L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

**SECONDARY EDUCATION CERTIFICATE LEVEL
2020 MAIN SESSION**

SUBJECT: **Chemistry**
PAPER NUMBER: I
DATE: 30th September 2020
TIME: 4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: Fe = 56

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}

Q = It

$\Delta H = mc\Delta\theta$

_____

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.

- Write all your answers in the spaces provided in this booklet.

- The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated in brackets.

- You are reminded of the necessity for orderly presentation in your answers.

- In calculations you are advised to show all the steps in your working, giving your answer at each stage.

- The use of electronic calculators is permitted.

- A Periodic Table is printed on the back of this booklet.

For examiners' use only:

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

DO NOT WRITE ABOVE THIS LINE

Section A:

1. Chemical reactions are all around us.
   a) What particles in an atom take part in chemical reactions?

   _____ (1)

   b) Some atoms may exist on their own while others combine with themselves or with others to form molecules.
      i) Use the Periodic Table provided to give the name or symbol of a substance that exists as single atoms under normal conditions at room temperature.

   _____ (1)

      ii) Give the name or formula of a molecule that consists of two atoms of the same element.

   _____ (1)

   c) Chemists are always researching new compounds. Sometimes these new compounds cannot be stored. Suggest a reason for this.

   _____ (1)

   d) The quality of the air we breathe has a significant effect on our health.
      i) Mention **ONE** air pollutant.

   _____ (1)

      ii) Mention **ONE** health problem the pollutant in part (d) (i) may cause.

   _____ (1)

   (Total: 6 marks)

   6

2. Some substances are unstable to heat and decompose to give various products. Fill in the missing data in the equations below, which represent the action of heat on different solid substances:
   a) $Ca(HCO_3)_2 \rightarrow CaCO_3 + $ _____ + _____ (2)

   b) 2 _____ $\rightarrow 2KNO_2 + O_2$ (1)

   c) $2Zn(NO_3)_2 \rightarrow 2$ _____ + __ $NO_2 + $ _____ (3)

   (Total: 6 marks)

   6

DO NOT WRITE ABOVE THIS LINE

3. a) Water is sometimes called a universal solvent but this term is not perfectly correct. Give the name or formula of:
   i) **ONE** pure liquid substance which does **not** dissolve in water.

   _____ (1)

   ii) **ONE** solid substance which does **not** dissolve in water.

   _____ (1)

   b) Sodium chloride is the chemical name for common salt. If too much salt is added to a small beaker of water, a saturated solution is obtained.
   i) In the space below show, in terms of particles, what happens when salt is stirred well and dissolves completely in water. Label the salt and water particles carefully. (2)

   ii) What happens when a saturated solution is obtained?

   _____ (1)

   c) Marine creatures can survive because air dissolves in water. However, the percentages of the gases in water are different from the percentages of the gases present in the air we breathe. Give **ONE** reason for this.
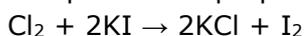
   _____ (1)

   (Total: 6 marks)

   6

4. This question is about the halogens: chlorine, bromine, and iodine.
   a) The equation below represents the displacement property of the halogens.
   $$Cl_2 + 2KI \rightarrow 2KCl + I_2$$
   Give an ionic equation (omitting spectator ions) for the above reaction. Include state symbols.

   _____

   _____ (3)

   b) In the reaction in part (a), chlorine is acting as an oxidising agent. Explain by using oxidation numbers.

   _____

   _____ (3)

   (Total: 6 marks)

   6

5. During a chemistry session two groups of students, Group A and Group B, are discussing the properties of hydrogen.
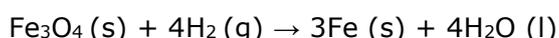   a) Complete the following statements about hydrogen.
      Group A says 'It is better **not** to use hydrogen as a fuel because…'

   _____ (1)

      Group B says 'Hydrogen is a good choice for a fuel because…'

   _____ (1)

   b) Hydrogen has many important properties one of which is shown in the following reaction.

   $$Fe_3O_4 \text{ (s)} + 4H_2 \text{ (g)} \rightarrow 3Fe \text{ (s)} + 4H_2O \text{ (l)}$$

      i) In this reaction what is hydrogen acting as?

   _____ (1)

      ii) Calculate the mass of iron that may be obtained if 0.8 moles of hydrogen gas are used in the reaction.

   _____

   _____

   _____

   _____ (4)

   (Total: 7 marks)

   7

6. a) Sodium and calcium are both metals, but they belong to different groups in the Periodic Table. Sodium is in Group 1 while calcium is in Group 2.
      Give the formula of the oxide of each metal:

      i) oxide of sodium; _____ (1)

      ii) oxide of calcium. _____ (1)

   b) Use the Periodic Table provided to give the name or symbol of:
      i) a metal in Group 1 whose atoms are bigger than the atoms of sodium;

   _____ (1)

      ii) a metal in Group 2 which is less reactive than calcium.

   _____ (1)

   (Total: 4 marks)

   4

7. a) Carbon dioxide and carbon monoxide are two oxides of carbon. Their properties are very different. Why is it dangerous to breathe carbon monoxide gas?

_____ (1)

    a) A gas jar contains a mixture of carbon dioxide and carbon monoxide. A group of students decides to separate the mixture by bubbling the mixture through sodium hydroxide solution.
       i) Which **ONE** of the two gases reacts?

_____ (1)

       ii) Give a balanced equation for the reaction occurring in part (b) (i).

