FIDE ET LITERIS

ST PAUL'S SCHOOL
JUNIOR SCHOLARSHIP EXAMINATION

CHEMISTRY

NAME ____

MAY 2014

SECTION C – CHEMISTRY

1. A student is presented with nine separate vials of unknown solid compounds and asked to determine the identity of some of the compounds as well as determine the reactivity order (in the reactivity series) of three metals.

The compounds are known to be metal oxides, metal carbonates and metal sulfates. The table below shows the colours of some common metal compounds, either as solids or in aqueous solution.

Metal	**Colour of metal sulfate in aqueous solution**	**Colour of solid metal oxide**	**Colour of solid metal carbonate**
Cobalt	Red	Green	Red
Zinc	Colourless	White	White
Copper	Blue	Black	Green

The student initially carried out four reactions which he hoped would enable him to deduce the reactivity order of the metals. The basic procedure and key observations in each of these four reactions are given in the table below:

	Procedure	**Major Observations**
Reaction 1	A spatula measure of a green solid is heated in a Bunsen flame.	The green solid turned to a black solid powder.
Reaction 2	A spatula measure of the black solid is added to dilute sulfuric acid.	The black solid reacts fully leaving a blue solution.
Reaction 3	Zinc granules are added to the blue solution formed in reaction 2.	The blue colour fades to colourless and a salmon-pink solid is deposited at the bottom of the test tube.
Reaction 4	A spatula measure of a red solid is added to dilute hydrochloric acid.	The solution fades from red to pink and fizzing is observed.

a) Identify, *by name*, the green solid used in **Reaction 1**

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b) Write a *word equation* for **Reaction 1**

………………………………………………………………………………………… [1]

c) *Name* the blue solution formed in **Reaction 2**

……………………………………………………………………………………… [1]

d) Write a *word equation* for **Reaction 2**

……………………………………………………………………………………… [1]

e) What *'class of reaction'* has occurred in **Reaction 3**?

……………………………………………………………………………………… [1]

f) Write a *word equation* for **Reaction 4**

……………………………………………………………………………………… [2]

Following Reaction 4, copper metal is added to the pink solution and there is ***no observable change***.

g) Explain why the results of the experiments conducted by the student thus far are insufficient to deduce the reactivity order of the three metals.

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……………………………………………………………………………………… [2]

h) Describe *one further experiment* that the student could carry out in order to fully derive a reactivity order. You should ***quote any possible observations*** you might expect during the experiment that would enable the reactivity order to be confirmed.

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……………………………………………………………………………………… [3]

TURN OVER

2. A student was considering the reactions of various metals with oxygen gas. The two metals investigated were magnesium and iron. Two initial experiments were conducted:

Experiment 1 – Magnesium metal was burnt in a gas jar of oxygen. The magnesium burnt with a brilliant white light and gave off a considerable amount of heat. At the end of the reaction a powdered white solid was left over at the bottom of the gas jar.

Experiment 2 – Iron wool was burnt in a gas jar of oxygen. The wool glowed red giving off a small amount of heat. At the end of the reaction a dark red solid was left over at the bottom of the gas jar.

a) Explain carefully why both of these reactions are described as exothermic reactions

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.... [1]

b) Explain how the student was able to deduce that iron is a less reactive metal than magnesium from these two experiments.

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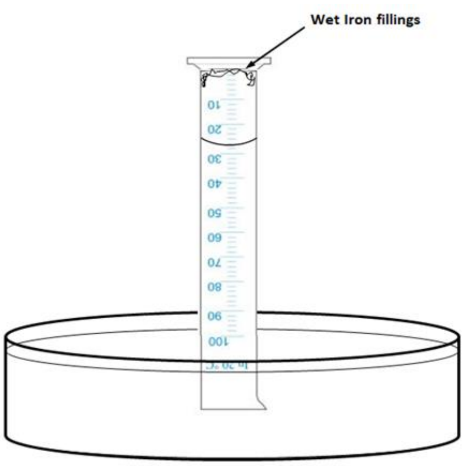
.... [1]

The reaction between iron and oxygen, in the presence of water, is chiefly responsible for the production of rust. The word equation below illustrates this reaction:

Iron + oxygen + water → *hydrated* iron (III) oxide

"Rust"

This reaction can then be used to calculate the percentage (%) of oxygen in a standard sample of air. An experimental set-up used to calculate the percentage of oxygen in air is shown below:



c) Explain why the water level was seen to rise within the measuring cylinder during the reaction.

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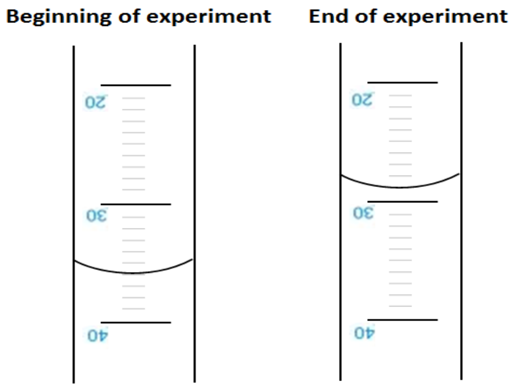
.... [1]

The readings on the measuring cylinder at the beginning and end of the experiment are shown in the diagrams below:



d) Record the initial and final readings carefully in the spaces provided using the scale on the measuring cylinder and hence use these two readings to calculate the percentage of oxygen in the sample of air.

Give your answer to the nearest whole number percentage value.

Show your working in the space provided.

Reading on measuring cylinder at beginning of experiment = ___________ cm^3

Reading on measuring cylinder at end of experiment = ___________ cm^3

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.... [3]

TURN OVER

e) Another student repeated the experiment and obtained a value of 12% for the percentage oxygen in air. He was told by his teacher that the actual percentage of oxygen in the air is 21%. Suggest one sensible reason why the student may have obtained this lower value.

Explain your answer

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.... [2]

Read all the information below carefully to answer part (f) of this question.

- Chemists use chemical symbols to represent each element in the periodic table.
- Chemical formulae are used to represent combinations of elements within molecules and compounds.
- Chemical formulae can then be used to translate chemical word equations into balanced chemical equations which demonstrate the exact reacting ratios between the different chemicals in a reaction.

A word equation is shown below together with a balanced chemical equation which describes the reaction:

Magnesium + iron (III) oxide → magnesium oxide + iron

3Mg + Fe_2O_3 → **3**MgO + 2Fe

Mass is not created or destroyed during a chemical reaction and the masses of the atoms of different elements can be compared using atomic mass units (**a.m.u.**).

Each atom of ***magnesium*** has an atomic mass of ***24 a.m.u.*** and each atom of ***iron*** has an atomic mass of ***56 a.m.u.***

f) Use the information above and the balanced chemical equation to work out the expected mass of iron that would be formed if 7.2g of magnesium were fully reacted with the iron (III) oxide. **Show your workings clearly below.**

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Mass of iron formed ……………………………..g [3]

g) Explain why this reaction is classed as a redox reaction and hence identify the reducing agent in the reaction.

The reaction is a redox reaction because…………………………….…………

……………………………………………………………………….…………

The reducing agent is …………………………..…………………………… [2]

END OF CHEMISTRY

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