Index Number:_____ SEC06/1.22m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2022 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	17th May 2022
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, C = 12, O = 16, K = 39, Ca = 40

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

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

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

Faraday constant = 96500 C mol^{-1}

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

$\Delta H = mc\Delta\theta$

Directions to Candidates

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

For examiners' use only:

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

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Section A: Answer ALL questions.

1. Use the terms below to complete the paragraph. Each term may be used once, more than once or not at all.

positive	negative	heavier	same
less	electrons	protons	neutrons

The nucleus of an atom contains neutrons and _____. An atom is neutral because it contains equal numbers of _____ and _____. The charge of an electron is _____. The mass of an electron is _____ than the mass of a proton. Isotopes of an element are atoms of the same element having a different number of _____.

(Total: 6 marks)

6

2. Some substances are acidic, some are alkaline while others are neutral.
   a. The table below shows some common substances. Complete the table by stating whether the pH value will be less than 7, 7, or higher than 7. The first one has been filled in as an example.

	Substance	**pH**
i.	Orange juice	Less than 7
ii.	Distilled water	
iii.	Milk of magnesia	
iv.	Sugar solution	
v.	Vinegar	

(4)

   b. When hydrogen chloride is added to water an acidic solution is produced but when hydrogen chloride is added to methylbenzene the solution produced is **not** acidic. Give **TWO** reasons for this statement.

      i. Reason 1: _____ (1)

      ii. Reason 2: _____ (1)

(Total: 6 marks)

6

3. A student places 5.0 g of powdered calcium carbonate in a boiling tube. On adding excess of dilute hydrochloric acid to this solid, carbon dioxide is given off according to the equation:

$$CaCO_3\ (s) + 2\ HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$

   a. Calculate the number of moles of carbon dioxide produced.

_____

_____

_____

_____ (4)

   b. Calculate the volume, measured at STP, occupied by the carbon dioxide produced in part (a).

_____

_____ (2)

   c. When excess dilute sulfuric acid is used instead of excess dilute hydrochloric acid a smaller volume of carbon dioxide is produced and the reaction stops even though some solid is left in the boiling tube. Explain.

_____

_____ (1)

(Total: 7 marks)

7

4. Various solid substances decompose when they are heated and some of these are shown in the equations below. Complete the missing substances in the equations.

   a. $2\ NaHCO_3 \rightarrow$ _____ + _____ + CO_2

   b. $2\ KNO_3 \rightarrow 2$_____ + _____

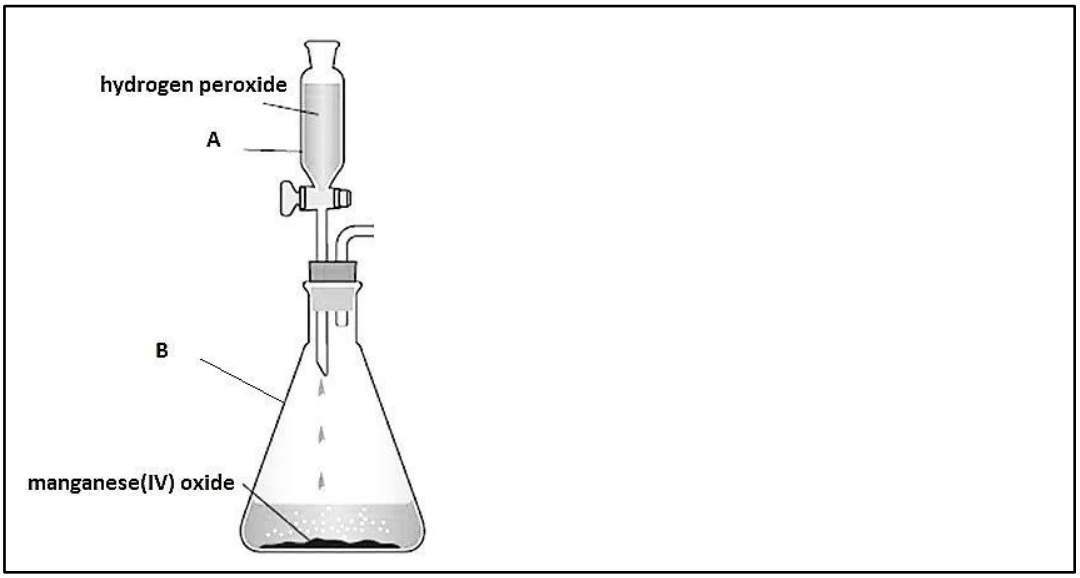
   c. _____ $\rightarrow\ CuO + H_2O$

(Total: 5 marks)

5

Please turn the page.

5. The diagram below shows a part of the apparatus that may be used to prepare oxygen gas in the laboratory by using hydrogen peroxide and manganese(IV) oxide.



(Picture adapted from slidetodoc.com)

a. Write a balanced chemical equation for the reaction.

_____ (2)

b. Give the name of the apparatus labelled A and B in the diagram.

A: _____ B: _____ (2)

c. Give the name of the apparatus that may be used to collect a sample of the oxygen produced.