_____ (2)

    b) Two allotropes of carbon are diamond and graphite and they have very different properties. State which **ONE** of the two allotropes, diamond or graphite, may be used in the following situations:

       i) to cut glass; _____ (1)

       ii) as a lubricant; _____ (1)

       iii) in pencil nibs. _____ (1)

7

(Total: 7 marks)

8. a) A student needs to prepare a variety of salts. Several substances are available. Give the names or formulae of **TWO** appropriate substances that the student may add together to form the following salts. (4)

	Name of salt	Substance 1	Substance 2
i)	Barium sulfate, $BaSO_4$		
ii)	Zinc nitrate, $Zn(NO_3)_2$		

    b) Use the substances that you gave in your answer to part (a) (ii) to write a balanced equation for the reaction.

_____ (2)

6

(Total: 6 marks)

Please turn the page.

9. The diagram below gives some information about the factors that affect the rates of reactions.

```
  ┌──────────────┐                              ┌──────────────┐
  │ Temperature  │                              │    Light     │
  └──────────────┘        ┌──────────────┐      └──────────────┘
                          │ Factors affecting │
                          │ rates of reactions │
                          └──────────────┘
  ┌──────────────┐                              ┌──────────────┐
  │ Concentration│                              │   Pressure   │
  └──────────────┘                              └──────────────┘
```

a) Give **ONE** reason why an increase in temperature increases the rate of a reaction.

_____

_____ (1)

b) Give **TWO** reasons why a decrease in the pressure in a reaction involving gases, decreases the rate of the reaction.

Reason 1: _____ (1)

Reason 2: _____ (1)

c)
   i) The rate of some reactions increases in the presence of UV light. Give an example of such a reaction.

_____ (1)

   ii) What is the name given to such reactions as in part (c) (i)?

_____ (1)

d) An increase in concentration of one of the reactants in a reaction may increase the rate of the reaction. Explain this in terms of the particles present.

_____

_____ (1)

(Total: 6 marks)

6

10. The ground water in Malta is hard water due to some substances it contains.
   a) Give the names or formulae of **TWO** substances which may cause the water to be hard.
      i) Substance A: _____ (1)

      ii) Substance B: _____ (1)

   b) What is the difference between permanent hard water and temporary hard water?

   _____

   _____ (2)

   c) Consider the following statement:

      '…when it comes to industrial settings, hard water may pose a lot of critical problems. In such environments, water hardness needs to be monitored to avoid costly breakdowns in cooling towers, boilers, and other equipment that is somehow connected to water.'
      https://www.waterfiltermag.com/

      Mention **ONE** disadvantage of hard water in industry.

   _____ (1)

   d) In everyday living circumstances, there are advantages associated with hard water. Mention **ONE** such advantage.

   _____ (1)

   (Total: 6 marks)

   6

   Please turn the page.

Section B:

11. a) A short piece of hot magnesium ribbon is very quickly lowered into a gas jar full of air. State **TWO** observations that can be made during this reaction.

Observation 1: _____ (1)

Observation 2: _____ (1)

b) In the reaction in part (a), magnesium actually undergoes more than one reaction since it reacts mainly with oxygen, as well as with nitrogen and with carbon dioxide. It will also react with any humidity present. Complete the table below by giving the name or formula of the products as indicated. (3)

	Magnesium + Oxygen	Magnesium + Steam
Name or formula of the product/s		

c) When firemen arrive at the scene of a fire they check to see if the fire could be due to burning magnesium. Fire extinguishers containing carbon dioxide cannot be used since magnesium reacts with carbon dioxide as well.
   i) Give a balanced equation for the reaction that occurs between magnesium and carbon dioxide to form magnesium oxide and carbon. Include state symbols.
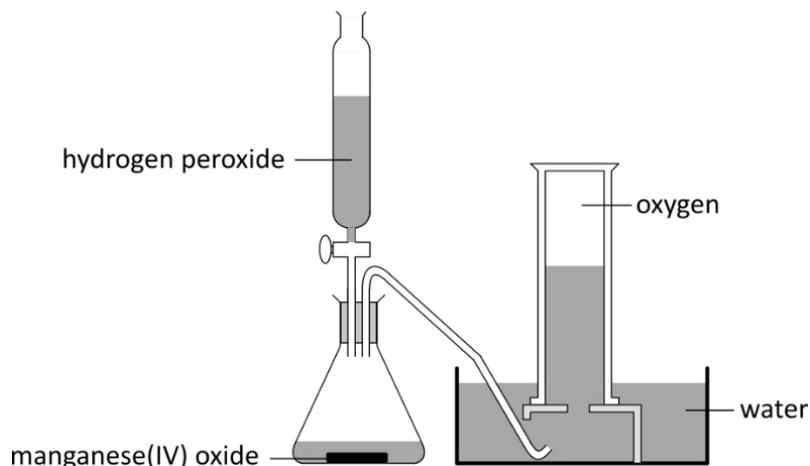
_____ (3)

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

_____ (1)

   iii) A small magnesium fire can be put out by covering it with sand. Explain.

_____ (1)

d) The diagram below shows a student's diagram for the preparation of oxygen from hydrogen peroxide in the presence of manganese(IV) oxide.

i) Name the part of the apparatus containing the manganese(IV) oxide.

_____ (1)

ii) In the diagram shown, oxygen is collected over water. Suggest **TWO** other ways which are suitable to collect the oxygen gas produced.

_____

_____ (2)

iii) The reaction occurring may be represented by the equation

$$2H_2O_2 (aq) \rightarrow 2H_2O (l) + O_2 (g)$$

Calculate the volume of oxygen that may be collected at standard temperature and pressure when using 0.5 mole of hydrogen peroxide. Assume that no oxygen is lost or dissolved in water.

_____

_____

_____

_____ (4)

iv) What will happen if manganese(IV) oxide is **not** used in the reaction?

_____ (1)

v) Moist blue and red litmus papers are placed in the gas jar of oxygen. What effect will there be, if any? Explain your answer.

