NAME:	NO:	CLASS:

ADMIRALTY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2020

SUBJECT	:	Chemistry
CODE/PAPER	:	6092/2
LEVEL/STREAM	:	Secondary 4 Express
DATE	:	26 Aug 2020
TIME	:	0800h – 0945h
DURATION	:	1 hour 45 minutes

Instructions to candidates:
Write your name, index number and class on the cover page.
Write in dark blue or black pen.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A: Short Answer Questions [50 marks]
Answer all questions. Write your answers in the spaces provided in the question paper.

Section B: Structured Questions [30 marks]
Answer **all** questions, the last question is in the form either/or. Write your answers in the spaces provided in the question paper.

Candidates are reminded that all quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table is provided on the last page of this paper.

For Examiner's Use	
Section A	/ 50
Section B	/ 30
Total	/ 80

DO NOT TURN OVER THIS PAPER UNTIL YOU ARE TOLD TO DO SO.

Section A

Answer all questions.

1 The table shows some information about substances A to D.

substance	melting point/ °C	boiling point/ °C	Does it conduct electricity when it is a solid?	Does it conduct electricity when molten?
A	−57	126	no	no
B	858	1502	no	yes
C	1240	2100	yes	yes
D	1649	2231	no	no

(a) Which substance is a liquid at 1000 °C?

…… [1]

(b) Which substance is most likely to be silicon dioxide (sand)?

…… [1]

(c) **(i)** Which substance is most likely potassium fluoride?

…… [1]

(ii) Describe what happens to the arrangement and movement of the particles in potassium fluoride when it dissolves in water.

……

……

……

…… [2]

2 Covida tried to make some beer at home by adding solid malt extract to water, and then adding yeast powder to the resulting mixture before allowing the mixture to ferment inside an air-tight container.

After two weeks, she opened up the lid of the container and used separation technique A to separate the solid sediments found at the bottom of the container from the rest of the mixture.

The resulting mixture contained two miscible liquids X and Y.

liquid	melting point/ °C	boiling point/ °C
X	−114	78
Y	0	100

She used separation technique B to separate the resulting mixture.

(a) Define the term 'mixture'.

……

…… [1]

(b) Identify separation technique A and B.

A: ……

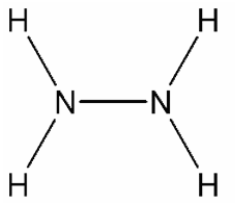
B: …… [2]

(c) Explain how Covida can determine whether the liquid X collected is pure.

……

…… [2]

3 A molecule of hydrazine, N_2H_4, has the following structure.



Hydrazine reacts with fluorine gas to produce nitrogen gas and hydrogen fluoride gas. The reaction can be represented by the following equation.

$$N_2H_4(g) + 2F_2(g) \rightarrow N_2(g) + 4HF(g) \qquad \Delta H = -1166 \text{ kJ/mol}$$

(a) Using ideas about breaking and forming bonds, explain why the enthalpy change for the reaction has a negative sign.

……

……

…… [2]

(b) The table shows some data about bond energies.

bond	bond energy / kJ/mol	bond	bond energy / kJ/mol
N – N	163	H – F	565
N – H	390	N ≡ N	945

Using all information provided in this question, calculate the bond energy of F–F bond.

[3]

(c) Draw an energy profile diagram for the reaction between hydrazine and fluorine. Indicate the enthalpy change, ΔH and activation energy, E_a on the diagram clearly.

[3]

4 Some experiments were carried out with four metals, W, X, Y and Z. The table list the results of the experiments.

metal	experiment		
	reaction with steam	reaction with dilute acid	reduction of its oxide with carbon
W	It glows.	Reacts moderately. Light green solution formed.	Grey solid formed.
X	No reaction.	No reaction.	Reddish brown solid formed.
Y	Moderate reaction.	Fast reaction. Colorless solution formed.	Shiny grey solid formed.
Z	Reacts vigorously.	Reacts vigorously. Colourless solution formed.	No reaction.

(a) Place the metals in descending order of reactivity.

…… [1]

(b) A simple cell was set up using two of the metals.

(i) State the two metals that should be used to give the highest potential difference.

…… [1]

(ii) Draw the simple cell diagram using the two metals in **(b)(i)**.

Label the parts in your diagram, including a suitable electrolyte and the direction of flow of electrons along the connecting wires.

[2]

(c) Predict one observation when metal Y is placed in a salt solution of W.

