



# WESTMINSTER SCHOOL THE CHALLENGE 2022 CHEMISTRY

Thursday 28 April 2022  
**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.**

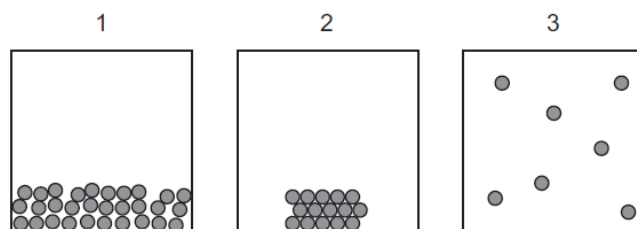
For examiner use only

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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 diagrams below show particles in a container, in different states of matter.

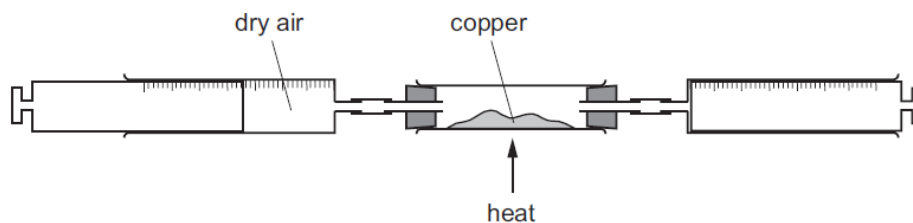


State which two diagrams show the process of evaporation.

- A 1 → 2
- B 1 → 3
- C 2 → 3
- D 3 → 1

- b) On average, in a sample of dry air, 20% of the volume is made up of oxygen gas.

In an experiment, dry air is passed over hot copper metal until all of the oxygen has reacted. The volume of the gas at the end of the reaction is  $120\text{cm}^3$ .



Calculate the starting volume of dry air.

- A  $570\text{cm}^3$
- B  $180\text{cm}^3$
- C  $152\text{cm}^3$
- D  $132\text{cm}^3$

- c) Which of the following methods would be best suited to remove ethanol (alcohol) from a sample of wine?
- A** Filtration
- B** Fractional distillation
- C** Decanting
- D** Chromatography
- d) Consider the data in the table to answer this question.

	<b>X</b>	<b>Y</b>	<b>Z</b>
Melting point / °C	-114	115	-101
Boiling point / °C	78	445	-34

State the identities of X, Y and Z.

	<b>X</b>	<b>Y</b>	<b>Z</b>
<b>A</b>	Chlorine	Ethanol	Sulphur
<b>B</b>	Ethanol	Sulphur	Chlorine
<b>C</b>	Sulphur	Chlorine	Ethanol
<b>D</b>	Sulphur	Ethanol	Chlorine

- e) The process by which a solid turns directly into a gas is called...
- A** Melting
- B** Solidifying
- C** Precipitation
- D** Sublimation

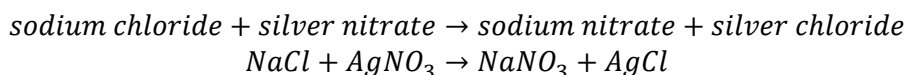
**[Total for Q = 5 marks]**

**Question C2 begins on the next page**

**This question is about separating mixtures.**

There are several techniques that chemists can employ to separate the different components in a mixture, exploiting differences between chemical or physical properties.

In general, when two compounds react, we can assume that the metal in one compound swaps with the metal in the other. For example:



a) In the example above, AgCl is insoluble in water so one would observe a white precipitate forming.

(i) Explain why it is not advisable to boil off all of the water in the solution in order to separate the solid at the end of the reaction.

..... [1]

(ii) Suggest how you might actually separate the silver chloride from the reaction mixture.

..... [1]

(iii) Suggest why it does not matter what amounts of sodium chloride and silver nitrate are used.

.....  
..... [2]

b) Use the information in the table to answer the questions that follow. In all cases, any solutions formed are colourless.

Compound	Solubility in water	Solubility in acid
Sodium sulphate	Soluble	Soluble
Barium sulphate	Insoluble (white precipitate)	Insoluble (white precipitate)
Sodium sulphite	Soluble	Soluble; bubbles form
Barium sulphite	Insoluble (white precipitate)	Soluble; bubbles form
Sodium chloride	Soluble	Soluble
Barium chloride	Soluble	Soluble

- (i) Suggest a combination of reagents that would allow you to produce a solid sample of barium sulphate, which could then be separated from the mixture.