_____

_____

_____ (2)

(Total: 20 marks)

20

Please turn the page.

12. Alkenes and alkynes are hydrocarbons which do not belong to the same homologous series. They are unsaturated and give addition reactions.
    a) Explain briefly the following terms.
       i) Hydrocarbons

    _____ (1)

       ii) Unsaturated

    _____ (1)

       iii) Addition reactions

    _____ (1)

    b) In the spaces below draw the structures of butane, propene and ethyne, showing **all** the bonds. (3)

butane	propene	ethyne

    c) Propane, C_3H_8, belongs to the homologous series of the alkanes.
       i) Give the general formula for the alkanes.

    _____ (1)

       ii) Give a balanced equation for the reaction of propane with chlorine.

    _____ (2)

       iii) Give a chemical test for the gas given out in part (c) (ii).

    _____ (1)

       iv) Describe what is observed when the gas produced in part (c) (ii) is released in a humid environment.

    _____ (1)

       v) Propene also gives a reaction with chlorine but the products are different to those in part (c) (ii). Show this in a balanced equation.

    _____ (2)

vi) Propane and ethyne both react with oxygen. How are the observations during these two reactions different?

Propane: _____ (1)

Ethyne: _____ (1)

d)

i) Alkenes undergo addition polymerisation, but alkanes do not. Explain this difference briefly.

_____

_____ (2)

ii) Draw the structure of the polymer that may be formed from ethene, showing **TWO** repeating units and **all** the bonds and atoms clearly. (2)

iii) Give the name of the polymer formed in part (d) (ii).

_____ (1)

(Total: 20 marks)

20

Please turn the page.

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

SUBJECT: **Chemistry**
PAPER NUMBER: IIA
DATE: 1st October 2020
TIME: 4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, N = 14, O = 16; S = 32.

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}

Q = It

$\Delta H = mc\Delta\theta$

_____

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	7	6	5	5	7	20	20	20	20	100

Section A: Answer ALL questions.

1. All matter is made of particles. Give **TWO** statements about what happens to particles when the following changes take place.
   a) Liquid ethanol becomes ethanol vapour.

      i) _____ (1)

      ii) _____ (1)

   b) The smell of a pungent gas may be detected some distance away from where it is generated.

      i) _____ (1)

      ii) _____ (1)

   c) The spreading of the purple colour through water when a potassium permanganate crystal is dropped in it.

      i) _____ (1)

      ii) _____ (1)

      (Total: 6 marks)

      6

2. Most elements have isotopes.
   a) What are isotopes?

   _____

   _____ (2)

   b) Copper has two main isotopes ^{63}Cu with a natural abundance of 69.2% and ^{65}Cu with a natural abundance of 30.8%. Prove that the relative atomic mass of copper is 63.6.

   _____

   _____

   _____

   _____ (2)

   c) Use the Periodic Table given, to write the name or symbol for the element which has:

      i) an electronic configuration of 2,8,5; _____ (1)

      ii) 12 protons. _____ (1)

      (Total: 6 marks)

      6

3. Which separating technique would be used in the laboratory to separate each of the following mixtures?

Mixture		Separating technique
a)	A mixture of two liquids whose boiling points differ by 20 °C.	
b)	A mixture of white sand and ammonium chloride.	
c)	The pigments in red flower petals.	
d)	A mixture of lead(II) sulfate and water.	
e)	A mixture of iron(II) sulfate in water keeping both the solvent and the solute.	
f)	Two liquids with different densities that do **not** mix together.	

(Total: 6 marks)

6

4. The following diagram shows a molecule of methane.
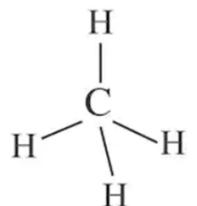
a) What type of bonding links the carbon and hydrogen atoms together?

_____ (1)

b) How is the bond between the carbon and hydrogen formed?

_____ (1)

c) The type of bonding that exists in methane characterises its physical properties. Give **TWO** physical properties which are typical of substances having this type of bond.

Property 1: _____ (1)

Property 2: _____ (1)

d) Methane and diamond both have the same type of bonding. However, their physical properties are different from each other. Explain.

_____

_____ (2)

6

(Total: 6 marks)

5. The following is a reversible reaction.

$$NH_4Cl \text{ (s)} \rightleftharpoons NH_3 \text{ (g)} + HCl \text{ (g)} \qquad \Delta H \text{ is positive.}$$

a) Why is this reaction a reversible reaction?

_____ (1)

b) This reaction may reach a state of dynamic equilibrium.
   i) Explain the term dynamic equilibrium.

_____ (1)

   ii) Give **TWO** ways of favouring the forward reaction.

_____ (2)

   iii) Give an equation for a different reversible reaction where an increase in pressure is used to favour the forward reaction.

_____ (2)

(Total: 6 marks)

6

6. The diagram below shows the electrolysis of sodium sulfate solution to which a few drops of universal indicator have been added.