_____ (1)

d. Use your answer to part (c), or otherwise, to complete the diagram above. (1)

(Total: 6 marks)

6

6. Ethanol may be produced starting from glucose or crude oil.
   a. Ethanol, C_2H_5OH, is produced from glucose, $C_6H_{12}O_6$, by a fermentation process according to the equation shown below. Starting with one mole of glucose, what mass of ethanol may be obtained?

$$C_6H_{12}O_6\ (s) \rightarrow 2\ C_2H_5OH\ (l) + 2\ CO_2\ (g)$$

_____

_____

_____

_____ (4)

   b. One of the products obtained during refining of petroleum is ethene, C_2H_4. Write a balanced equation to show how ethene is converted into ethanol.

_____ (2)

(Total: 6 marks) 6

7. Consider the following reactions:
   a. $CuO\ (s) + H_2\ (g) \rightarrow Cu\ (s) + H_2O\ (l)$
      i. Which substance has been oxidised?

_____ (1)

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

_____ (1)

   b. $2\ FeCl_2\ (s) + Cl_2\ (g) \rightarrow 2\ FeCl_3\ (s)$
      i. State the oxidation number of Cl in $FeCl_2$ and in Cl_2.

Cl in $FeCl_2$: _____ (1)

Cl in Cl_2: _____ (1)

      ii. What is chlorine gas acting as in the reaction in part (b)?

_____ (1)

      iii. Explain your answer to part (b) (ii) in terms of electrons.

_____ (1)

(Total: 6 marks) 6

Please turn the page.

8. This question is about the effect of heat on some substances.

   a. Burning wood or other fuels in a fireplace can be very dangerous if the amount of oxygen in the air is limited. Explain this statement.

_____

_____ (2)

   b. Why are some fuels considered as 'clean fuels'?

_____ (1)

   c. Oxalic acid is a toxic solid substance having the formula $C_2H_2O_4$. When it is heated strongly the following reaction occurs:

$$C_2H_2O_4\ (s) \rightarrow CO_2\ (g) + CO\ (g) + H_2O\ (l)$$

      i. State the chemical test and expected result to confirm the presence of carbon dioxide.

_____ (1)

      ii. Give the name or formula of a substance that can be used to remove the carbon dioxide from the gaseous mixture using a chemical reaction.

_____ (1)

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

_____ (2)

(Total: 7 marks)

7

9. Sodium and potassium are found in the same Group in the Periodic Table. The table below contains some statements about sodium and potassium but some of the statements are **not** correct. Place a ✓ near the ones that are correct and a X near the ones that are incorrect.

	Statement	**✓ or X**
a.	Sodium and potassium are soft metals.	
b.	Sodium and potassium do **not** react with water.	
c.	Sodium and potassium both form oxides of the type M_2O.	
d.	It is very dangerous to hold either sodium or potassium directly in the hand.	
e.	The carbonates of sodium and potassium decompose easily on heating.	

(Total: 5 marks)

5

10. Some substances are non-conductors of electricity while others are conductors. There are substances which conduct electricity and will also decompose when an electric current is passed.

    a. What are substances which conduct electricity and also decompose called?

_____ (1)

    b. Consider the substances below. Each substance may be used only once.

paper	iron	copper ribbon	dilute sulfuric acid	wood

        i. Select **ONE** substance which conducts electricity and decomposes when an electric current is passed through it.

_____ (1)

        ii. Select **ONE** substance which conducts electricity and does **not** decompose.

_____ (1)

        iii. Select **ONE** substance which is an insulator.

_____ (1)

    c. For the substance chosen in part (b) (i) identify:
        i. the substance produced at the negative electrode;

_____ (1)

        ii. the substance produced at the positive electrode.

_____ (1)

(Total: 6 marks)

6

Please turn the page.

Section B: Answer ALL questions from this section.

11. Titrations are used in chemistry to determine the concentrations of acids and alkalis.
    a. What is a 'standard solution'?

_____ (1)

    b. A student weighs 1.4 g potassium hydroxide pellets in a weighing boat and transfers the solid completely to a small beaker. Water is added carefully and the contents are stirred. The contents of the beaker are then transferred to a 250 cm^3 volumetric flask and made up to the mark with distilled water.
        i. How does one transfer a solid completely from the weighing boat to the beaker?

_____ (1)

        ii. Give **TWO** reasons why a filter paper **cannot** be used instead of a weighing boat.

Reason 1: _____ (1)

Reason 2: _____ (1)

        iii. Calculate the concentration of the potassium hydroxide solution in mol dm^{-3}.

_____

_____

_____

_____

_____ (5)

c. The student takes 25.0 cm^3 of the potassium hydroxide solution from the volumetric flask and places it in a conical flask together with one drop of indicator. Using a burette, sulfuric acid is added dropwise to the flask with stirring until the indicator changes colour. The experiment is repeated and the readings entered in the table shown below.

	1st titration	**2nd titration**	**3rd titration**	**4th titration**
2nd burette reading	16.60	16.10	15.75	16.95
1st burette reading	0.70	0.50	0.20	1.30
Volume used /cm^3	15.90	15.60	15.55	15.65

i. Name the apparatus that is used to withdraw exactly 25.0 cm^3 potassium hydroxide solution from the volumetric flask.

_____ (1)

ii. Use the readings in the table to calculate the average volume of sulfuric acid used.

