SCIENCE FOUNDATIONS

Le Châtelier's principle

Difficulty level: Advanced

Science Foundations

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Overview of the concept

This is how factories squeeze more ammonia fertiliser out of a reaction, by changing the pressure or removing product so the balance shifts toward making more of it. When a reaction is pushed out of balance, it shifts to fight the change, like a see-saw tipping back toward level. A winemaker uses the same idea to stop a fermentation from going too far. Knowing Le Chatelier's principle tells you which knob to turn when you want more product, and what will happen if conditions change on their own.



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Rule

Le Chatelier's principle: when a system at equilibrium is disturbed, it shifts to undo the change.

Adding a reactant shifts the equilibrium toward the products, and raising the pressure shifts it toward the side with fewer gas molecules. A catalyst speeds up both directions and does not change the equilibrium position.

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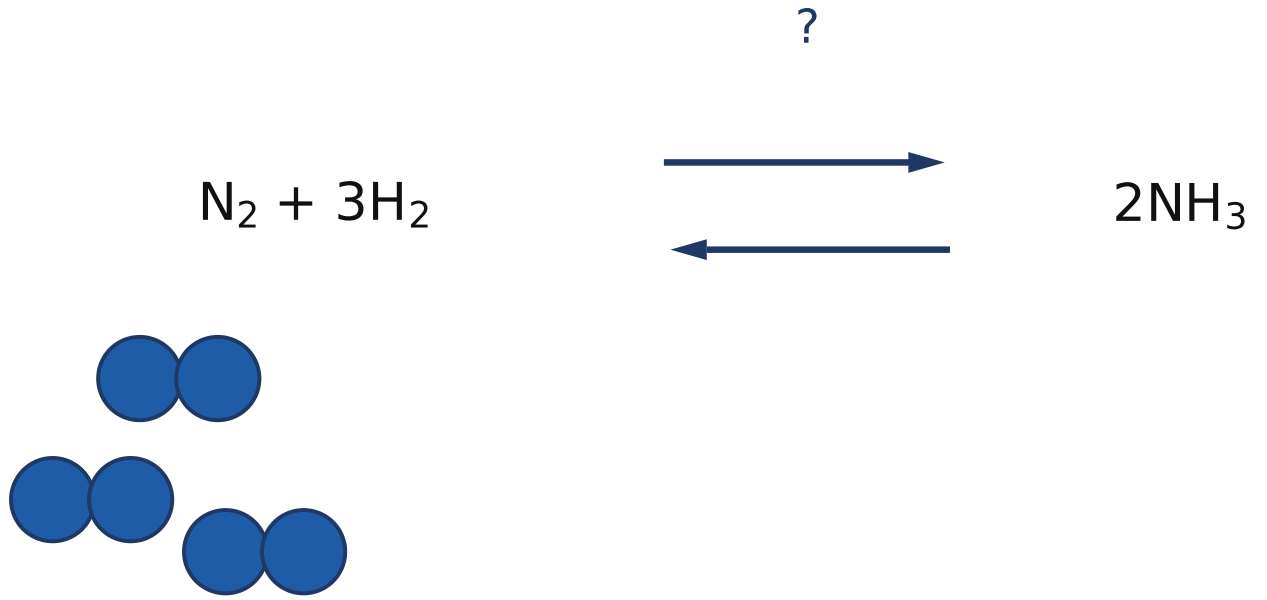
Worked examples

EXAMPLE 1

Q $N_2 + 3H_2 \rightarrow 2NH_3$ at equilibrium: what happens if more N_2 is added?



SOLUTION

Name the disturbance: more reactant added.

Apply the rule: the system shifts to use up the added reactant.

Direction: toward products, making more ammonia.

The result is shift right, more ammonia forms.

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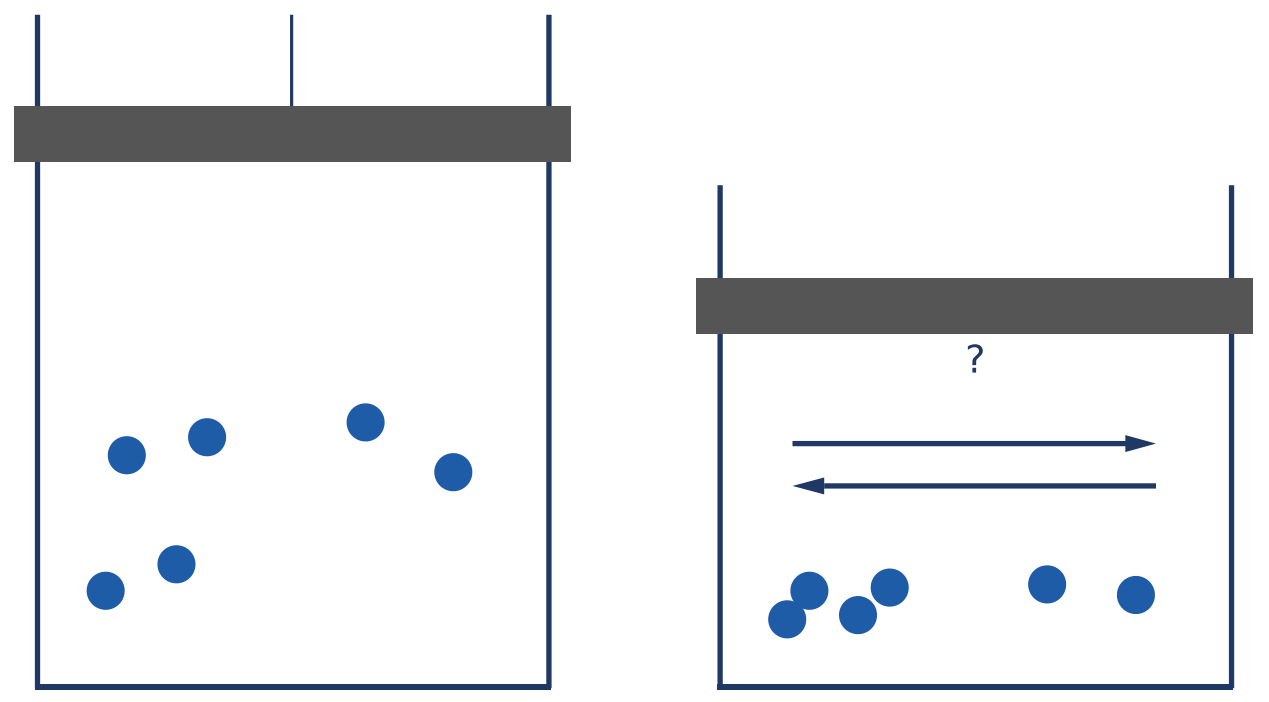
EXAMPLE 2