Power supply

A   B

Carbon electrode

Clamp

U-tube

Sodium sulfate solution mixed with a few drops of universal indicator
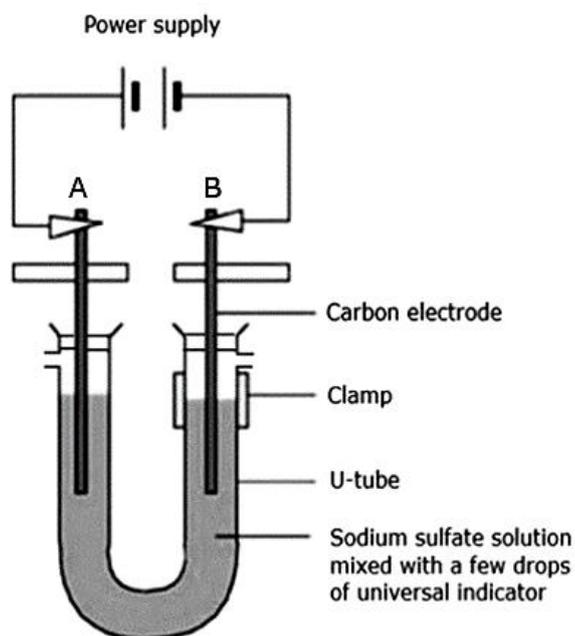
Picture adapted from: http://praticalscience.blogspot.com/

a) During this experiment two substances are formed, one at each electrode.
   i) Give the name of the substance formed at electrode B.

_____ (1)

   ii) Give the half equation for the reaction that takes place at electrode A.

_____ (2)

iii) The colour of the solution changes as the experiment proceeds. Give the colour changes which will be observed at each of the electrodes.
(Note that the colour of universal indicator in acidic solutions is red, in alkaline solutions is blue and in neutral solutions is green.)

At the cathode: _____ (1)

At the anode: _____ (1)

b) This experiment was carried out in the laboratory using a current of 3 A for 4800 seconds.

i) Calculate the amount of charge that passed through the circuit during the experiment.

_____ (1)

ii) Calculate how many moles of electrons passed through each electrode.

_____ (1)

(Total: 7 marks)

7

7. Billions of litres of alcohol are produced using fermentation.
   a) Give the equation for the reaction by which ethanol is produced in the laboratory by fermentation of glucose.

_____ (2)

b) In the laboratory, ethanol may be converted into ethanoic acid. State:
   i) the reagent used to bring about this change;

_____ (1)

   ii) **ONE** condition that is required during the reaction.

_____ (1)

c) Draw the structural formula of ethanoic acid. (1)

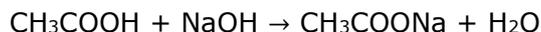d) Both ethanol and ethanoic acid react with sodium to give the same product. Give the name or formula for this substance.

_____ (1)
(Total: 6 marks)

6

8. Jesmond carries out a titration to calculate the concentration of ethanoic acid in a sample of white vinegar. The chemical equation for this reaction follows:

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

He transfers 25.0 cm^3 of vinegar into clean conical flasks adding two drops of phenolphthalein indicator to each flask. He fills a clean burette with 0.5 mol dm^{-3} sodium hydroxide solution. He slowly adds sodium hydroxide solution to each sample of vinegar until the reaction is complete.

a) What equipment is used to transfer 25.0 cm^3 of vinegar into the conical flasks?

_____ (1)

b) What colour change will occur when the reaction is complete?

_____ (1)

c) In the experiment, 18.5 cm^3 of 0.5 mol dm^{-3} sodium hydroxide are required to neutralise 25.0 cm^3 of vinegar.
   i) Calculate the amount (in moles) of sodium hydroxide used.

_____ (1)

   ii) What is the amount (in moles) of ethanoic acid present in the 25.0 cm^3 sample of vinegar?

_____ (1)

   iii) Calculate the concentration of ethanoic acid in the sample of vinegar.

_____ (1)

(Total: 5 marks)

5

9. The method used for the extraction of metals from their ores depends on their position in the activity series.
   a) Give the equation for the reaction that takes place during the extraction of iron from its ore.

_____ (2)

   b) Give the half equation for the reaction by which aluminium is extracted from its ore.

_____ (2)

   c) Explain why different methods are used to extract iron and aluminium.

_____

_____ (1)

(Total: 5 marks)

5

10. A white solid A does not give any positive flame test. Substance A dissolves in water and when tested with barium chloride, it gives a white precipitate insoluble in excess dilute hydrochloric acid. Substance A also gives a white precipitate with dilute sodium hydroxide solution which is insoluble when adding excess alkali.

a) Give the name or formula for substance A.

_____ (2)

b) Give the equation for the reaction of substance A with barium chloride.

_____ (2)

c) Give the ionic equation (omitting spectator ions) for the reaction of substance A with sodium hydroxide.

_____

_____ (3)

7

(Total: 7 marks)

Please turn the page.

Section B: Answer TWO questions from this section.

11. Worldwide, airplane flights in 2018 produced 895 million tonnes of CO_2. Globally, humans produced over 42 billion tonnes of CO_2. (https://www.atag.org/facts-figures.html)
    a) This amount of carbon dioxide in the Earth's atmosphere is adversely affecting our planet.
       i)   Give the name of the process that is adversely affecting our planet. (1)
       ii) Explain how Earth is being affected by this amount of carbon dioxide. (3)
       iii) Give **TWO** ways by which this may negatively impact society. (2)
       iv) Give the name of **TWO** other gases that are released by human activity that cause the same effect. (2)
       v)   Most of the carbon dioxide in the atmosphere comes from burning fossil fuels. Name the gas produced when fossil fuels are **not** burnt completely. (1)
       vi) Why is the gas in part (a) (v) difficult to detect? (1)
    b) Acid rain is also an unfortunate by-product of human activity.
       i)   Give the name or formula of **TWO** gases that cause acid rain. (2)
       ii) What is the origin of these gases? (2)
       iii) The catalytic converter is used to reduce the emissions of one of these gases. Explain briefly how this is done. (1)
       iv) List **TWO** disadvantages of acid rain. (2)
    c) CFC production was banned in 1996.
       i)   Why were these chemicals banned? (1)
       ii) Explain why CFCs were having an adverse effect on living things. (2)
       (Total: 20 marks)