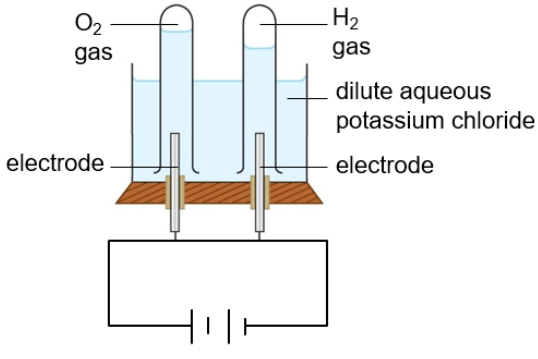
…… [1]

(d) Recycling of metals has been encouraged as a way to produce useful metals instead of extracting them from their ores. Explain why.

……

…… [1]

5 Dilute aqueous potassium chloride forms hydrogen and oxygen during electrolysis.



(a) (i) Write a half-equation, with state symbols, for the reaction that forms oxygen.

…… [2]

(ii) Is the reaction in **(a)(i)** an oxidation or reduction reaction? Explain your reasoning.

…… [1]

(b) During the reaction, 6.0 cm^3 of oxygen was collected. Calculate the mass of 6.0 cm^3 of oxygen.

[2]

(c) **(i)** In theory, the ratio of hydrogen to oxygen collected should be 2:1. Explain why.

……

……

…… [2]

(ii) In actual observation, the ratio of hydrogen to oxygen collected is about 3:1. Suggest a possible reason for this observation.

…… [1]

(d) After the electrolysis has been running for some time, the solution becomes more concentrated.

Give one difference between the products of the electrolysis of dilute and concentrated aqueous potassium chloride.

……

…… [1]

6 Vanadium (V) oxide, V_2O_5, undergoes various types of chemical reactions. Three of such reactions are represented in the following chemical equations.

reaction 1: $V_2O_5\,(s) + 2HNO_3\,(aq) \rightarrow 2VO_2NO_3\,(aq) + H_2O\,(l)$

reaction 2: $V_2O_5\,(s) + SO_2\,(g) \rightarrow V_2O_4\,(s) + SO_3\,(g)$

reaction 3: $V_2O_5\,(s) + 6NaOH\,(aq) \rightarrow 2Na_3VO_4\,(aq) + 3H_2O\,(l)$

(a) Explain whether SO_2 is an oxidising agent or a reducing agent in reaction 2.

……...

……...

……...

……... [2]

(b) Explain, in terms of its bonding and structure, why vanadium (V) oxide is a solid at room temperature.

……...

……...

……...

……... [2]

(c) Adel claims that vanadium (V) oxide is an amphoteric oxide.

Explain whether you agree with her claim.

……...

……...

……... [1]

(d) 0.50 g of vanadium (V) oxide was reacted with 50 cm^3 of sulfur dioxide. Calculate the volume of sulfur trioxide formed.

[4]

7 Ammonium chloride is used as a fertiliser. It is commonly made from ammonia.

(a) Complete the table about the source of the gases used in the manufacture of ammonia.

gas	source	obtained by
nitrogen		fractional distillation
hydrogen	crude oil	

[2]

(b) Fertilisers containing ammonium-based substance tend to be mildly acidic and may affect plant growth in the long run. To increase the pH of soil, lime-containing products such as calcium carbonate or calcium hydroxide are added.

Explain why calcium hydroxide should not be used on soil that has been recently added with fetiliser containing ammonium chloride.

……

…… [2]

8 The amount of carbon dioxide in the atmosphere is increasing due to our use of fossil fuels.

(a) What environmental problem does carbon dioxide cause?

…… [1]

(b) Suggest why planting more trees is **no**t a long term solution to the increase in the amount of carbon dioxide.

……

…… [2]

(c) Name another environmentally harmful gas that is produced by the combustion of fossil fuel and describe the problem it causes.

……

…… [1]

Section B

Answer all three questions in this section.
The last question is in the form **either/or** and only one of the alternative should be attempted.

9 Many carbonates thermally decompose to form carbon dioxide and an oxide. For instance, calcium carbonate thermally decompose to form carbon dioxide and calcium oxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

Four 2.00 g samples of carbonates are heated strongly until there is no further change in mass. The table shows the mass of solid remaining at the end of the heating.

carbonate	mass after heating/ g
calcium carbonate	1.12
copper(II) carbonate	1.29
iron(II) carbonate	1.24
magnesium carbonate	0.95

(a) (i) Calculate the mass of carbon dioxide formed when 2.00 g of calcium carbonate is heated.

