L-Università
ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2018 SUPPLEMENTARY SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	30th August 2018
TIME:	9:00 a.m. to 11:05 a.m.

Useful data:

Relative atomic masses: H = 1; C = 12; O = 16; Na = 23; Fe = 56

Standard temperature and pressure (stp): 0 ^{o}C and 1 atm

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

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	3	7	8	4	7	6	7	6	6	6	20	20	100

SECTION A

1) Use the Periodic Table provided to answer the questions that follow.
 a) Give the symbol of **ONE** element which has:

 i) two electrons in its last/valence shell; _____(1)

 ii) two shells of electrons; _____(1)

 iii) a complete outer shell of electrons. _____(1)

 (Total: 3 marks)

 `3`

2) Carbon dioxide can be prepared in the laboratory by the action of a dilute acid on a carbonate.
 a) Give a balanced chemical equation for a reaction that may be used to prepare carbon dioxide as explained above.

 _____ (2)

 b) Tick the best method to collect the maximum possible amount of the carbon dioxide prepared.

 collection over water   ☐
 upward delivery   ☐
 downward delivery   ☐

 (1)

 c) Give **TWO** properties of carbon dioxide which dictate that it is best collected by the method chosen in part (b).

 _____

 _____ (2)

 d) The carbon dioxide needs to be collected dry. Suggest a suitable drying agent that may be used to dry the gas.

 _____ (1)

 e) Describe how the test for carbon dioxide is performed in the laboratory including the expected result.

 _____ (1)

 (Total: 7 marks)

 `7`

3) Sodium chloride is an ionic compound and exists as a giant lattice. Water is a covalent compound which exists as simple molecules.

a) Draw a dot-and-cross diagram, showing outer electrons only, to show the bonding in:

    i) sodium chloride;   ii) water.

(4)

b) Sodium chloride is made of ions while water is made of molecules. Explain by referring to your answer in part (a).

_____

_____ (2)

c) Sodium chloride has a higher melting point than simple covalent compounds such as water. Explain by referring to the bonding in both structures.

_____

_____

_____ (2)

(Total: 8 marks)

8

4) Iron(II) oxalate consists of 56.0% iron, 12.0% carbon and 32.0% oxygen by mass. Calculate the empirical formula iron(II) oxalate.

_____

_____

_____

_____

_____

(Total: 4 marks)

4

5) This question concerns some chemicals which are readily available in households.
   a) Give **ONE** household use for:

i) sodium hydroxide (caustic soda); _____ (1)

ii) magnesium hydroxide (milk of magnesia). _____(1)

  b) Why is baking soda (sodium hydrogencarbonate) used in baking to make cakes rise? Your answer should include a balanced chemical equation.

_____

_____

_____ (3)

  c) Why is white vinegar (ethanoic acid) used to clean water stains on glass or to unblock showerheads?   Your answer should name the substance causing water stains and blocking of showerheads.
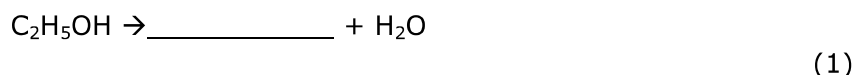
_____

_____ (2)

(Total: 7 marks) | 7 |

6) Ethanol, C_2H_5OH, is an alcohol. Alcohols undergo several important reactions.
   a) Give the general formula for alcohols.

_____ (1)

  b) Complete the following equation for the dehydration of ethanol in the presence of concentrated sulfuric acid.

$$C_2H_5OH \rightarrow \underline{\hspace{3cm}} + H_2O$$

(1)

  c) Give a balanced chemical equation to show the reaction of ethanol with sodium.

_____ (2)

  d) Consider the equation below for one of the reactions of ethanol:

$$C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + POCl_3 + HCl$$
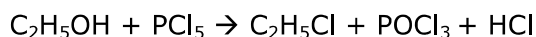
   i) State **ONE** observation that can be made during this reaction.

_____ (1)

   ii) Why is this reaction used in the laboratory?

_____ (1)

(Total: 6 marks) | 6 |

7) Butane and ethanol are two organic substances belonging to different families of compounds. Both compounds have isomers.

   a) Use the space below to draw, showing all bonds, the structures of:

     i) **TWO** isomers with molecular formula C_4H_{10};

(2)

     ii) **TWO** isomers with molecular formula C_2H_6O.