12. Nitrogen is a vital element for the survival of humankind.
    a) Describe briefly how nitrogen is obtained industrially. (3)
    b) Describe briefly an experiment to obtain pure nitrogen in the laboratory from a sample of a gas which has water vapour and carbon dioxide impurities only. Your answer should include a labelled diagram of the laboratory setup. (4)
    c) Most of the manufactured nitrogen is converted into ammonia. List **TWO** other uses of nitrogen. (2)
    d) How is nitrogen converted to ammonia on a large scale? Your answer should include any equations and conditions that may be important for the process to take place. (6)
    e) Dry ammonia can be prepared in the laboratory using the following reaction.

    $$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O + 2NH_3$$
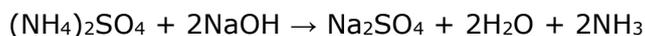
       i)   Name a drying agent that would be suitable to dry ammonia. (1)
       ii) Give a test for ammonia gas. (1)
       iii) Calculate the maximum volume of ammonia produced if a mass of 1.65 g of ammonium sulfate reacts completely at standard temperature and pressure. (3)
       (Total: 20 marks)

DO NOT WRITE ABOVE THIS LINE

13. When alcohols are burned energy is produced.
    a) Describe an experiment a student would carry out in the laboratory to determine the heat of combustion of an alcohol.
       Your answer should include:
       - A labelled diagram of the apparatus used in this experiment.
       - The method followed.
       - The measurements made during the experiment. (7)
    b) Draw a labelled energy level diagram for the experiment in part (a). (4)
    Heat is also produced during neutralisation reactions.
    c) Give the equation for the complete neutralisation of potassium hydroxide with sulfuric acid. (2)
    d) Calculate the volume of 2 mol dm^{-3} sulfuric acid that would be required to neutralise 50 cm^3 of 2 mol dm^{-3} potassium hydroxide. (3)
    e) Calculate the heat of neutralisation (in kJ mol^{-1}) if during the experiment in part (d) there was a temperature change of 14 °C. Assume that the density of the solution is 1 g dm^{-3}. (3)
    f) The expected heat of neutralisation is -57.5 kJ mol^{-1}. Give a reason for the difference between this value and that calculated in part (e). (1)
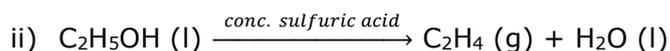
    (Total: 20 marks)

14. Sulfur exists in the form of two main allotropes.
    a) What are allotropes? (1)
    b) Give the names and draw the structures of the main allotropes of sulfur. (4)
    c) Most of the sulfur extracted from the ground is converted to sulfuric acid. With the help of balanced equations explain how this is brought about on a large scale. (11)
    d) State the role of sulfuric acid in each of the following reactions. (3)
       i) $Cu (s) + 2H_2SO_4 (l) \rightarrow CuSO_4 (aq) + 2H_2O (l) + SO_2 (g)$

       ii) $C_2H_5OH (l) \xrightarrow{conc.\ sulfuric\ acid} C_2H_4 (g) + H_2O (l)$

       iii) $Na_2CO_3 (s) + H_2SO_4 (aq) \rightarrow Na_2SO_4 (aq) + H_2O (l) + CO_2 (g)$

    e) Sulfuric acid is hygroscopic. What is a hygroscopic substance? (1)

    (Total: 20 marks)

_____

_____

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SEC06/2A.20m

SEC06/2A.20m

SEC06/2A.20m

SEC06/2A.20m

SEC06/2A.20m

SEC06/2A.20m

PERIODIC TABLE

	I	II														III	IV	V	VI	VII	VIII
																					4 **He** 2
	1 **H** 1															11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
	7 **Li** 3	9 **Be** 4														27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
	23 **Na** 11	24 **Mg** 12	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
	39 **K** 19	40 **Ca** 20	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
	85 **Rb** 37	88 **Sr** 38	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
	133 **Cs** 55	137 **Ba** 56	227 **Ac** 89																		
	223 **Fr** 87	226 **Ra** 88																			

Key

Relative atomic mass	A
	X
Atomic Number	Z

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
2020 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIB
DATE:	1st October 2020
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1; C = 12, Ca = 40, Cl = 35.5.

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}

Q = It

ΔH = mcΔθ

_____

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	3	7	8	5	7	6	6	6	6	20	20	20	20	100

Section A: Answer ALL questions.

1. a) The following diagrams show the arrangements of particles of the same substance at different temperatures and pressures. Match the comments on the left with diagrams on the right. (4)

Liquid
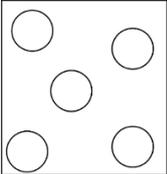
A gas at high pressure
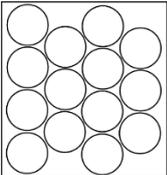
Solid
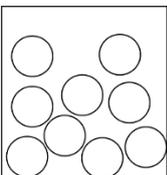
A gas at low pressure
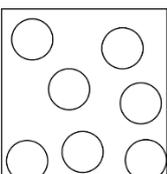
b) Small dust particles move irregularly in the air before they fall towards the ground as shown in the diagram below.

Picture adapted from https://commons.wikimedia.org/
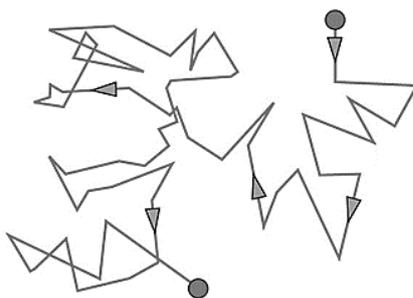
i) Why do dust particles move irregularly in the air?

_____ (1)

ii) Name this effect.