_____

_____ (2)

iii. Give the name of an indicator which may be used in such a titration.

_____ (1)

iv. Universal indicator is **not** used as an indicator for a titration. Explain.

_____ (1)

v. Calculate the concentration of the sulfuric acid used, given that the equation for the reaction is:

$$2\ KOH\ (aq) + H_2SO_4\ (aq) \rightarrow K_2SO_4\ (aq) + 2\ H_2O\ (l)$$

_____

_____

_____

_____

_____

_____ (6)

(Total: 20 marks)

Please turn the page.

20

12. Consider the following laboratory situations and then answer the questions that follow.
    a. A bluish green solid **E** is heated on a Bunsen flame. A black solid **F** is formed and two gases **G** and **H** are given off. **G** has a pungent smell and is brown while **H** is colourless and relights a glowing splint.
        i. Give names or formulae for substances **F**, **G**, and **H**.

F: _____ **G**: _____

H: _____ (3)

        ii. Hence, identify compound **E**.

_____ (2)

    b. A colourless solution **I** is divided between two test tubes. In one of the test tubes containing **I**, dilute sodium hydroxide solution is added carefully and the contents warmed gently. A pungent gas **J** that turns moist red litmus blue is obtained. To the other test tube containing **I**, a few drops of silver nitrate solution are added. A white precipitate **K** that darkens in sunlight is obtained.
        i. Give names or formulae for the substances **J** and **K**.

J: _____ **K**: _____ (2)

        ii. Hence, identify compound **I**.

_____ (2)

    c. Substance **L** gives a dazzling yellow colour in a Bunsen flame. When a few drops of a solution of **L** are added to an acidified solution of barium chloride, $BaCl_2$, an immediate white precipitate **M** is observed.
        i. Give the name or formula for substance **M**.

M: _____ (1)

        ii. Hence, identify compound **L**.

_____ (2)

d. When a yellow powder **N** is burnt in air a pungent smelling gas **O** is given off. When **O** is bubbled into water an acidic solution **P** is obtained.
Give the names or formulae of substances **N**, **O**, and **P**.

N: _____ **O**: _____

P: _____ (3)

e. Solid **Q** is soluble in water. On addition of dilute sodium hydroxide solution dropwise a white precipitate **R** is formed which dissolves on adding excess sodium hydroxide. Substance **Q** gives a yellow precipitate **T** when potassium iodide solution is added. Solid **Q** makes a crackling sound on heating and produces a solid **U** which is white when cold and yellow-brown when heated.

i. Give the name or formulae for substances **R**, **T**, and **U**.

R: _____ **T**: _____

U: _____ (3)

ii. Hence, identify compound **Q**.

_____ (2)

(Total: 20 marks)

20

PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 **He** 2
7 **Li** 3	9 **Be** 4											11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12											27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

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

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

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2022 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIA
DATE:	18th May 2022
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, N = 14, O = 16, S = 32, K = 39, Pb = 207

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.

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Question	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Total**
Score															
Maximum	**6**	**6**	**6**	**7**	**5**	**6**	**7**	**5**	**6**	**6**	**20**	**20**	**20**	**20**	**100**

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Section A: Answer ALL questions.

1. Magnesium chloride ($MgCl_2$) is an ionic/electrovalent compound.
   a. Draw a dot and cross diagram to show the bonding in magnesium chloride.

(2)

   b. With reference to your answer to part (a), explain why:
      i. ionic compounds conduct electricity when aqueous;

_____

_____ (1)

      ii. ionic compounds have higher melting points than simple covalent compounds but lower melting points than giant covalent molecules.

_____

_____

_____ (3)

(Total: 6 marks)

6

2. The reaction of calcium carbonate with an acid is frequently used to study the rates of chemical reactions.
   a. Define the term 'rate of a chemical reaction'.

_____

_____ (2)

   b. Place the following reactions in order of their rate of reaction. Use 1 to represent the slowest reaction and 4 to represent the fastest one. (4)

	Reaction	**Order**
i.	A mass of 2 g calcium carbonate powder is reacted with 3 mol dm^{-3} hydrochloric acid at 50 °C	
ii.	A mass of 2 g calcium carbonate powder is reacted with 2 mol dm^{-3} hydrochloric acid at 20 °C	
iii.	A mass of 2 g calcium carbonate chips is reacted with 2 mol dm^{-3} hydrochloric acid at 20 °C	
iv.	A mass of 2 g calcium carbonate powder is reacted with 3 mol dm^{-3} hydrochloric acid at 20 °C	

(Total: 6 marks)

6

3. Air is made up of a mixture of gases.
   a. Draw a diagram, in the space provided below, of the experiment carried out in the laboratory to determine the percentage composition of oxygen in a sample of dry air.

(3)

   b. The air that is used in this experiment is first passed through a solution of sodium hydroxide and a U-tube filled with anhydrous calcium chloride. Explain why the air is passed through:

      i. a solution of sodium hydroxide; _____(1)

      ii. anhydrous calcium chloride. _____ (1)

   c. Give the name of **ONE** substance, besides nitrogen, that is left after the experiment is finished.

