaction including state symbols.

____ (3)

b. Points X and Y show different stages during the reaction. Indicate where:

i. oxygen is being produced; ____________ (1)

ii. the reaction has stopped. ____________ (1)

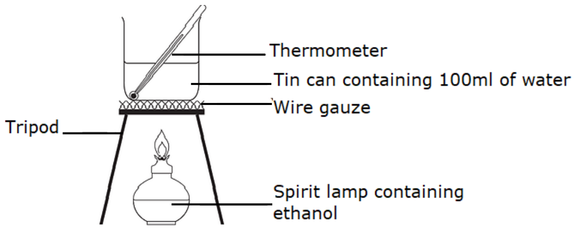
c. On the same graph sketch the curve that would be obtained if the experiment was carried out with 15% hydrogen peroxide. Label this graph Z. (1)

(Total: 6 marks) 6

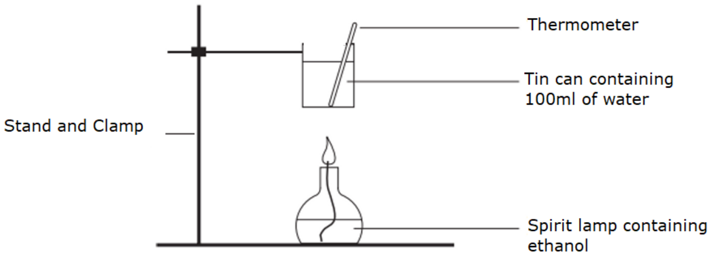
SECTION B

11. During a chemistry lesson, the teacher asked two groups of students to draw the best apparatus to find the enthalpy of combustion of ethanol.

The students drew the following two diagrams.



Experiment A



Experiment B

(Adapted from: Barker College Chemistry Department https://andrewchoi2.wixsite.com/past-hsc-chem2)

With reference to the diagrams above:

a. Explain why the tripod should **not** be used in experiment A. (1)
b. In experiment B, the beaker and the Bunsen burner should be closer. Explain why. (1)

When doing the experiment, the students obtained the following results.

	Results
Mass of spirit lamp with ethanol before	29.974 g
Mass of spirit lamp with ethanol after	29.592 g
Temperature of 100 cm^3 of water before	17.1 ^oC
Temperature of 100 cm^3 of water after	41.2 ^oC

c. Assuming that all the heat that was released from the spirit burner was transferred to the water:
   i. Calculate the heat energy produced from the burning of ethanol to heat the 100mL of water in this experiment. (3)
   ii. Calculate the mass of ethanol burnt during the experiment. (1)
   iii. Calculate the number of moles of ethanol burnt. (3)
   iv. Work out the enthalpy of combustion of ethanol in kJ/mol. (2)

d. The students continuously stirred the water using a stirrer during the experiment. Give **ONE** reason for this precaution. (1)

e. The enthalpy of combustion of ethanol found during the experiment was less than the data book value. Give **ONE** reason for this. (1)

f. What is meant by the term 'exothermic reaction'? (1)

g. Draw an energy level diagram of the combustion of ethanol. Your diagram should show:
   i. labelled x axis;
   ii. labelled y axis;
   iii. energy of products;
   iv. energy of reactants;
   v. activation energy;
   vi. heat of reaction. (3)

This question continues on next page.

h. Ethanol is a fuel made from various plants, such as corn, sugarcane, and grains, collectively known as biomass. Glucose, found in plant material, changes into ethanol using the following reaction: $C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2CO_2$
   i. Name the reaction taking place. (1)
   ii. Yeast can be added to increase the rate of the reaction. What is yeast called in this reaction? (1)
   iii. Give **ONE** advantage of using ethanol as a fuel. (1)

(Total: 20 marks)

12. This question is about substances **A**, **B** and **C**. Use the following table to answer the questions below.

	Melting point (°C)	Boiling point (°C)	Electrical conductivity as solid	Electrical conductivity as liquid	Electrical conductivity as aqueous solution
A	615	876	Poor	Good	Good
B	-105	-45	Poor	Poor	Good
C	3777	4332	Good	Not applicable	Not applicable

a. By looking at the melting points and boiling points in the table, state whether each of **A**, **B**, and **C** is a solid, liquid, or gas at room temperature. (3)
b. Classify substances **A**, **B**, and **C** as having ionic, simple covalent, giant covalent, or metallic bonding by looking at their properties. (3)
c. Classify the bonds below as being either strong or weak bonds:
   i. ionic bond as in NaCl; (1)
   ii. covalent bond as in O_2; (1)
   iii. metallic bond as in Ag; (1)
   iv. intermolecular bond between O_2 molecules. (1)
d. Explain each of the following statements:
   i. Pencils with a graphite tip should **not** be inserted into electric sockets. (1)
   ii. When galvanised, iron is covered with zinc. (1)
   iii. Drills have diamond tips. (1)
   iv. It is better to use aluminium rather than iron for door and window frames (1)
   v. The noble gas neon is **not** reactive. (1)
   vi. Metals can be hammered into different shapes. (1)
e. Methane exists as molecules.
   i. Draw a dot-cross diagram to show the bonding in methane (CH_4). (2)
   ii. What is the state of methane at room temperature? (1)
   iii. Is methane soluble in water? (1)