(2)

   b) Short chain alkanes, such as butane, are sometimes produced from longer chain alkanes. Name this process.

_____ (1)

   c) By referring to the structures drawn above, explain why the isomer of butane has similar chemistry to butane while the isomer of ethanol does not have similar chemistry to ethanol.

_____

_____ (2)

(Total: 7 marks)

7

Please turn the page.

8) Some compounds (solutes) can dissolve in other compounds (solvents) to form solutions.

a) What does it mean when a solution is said to be saturated?

_____

_____ (1)

b) The graph below shows the solubility curve for sugar in water. Use the graph to answer the questions that follow.

Picture adapted from https://www.chemix-chemistry-software.com/

i) What is the approximate solubility of sugar at:

• 80 °C; _____(1)

• 20 °C? _____(1)

ii) What mass of sugar will precipitate if a saturated solution containing 25 g of water is cooled from 80 °C to 20 °C?

_____

_____ (2)
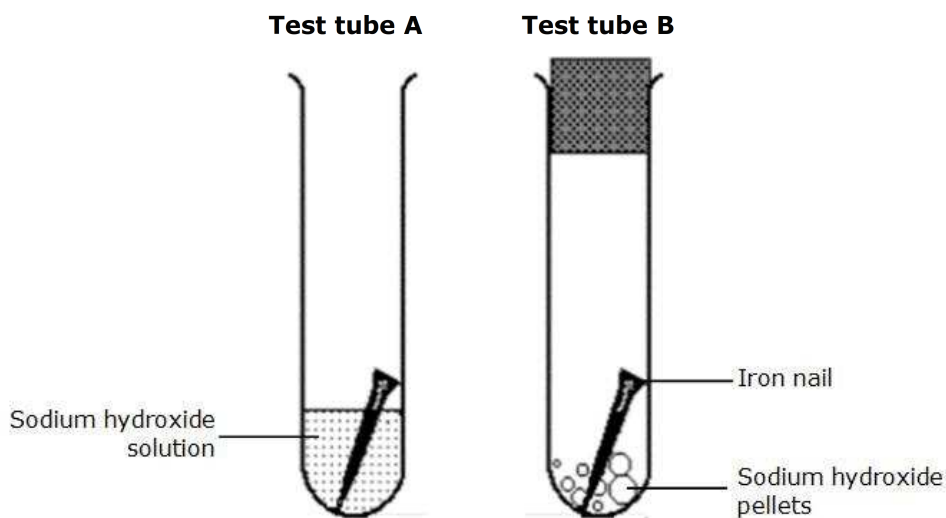
iii) Why is the maximum temperature shown on the graph 100 °C?

_____ (1)

(Total: 6 marks)

6

9) Two iron nails were allowed to stand for a few days. One was placed in sodium hydroxide solution while the other was placed in sodium hydroxide pellets as shown below.

Test tube A   **Test tube B**

Iron nail

Sodium hydroxide solution

Sodium hydroxide pellets

Picture adapted from www.uq.edu.au

a) Which nail, if any, would show signs of rusting?

_____ (1)

b) Justify your answer to part (a) by clearly referring to requirements of rusting which are present or absent and the different conditions in **EACH** test tube.

_____

_____ (2)

c) Name **ONE** suitable catalyst to increase the rate of reaction for rusting.

_____ (1)

d) Mention **TWO** ways by which rusting can be prevented.

_____ (2)

(Total: 6 marks)

6

Please turn the page.

10) A solution containing cobalt(II) ions in water has a pink colour. A teacher demonstrates the effect of adding chloride ions to a solution of cobalt(II) in water according to the following equation.

$$[Co(H_2O)_6]^{2+} (aq) + 4\ Cl^- (aq) \rightleftharpoons [CoCl_4]^{2-} (aq) + 6\ H_2O\ (l)$$

      pink   blue
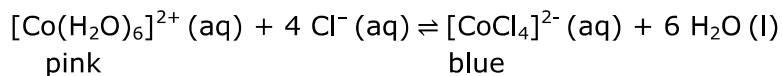
a) What does the $\rightleftharpoons$ symbol mean?

_____ (1)

b) To which side will the equilibrium shift if:
   i) chloride ions are added;

_____ (1)

   ii) water is added;

_____ (1)

   iii) a catalyst is added to the reaction mixture.