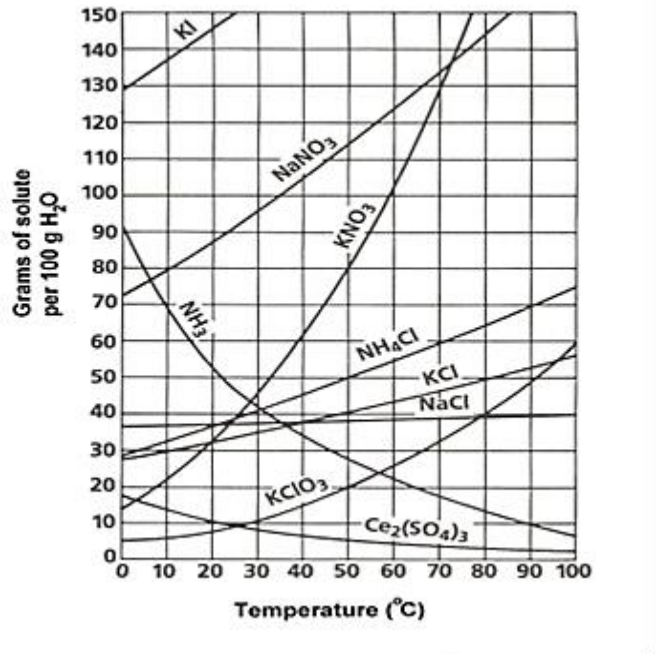
_____ (1)

(Total: 6 marks)

6

Please turn the page.

4. Study the solubility curves below and answer the following questions.



(Picture taken from https://sites.prairiesouth.ca/)

a. What is a 'saturated solution'?

_____ (1)

b. How much KNO_3 needs to be dissolved:
   i. in 100 g of water at 70 ºC to achieve a saturated solution?

_____ (1)

   ii. in 100 g of water at 20 ºC to achieve a saturated solution?

_____ (1)

c. Explain, in terms of particles, why the answers for part (b) (i) and part (b) (ii) differ.

_____

_____ (2)

d. A student was given a mixture of 60 g of $KClO_3$ and 60 g of $NaNO_3$ in 100 g of water at 100 ºC. What would happen to the substances if the mixture was cooled to 20 ºC?

_____

_____ (2)

(Total: 7 marks)

7

5. This question is about the preparation of some salts.
   a. Sodium sulfate crystals may be prepared in the laboratory by reacting sodium carbonate and dilute sulfuric acid. Describe how pure crystals of sodium sulfate may be obtained from this reaction.

_____

_____

_____ (3)

   b. A technique which may be used to obtain a salt from its solution in water is called evaporation to dryness. Give **TWO** reasons why this method is **not** suitable to obtain crystals of copper(II) nitrate from its solution.

_____

_____ (2)

(Total: 5 marks)

5

6. Two 100 cm^3 samples of tap water, labelled **Y** and **Z**, were titrated against a soap solution in a laboratory. Sample **Y** required 19.5 cm^3 of soap for it to form a permanent lather. Sample **Z** required 6.5 cm^3 of soap to form a permanent foam.
   a. What is the difference between the two samples of water?

_____ (1)

   b. When sample **Y** was boiled and the experiment repeated, 9.0 cm^3 of soap was used to achieve a permanent foam. Explain.

_____ (1)

   c. Give an equation and explain why sample **Y** takes longer to form lather with soap (sodium stearate, Na(St)).

Equation: _____ (2)

Explanation: _____

_____ (1)

   d. Why have many Maltese households switched to using synthetic detergents rather than soap?

_____

_____ (1)

(Total: 6 marks)

Please turn the page.

6

7. Pentane has a number of isomers.

   a. Draw the structural formula and state the corresponding name of **TWO** isomers of pentane.

	Isomer 1	**Isomer 2**
Structural Formula		
Name		

(4)

   b. Why is pentane referred to as a saturated hydrocarbon?

_____ (1)

   c. Pentane readily undergoes combustion. Give the equation for the complete combustion of pentane.

_____ (2)

(Total: 7 marks)

7

8. The following equation shows a reversible reaction

$$2\ CrO_4^{2-}\ (aq) + 2\ H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$$

yellow orange

   a. What does it mean when a system reaches chemical equilibrium?

_____ (1)

   b. How does adding water affect the equilibrium position of this reaction?

_____ (1)

   c. How does adding an alkali affect the equilibrium position of this reaction?

_____ (1)

   d. Name the principle on which your answers to part (b) and part (c) are based.

_____ (1)

   e. A mixture that contains CrO_4^{2-} and $Cr_2O_7^{2-}$ turns from yellow to orange when it is heated. What does this show about the enthalpy of the reaction?

_____ (1)

(Total: 5 marks)

5

9. A sample of 6.0 g of an oxide of lead are reduced to give 5.2 g of pure lead.
   a. Deduce the formula of this oxide.

_____

_____

_____

_____

_____ (4)

   b. Carbon monoxide was used to reduce the oxide of lead to lead. Write an equation for this reaction.

_____ (2)

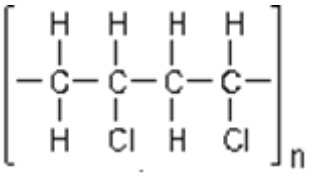
(Total: 6 marks)

6

10. This question is about polymers.
   a. What are polymers?

_____ (1)

   b. Give the name of the polymer with the formula shown below.



