

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	$2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$	Reactor kept at 60 °C. Uses concentrated sulfuric acid. A solution of ammonium sulfate is made.	Reaction is exothermic. Atom economy 100%.
2	$2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4$	Sulfuric acid is sprayed into dry ammonia gas. Any water in the mixture evaporates. Dry powdered ammonium sulfate is made.	Reaction is exothermic. Atom economy 100%.
3	$(\text{NH}_4)_2\text{CO}_3 + \text{CaSO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4 + \text{CaCO}_3$	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]

- (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

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