_____ (1)

(Total: 6 marks)

6

2. This question is about electron configuration.
    a) Draw the electron configuration in a chlorine atom. (2)

    b) Fill in the blank space:
       Atoms are neutral because they have the same number of protons and _____
       (1)

       3

       (Total: 3 marks)

3. Oxygen reacts with magnesium to form magnesium oxide, a white solid at room temperature and pressure (RTP). Oxygen also reacts with hydrogen to form water, a colourless, odourless liquid at RTP.
    a) Draw dot and cross diagrams to show the bonding in magnesium oxide and in water. Show outer electrons only. (4)

    MgO

    H_2O

    b) Name the type of bonding present in each compound.

       i) Magnesium oxide: _____ (1)

       ii) Water: _____ (1)

    c) Why is magnesium oxide a solid at RTP? Refer to the bonding present.

    _____ (1)

    7

    (Total: 7 marks)

4. Two students find four test tubes each containing a white, crystalline solid. They try to determine the melting point of each solid in test tubes labelled E, F, G, and H.

Test tube	Melting Range (°C)	
	Minimum	Maximum
E	801.0	801.0
F	682.5	724.7
G	180.4	180.5
H	206.3	241.8

a) Which of the test tubes contain a mixture? Why?

_____

_____ (2)

They add some water to the test tubes containing mixtures. Only part of the mixture is soluble in water. They decide to separate the solution obtained from the remaining insoluble parts.

b) Which separation technique should be used?

_____ (1)

c) Draw a labelled diagram of the setup used for this technique.   (5)

8

(Total: 8 marks)

5. Potassium chromate, K_2CrO_4, forms a yellow solution when dissolved in water. Potassium dichromate, $K_2Cr_2O_7$, forms an orange solution when dissolved in water. The chromate and dichromate ions exist in equilibrium according to the equation below.

$$Cr_2O_7^{2-} (aq) + H_2O (l) \rightleftharpoons 2CrO_4^{2-} (aq) + 2H^+ (aq)$$
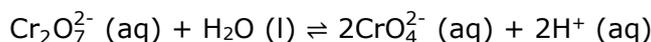
a) What does 'exist in equilibrium' mean?

_____ (1)

b) What would be the effect on the equilibrium if the concentration of hydrogen ions is increased?

_____ (1)

c) How can the concentration of hydrogen ions be increased?

_____ (1)

Reactions that exist in equilibrium are different from reversible reactions.

d) State **ONE** difference between reversible reactions and reactions in equilibrium.

_____

_____ (1)

e) Give an example of a reversible reaction.

_____ (1)

(Total: 5 marks)

5

6. Maria has printed an incomplete reactivity series, as shown below. She wants to add zinc, sodium, copper, and tin to this series.

K		Ca		Mg		C		Fe		Pb	H		Ag

a) Insert zinc, sodium, and copper in the reactivity series above. (3)

b) Tin is close to iron in the reactivity series. Maria observes that a reaction does **not** occur when tin is added to a solution of iron(III) chloride.
Insert tin (Sn) in the reactivity series above. (1)

c) Some metal oxides can be reduced by using carbon or hydrogen while other metal oxides are reduced by electrolysis. Which of calcium oxide, zinc oxide, and silver oxide (the substances mentioned can only be used once) may be reduced using:

   i) hydrogen; _____ (1)

   ii) carbon; _____ (1)

   iii) electrolysis only. _____ (1)

(Total: 7 marks)

7

7. Aluminium is obtained in industry from an ore of aluminium oxide by electrolysis.
   a) Give the symbols of the ions present in aluminium oxide.

   _____ (2)

   b) Write an ionic half equation for the formation of aluminium from its ions in this process.

   _____ (2)

   c) Does the reaction in part (b) take place at the cathode or anode? Why?

   _____

   _____ (2)

   (Total: 6 marks)

   6

8. Explain why each of the following steps are taken during a titration.

   a) The tap of the burette is opened before using the burette.

   _____ (1)

   b) A rough titration is carried out.

   _____ (1)

   c) More than one titration is carried out.

   _____ (1)

   d) Phenolphthalein is added to the acid.

   _____ (1)

   e) The solution in the burette is added dropwise towards the end of the titration.

   _____ (1)

   f) The conical flask is placed on a white tile.

   _____ (1)

   (Total: 6 marks)

   6

9. Krista needs to distinguish between three unlabelled organic liquids which are octane, ethanol, and ethanoic acid. She carries out three tests on each liquid:
   1. addition of phosphorus pentachloride;
   2. solubility in water;
   3. pH measurement.

Results are shown in the table below.

	Addition of phosphorus pentachloride	Solubility in water	pH
Substance I	White misty fumes	Yes	6.9
Substance J	White misty fumes	Yes	3.9
Substance K	No reaction	No	n/a

a) Identify substances I, J, and K. (3)

I: _____

J: _____

K: _____

b) Why is substance K **not** soluble in water?

_____ (1)

c) Why do substances I and J, react similarly with phosphorus pentachloride?

_____ (1)

d) Two of the substances react together to form a compound with a fruity smell. Name the compound formed.

_____ (1)

(Total: 6 marks)

6

Please turn the page.

