The effect of changing concentration (HT only)

5.6.2.5 · Chemistry · revision notes

Higher tier only. Changing the concentration of a reactant or product means the system is no longer at equilibrium, and the concentrations of all the substances change until a new equilibrium is reached. You need to predict the effect, often using colour changes or data given in the question.

Key facts

- Add more reactant → more product forms (shift right)
- Add more product → more reactants form (shift left)
- All the concentrations change until equilibrium is reached again
- Remove product → more reactants react (shift right)
- Remove reactant → shift left
- The system uses up what you add and replaces what you remove

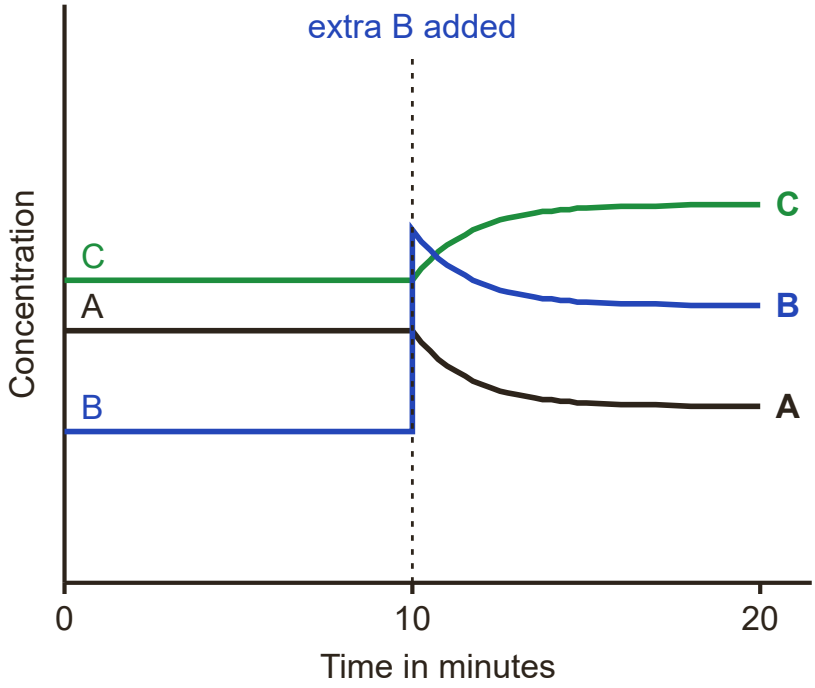
Notes

The rules

- If the concentration of one of the reactants or products is changed, the system is no longer at equilibrium.
- The concentrations of **all** the substances then change until equilibrium is reached again.
- Increase the concentration of a **reactant**: more products are formed until equilibrium is reached again (the position shifts right).
- Decrease the concentration of a **product** (for example, by removing it): more reactants react until equilibrium is reached again (the position shifts right).
- Increase the concentration of a product, or decrease the concentration of a reactant: the position shifts left, so more reactants form.

Why it happens

- Adding a substance: the system counteracts the change by using some of it up.
- Removing a substance: the system counteracts the change by making more of it.
- Removing a product as it forms keeps the forward reaction going, so more of the reactants are turned into products.
- After extra reactant is added, its concentration falls a little as it reacts, but at the new equilibrium it is still higher than before the change. Grade 8+ only



A + B ⇌ C after extra B is added: B ends higher than before, A lower, C higher.

Example: a colour change

- Yellow chromate ions and orange dichromate ions are in equilibrium in solution:
  $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$
- Adding acid increases the concentration of H^+ ions, so the position shifts right and the solution turns orange.
- Adding alkali removes H^+ ions (they react to form water), so the position shifts left and the solution turns yellow.
- You do not need to learn this example: in the exam you are given the equation and the colours.

How to answer each type of question

Predict the effect of changing a concentration

1 to 2 marks | Grade 5

1. Find the substance whose concentration changes, and which side of the equation it is on.
2. Added: the position shifts away from it. Removed: the position shifts towards it.
3. State what happens to the substance the question asks about.