_____ (1)

c) Nitrogen dioxide and dinitrogen tetroxide exist in equilibrium according to the equation:

$$2\ NO_2 (g) \rightleftharpoons N_2O_4 (g) \qquad \Delta H = -57.2\ kJ\ mol^{-1}$$

Suggest **TWO** ways by which the percentage of dinitrogen tetroxide in the equilibrium mixture can be increased.

_____

_____ (2)

(Total: 6 marks)

6

SECTION B

11) A student dissolved 1.00 g of sodium hydroxide in 250.0 cm^3 of water. The student transferred 25.0 cm^3 samples of the sodium hydroxide solution to clean conical flaks. On average, 19.2 cm^3 of sulfuric acid were required to completely neutralise 25.0 cm^3 of the sodium hydroxide solution.

  a) From the list of apparatus in the word bank below, choose **ONE** which (each word may be used once, more than once, or not at all):

conical flask	burette	pipette	beaker
volumetric flask	electronic balance	white tile	funnel

i)	is washed three times with distilled water only;	
ii)	is washed three times with distilled water and three times with the solution it will contain;	
iii)	is used to prepare and store the 250.0 cm^3 standard solution of sodium hydroxide;	
iv)	is used to measure and transfer 25.0 cm^3 of sodium hydroxide;	
v)	is used to add a known volume of sulfuric acid until neutralisation;	
vi)	is used to make colour changes more visible.	

(6)

  b) An acid-base indicator is used in this experiment.
    i) What is the role of the indicator in this experiment?

    _____ (1)

    ii) Suggest a suitable indicator for this experiment.

    _____ (1)

  c) Write a balanced chemical equation for the reaction between sodium hydroxide and sulfuric acid.

    _____ (2)

  d) Work out:
    i) the amount (in moles) of sodium hydroxide dissolved in 250 cm^3 of water;

    _____

    _____ (1)

This question continues on the next page.

ii) the concentration (in mol dm^{-3}) of the resultant solution;

_____ (1)

iii) the amount (in moles) of sodium hydroxide present in 25.0 cm^3 of the solution;

_____ (1)

iv) the amount (in moles) of sulfuric acid required to neutralise the sodium hydroxide used;

_____ (1)

v) the concentration (in mol dm^{-3}) of the sulfuric acid used.

_____ (1)

e) An acid salt may be obtained if the same amount of sodium hydroxide used in part (a) is added to double the amount of sulfuric acid used in part (a).
i) Give the name of the acid salt formed during this reaction.

_____ (1)

ii) Explain the difference between the salt prepared in part (a) and the acid salt prepared in part (e). Your answer should refer to ions formed when these salts dissolve in water.

_____ (2)

f) Following the experiment, the teacher criticizes the student's choice of sodium hydroxide to prepare a standard solution.
i) Why is solid sodium hydroxide **not** ideal to prepare a standard solution?

_____ (1)

ii) Suggest another solid, basic substance which might have been used to prepare a better standard solution.

_____ (1)

(Total: 20 marks) | 20 |

12) A greyish, shiny solid A is reacted with dilute sulfuric acid to give a pale green solution B and a gas C. When aqueous sodium hydroxide is added to the pale green solution B, a green precipitate D is formed which is insoluble in excess aqueous sodium hydroxide. However substance D dissolves in excess dilute hydrochloric acid to give another pale green solution E. When chlorine water is added to solution E, a brown solution F is obtained. When aqueous sodium hydroxide is added to F, a rust brown precipitate G is obtained.

a) Identify the substances A, B, C, D, E, F, and G.

A:	B:
C:	D:
E:	F:
G:	

(12)

b) Write balanced ionic equations, omitting spectator ions and including state symbols, for the reaction of:
i) A with sulfuric acid;

_____ (3)

ii) E with chlorine.

_____ (3)

c) What does the reaction in part (b)(ii) show about chlorine?

_____ (1)

d) Describe how the test for gas C is performed in the laboratory including the expected result.

_____ (1)

(Total: 20 marks) 20

PERIODIC TABLE

Key

Relative atomic mass	A
	X
	Z ——— Atomic Number

I	II												III	IV	V	VI	VII	VIII
1 **H** 1																		4 **He** 2
7 **Li** 3	9 **Be** 4												11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12												27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30		70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48		115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80		204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89																

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

L-Università
ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

SECONDARY EDUCATION CERTIFICATE LEVEL
2018 SUPPLEMENTARY SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	IIB
DATE:	30th August 2018
TIME:	4:00 p.m. to 6:05 p.m.