.....  
[2]

- (ii) A student mixes two chemicals together and a white precipitate forms (one of those in the table). Suggest, by name or formula, a compound that the student might add to confirm the identity of the precipitate.

.....  
[1]

- (iii) Barium carbonate also reacts with acids to produce a colourless gas. State the identity of this gas and a test that would allow you to identify it.

.....  
.....  
.....  
.....  
.....  
.....  
[3]

**[Total for Q = 10 marks]**

**C2. This question is about Marie-Anne Paulze Lavoisier.**

Antoine Lavoisier (1743-1794) is regarded as the father of modern chemistry, but it seems increasingly likely that his wife, Marie-Anne Paulze Lavoisier (1771-1794), also had a significant part to play. This question looks at some of the reactions the two of them might have conducted at the time and celebrates Marie-Anne's contribution to chemistry, as well as some other forgotten chemists.



Most chemists at that time believed that anything combustible contained a fiery substance called **phlogiston**.

In the mid-18<sup>th</sup> Century, there were two significant discoveries:

- English chemist Joseph Priestly discovered a gas, which he called 'dephlogisticated air'. This was later named by Lavoisier as **oxygen**.
- Around the same time, Henry Cavendish discovered 'inflammable air', which Lavoisier later named **hydrogen**.

- a) Lavoisier was a creator of what was called 'the new chemistry', based on key principles such as elements and compounds, and published a new, methodical system for naming chemicals in his book *Méthode de nomenclature chimique*.

Define the following terms:

- (i) Element

.....  
.....  
.....

[1]

- (ii) Compound

.....  
.....  
.....

[1]

b) **Water**

Lavoisier believed that oxygen together with the 'inflammable air' that he called hydrogen formed the compound water, while in the old theory, water was an elementary substance.

- (i) Suggest why it had previously been believed that water was an elementary substance.

.....  
.....  
.....

[1]

- (ii) Write a balanced chemical equation for the reaction between hydrogen and oxygen to produce water.

[2]

- (iii) Give a chemical test that would show that the liquid produced was indeed water.

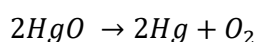
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[3]

c) **Oxygen**

Credit for the discovery of oxygen is a contentious issue, but Carl Scheele undoubtedly was one of the first, although delays in publication were an issue.

He conducted experiments on mercuric oxide, HgO, such as the one below.



- (i) Suggest how Scheele converted mercuric oxide into oxygen.

.....  
.....

[1]

(ii) Mercury is a metal. Suggest a physical test that may be used to determine this.

.....  
.....  
[1]

(iii) Mercury is a liquid over a wide range of temperatures, but it expands when heated. Suggest a piece of chemical apparatus that exploits this property.

.....  
[1]

(iv) Mercury is one of only ten elements on the Periodic Table whose chemical symbol starts with a different letter to its name. Name two more elements for which this is the case.

.....  
[2]

d) **Hydrogen**

The word *hydrogen* means 'water former', whilst *oxygen* means 'acid-former'. It is now understood that these two elements have incorrect names. One reason for this is that acids contain hydrogen – or, more exactly, they are a source of hydrogen ions (H<sup>+</sup>).

The pH scale is essentially a measure of the amount of free hydrogen ions that a substance produces when dissolved in water.

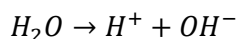
(i) Using your knowledge of acids and bases, suggest approximate pH values for solutions of the following:

Sodium oxide: .....

Sulphur dioxide: .....

[2]

Water also contains hydrogen ions that are produced according to the following equation.



Only some of the water breaks down and this results in a low concentration of hydrogen ions and a pH of 7, measured at 25°C. At 99°C, the pH of pure water is 6, but this is still described as being neutral.

(ii) At 99°C, state whether the number of hydrogen ions produced by water has gone up or down.

.....  
[1]

(iii) Suggest why this happens at higher temperature.

.....  
.....

[1]

(iv) By considering what **hasn't** changed at higher temperature, suggest a better definition of the term *neutral*.

.....  
.....

[1]

In 1787 an Irish Chemist, Richard Kirwan, published his '*Essay on Phlogiston*'. Marie-Anne translated this into French so Antoine could read it. Without her help, they would not have been able to analyse and test its contents, and eventually overturn the flawed phlogiston theory. For this alone she should be remembered, but it is likely that she contributed a good deal more than that.

**[Total for Q = 18 marks]**

**END OF CHEMISTRY PAPER**

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