(Total: 20 marks)

13. This question is about two unknown substances **P** and **R**.
a. Solid **P** is a white powder. When heated strongly, carbon dioxide is evolved, and a solid **Q** remained in the test tube. Solid **Q** is white when cool but yellow when hot.
   i. Identify solids **P** and **Q**. (2)
   ii. Write an equation for the thermal decomposition of **P** to form **Q**. Include state symbols. (3)
   iii. Solid **Q** reacts with both acids and bases. Is it acidic, basic, or amphoteric? (1)
   iv. Is compound **P** soluble or insoluble? (1)

v. Name and give the chemical formula of the salt produced when compound **P** reacts with hydrochloric acid. (2)

b. A green solution forms when a crystalline powder **R** is dissolved in water. On adding a few drops of sodium hydroxide, a green precipitate **S** forms which remains insoluble when an excess of the hydroxide is added. Moreover, a brown precipitate **T** forms when the test tube is left exposed to air for some time. When a few drops of acidified silver nitrate solution are added to another solution of **R** a white precipitate **U** is produced.

i. Identify substances **R**, **S**, **T**, and **U**. (4)

ii. Complete the ionic equation for the reaction of solution **R** with sodium hydroxide solution.

___________ (___) + 2 OH^- (aq) $\rightarrow$ _______________ (s) (3)

iii. Explain why green substance **S** turns rusty brown on exposure to air. (2)

iv. On addition of acidified silver nitrate solution to a solution containing an unknown ionic compound, a yellow precipitate was obtained. Give the name and formula of the yellow precipitate formed. (2)

(Total: 20 marks)

14. Read the following passage and then answer the questions that follow.

As Iraqi forces pulled out of Kuwait in 1991, they set more than 700 oilwells ablaze. These were put out within months, but pollution still mars [means 'harms'] the desert. For 10 months in Kuwait, everything was upside down. Daytime was full of darkness from the thick smoke, and nights were bright from the distant glow of burning oilwells.

The oilwells burned uncontrollably. The smoke plume [means 'cloud'] above them initially stretched for 800 miles. A staggering 11 million barrels of crude oil poured into the Persian Gulf, creating a slick nine miles long. Nearly 300 oil lakes formed on the surface of the desert, polluting the soils.

An international coalition of firefighters battled the fires for months until the last well was finally capped on 6 November 1991 and Kuwait celebrated under clear skies.

(The Guardian. December 2021)

a. Explain the meaning of the term 'pollution'. (1)

b. Name the fractions from crude oil which are used:

i. as fuel for trucks and heavy vehicles; (1)

ii. for waterproofing and road construction. (1)

This question continues on next page.

c. The article mentions the burning of 700 oilwells. Such an activity produces large amounts of carbon dioxide (besides other products).
   i. Name the effect which is the result of too much carbon dioxide in the atmosphere. (1)
   ii. Explain briefly how excessive amounts of carbon dioxide in the air are causing climate change. (2)
   iii. Name the substance that is present in the black smoke described in the article. (1)

d. When fossil fuels burn, the sulfur forms sulfur dioxide. This sulfur dioxide eventually forms acid rain.
   i. Write an equation for the combustion of sulfur in air (oxygen). (2)
   ii. Sulfur dioxide can be tested by using acidified potassium dichromate. Give the colour changes observed. (2)
   iii. State **ONE** harmful effect of acid rain. (1)

e. Butane is one of the compounds obtained from crude oil.
   i. Draw the molecule of butane, showing **all** the atoms and bonds. (2)
   ii. Draw an isomer of butane, showing **all** the atoms and bonds. (2)
   iii. Give the general formula of the homologous series to which butane belongs. (1)

f. In order to reduce pollution, cars are fitted with a device on their exhaust systems which converts NO and CO into less harmful gases.
   i. Name this device. (1)
   ii. State the names or formulae of the **TWO** gases released on conversion of NO and CO through this device. (2)

(Total: 20 marks)

DO NOT WRITE ABOVE THIS LINE

DO NOT WRITE ABOVE THIS LINE

PERIODIC TABLE

Key

Relative atomic mass — A
X
Z — Atomic Number

I	II											III	IV	V	VI	VII	VIII
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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