Oxford Cambridge and RSA

# GCSE Chemistry B (Twenty First Century Science)

**J258/04** Depth in chemistry (Higher Tier)

## Question Set 17

**1.** Ammonium sulfate is a fertiliser. It is usually sold to farmers as a solid in large sacks.

Different industrial processes can be used to make ammonium sulfate, as shown in **Table 6.1**.

| Process | Equation | How the process works | Other points |
|---|---|---|---|
| 1 | $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ | Reactor kept at 60 °C.<br>Uses concentrated sulfuric acid.<br>A solution of ammonium sulfate is made. | Reaction is exothermic.<br>Atom economy 100%. |
| 2 | $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ | Sulfuric acid is sprayed into dry ammonia gas.<br>Any water in the mixture evaporates.<br>Dry powdered ammonium sulfate is made. | Reaction is exothermic.<br>Atom economy 100%. |
| 3 | $(NH_4)_2CO_3 + CaSO_4 \rightarrow (NH_4)_2SO_4 + CaCO_3$ | Calcium carbonate forms as a precipitate in a solution of ammonium sulfate. | Calcium carbonate is a waste product. |

**Table 6.1**

Use information from **Table 6.1** to answer these questions.

**(a)** Both **process 1** and **process 2** are exothermic.

Explain why an exothermic reaction has a positive effect on how each process works.

**[3]**

**(b)** **Process 1** and **process 3** both need to go through further separation after the main reactions.

How can pure, solid ammonium sulfate be separated from the reaction mixtures in **process 1** and **process 3**?

**[2]**

**(c)** Use relative formula masses to calculate the **atom economy** of **process 3**.

Give your answer to **1** decimal place.

**[3]**

Atom economy = ..... %

**(d)** The **sustainability** of each process in **Table 6.1** is different.

**(i)** Explain what **sustainability** means. **[1]**

**(ii)** Give **two** examples from **Table 6.1** to explain why some processes are more sustainable than others. **[2]**

**(e)** **Process 3** can be carried out as a batch process in the laboratory.

In industry, **process 3** is carried out as a continuous process.

Explain why batch processes are more suitable for use in the laboratory, but continuous processes are more suitable for industry. **[2]**

## Total Marks for Question Set 17: 13