Name: _____ (1)

   c. Give the structural formula of the monomer from which this polymer was formed.

(1)

   d. Give **TWO** uses of this polymer.

_____ (2)

   e. Give the structural formula of polytetrafluoroethene.

(1)

(Total: 6 marks)

Please turn the page.

6

Section B: Answer TWO questions from this section.

11. Living things depend on the availability of nitrogen containing compounds to survive. Since nitrogen gas found in the Earth's atmosphere is inert, scientists searched for a way to make it react to produce useful nitrogen containing compounds. In 1905, Fritz Haber reached this goal by successfully reacting nitrogen with hydrogen to produce ammonia, which is a precursor for many artificial fertilizers and other products.
    a. Explain why nitrogen is so difficult to react with other substances. (2)
    b. Name the process by which nitrogen is obtained from Earth's atmosphere on an industrial scale. (1)
    c. Describe how ammonia is produced in the Haber Process. Your description must include:
        i. a balanced chemical equation; (2)
        ii. the conditions required; (3)
        iii. why these conditions are used. (2)
    d. Name **ONE** use for ammonia that is **not** mentioned in this question. (1)
    e. When ammonia gas is bubbled through water, ammonia solution is produced. Write a balanced chemical equation including state symbols to show how ammonium sulfate can be produced starting from ammonia solution and any other chemical/s. (3)
    f. On the 4th August 2020 in Lebanon, a storage facility containing an estimated 2.75×10^9 g of ammonium nitrate caught fire and exploded violently. If the enthalpy of decomposition of ammonium nitrate is 36 kJ mol^{-1}, calculate the heat released by 2.75×10^9 g of ammonium nitrate. (3)
    g. Artificial fertilizers include ammonium sulfate and potassium nitrate among others.
        i. Calculate the percentage by mass of nitrogen in these **TWO** substances. (2)
        ii. Hence, indicate which salt is the better artificial fertilizer. (1)

(Total: 20 marks)

12. Sulfur is the sixth most abundant element in the Universe. It can be found free in nature. The powdered form of sulfur as well as sulfur dioxide and sulfites are used in agriculture and the food industry.
    a. Name the allotropes of sulfur. (2)
    b. Two steps are necessary to convert sulfur dioxide gas to sodium sulfite. Write **TWO** balanced chemical equations to show how sulfur dioxide can be converted to sodium sulfite. (4)
    c. Describe a specific chemical test for sulfur dioxide including the expected result. (2)
    d. The Contact Process produces sulfuric acid on a large scale in industry. Describe this process. Include balanced chemical equations and specific conditions where applicable. (11)
    e. Give **ONE** use of concentrated sulfuric acid. (1)

(Total: 20 marks)

13. Two students noted that when sulfuric acid was mixed with sodium hydroxide solution, the reaction vessel became warmer. This happens because neutralisation reactions are exothermic.

$$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$$

a. Define heat of neutralisation. (1)

b. Describe an experiment to measure the heat of neutralisation. Your answer should include
   i. a labelled diagram of the apparatus setup; (2)
   ii. the method followed; (4)
   iii. **THREE** precautions taken to minimise errors. (3)

c. Using the data collected by the students in the following table, calculate the heat of neutralisation. (6)

Data	**Value**
Concentration of sulfuric acid solution	1 mol dm^{-3}
Volume of sulfuric acid solution	25 cm^3
Concentration of sodium hydroxide solution	2 mol dm^{-3}
Volume of sodium hydroxide solution	25 cm^3
Initial temperature of solutions	25 °C
Final temperature of mixed solutions	35 °C

d. The data book value for the heat change of neutralisation is given as −57 kJ mol^{-1}. Give a reason why this value is different than the one calculated. (1)

e. Draw a labelled energy level diagram for this reaction. (3)

(Total: 20 marks)

14. Chlorine can be prepared in the laboratory by the oxidation of concentrated hydrochloric acid using manganese(IV) oxide.

a. Describe how pure, dry chlorine can be prepared in the laboratory using the method indicated above. Your answer should include:
   i. a labelled diagram of the setup; (6)
   ii. **THREE** precautions including a reason for each precaution; (6)
   iii. **TWO** observations; (2)
   iv. a balanced chemical equation for the reaction. (2)

b. Give a test for chlorine gas including the expected result. (1)

c. When chlorine gas is mixed with water chlorine water forms. The resulting solution is a bleaching agent.
   i. Write a balanced chemical equation for the reaction that happens when chlorine gas is mixed with water. (2)
   ii. Name the ion in part (c) (i) that causes the bleaching effect. (1)

(Total: 20 marks)

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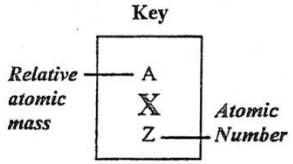
PERIODIC TABLE



I	II											III	IV	V	VI	VII	VIII
																	4 He 2
7 Li 3	9 Be 4											11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
23 Na 11	24 Mg 12											27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
39 K 19	40 Ca 20	45 Sc 21	48 Ti 22	51 V 23	52 Cr 24	55 Mn 25	56 Fe 26	59 Co 27	59 Ni 28	63.5 Cu 29	65 Zn 30	70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
85 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178.5 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

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

SEC06/2A.22m

Index Number:_____ SEC06/2B.22m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2022 MAIN SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIB
DATE:	18th May 2022
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: H = 1, N = 14, O = 16, S = 32, K = 39, Pb = 207

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

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Section A: Answer ALL questions.