[1]

(ii) Limestone is a sedimentary rock that is mainly made up of calcium carbonate. 2.00 g of limestone was heated strongly until there is no further change in mass. The mass of solid that remains after heating weighs 1.34 g.

Calculate the percentage purity of calcium carbonate in the limestone.

[2]

(b) Explain why the mass of carbon dioxide formed is different for each carbonate.

……..

…….. [1]

(c) The thermal stability of the carbonates is related to the reactivity of the metal. Explain why copper(II) carbonate is the least thermally stable.

……..

……..

…….. [1]

(d) **(i)** Draw a dot-and-cross diagram to show the arrangement of outer shell electrons and charges in calcium and oxide ion.

[2]

(ii) Draw a dot-and-cross diagram to show the bonding in carbon dioxide. Show the outer shell electrons only.

[2]

(e) In a separate experiment, pure sample of copper(II) chloride crystals can be prepared by the reaction of copper(II) carbonate and dilute hydrochloric acid.

(i) Which reactant, copper(II) carbonate or dilute hydrochloric acid, should be added in excess? Explain your answer.

……

……

…… [2]

(ii) State another reactant that can be used in place of copper (II) carbonate to prepare copper(II) chloride crystals.

…… [1]

10 Electronegativity and chemical bonding

Electronegativity

Electronegativity is the strength an atom has to attract a bonding pair of electrons to itself. The Periodic Table in Fig. 10.1 shows the electronegativity values of the various elements. The larger the value of the electronegativity, the greater the atom's strength to attract a bonding pair of electrons.

1 H 2.1																
3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0
11 Na 0.9	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl
19 K 0.8	20 Ca 1.0	21 Sc 1.3	22 Ti 1.5	23 V 1.6	24 Cr 1.6	25 Mn 1.5	26 Fe 1.8	27 Co 1.9	28 Ni 1.9	29 Cu 1.9	30 Zn 1.6	31 Ga 1.6	32 Ge 1.8	33 As 2.0	34 Se 2.4	35 Br 2.8
37 Rb 0.8	38 Sr 1.0	39 Y 1.2	40 Zr 1.4	41 Nb 1.6	42 Mo 1.8	43 Tc 1.9	44 Ru 2.2	45 Rh 2.2	46 Pd 2.2	47 Ag 1.9	48 Cd 1.7	49 In 1.7	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5
55 Cs 0.7	56 Ba 0.9	57 La 1.1	72 Hf 1.3	73 Ta 1.5	74 W 1.7	75 Re 1.9	76 Os 2.2	77 Ir 2.2	78 Pt 2.2	79 Au 2.4	80 Hg 1.9	81 Tl 1.8	82 Pb 1.9	83 Bi 1.9	84 Po 2.0	85 At 2.2
87 Fr 0.7	88 Ra 0.9	89 Ac 1.1														

Electronegativities of the Elements

Fig. 10.1

Electronegativity gives information about what will happen to the bonding pair of electrons when two atoms bond. When a fluorine atom covalently bonds to another fluorine atom, the bonding pair of electrons is shared equally between the two atoms as they have the same electronegativity. The electrons that comprises the covalent bond is located halfway between the two atoms. However, when two atoms of different elements are involved in a bond, then the two atoms will have different attractive forces, and will attract the bonding pair of electrons to different degree. The end result is that the electron pair is shifted toward one atom.

Electronegativity difference

The electronegativity difference, ΔX, between two atoms can be calculated as follows:

$$\Delta X = X_A - X_B$$

where

X_A = electronegativity value of atom A (atom with the larger electronegativity value)

X_B = electronegativity value of atom B (atom with the smaller electronegativity value)

The electronegativity difference provides a way of predicting the kind of chemical bond that will form between two elements, as indicated in Fig. 10.2.

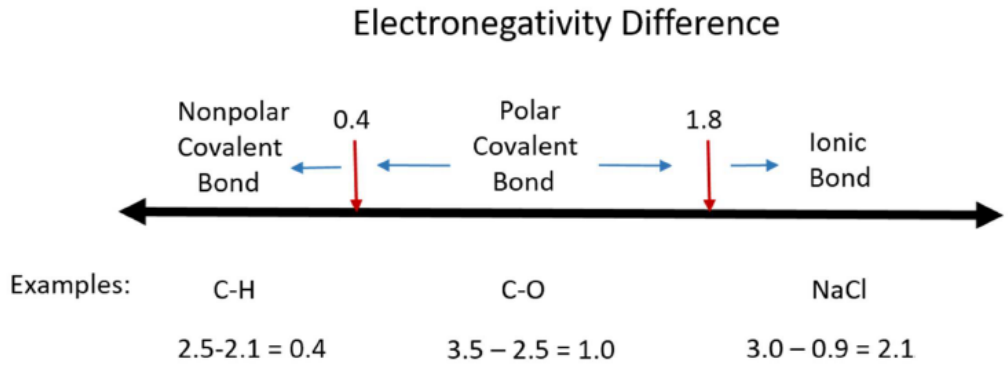


Fig. 10.2

A bond in which the electron pair is equally shared is called a nonpolar covalent bond. This occurs when the two atoms involved in the bond are the same or having very small difference in the electronegativities of the atoms involved in the bond.

