Reversible reactions

4.6.2.1 · The rate and extent of chemical change · revision notes

Some reactions can go both ways: the products can react to re-form the original reactants. You need to recognise and use the ⇌ symbol, describe what happens when ammonium chloride is heated and cooled, and know that changing the conditions can change the direction of a reversible reaction.

Key facts

- ⇌ = reversible reaction
- Reversible reaction: the products can react to re-form the original reactants
- Forward reaction: left to right; reverse reaction: right to left
- $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$
- Heat ammonium chloride → ammonia + hydrogen chloride; cool the gases → ammonium chloride again
- Changing the conditions can change the direction of a reversible reaction

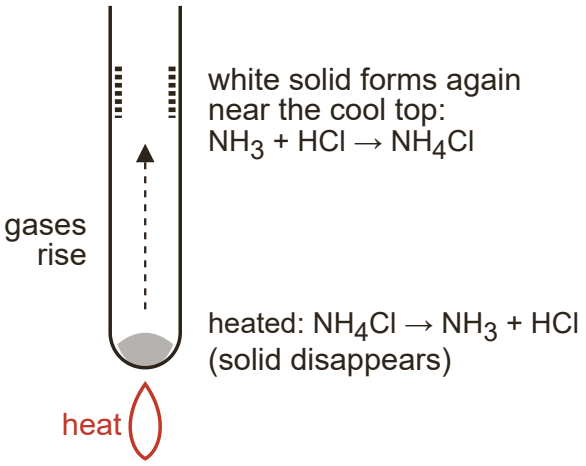
Notes

What is a reversible reaction?

- In a **reversible reaction**, the products of the reaction can react to produce the original reactants.
- The symbol ⇌ shows this: A + B ⇌ C + D.
- The **forward reaction** goes from left to right (A + B → C + D). The **reverse reaction** goes from right to left (C + D → A + B).
- Reactions that cannot easily be reversed, such as burning a fuel, are shown with a single arrow →.
- The direction of a reversible reaction can be changed by changing the conditions, for example the temperature.

Example: ammonium chloride

- ammonium chloride ⇌ ammonia + hydrogen chloride
- $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$
- **Heating**: white solid ammonium chloride decomposes into two colourless gases, ammonia and hydrogen chloride (the forward reaction).
- **Cooling**: the two gases react to form white solid ammonium chloride again (the reverse reaction).
- In the lab: heat a little ammonium chloride at the bottom of a test tube. The solid at the bottom disappears, and a white solid forms again near the cooler top of the tube.



Both reactions in one tube: decomposition at the hot bottom, re-forming at the cool top.

How to answer each type of question

Recall: the ⇌ symbol and the ammonium chloride example

1 to 3 marks | Grade 3

1. Say what ⇌ means in plain words: the reaction can go both ways.
2. Learn the names of both products of decomposing ammonium chloride.

Example. (a) What does the symbol ⇌ show about a reaction?
(b) Complete the word equation for the reversible reaction that happens when ammonium chloride is heated.
ammonium chloride ⇌ _____ + _____

Model answer.

(a) The reaction is reversible / can go in both directions (1)
(b) ammonia (1) + hydrogen chloride (1)

Explain observations in a reversible reaction

3 marks | Grade 5

1. Describe what happens at each stage (colour, state).
2. Say which reaction happens: forward on heating, reverse on cooling.
3. Name the substances formed.

Example. A student heated a small amount of white ammonium chloride at the bottom of a test tube. The solid at the bottom disappeared and a white solid appeared near the top of the tube.
Explain these observations.

Model answer. Heating decomposes the ammonium chloride into ammonia and hydrogen chloride (1). These are gases, so the solid at the bottom disappears (1). Near the cool top of the tube the gases react to form solid ammonium chloride again, which is the reverse reaction (1).

Write a balanced equation for a reversible reaction

2 marks | Grade 5

1. Write the correct formula for each substance.
2. Balance the equation.
3. Use ⇌ instead of →, and add state symbols if the question asks for them.

Example. Hydrogen gas reacts with iodine gas to form hydrogen iodide gas, HI, in a reversible reaction.
Write a balanced symbol equation for this reaction.

Model answer.

$H_2 + I_2 \rightleftharpoons 2HI$

correct formulae with the ⇌ symbol (1); correctly balanced (1)

Don’t lose marks

- Using → instead of ⇌ in the equation for a reversible reaction.
- Saying ammonium chloride melts or evaporates when heated. It decomposes into two different gases.
- Writing 'ammonium' or 'chlorine' instead of ammonia and hydrogen chloride.
- Mixing up which change is the forward reaction and which is the reverse: forward is left to right as the equation is written.

More tips

Memory tricks

- Two half-arrows = two directions: the top one points forward, the bottom one points back.
- Ammonium chloride: heat splits it apart, cooling puts it back together.
- If a question mentions 'the reverse reaction', read the equation from right to left.

Exam technique

- Learn the ammonium chloride example fully: the names, the states and which way heating and cooling push the reaction.
- When describing a reversible reaction, use the terms 'forward reaction' and 'reverse reaction'.
- In observation questions, describe what you would see (white solid disappears, white solid reappears), not only the chemistry.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Recognise the reversible reaction symbol ⇌

The ⇌ symbol shows that a reaction can go in both directions.

Grade 4

Describe what a reversible reaction is

The products of the reaction can react to produce the original reactants.

Grade 5

Describe heating and cooling ammonium chloride

Heating decomposes it into ammonia and hydrogen chloride; cooling makes these gases re-form the white solid.

Grade 5

Write equations for reversible reactions

Use ⇌ in word and balanced symbol equations, e.g. $NH_4Cl \rightleftharpoons NH_3 + HCl$.

Grade 5

Use observations as evidence of reversibility

E.g. a white solid re-forming at the cool top of a heated tube shows the reverse reaction happening.

Grade 6

Explain how conditions change the direction

Changing a condition such as temperature can make the forward or the reverse reaction happen.

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