# Changing conditions and equilibrium

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

Higher tier only. The relative amounts of reactants and products at equilibrium depend on the conditions. Le Chatelier's principle lets you predict which way the position of equilibrium shifts when a condition is changed. Questions give you an equation and some information, and ask you to predict and explain.

## Key facts

- Le Chatelier: the system responds to counteract the change
- Add a substance → shift away from it; remove a substance → shift towards it
- Raise the pressure → side with fewer gas molecules; lower it → side with more
- Shift right = more products; shift left = more reactants
- Heat up → endothermic direction favoured; cool down → exothermic direction favoured
- Catalyst: no change to the position; equilibrium is reached faster

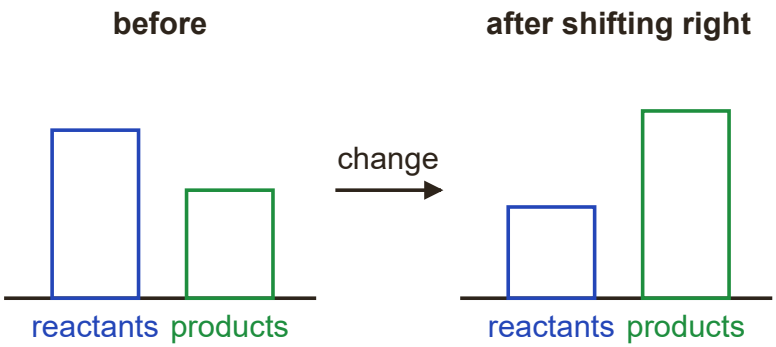
## Notes

### Le Chatelier's principle

- The relative amounts of all the reactants and products at equilibrium depend on the conditions: concentration, temperature and, for gases, pressure.
- **Le Chatelier's principle**: if a system is at equilibrium and a change is made to any of the conditions, the system responds to **counteract** the change.
- The system does not undo the change completely; it reduces its effect.

## Position of equilibrium

- The **position of equilibrium** describes the relative amounts of reactants and products.
- If it shifts to the **right**, the forward reaction is favoured, so there are more products at equilibrium.




Shifting right means more products and fewer reactants at the new equilibrium.

- If it shifts to the **left**, the reverse reaction is favoured, so there are more reactants at equilibrium.
- After the change, the forward and reverse rates become equal again and a new equilibrium is reached.

## Quick guide to the changes

- Increase the concentration of a substance: the position shifts away from that substance, to use some of it up.
- Increase the temperature: the position shifts in the endothermic direction, which takes in energy.
- Increase the pressure (gases only): the position shifts towards the side with fewer molecules, which lowers the pressure.
- Decreasing any of these has the opposite effect.
- A **catalyst** does not change the position of equilibrium. It speeds up the forward and reverse reactions equally, so equilibrium is reached more quickly.

## How to answer each type of question

**State Le Chatelier's principle** 2 marks **Grade 5**

1. Start with the condition: a system at equilibrium has one of its conditions changed.
2. Finish with the response: the system responds to counteract (oppose) the change.

**Example.** State Le Chatelier's principle.

**Model answer.** If a change is made to the conditions of a system at equilibrium (1), the system responds to counteract the change (1).

### Predict and explain the effect of a change

2 to 3 marks | Grade 7

1. Identify the change: concentration, temperature or pressure.
2. Say which way the position of equilibrium shifts to counteract it.
3. Say what happens to the amount of product, or to the colour if colours are given.

**Example.** Brown nitrogen dioxide gas forms colourless dinitrogen tetroxide gas in a reversible reaction.

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

The forward reaction is exothermic.

A sealed syringe containing the equilibrium mixture is put into iced water.

Predict how the colour of the mixture changes. Explain your answer.

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**Model answer.** The mixture becomes paler (1). Lowering the temperature shifts the position of equilibrium in the exothermic direction, to the right (1), so there is less brown $NO_2$ and more colourless $N_2O_4$ (1).

### Explain the effect of a catalyst on an equilibrium

2 marks | Grade 6

1. Say the catalyst increases the rates of the forward and reverse reactions equally.
2. Conclude: the position of equilibrium does not change, but equilibrium is reached faster.

**Example.** A manufacturer adds a catalyst to a reversible reaction.

Explain why the catalyst does not change the amount of product in the equilibrium mixture.

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**Model answer.** The catalyst increases the rates of the forward and reverse reactions equally (1), so the position of equilibrium does not change; equilibrium is just reached more quickly (1).

## Don’t lose marks

- Writing 'the equilibrium shifts to counteract the change' without saying which direction and what happens to the amount of product.
- Saying a catalyst increases the yield or shifts the position of equilibrium.
- Saying the system cancels the change completely. It only reduces the effect.
- Mixing up the position of equilibrium (how much product) with how quickly equilibrium is reached (the rate).

## More tips

### Memory tricks

- Le Chatelier's principle in three words: 'do the opposite'. Whatever you change, the system tries to oppose it.
- Right = products: 'shifts to the right' always means more product.
- Three levers move the position: concentration, temperature and pressure. A catalyst only changes the speed.

### Exam technique

- Structure your answer: change → direction of shift → effect on the amount of product (or colour). Each part is often a mark.
- Use the phrase 'the position of equilibrium shifts to the right (towards the products)' or 'to the left (towards the reactants)'.
- Read the information given carefully: the question tells you whether the forward reaction is exothermic and gives the equation you need.

## What each grade needs

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

**Grade 5**

**State Le Chatelier's principle**

If a condition of a system at equilibrium is changed, the system responds to counteract the change.

**Grade 6**

**Explain what shifting right or left means**

Shifting right gives more products at equilibrium; shifting left gives more reactants.

**Grade 6**

**Know a catalyst does not move equilibrium**

A catalyst speeds up both reactions equally, so equilibrium is reached faster but its position does not change.

**Grade 7**

**Predict the effect of a change in conditions**

Use the information given (equation, energy change, numbers of molecules) to say which way the position shifts.

**Grade 8**

**Explain a prediction fully using Le Chatelier**

Say what the change is, how the system counteracts it, which way the position shifts and what happens to the product.

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