A bond in which the electron pair is shifted toward one atom is called a polar covalent bond. This occurs when the atom that more strongly attracts the bonding electron pair gains a slight negative charge due to the electron pair located nearer to it, while the other atom is slightly more positive due to the electron pair being shifted further away from it. The larger the difference in the electronegativities, the more negative and positive the atoms become. When this difference reaches an extreme, such as in the case of sodium chloride (NaC*l*), then ionic bonding will occur.

References: https://www.dummies.com/education/science/chemistry/electronegativity-and-polar-covalent-bonding/

(a) Using the Periodic Table shown in Fig. 10.1, describe the pattern of the changes in the electronegativity values across Period 2 and down Group VI.

……

……

…… [2]

(b) Using the Periodic Table shown in Fig. 10.1, predict the electronegativity value for chlorine.

…… [1]

(c) Based on Fig. 10.2, carbon monoxide contains polar covalent bond. Explain which atom, carbon or oxygen, has a slightly negative charge.

……..

……..

……..

…….. [3]

(d) Based on Fig. 10.2, explain, with calculations, the type of chemical bonding that is present in tin fluoride.

…….. [2]

EITHER

11 A student investigated the rate of reaction when dilute acid reacts with excess zinc metal.

He used the same volume of acid each time. He measured the time taken to collect 10 cm^3 of gas at room temperature and pressure. He also measured the total volume of gas at the end of the experiment at room temperature and pressure. The table shows his results.

experiment	acid	concentration in mol/dm^3	time taken to collect 10 cm^3 of gas / s	total volume of gas / cm^3
1	nitric	0.5	17	60
2	nitric	1.0	8	120
3	nitric	0.5	9	60
4	hydrochloric	0.5	17	60

(a) Give the formula for the salt which forms in experiment 4.

…… [1]

(b) **(i)** The student carried out three experiments using zinc metal strip and one experiment using zinc powder.

Which experiment was carried out using zinc powder? Explain your reasoning.

……...

……...

……... [2]

(ii) Explain, in terms of collisions between reacting particles, why using zinc powder affects the rate of reaction.

……...

……...

……...

……...

……... [3]

(c) The student carried out two further experiments using 0.5 mol/dm^3 ethanoic acid and 0.5 mol/dm^3 sulfuric acid. He used the same volume of acids as in the previous experiments with excess zinc metal strips. The table shows his results.

experiment	acid	concentration in mol/dm^3	time taken to collect 10cm^3 of gas / s	total volume of gas / cm^3
5	ethanoic	0.5	23	60
6	sulfuric	0.5	8	120

(i) Compare and explain the results between experiments 1 and 5.

……...

……...

……...

……... [2]

(ii) Compare and explain the results between experiments 4 and 6.

……...

……...

……...

……... [2]

OR

12 Iron(II) sulfate, also known as ferrous sulfate, is used to fortify food and to treat and prevent iron deficiency anemia. It is also used as a reducing agent in the treatment of cement.

Iron(II) sulfate is prepared commercially by the reaction of pyrite (iron(II) disulfide, FeS_2) with oxygen and water.

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$

(a) Use ideas about oxidation state to explain why the reaction of pyrite with oxygen and water is a redox reaction.

……..

……..

…….. [2]

(b) In the laboratory, iron(II) sulfate can be prepared by reacting iron with sulfuric acid.

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$$

(i) State the observations made for the reaction.

……..

…… [2]

(ii) Describe how you would show that iron(II) sulfate rather than iron(III) sulfate is formed when iron is dissolved in dilute sulfuric acid.

……

……

……

…… [2]

(iii) Suggest, with the aid of an equation, another reaction that can form iron(II) sulfate, with iron as one of the starting material.

……

……

…… [2]

(c) Iron(II) sulfate commonly exists as hydrated crystal with the chemical formula, $FeSO_4.xH_2O$. The M_r of hydrated iron(II) sulfate is 278.

Find the value of *x*.

[2]

END OF PAPER