Useful data:

Relative atomic masses: Cl = 35.5; Cu = 63.5

Standard temperature and pressure (stp): 0 ^{o}C and 1 atm

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

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 script/s provided.

- 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.

- Candidates who choose to answer Question 14 are to request a graph sheet from the invigilator.

For examiners' use only:

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

SECTION A

Answer ALL questions from this section.

1) Salt is a solid while water is a liquid at room temperature and pressure (rtp).
    a) Use the space below to show the arrangement of particles in salt and water at rtp.

    arrangement of particles in a solid   arrangement of particles in a liquid
                                                                                                        (2)
    b) Salt dissolves in water. A mixture of salt and water can be separated using distillation.
       i) At what temperature will the water start to distil?

       _____(1)

       ii) Why is it necessary to have water running round the condenser?

       _____(1)

    c) Suggest a suitable separation technique to separate the following mixtures:
       i) A and B are two miscible liquids which boil at 90 °C and 100 °C respectively;

       _____(1)

       ii) C and D are two immiscible liquids.

       _____(1)

                                                                               (Total: 6 marks) 6

2) The table below shows the subatomic particles present in some atoms.

		Mass no.	No. of electrons	No. of protons	No. of neutrons
A	Carbon atom	12			6
B	Carbon atom	13	6		
C	Lithium ion, Li$^+$	7		3	

    a) Complete the table above.   (6)
    b) A and B both represent carbon atoms, but the two atoms are not identical. What is the
       name given to such atoms?

       _____ (1)

                                                                               (Total: 7 marks) 7

3) Use words from the word bank below to fill in the blanks in the following method to measure the heat of neutralisation of a reaction. Each word may be used once, more than once, or not at all.

beaker	maximum	volume	lagging
lid	polystyrene cup	final	temperature

50 cm^3 of 1 mol dm^{-3} hydrochloric acid were added to a _____. The

solution was stirred and the _____ was recorded once it became

steady. A _____ was used to avoid energy loss by evaporation of

water. 50 cm^3 of 1 mol dm^{-3} sodium hydroxide were added. The

_____ temperature was recorded.

(Total: 4 marks)

4

4) Copper(II) sulfate may be used to test for the presence of water.

$$CuSO_4 + 5\ H_2O \rightarrow CuSO_4.5H_2O$$
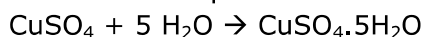
   a) Describe how the appearance of copper(II) sulfate changes in the reaction shown above.

   _____

   _____ (2)

   b) Anhydrous copper(II) sulfate is hygroscopic. Other substances may be efflorescent or deliquescent. Complete the table below to provide an example and a description of each of these types of substances.

Type	Example	Description
Hygroscopic	Anhydrous copper(II) sulfate	Absorbs moisture (water) from air
Deliquescent		
Efflorescent		

(4)

(Total: 6 marks)

6

5) Sulfuric acid is an important laboratory reagent.
   a) Complete the equations below, showing reactions of dilute sulfuric acid with magnesium and of concentrated sulfuric acid with copper:

   i) $Mg + H_2SO_4 \rightarrow$ _____ + _____

   ii) $Cu + 2 H_2SO_4 \rightarrow CuSO_4 + 2$ _____ + _____   (4)

   b) Give the names or formulae of **TWO** products obtained when concentrated sulfuric acid is added to some sugar in a small beaker.

   _____ (2)

   (Total: 6 marks)   6

6) An electrochemical cell converts chemical energy into electrical energy. With time, the zinc electrode gets smaller while the copper electrode increases in mass.
   a) Give a balanced half ionic equation, including state symbols, to show what happens at the zinc electrode.

   _____ (3)

   b) Give a balanced half ionic equation, including state symbols, to show what happens at the copper electrode.

   _____ (3)

   (Total: 6 marks)   6

7) Propane, C_3H_8, may be used as a fuel.
   a) Mark with an X **ONE** application where propane is used as a fuel.

   | Automotive (cars) | ☐ | Jet engines | ☐ |
   | LPG (cooking equipment) | ☐ | Electrochemical batteries | ☐ |

       (1)

   b) Give a balanced equation for the reaction of propane in a plentiful supply of oxygen.

   _____ (2)

   c) Why should propane and other organic fuels **not** be burnt in closed, small spaces with little ventilation? Explain.