10. Substance L is a green-brown solid which is insoluble in water. It reacts with hydrochloric acid to produce a gas, M, and a pale green solution, N. The gas M forms a white precipitate when bubbled through lime water. When sodium hydroxide solution is added to solution N, a pale green precipitate, O, forms. Substance O turns brown to form substance P on standing. This is shown in the diagram below.

```
┌─────────────────┐
│  Green brown    │
│  solid L        │
└─────────────────┘
         │
      + HCl (aq)
         │
         ▼
┌──────────┐   + limewater   ┌──────────────┐
│  Gas     │ ──────────────▶ │  White       │
│  M       │                 │  precipitate │
└──────────┘                 └──────────────┘
    +
┌──────────┐   + NaOH (aq)   ┌──────────────┐  on standing  ┌──────────────┐
│  Pale    │ ──────────────▶ │  Pale green  │ ────────────▶ │  Brown       │
│  green   │                 │  precipitate │               │  substance P │
│ solution N│                │  O           │               └──────────────┘
└──────────┘                 └──────────────┘
```
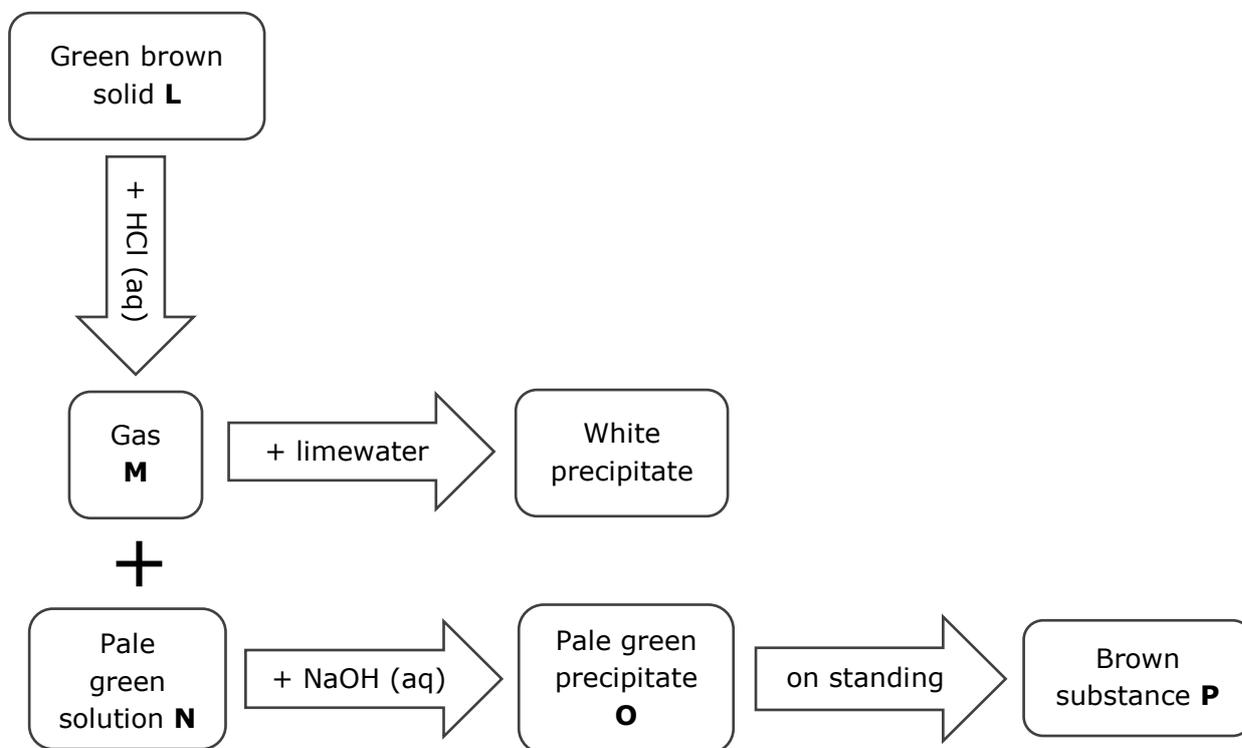
a) Give the chemical formula of substances M, N, O and P.

M: _____

N: _____

O: _____

P: _____ (4)

b) Hence, give the chemical formula of substance L.

_____ (2)

(Total: 6 marks)

6

Section B: Answer TWO questions from this section.

11. Fossil fuel combustion is the largest contributor to air pollution in urban areas, including pollutants like carbon monoxide, smog, sulfur dioxide, NO_x, and greenhouse gases. Traffic further increases the likelihood of these pollutants.
    a) Name a common type of fossil fuel which is: (3)
       i)   a solid;
       ii) a liquid;
       iii) a gas.
    b) How does combustion of fossil fuels generate each of these pollutants? (5)
       i)   Greenhouse gases
       ii) Carbon monoxide
       iii) Smog
       iv) Oxides of nitrogen
       v)   Sulfur dioxide
    c) How does each of the following pollutants harm the environment? (5)
       i)   Greenhouse gases
       ii) Carbon monoxide
       iii) Smog
       iv) Oxides of nitrogen
       v)   Sulfur dioxide
    d) What measures are used to decrease the likelihood of the following gases from being produced: (2)
       i)   Sulfur dioxide;
       ii) Carbon monoxide and oxides of nitrogen.
    e) The formulae for two common fossil fuels are C_8H_{18} and $C_{16}H_{34}$.
       i)   Calculate the percentage by mass of carbon in C_8H_{18}. (2)
       ii) Write a balanced chemical equation for the combustion of $C_{16}H_{34}$. (2)
       iii) Given that the percentage by mass of carbon in $C_{16}H_{34}$ is 84.9%, which one of the two substances is more likely to produce carbon monoxide and smog? (1)
                                                                                    (Total: 20 marks)

12. Nitrogen makes up the inert part of the Earth's atmosphere.
    a) What percentage of air is composed of nitrogen? (1)
    b) Why is nitrogen unreactive? Refer to the bonding present. (2)
    c) Nitrogen is obtained from the Earth's atmosphere.
       i)   Name the process by which nitrogen is obtained from the Earth's atmosphere. (1)
       ii) Briefly explain the principle behind the process in part c (i). (3)
    One of the uses of nitrogen is the production of ammonia. Ammonia is one of the most produced chemicals on Earth. In this process, nitrogen and hydrogen are mixed with a suitable catalyst under high pressure and allowed to reach equilibrium. Ammonia, NH_3, is removed by cooling the mixture. Unused gases are recycled back into the reaction chamber.
    d) Give **ONE** other use of nitrogen besides the production of ammonia. (1)
    e) Write a chemical equation for the reaction to prepare ammonia as explained above. (2)
    f) Give a value for pressure and temperature as well as a suitable catalyst for this reaction. (3)
    g) Why is a high pressure used? (1)
    h) Why is a relatively high temperature used? (1)