Example. Hydrogen and iodine react in a sealed container and reach equilibrium.
$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
More iodine is added to the container.
Predict what happens to the amount of hydrogen iodide. Explain your answer.

Model answer. The amount of hydrogen iodide increases (1). The position of equilibrium shifts to the right to use up some of the added iodine (1).

Explain why removing a product gives more product

2 marks | Grade 6

1. Say that removing the product lowers its concentration.
2. Say the position shifts to the right to replace it, so more reactant reacts.

Example. Calcium carbonate decomposes when it is heated in a reversible reaction.
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
In a lime kiln, a flow of air carries the carbon dioxide away.
Explain why removing the carbon dioxide means more calcium oxide is produced.

Model answer. Removing the carbon dioxide lowers its concentration (1), so the position of equilibrium shifts to the right to replace it and more calcium carbonate decomposes (1).

Predict and explain a colour change from given information

3 marks | Grade 7

1. Identify which substance's concentration changes, and whether it goes up or down.
2. Say which way the position shifts to counteract this.
3. Link to the colour of the substance that increases.

Example. In a solution, a pink substance and chloride ions are in equilibrium with a blue substance:
pink substance + chloride ions ⇌ blue substance + water
A student adds concentrated hydrochloric acid, which contains chloride ions, to the pink equilibrium mixture.
Predict and explain the colour change.

Model answer. The solution turns (more) blue (1). The concentration of chloride ions increases (1), so the position of equilibrium shifts to the right to use up chloride ions, forming more of the blue substance (1).

Describe how all the concentrations change after a disturbance 3 to 4 marks **Grade 8**

1. The added substance: a sudden rise, then a small fall as it reacts, levelling off higher than before.
2. The other reactant: falls, then levels off lower than before.
3. The product: rises, then levels off higher than before.

Example. A and B react to form C in a sealed container.
$A(g) + B(g) \rightleftharpoons C(g)$
The mixture is at equilibrium. At 10 minutes, extra B is added.
Describe how the concentrations of A, B and C change after 10 minutes until equilibrium is reached again.

Model answer. The concentration of B rises suddenly, then decreases (1) but levels off higher than it was before 10 minutes (1). The concentration of A decreases and levels off lower than before (1). The concentration of C increases and levels off higher than before (1).

Don't lose marks

- Saying the added substance ends up back at its original concentration. It falls a little but stays higher than before.
- Saying only the substance you changed has a different concentration. All of them change.
- Getting the direction backwards: adding a reactant shifts the position right, not left.
- Describing a colour change without linking it to the substance in the equation that has that colour.

More tips

Memory tricks

- You add it, it uses it; you take it, it makes it.
- Adding a reactant and removing a product both push the position to the right, towards more product.
- Colour questions: find the colour of the side the position shifts towards.

Exam technique

- Say what happens to the concentration first (e.g. 'the concentration of H^+ ions increases'), then the shift, then the result.
- 'Predict' questions only need the outcome; 'explain' questions also need the reason (the system counteracts the change).
- Look for hidden concentration changes: adding an alkali removes H^+ ions, and a substance that reacts with a product removes that product.

What each grade needs

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

Grade 5 **Predict the effect of adding more reactant**
More products are formed until equilibrium is reached again.

Grade 6

Predict the effect of removing a product

More reactants react until equilibrium is reached again, so more product forms.

Grade 6

Predict the effect of adding more product

The position shifts to the left, so more reactants form.

Grade 7

Explain shifts using Le Chatelier's principle

The system counteracts the change by using up an added substance or replacing a removed one.

Grade 8

Interpret colour changes and given data

Use the colours or concentrations in the question to decide which way the position moved.

Grade 8

Describe all concentration changes after a disturbance

An added substance falls a little but stays higher than before; the other concentrations change until constant again.

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