# WESTMINSTER SCHOOL
# THE CHALLENGE 2018
# CHEMISTRY

Thursday 3 May 2018
**Time allowed: 30 minutes**

**Instructions to candidates**:

This paper has **three** questions.
You should answer **all** questions
There are 33 marks available.

The marks for individual questions and parts of questions are shown in square brackets []. **Calculators are allowed.** Any data needed will be given in the questions.

**Please write in black or blue ink.**
**Write your answers in the spaces provided.**

For examiner use only

| | |
|---|---|
| Total Mark | |

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**C1. The following multiple choice questions test a range of chemical principles. For each question, circle the letter corresponding to your chosen answer.**

a) The equation for the effect of heat on hydrated sodium carbonate is as shown.

$$Na_2CO_3.10H_2O(s) \rightarrow Na_2CO_3(s) + 10H_2O(g)$$

Statements made by four students about the reaction are given.

**P** Anhydrous sodium carbonate is formed.
**Q** Steam is formed.
**R** There is a colour change from blue to white.
**S** The reaction is reversible.

Which students' statements are correct?

**A** P, Q and R only

**B** P, Q and S only

**C** Q, R and S only

**D** P, Q, R and S

b) Elements **W** and **X** are metals. Elements **Y** and **Z** are non-metals. The oxides of **W**, **X**, **Y** and **Z** all form solutions when added to water.

Which statement is correct?

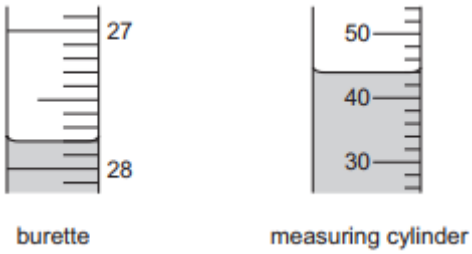
**A** The solution of the oxide of element **W** turns blue litmus red.

**B** The solution of the oxide of element **X** fizzes when sodium carbonate is added.

**C** The solution of the oxide of element **Y** has a pH greater than pH 7.

**D** The solution of the oxide of element **Z** fizzes when powdered magnesium is added.

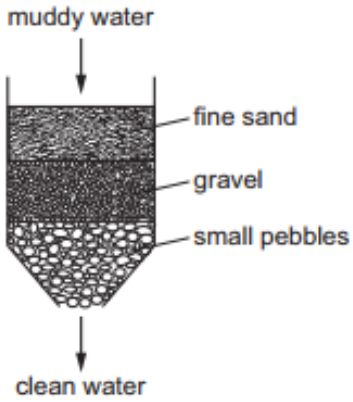
c) The diagrams show liquids in a burette and a measuring cylinder.




Which row shows the correct readings for the burette and the measuring cylinder?

| | Burette | Measuring cylinder |
|---|---|---|
| **A** | 27.8 | 42 |
| **B** | 27.8 | 44 |
| **C** | 28.2 | 42 |
| **D** | 28.2 | 44 |

d) The diagram shows how muddy water can be purified.




Which process for purifying the muddy water is shown?

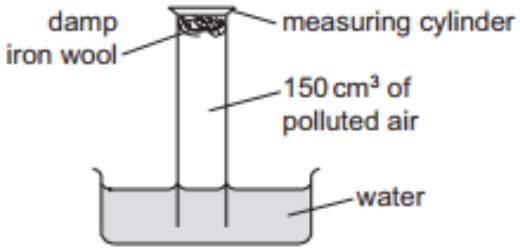
**A** Crystallisation

**B** Distillation

**C** Filtration

**D** Solvent extraction

e) An experiment to find the percentage of oxygen in 150cm$^3$ of polluted air is shown below.




The apparatus is left for one week, during which the oxygen reacts with the iron wool. After this time, the volume of gas in the measuring cylinder is 122cm$^3$.

What is the percentage of oxygen, to the nearest whole number, in the polluted air?

**A** 19%

**B** 21%

**C** 28%

**D** 81%

***[Total for C1: 5 marks]***

***Question C2 begins on the next page***

**C2. This question is about thermal decomposition.**

Many compounds break down when subjected to heat. This type of reaction is often used in the laboratory preparation of a useful reagent (for example, to produce oxygen gas for use in a reaction).

One such example is the thermal decomposition of copper carbonate.

a) Complete the following word equation for the decomposition of copper carbonate, which produces copper oxide and a gaseous product.

copper carbonate → copper oxide + …….

[1]

b) State the colour change that you would expect to see during this process.

…….

[1]

c) Addition of hydrochloric acid to copper carbonate produces three compounds, as shown below.

copper carbonate + hydrochloric acid → **solution A** + **gas B** + water

(i) Define the term **compound**.