DO NOT WRITE ABOVE THIS LINE

---

i) Why can ammonia be removed by cooling the mixture? (1)
j) Why are there unused gases at the end of the reaction? (1)
More than half the ammonia produced is used to produce fertilisers. One such fertiliser is ammonium nitrate, which is produced by the reaction between ammonia and nitric acid, HNO_3.
k) Give **ONE** use of ammonia besides the production of fertilisers. (1)
l) Write a balanced chemical equation for the reaction between ammonia and nitric acid. (2)

(Total: 20 marks)

13. Instant hot packs warm up while instant cold packs cool down when pressed.

    Hand warmers are instant hot packs used to warm hands or feet on cold days. Some of these contain iron powder which reacts with air once the plastic cover is removed.

    Instant cold packs are used to treat a bruise. Some of these contain powdered urea crystals and water in separate containers. Once the pack is pressed, these containers break and the urea dissolves in water, absorbing heat energy from the surroundings.

    a) With which component of air does iron react? (1)
    b) Why are the iron and urea both in the form of a powder? (1)
    c) Why do reactions release or absorb heat? Explain in terms of bonding. (2)
    d) Use the information provided above and your knowledge of chemistry to select the correct answer from the brackets in each case. [Do **not** give your answer on this page.]
       i) The reaction in the instant cold pack is an example of a (chemical / physical / biological) change. (1)
       ii) The reaction in the instant cold pack is an example of an (isothermic / endothermic / exothermic) reaction. (1)
       iii) A suitable value for the change in heat of the reaction in the instant cold pack is of: ($- 28.5$ kJ mol^{-1} / $+ 15.3$ kJ mol^{-1} / $- 824.2$ kJ mol^{-1}). (1)
    e) The unlabelled energy diagram below shows the heat change during one of the reactions described above. Copy this diagram and label: (7)
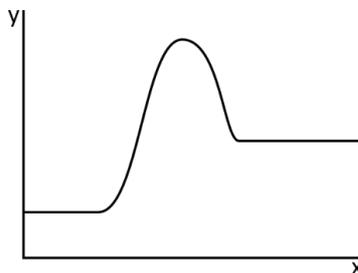
       i) whether it shows an exothermic or endothermic change;
       ii) heading for the x-axis;
       iii) heading for the y-axis;
       iv) energy level of products;
       v) energy level of reactants;
       vi) the heat change, ΔH, of reaction;
       vii) the activation energy, E_A, of the reaction.
    f) Rachel learns that calcium chloride and water are also used in instant hot or cold packs. Rachel wants to calculate the heat given off when calcium chloride is dissolved in water.

When 2.0 g of calcium chloride are added to 200 g of water, the temperature increases by 2.5 °C.
i) Calculate the energy change when 200 g of water heat up by 2.5 °C. (2)
ii) Calculate the amount of substance (in moles) in 2.0 g of calcium chloride, $CaCl_2$. (2)
iii) Calculate the heat change if one mole of calcium chloride had to be dissolved in excess water. (2)

(Total: 20 marks)

14. This question is about sulfur and its compounds.
    a) Give the names of the different forms of sulfur shown below. (2)

    i)   ii)
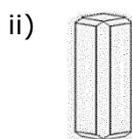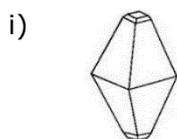
    Pictures adapted from www.uq.edu.au

    b) Name **ONE** major source of sulfur. (1)
    c) Sulfur burns in air with a clean blue flame. Write a balanced chemical equation including state symbols for this reaction. (3)
    d) Give **TWO** physical properties of the gas produced in part (c). (2)
    e) Write a balanced chemical equation for the reaction between the gas produced in part (c) and water. (2)
    f) Name the compound produced when the solution produced in part (e) is oxidised. (1)
    g) Concentrated sulfuric acid shows different roles in the reactions listed below. Give the missing information for each reaction.
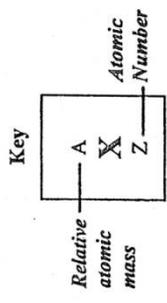   [Do **not** give your answers on this sheet.]

Reaction 1	Concentrated sulfuric acid with table sugar	
Equation	$C_6H_{12}O_6$ (s) + H_2SO_4 (l) → $6H_2O$ (l) + 6C (s) + H_2SO_4 (aq)	
Observations	i)	(1)
Role of H_2SO_4	ii)	(1)

Reaction 2	Concentrated sulfuric acid with table salt	
Equation	H_2SO_4 + NaCl → HCl + $NaHSO_4$	
Observations	iii)	(1)
Role of H_2SO_4	iv)	(1)

Reaction 3	Concentrated sulfuric acid with ethanol	
Equation	v)	(2)
Observations	Gas with a sweet smell	
Role of H_2SO_4	vi)	(1)

Reaction 4	Concentrated sulfuric acid with copper	
Equation	Cu (s) + $2H_2SO_4$ (l) → $CuSO_4$ (aq) + SO_2 (g) + $2H_2O$ (l)	
Observations	vii)	(1)
Role of H_2SO_4	viii)	(1)

(Total: 20 marks)

PERIODIC TABLE

Key

	A
	X
	Z

Relative atomic mass
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