1. Fill in the blanks in the paragraph below with the words from the following table. Each word may be used once, more than once or not at all.

conducts electricity	negative	low	accepts
covalent	positive	loses	ionic
high	metallic	insoluble	soluble

Magnesium chloride ($MgCl_2$) is an _____ compound. It is formed when magnesium _____ two electrons from its outer-most shell and the chlorine atom _____ one electron into its outer-most shell. As a result, the magnesium atom turns into a _____ ion while the chlorine atom turns into a _____ ion. The magnesium ions and chloride ions would attract each other thus forming an _____ bond. This type of bonding gives magnesium chloride its _____ boiling point.

(Total: 7 marks)

7

2. For each of the following reactions state the factor which influences the rate at which the reaction occurs.

	Reaction	**Factor influencing the rate of reaction**
a.	The reaction of zinc with 1 mol dm^{-3} sulfuric acid is faster when zinc powder is used instead of zinc granules.	
b.	Carbon dioxide is liberated faster when 2 mol dm^{-3} hydrochloric acid is added to marble chips than when 1 mol dm^{-3} hydrochloric acid is used.	
c.	Decolouration of bromine water by propene occurs slowly in a closed cabinet, but faster when placed on a table.	
d.	Manganese(IV) oxide is added to hydrogen peroxide in the laboratory preparation of oxygen.	
e.	Manganese(IV) oxide and hydrochloric acid are heated in the laboratory preparation of chlorine.	

(Total: 5 marks)

5

3. Air is a mixture of gases, containing nitrogen, oxygen, carbon dioxide, water vapour, and noble gases. An experiment is performed to calculate the percentage of oxygen in dry air. These are the steps followed:
   I. air is passed through aqueous sodium hydroxide;
   II. air is passed over calcium chloride;
   III. air is placed in a 100 cm^3 syringe, connected to a combustion tube with copper and an empty 100 cm^3 syringe;
   IV. air is moved from one syringe to the next over heated copper in a combustion tube;
   V. air is allowed to cool down and the final volume measured.

   a. Which gas is removed through step I?

_____ (1)

   b. Which substance is removed through step II?

_____ (1)

   c. Which gas is removed through step IV?

_____ (1)

   d. Which gases remain in the syringe at the end of the experiment?

_____ (2)

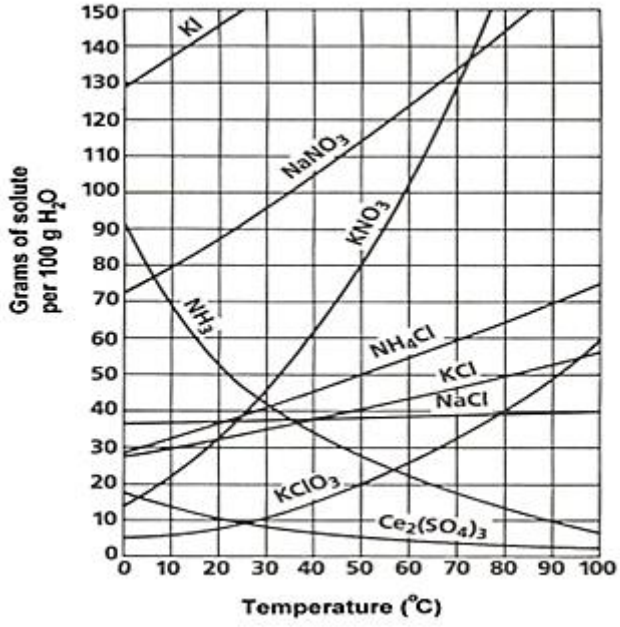
   e. Why is the air allowed to cool down before taking the final reading?

_____ (1)

(Total: 6 marks) 6

Please turn the page.

4. Study the solubility curves below and answer the following questions.



(Picture taken from https://sites.prairiesouth.ca/)

a. What is a saturated solution?

_____ (1)

b. From the diagram find:

i. the most soluble substance at 20 ºC;

_____ (1)

ii. a substance whose solubility decreases with a rise in temperature;

_____ (1)

iii. the mass of KNO_3 that needs to be dissolved in 100 g of water at 70 ºC to achieve a saturated solution.

_____ (1)

iv. the mass of KNO_3 that would recrystallise if a saturated solution with 100 g of water at 70 ºC is cooled to 20 ºC (use your answer to part (b) (iii)).

_____

_____ (2)

(Total: 6 marks)

6

5. Calcium nitrate may be prepared in the laboratory by reacting calcium carbonate and dilute nitric acid.
   a. List the steps needed to obtain pure crystals of calcium nitrate from this reaction.

_____

_____

_____ (3)

   b. Another technique which may be used to obtain a salt from its solution in water is by heating the solution, called evaporation to dryness. Give **TWO** reasons why this method is **not** suitable to obtain crystals of calcium nitrate from its solution.