……

……

[2]

(ii) Identify the products of the reaction above.

**Solution A** …….

**Gas B** ……

[2]

(iii) The presence of water may be confirmed by addition of an anhydrous solid. Give the name of a solid that may be used and the observation you might make.

Solid……

Observation……

[2]

On the International Space Station, oxygen candles are used in case an emergency supply of oxygen is required. These work by the thermal decomposition of an oxygen-rich substance such as lithium perchlorate ($LiClO_4$), with iron burning to produce the heat.




A possible equation for this reaction is as follows:

$$LiClO_4 \rightarrow LiCl + 2O_2$$

Use the data below to answer the questions that follow:

- Lithium perchlorate has a density of 2.42g/cm$^3$
- 60.2% of its mass is oxygen
- Liquid oxygen has a density of 1.14g/cm$^3$

d) Lithium perchlorate has a greater mass of oxygen per cm$^3$ than liquid oxygen. Calculate the **percentage difference** in the mass of oxygen per cm$^3$ in lithium perchlorate compared to liquid oxygen.

[2]

e) An oxygen candle was burnt and the rate of oxygen production over time was recorded. The following data was collected.

| Time / mins | Rate of $O_2$ production / litres per min |
|---|---|
| 0 | 0 |
| 5 | 50 |
| 10 | 90 |
| 15 | 85 |
| 20 | 81 |
| 25 | 80 |
| 30 | 78 |
| 35 | 80 |
| 40 | 80 |
| 45 | 82 |
| 50 | 60 |
| 55 | 30 |
| 60 | 0 |

(i) Plot this data on the graph paper provided, putting 'time' on the x-axis and 'rate of oxygen production' on the y-axis. You should choose a sensible scale.

[3]

(ii) On your graph, draw **three** lines of best fit, as follows:

- A straight line between time = 0 and the time at maximum rate
- A smooth curve between the time of maximum rate and the time when the rate starts to decrease again (around t = 45mins)
- A straight line to show the final decrease in rate.

[1]

(iii) Approximately how many litres of oxygen are being produced per minute after 28 minutes have elapsed?

……

[1]

(iv) At what time is the rate of oxygen production the greatest?

……

[1]

(v) Suggest why the rate doesn't remain perfectly constant between 15 and 45 minutes.

……

……

[1]

(vi) Suggest why the rate of oxygen production falls back to zero.

……

……

[1]

(vii) Using your graph, approximate the amount in litres for the **total** volume of oxygen produced by the candle after an hour. You should make it clear on your how you have come to this value.

Total volume: …… litres

[2]

***[Total for C2: 20 marks]***

**Question C3 starts on the next page**

**C3. This question is about a variety of different compounds.**

The table below provides information about a number of different compounds. Use this, in conjunction with your own knowledge, to answer the questions that follow.

| Compound | Formula | Solubility in water | Colour in solution | Colour of solid |
|---|---|---|---|---|
| Magnesium chloride | $MgCl_2$ | Soluble | Colourless | White |
| Iron sulphate | $FeSO_4$ | Soluble | Green | Green |
| Barium sulphate | $BaSO_4$ | Insoluble | - | White |
| Barium chloride | $BaCl_2$ | Soluble | Colourless | White |
| Silver carbonate | $Ag_2CO_3$ | Insoluble | - | White |
| Magnesium sulphate | $MgSO_4$ | Soluble | Colourless | White |
| Silver chloride | $AgCl$ | Insoluble | - | White |
| Silver nitrate | $AgNO_3$ | Soluble | Colourless | White |
| Sulphuric acid | $H_2SO_4$ | Soluble | Colourless | - |

a) Magnesium sulphate can be prepared by adding excess magnesium powder to iron sulphate solution.

(i) What would you observe happening *to the solution* during this reaction?

……

……

[1]

(ii) Explain why excess magnesium should be used.

……

……

[1]

(iii) What type of reaction has taken place?

……

[1]

(iv) What does this reaction tell you about the reactivities of magnesium and iron?

……

[1]

b) When pieces of iron are placed in a solution of magnesium chloride, they slowly become coated in a brown solid. What is this solid?

……

[1]

c) Describe what you would see when solutions of magnesium sulphate and barium chloride are mixed.

……

[1]

d) A chemist has lost the labels from a series of bottles containing solutions of the above compounds. For each of the combinations below, choose *from the table above* a compound that could be used to deduce which is which.

(i) Silver nitrate and barium chloride

……

[1]

(ii) Sulphuric acid and magnesium sulphate.

……

[1]

***[Total for C3: 8 marks]***

**END OF CHEMISTRY SECTION**