The effect of pressure changes on equilibrium (HT only)

5.6.2.7 · Chemistry · revision notes

Higher tier only. For reactions involving gases, changing the pressure can shift the position of equilibrium. You need to count the gas molecules on each side of the balanced equation and predict which way the position moves, or explain why pressure has no effect.

Key facts

- Higher pressure → side with fewer gas molecules
- Lower pressure → side with more gas molecules
- Same number of gas molecules on each side → pressure does not change the position
- Count molecules using the numbers in front of the formulae in the balanced equation (no number = 1)
- $N_2 + 3H_2 \rightleftharpoons 2NH_3$: 4 molecules → 2 molecules, so a higher pressure gives more NH_3
- A higher pressure also increases the rate of gas reactions

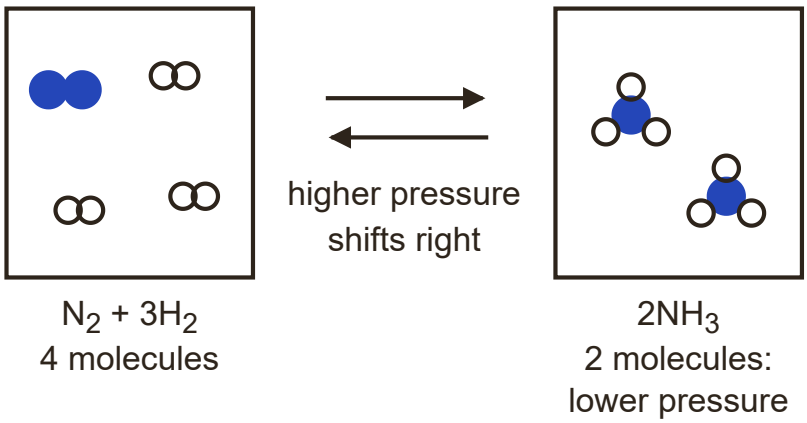
Notes

The rules (reactions involving gases)

- An **increase in pressure** shifts the position of equilibrium towards the side with the **smaller number of molecules**, as shown by the balanced symbol equation.
- A **decrease in pressure** shifts the position of equilibrium towards the side with the **larger number of molecules**.
- If both sides have the same number of gas molecules, changing the pressure does not change the position of equilibrium.

Counting molecules

- Add up the numbers in front of the formulae of the gases on each side. A formula with no number in front counts as 1.
- Count only the gases, marked (g). Do not count solids or liquids.
- $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$: 1 + 3 = 4 molecules on the left and 2 on the right. Increasing the pressure shifts the position to the right, so more ammonia forms.



Fewer gas molecules means a lower pressure, so a higher pressure shifts the position towards $2NH_3$.

- $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$: 2 molecules on each side, so changing the pressure does not change the position.

Why it works

- Gas pressure is caused by molecules colliding with the walls of the container. Fewer molecules in the same volume means a lower pressure.
- When the pressure is increased, the system counteracts the change by shifting towards the side with fewer molecules, which reduces the pressure.
- Increasing the pressure of reacting gases also increases the rates of both reactions (more frequent collisions), so equilibrium is reached faster.

How to answer each type of question

Predict and explain the effect of changing the pressure

2 to 3 marks | Grade 6

1. Count the gas molecules on each side of the equation and write the numbers down.
2. Higher pressure: shift to the side with fewer molecules. Lower pressure: shift to the side with more molecules.
3. Say what happens to the amount of the substance the question asks about.

Example. Methane reacts with steam in a reversible reaction.
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$
Predict and explain the effect of increasing the pressure on the amount of hydrogen at equilibrium.

Model answer. The amount of hydrogen decreases (1). There are 2 molecules on the left and 4 molecules on the right (1), so the position of equilibrium shifts to the left, towards the side with fewer molecules (1).

Explain why pressure has no effect on a particular equilibrium

2 marks | Grade 7

1. Count the gas molecules on each side and show they are equal.
2. Conclude that shifting in either direction would not change the pressure, so the position does not change.

Example. At very high temperatures, nitrogen and oxygen react to form nitrogen monoxide.
$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$
Explain why changing the pressure does not change the amount of nitrogen monoxide at equilibrium.

Model answer. There are 2 molecules on each side of the equation (1), so a shift in either direction would not change the pressure, and the position of equilibrium does not change (1).

Use pressure data to evaluate an equation or prediction 3 to 4 marks **Grade 8**

1. Describe the trend in the data as the pressure increases.
2. Say which way the position must be shifting.
3. Count the molecules in the suggested equation and check whether they fit the trend.

Example. Gas P decomposes in a reversible reaction. The percentage of P decomposed at equilibrium was measured at different pressures, at the same temperature.

Pressure in atmospheres	1	5	10
Percentage of P decomposed	40	19	14

A student suggests the equation is $P(g) \rightleftharpoons Q(g) + R(g)$.
Explain whether the data support the student's equation.

Model answer. As the pressure increases, the percentage of P decomposed decreases (1), so a higher pressure shifts the position of equilibrium to the left (1). The data support the equation: there is 1 molecule on the left and 2 on the right (1), and a higher pressure shifts the position towards the side with fewer molecules (1).

Don't lose marks

- Counting atoms instead of molecules. Use the big numbers in front of the formulae, not the small subscripts.
- Forgetting that a formula with no number in front counts as one molecule.
- Writing 'towards the smaller side' or 'the side with less mass'. Say 'towards the side with fewer molecules'.
- Applying the pressure rule to reactions in solution with no gases. Pressure does not affect their position of equilibrium.

More tips

Memory tricks

- Squeeze it and it shrinks: higher pressure favours the side with fewer molecules.
- Write the molecule count under each side of the equation before you answer.
- Same number of molecules on both sides: pressure does not move the position (but it still changes the rate).

Exam technique

- Quote the numbers: 'there are 4 molecules on the left and 2 on the right' earns credit that 'fewer on the right' alone may not.
- Use the balanced equation given in the question, and check it is balanced before you count.
- State the effect on the product (increases or decreases) as well as the direction of the shift.

What each grade needs

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

Grade 5

Count the molecules on each side

Add the numbers in front of each gas formula in the balanced equation (no number means 1).

Grade 6

Predict the effect of increasing the pressure

The position shifts towards the side with the smaller number of molecules.

Grade 6

Predict the effect of decreasing the pressure

The position shifts towards the side with the larger number of molecules.

Grade 7

Recognise when pressure has no effect

If both sides have the same number of gas molecules, changing the pressure does not move the position.

Grade 7

Explain pressure effects using Le Chatelier

Fewer molecules exert a lower pressure, so shifting to that side counteracts a pressure increase.

Grade 8

Use pressure data to test an equation

E.g. if the yield rises with pressure, the product side must have fewer gas molecules.

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