   _____

   _____ (2)

   (Total: 5 marks)   5

8) Ethene, C_2H_4, and ethane, C_2H_6, are both hydrocarbons.

a) Complete the table below to show the differences between ethene and ethane.

	Homologous series	Saturated or unsaturated?	Reactions: Addition or substitution?	Flame: Clean or sooty?
Ethene				
Ethane				

(4)

b) Draw the structures, showing all bonds, of the products formed when:

i) ethene reacts with chlorine;

ii) ethane reacts with chlorine.

(2)

c) Under the right conditions, some organic compounds undergo polymerisation reactions. For each of the following polymers, draw the structure of the monomer.

Polymer	Structure of monomer
Teflon (polytetrafluoroethene)	
PVC (polychloroethene)	

(2)

(Total: 8 marks)

8

9) Dry air was passed over heated copper using the apparatus shown below.

Picture adapted from http://www.fides.ug
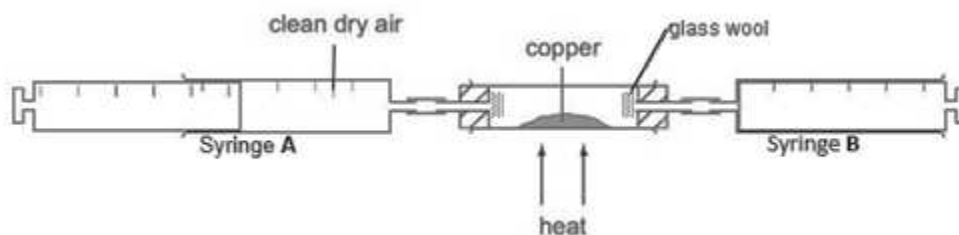
a) Which gas, if any, is used up during this experiment?

_____ (1)

b) Name **TWO** gases which remain in the apparatus following the experiment.

_____ (2)

c) What colour change is observed in the combustion tube?

_____ (1)

d) At the start of the experiment, there were 100 cm^3 of air in Syringe A. What volume of air remains in the apparatus following the experiment?

_____ (1)

e) Why should the apparatus be allowed to cool down to the initial temperature before the final reading of volume is taken?

_____

_____ (1)

(Total: 6 marks)

6

10) Hardness in Malta's ground water is associated with the island's limestone terrain.
   a) Outline how the island's limestone terrain contributes to water hardness.

_____

_____ (1)

b) Give the name or formula of **ONE** substances that causes:

i) permanent hardness; _____ (1)

ii) temporary hardness. _____ (1)

c) Mention **TWO** methods of softening water.

_____

_____ (2)

d) Synthetic detergents are very commonly used instead of soap. Give **ONE** advantage of synthetic detergents over soap.

_____ (1)

(Total: 6 marks)

6

SECTION B

Answer TWO questions from this section.

11) Two students prepared pure copper(II) chloride by the reaction of 0.75 mol dm^{-3} hydrochloric acid with excess copper(II) oxide.
   a) Write a balanced chemical equation for this reaction. Include state symbols. (3)
   b) Explain why copper(II) oxide was used in excess. (1)
   c) How can the students know that the reaction stopped? (2)
   d) Name the separation technique used to:
     i) remove the excess copper(II) oxide; (1)
     ii) obtain copper(II) chloride powder from its aqueous solution. (1)
   e) Draw a labelled diagram to show how copper(II) chloride crystals can be obtained from its solution. (3)
   f) The students did not record the volume of hydrochloric acid used to produce 1.0 g of copper(II) chloride. Hence, calculate:
     i) the relative formula mass of copper(II) chloride; (1)
     ii) the amount (in moles) in 1.0 g of copper(II) chloride; (1)
     iii) the amount (in moles) of hydrochloric acid used; (1)
     iv) the volume of hydrochloric acid used. (1)
   g) State the colour of copper(II) chloride crystals. (1)
   h) A student suggested another two sets of reagents which could be used to prepare copper(II) chloride.