_____

_____ (2)

(Total: 5 marks)

5

6. There are two samples of water. A sample labelled **Y** consists of hard water while the other sample, **Z**, is soft water.
   a. Which sample will require more soap to form a permanent foam?

_____ (1)

   b. Which sample will form a layer of scum before forming a foam?

_____ (1)

   c. Give an equation to explain your answer to part (b). Assume the formula of soap to be Na(St).

_____ (2)

   d. Distinguish between temporary and permanent hardness.

_____

_____ (2)

(Total: 6 marks)

6

Please turn the page.

7. Pentane, C_5H_{12}, has a number of isomers.

   a. Draw the structural formula and state the corresponding name of **TWO** isomers of pentane, C_5H_{12}.

	Isomer 1	**Isomer 2**
Structural Formula		
Name		

(4)

   b. Why is pentane referred to as a saturated hydrocarbon?

_____ (1)

   c. Give the name or formula of **ONE** unsaturated hydrocarbon with five carbon atoms.

_____ (1)

(Total: 6 marks)

6

8. The following equation shows a reversible reaction

$$2\ CrO_4^{2-}\ (aq) + 2\ H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$$

   a. The table below contains some statements about this reversible reaction but some of the statements are **not** correct. Place a ✓ near the ones that are correct and a X near the ones that are incorrect.

	Statement	**✓ or X**
i.	The reaction stops when no more CrO_4^{2-} is present.	
ii.	When the reaction reaches equilibrium, $Cr_2O_7^{2-}$ forms at the same rate at which CrO_4^{2-} is formed.	
iii.	When the reaction reaches equilibrium, the concentration of each substance seems to be constant.	
iv.	When the reaction reaches equilibrium, both forward and backward reactions stop.	

(4)

b. How does adding water affect the equilibrium position of this reaction?

_____ (1)

c. How does adding an alkali affect the equilibrium position of this reaction?

_____ (1)

d. Name the principle on which your answers to part (b) and part (c) are based.

_____ (1)

(Total: 7 marks)

7

9. A sample of 6.0 g of an oxide of lead are reduced to give 5.2 g of pure lead.

a. Calculate the amount (in moles) of lead which is formed.

_____ (1)

b. Calculate the mass of oxygen in the lead oxide sample.

_____ (1)

c. Calculate the amount (in moles) of oxygen in the lead oxide sample.

_____ (1)

d. Hence, deduce the formula of this oxide.

_____

_____ (1)

e. Carbon monoxide, CO, was used to reduce the oxide of lead to lead. Write an equation for this reaction.

_____ (2)

(Total: 6 marks)

6

Please turn the page.

10. Chloroethene and tetrafluoroethene are two monomers that undergo polymerization. In the space below, give:

a. the structural formula of these **TWO** substances;

structural formula of chloroethene	structural formula of tetrafluoroethene

(2)

b. the structural formula of the polymers that they form;

structural formula of polychloroethene	structural formula of polytetrafluoroethene

(2)

c. **ONE** use of **EACH** polymer.

i. Use of polychloroethene: _____ (1)

ii. Use of polytetrafluoroethene: _____ (1)

(Total: 6 marks)

6

Section B: Answer TWO questions from this section.

11. Living things depend on the availability of nitrogen containing compounds to survive. Since nitrogen gas found in the Earth's atmosphere is inert, scientists searched for a way to make it react to produce useful nitrogen containing compounds. In 1905, Fritz Haber reached this goal by successfully reacting nitrogen with hydrogen to produce ammonia, which is a precursor for many artificial fertilizers and other products.
    a. Explain why nitrogen is so difficult to react with other substances. (2)
    b. Name the process by which nitrogen is:
        i. obtained industrially from Earth's atmosphere; (1)
        ii. reacted with hydrogen in industry. (1)
    c. Write a balanced chemical equation to represent the reaction between nitrogen and hydrogen to produce ammonia. (2)
    d. State the conditions used in industry for the reaction in part (c). (3)
    e. Name **TWO** uses for ammonia that are **not** mentioned in this question. (2)
    f. When ammonia gas reacts with water, ammonia solution is produced. This in turn reacts with sulfuric acid to produce ammonium sulfate and water. Write a balanced chemical equation including state symbols for the reaction between ammonia solution and sulfuric acid. (3)
    g. On the 4th August 2020 in Lebanon, a storage facility containing many tonnes of ammonium nitrate caught fire and exploded violently. If the enthalpy of decomposition of ammonium nitrate is 36 kJ mol^{-1}, calculate the heat released by 1000 g of ammonium nitrate. (3)
    h. Artificial fertilizers include ammonium sulfate (RFM: 132) and potassium nitrate (RFM: 101) among others.
        i. Calculate the percentage by mass of nitrogen in each of these **TWO** substances. (2)
        ii. State which is the better artificial fertilizer in part (h). (1)

(Total: 20 marks)

Please turn the page.

12. Sulfur is the sixth most abundant element in the Universe. It can be found free in nature. The powdered form of sulfur as well as sulfur dioxide and sulfites are used in agriculture and the food industry.
    a. Name the allotropes of sulfur. (2)
    b. Sulfur dioxide can be used to produce sodium sulfite. This can be achieved by first bubbling sulfur dioxide through water and then by neutralising the solution using sodium hydroxide solution. Write **TWO** balanced chemical equations to show how sulfur dioxide is converted to sodium sulfite. (4)
    c. Describe a specific chemical test for sulfur dioxide including the expected result. (2)
    d. In industry the Contact Process produces sulfuric acid on a large scale. This process consists of the four steps described below.

