## Essential Question

How do Q and K explain Le Châtelier's principle?

# A Stress Changes Q or K

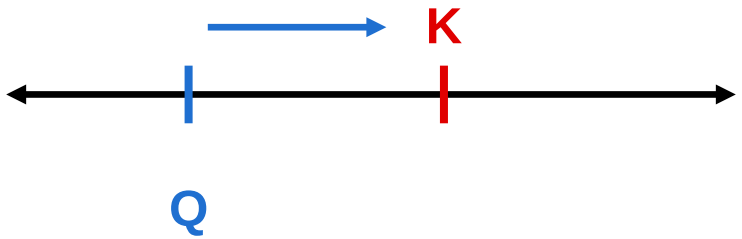
| Stress | Changes Q? | Changes K? |
|---|---|---|
| Add or remove a substance | yes | no |
| Change volume (gas moles differ) | yes | no |
| Change temperature | no* | yes |

**Q stays the same at first, but K moves away from it.*

# Adding a Reactant

- Reactant goes up → Q goes down
- Q < K → shift right

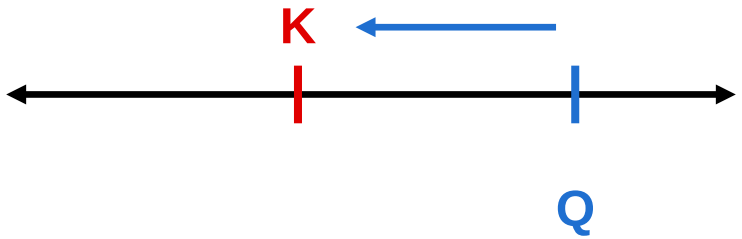
$$Q = \frac{[\text{products}]}{[\text{reactants}] \uparrow}$$



# Adding a Product

- Product goes up → Q goes up
- Q > K → shift left

$$Q = \frac{[\text{products}] \uparrow}{[\text{reactants}]}$$



# Changing Volume and Q

- Halve the volume → every concentration doubles
- The side with more gas moles is affected more

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

$$Q = \frac{[NO_2]^2}{[N_2O_4]}$$

$$Q_{new} = \frac{(2[NO_2])^2}{2[N_2O_4]}$$

**$= (4/2) \times Q = 2Q$**

# Temperature Changes K

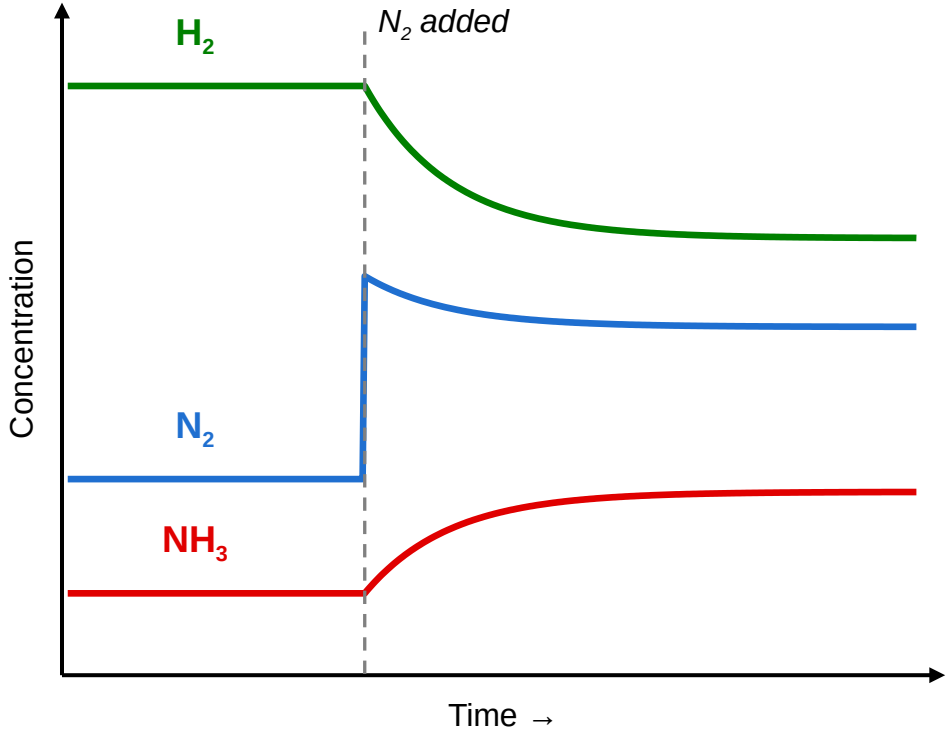
| Reaction type | Heat it | Cool it |
|---|---|---|
| Endothermic ($\Delta H > 0$) | K increases | K decreases |
| Exothermic ($\Delta H < 0$) | K decreases | K increases |

- Then the system shifts until Q = K

# Graphing a Stress

- Spike = substance added
- Others adjust gradually

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$



## Example: Adding a Reactant

At equilibrium, $[H_2] = 0.100$ M, $[I_2] = 0.100$ M, and $[HI] = 0.707$ M ($K_c = 50.0$). Extra $H_2$ is added so $[H_2]$ instantly becomes 0.200 M. Calculate Q and predict the shift.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

## Example: Compressing a Gas Mixture

At equilibrium, $[N_2O_4] = 0.200$ M and $[NO_2] = 0.0400$ M. The volume is suddenly cut in half. Calculate Q right after and predict the shift.

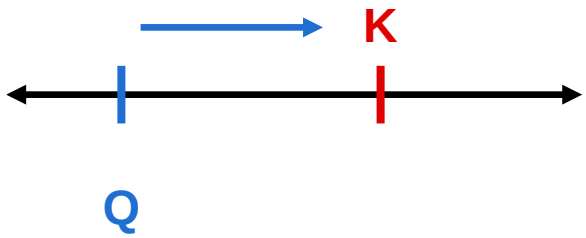
$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

# Example: Heating an Exothermic Reaction

For this reaction, $\Delta H = -57.2$ kJ/mol. The temperature is increased. Does K change? Does Q change right away? Which way does the system shift?

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

# Reaction Quotient and Le Châtelier's Principle

## Big Ideas

- A stress makes Q ≠ K
- Concentration or volume: Q changes
- Temperature: K changes
- System shifts until Q = K again