<div align="center">Set 1: Hydrochloric acid + copper
Set 2: Copper(II) sulfate + hydrochloric acid</div>

     i) Explain why these sets of reagents should **not** be used to prepare and collect pure copper(II) chloride in the laboratory. (2)
     ii) Suggest **TWO** reagents, at least one of which is different than those stated above, which could be used to prepare copper(II) chloride in the laboratory. (2)

(Total: 20 marks)

12) Metals are important materials. Some are found free in nature while others need to be extracted from their ores. The method of extraction depends on the metal's position in the activity series.

    a) Name **ONE** metal that is found free in nature. (1)

    b) Explain why some metals are found free in nature. (1)

    c) Other metals such as iron need to be extracted by heating the ore with a reducing agent.

       i) Name the ore from which iron is usually extracted. (1)

       ii) Name the reducing agent that is used to extract iron from its ore. (1)

       iii) Draw a labelled diagram of the blast furnace. (4)

       iv) Give a balanced chemical equation for the extraction of iron in the blast furnace. (2)

    d) Other metals, such as aluminium, were only extracted after the discovery of electricity.

       i) Name the ore from which aluminium is usually extracted. (1)

       ii) Explain why the ore is mixed with cryolite and how this produces cheaper aluminium. (2)

       iii) Give the ionic half equation of the reaction at the anode. (2)

       iv) Give the ionic half equation of the reaction at the cathode. (2)

    e) The difference in reactivity between iron and aluminium may be shown by reacting aluminium with iron(III) ions. Explain this statement. Your answer should include a balanced ionic equation for the reaction. (3)

(Total: 20 marks)

13) A volume of 200 dm^3 of hydrogen chloride gas was synthesized by the direct combination of hydrogen and chlorine gases according to the equation below.

$$H_2(g) + Cl_2(g) \rightarrow 2\ HCl(g)$$
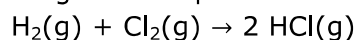
    a) Calculate the amount of hydrogen (in moles) required to produce 200 dm^3 of hydrogen chloride at stp. (2)

    b) Calculate the volume 200 dm^3 of hydrogen chloride gas at stp would occupy, if its temperature increased to 300 K and its pressure increased to 2 atm. (3)

    c) Hydrogen chloride gas is soluble both in water and methylbenzene. In which solvent, if any, does hydrogen chloride form an acidic solution? Explain. (3)

    d) Hydrochloric acid and chlorine gas both react with iron.

       i) Give a balanced chemical equation for the reaction of iron with:

         • hydrogen chloride; (2)

         • chlorine. (2)

       ii) By comparing the reactions above, which of hydrochloric acid or chlorine gas is the better oxidising agent? Explain your answer by referring to the oxidation state of iron in both resultant compounds. (3)

    e) Draw a diagram to show how pure, dry chlorine gas can be prepared in the laboratory starting from hydrochloric acid. Your diagram should clearly indicate:

       i) the arrangement of the apparatus; (2)

       ii) the other reagent used; (1)

       iii) method for drying the gas; (1)

       iv) method for collecting the gas. (1)

(Total: 20 marks)

14) Iron(II) sulfite chips and dilute hydrochloric acid react to produce iron(II) chloride, water and sulfur dioxide. The rate of this reaction can be measured by measuring the volume of sulfur dioxide that is produced over time. The table below shows data that was collected during one such experiment.

Time / min	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Volume of SO_2 / cm^3	0	14	23	27	30	33	35	35	35

a) Write a balanced chemical equation, including state symbols, for this reaction.　　　(3)
b) Suggest **ONE** measure, besides volume of sulfur dioxide, which can be used to calculate the rate of this reaction.　　　(1)
c) Plot a graph of volume of SO_2 on the y-axis against time on the x-axis.　　　(5)
d) At what time does the reaction stop?　　　(1)
e) At what time is the rate of reaction at its highest?　　　(1)
f) On the graph you plotted, draw:
　i) a sketch (labelled X) to show how the rate would change if larger chips of iron(II) sulfite were used;　　　(1)
　ii) a sketch (labelled Y) to show how the rate would change if the acid were heated.　　(1)
g) Use the kinetic theory to explain the effect of increasing the surface area of the iron(II) sulfite chips on the rate of reaction.　　　(2)
h) A student suspects that manganese(IV) oxide might act as a catalyst for this reaction. Describe how this can be investigated in the laboratory. Your answer should include:
　i) a labelled diagram of the apparatus;　　　(2)
　ii) a brief plan;　　　(2)
　iii) which measurements will be recorded.　　　(1)

(Total: 20 marks)

PERIODIC TABLE

Key

$$\frac{A}{Z}X \quad \begin{array}{l} \text{Atomic} \\ \text{Number} \end{array}$$

Relative atomic mass — A

I	II												III	IV	V	VI	VII	VIII
																		4 He 2
1 H 1																		
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