Q Same reaction: what happens if pressure is raised?



SOLUTION

Count gas molecules: left has 4, right has 2.

Raising pressure favours the side with fewer gas molecules.

Direction: toward products.

The result is shift right, more ammonia forms.

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Practice questions

1 **H2 + Cl2 -> 2HCl is at equilibrium. More Cl2 is added. Which way does the equilibrium shift, and does more or less HCl form?**

A Shift right, more HCl forms

B Shift left, less HCl forms

C No shift, the same HCl forms

D Shift left, more HCl forms

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2 **$H_2 + Cl_2 \rightarrow 2HCl$ is at equilibrium. More HCl is added. Which way does the equilibrium shift, and does more or less HCl form?**

A Shift left, less HCl forms

B Shift right, more HCl forms

C No shift, the same HCl forms

D Shift left, more HCl forms

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3

2SO2 + O2 -> 2SO3 is at equilibrium. The pressure is raised. Which way does the equilibrium shift, and why?

A. Shift right, the right side has fewer gas molecules (2 versus 3)

B. Shift left, the left side has fewer gas molecules

C. Shift right, the right side has more gas molecules

D. No shift, pressure does not affect gases

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$2SO_2 + O_2 \rightarrow 2SO_3$ is at equilibrium. The pressure is lowered. Which way does the equilibrium shift, and why?

A. Shift left, the left side has more gas molecules (3 versus 2)

B. Shift right, the right side has more gas molecules

C. Shift left, the left side has fewer gas molecules

D. No shift, pressure does not affect gases

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5 **$N_2 + 3H_2 \rightarrow 2NH_3$ is at equilibrium and the forward reaction is exothermic. The temperature is raised. Which way does the equilibrium shift?**

A. Shift left, toward the endothermic side

B. Shift right, toward the exothermic side

C. No shift, temperature does not affect equilibrium

D. Shift left, toward the exothermic side

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$H_2 + I_2 \rightarrow 2HI$ is at equilibrium. Some HI is removed. Which way does the equilibrium shift?

A Shift right, toward products

B Shift left, toward reactants

C No shift, removing product does nothing

D Shift right, toward reactants

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In one line, what does Le Chatelier's principle say a system at equilibrium does when it is disturbed?

A It shifts to partly undo the disturbance

B It shifts to make the disturbance bigger

C It stays exactly as it is

D It shifts to use up the catalyst

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Does adding a catalyst change the equilibrium position? Explain.

A No, it only speeds up reaching equilibrium

B Yes, it shifts the equilibrium to the products

C Yes, it shifts the equilibrium to the reactants

D No, it slows down reaching equilibrium

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$H_2 + I_2 \rightarrow 2HI$ is at equilibrium. The pressure is raised. Which way does the equilibrium shift, and why?

A. No shift, both sides have the same number of gas molecules (2 versus 2)

B. Shift right, the right side has fewer gas molecules

C. Shift left, the left side has fewer gas molecules

D. Shift right, the right side has more gas molecules

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10 **For $N_2 + 3H_2 \rightarrow 2NH_3$ at equilibrium, the pressure is raised and more N_2 is added at the same time. Which way does the equilibrium shift? Explain.**

A. Shift right, both changes favour the product side

B. Shift left, both changes favour the reactant side

C. No shift, the changes cancel out

D. Shift right, only the pressure change matters

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ANSWER KEY

1. Shift right, more HCl forms

2. Shift left, less HCl forms

3. Shift right, the right side has fewer gas molecules (2 versus 3)

4. Shift left, the left side has more gas molecules (3 versus 2)

5. Shift left, toward the endothermic side

6. Shift right, toward products

7. It shifts to partly undo the disturbance

8. No, it only speeds up reaching equilibrium

9. No shift, both sides have the same number of gas molecules (2 versus 2)

10. Shift right, both changes favour the product side

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