Step	Process
1	Sulfur is burned in air to produce sulfur dioxide.
2	Sulfur dioxide is reacted with further oxygen to produce sulfur trioxide.
3	Sulfur trioxide is reacted with sulfuric acid to produce oleum.
4	Oleum is mixed with water to produce concentrated sulfuric acid.

    i. Write balanced chemical equations for **EACH** step (1) to (4). (8)
    ii. List the required conditions for step (2). (3)
    iii. Give **ONE** use of concentrated sulfuric acid. (1)

(Total: 20 marks)

13. Two students noted that when sulfuric acid was mixed with sodium hydroxide solution, the reaction vessel became warmer. Sulfuric acid and sodium hydroxide undergo a neutralisation reaction according to the following equation:

$$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$$

a. Define heat of neutralisation. (1)

b. The following statements show the method followed by the students, however the steps are **not** in order. Arrange the steps by listing the statement numbers in the correct order.

Step	Process
1	Take the initial temperature of one of the solutions.
2	Plot a graph of temperature against time and then extrapolate the graph to obtain the temperature change at the point of mixing the solutions together.
3	Take five measurements of temperature starting at the first minute.
4	Pour 25 cm^3 of sulfuric acid into a polystyrene cup. Repeat this step for sodium hydroxide solution.
5	Mix the contents of one of the solutions with the other while starting a stopwatch.

(5)

c. Draw a labelled diagram of the setup used by the students using the following apparatus:
   i. thermometer;
   ii. lid;
   iii. stand and clamp;
   iv. polystyrene cup. (2)

d. List **TWO** precautions taken by the students to minimise errors. (2)

e. The table below shows the data collected by the students during their experiment.

Data	Value
Concentration of sulfuric acid solution	1 mol dm^{-3}
Volume of sulfuric acid solution	25 cm^3
Concentration of sodium hydroxide solution	2 mol dm^{-3}
Volume of sodium hydroxide solution	25 cm^3
Initial temperature of solutions	25 °C
Final temperature of mixed solutions	35 °C

Using the data given in the table:
   i. find the number of moles of water that are produced during this reaction; (2)
   ii. calculate the change in temperature; (1)
   iii. calculate the mass of solution that is heated by this reaction; (1)
   iv. calculate the amount of energy produced by the reaction; (1)
   v. calculate the change in heat of neutralisation in kJ mol^{-1}. (1)

f. The data book value for the heat change of neutralisation is given as −57 kJ mol^{-1}. Why is this value different than the one calculated in part (e) (v)? (1)

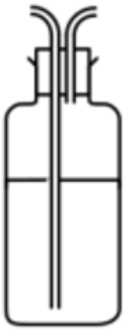
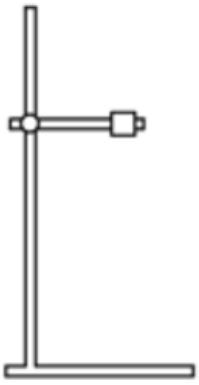
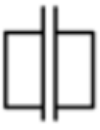
g. Draw a labelled energy level diagram for this reaction. (3)

(Total: 20 marks)

Please turn the page.

14. Pure, dry chlorine gas can be prepared in the laboratory by the oxidation of concentrated hydrochloric acid using manganese(IV) oxide.
    a. Draw a labelled diagram of the apparatus setup using the equipment drawn and materials listed below.

Materials		
manganese(IV) oxide	concentrated sulfuric acid	concentrated hydrochloric acid
water	chlorine gas	

Equipment		
		
		
 (Delivery tubes)	 (Rubber bungs)	

(5)

b. The following statements describe the method that should be used to carry out the preparation of chlorine gas. However, the statements are **not** in order. Use the numbers in front of the statements to place the instructions in order. (5)

1	Concentrated hydrochloric acid is poured into the thistle funnel until the level of the acid surpasses the bottom of the thistle funnel.
2	Heating is stopped when the gas jar fills with chlorine gas.
3	The apparatus is set up making sure that the system is airtight so that the gas produced would flow into the gas jar.
4	A Bunsen burner is used to heat the mixture so that the chemical reaction starts.
5	A few grams of manganese(IV) oxide are placed in the round bottomed flask.

c. Give **TWO** precautions for this experiment. (2)

d. Describe, with reference to your diagram, how the chlorine is collected:
   i. free from impurities of hydrochloric acid; (1)
   ii. free from impurities of water. (1)

e. Write a balanced chemical equation for the reaction. (2)

f. Give a test for chlorine gas including the expected result. (1)

g. Chlorine water forms when chlorine gas is mixed with water. The resulting solution is a bleaching agent.
   i. Write a balanced chemical equation for the reaction that happens when chlorine gas is mixed with water. (2)
   ii. Name the ion in part (g) (i) that causes the bleaching effect. (1)

(Total: 20 marks)

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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 **He** 2
7 **Li** 3	9 **Be** 4											11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12											27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

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

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