

Exercise walk-through

7.1

Chemical equilibria: reversible reactions, dynamic equilibrium

A-Level Chemistry

Dynamic equilibrium

A **dynamic equilibrium** is a closed system where the forward and reverse rates are equal. Concentrations stay constant, but both reactions still run.



It is **dynamic**: molecules keep reacting. It is **equilibrium**: nothing measurable changes.

Le Chatelier's principle

the equilibrium shifts to *oppose* the change you make

increase [reactant] → towards the **products**

increase pressure → to the **fewer-gas-molecules** side

increase temperature → in the **endothermic** direction

a **catalyst** speeds both directions equally, so it gives *no shift*

Le Chatelier's principle

: the equilibrium shifts to **oppose** a change.

- more reactant → towards products
- more pressure → fewer-gas side
- more heat → endothermic way
- a **catalyst** → no shift

Equilibrium constants

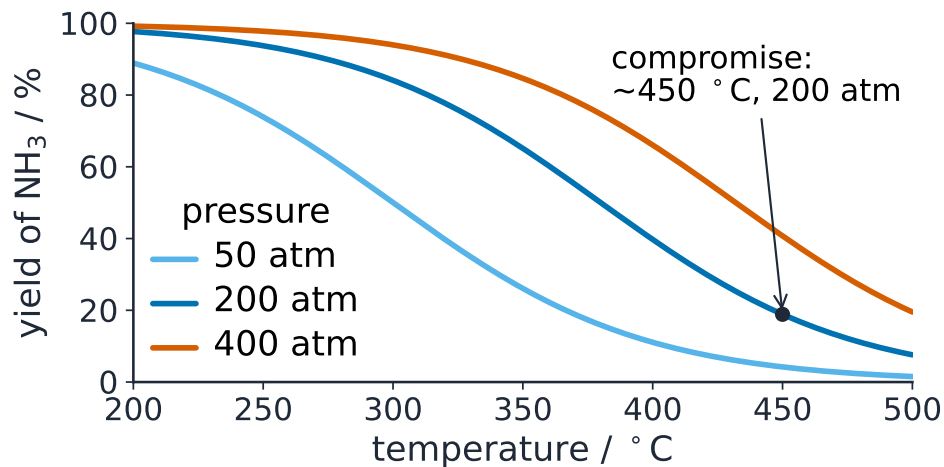
$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$



$$K_c = \frac{1.6^2}{0.20 \times 0.20} = 64 \text{ (no units here)}$$

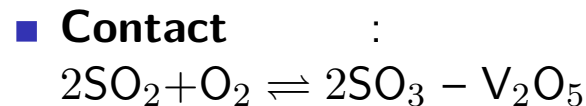
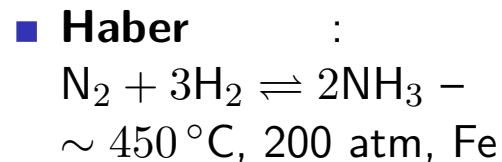
Only **temperature** changes K_c or K_p . For gases use **partial pressure** = **mole fraction**
× total pressure.

The Haber and Contact processes



exothermic: lower $T \uparrow$ yield · higher $P \uparrow$ yield

Conditions balance yield, rate & cost:



Low temperature gives more yield but too slowly.

Exercises 2.1·2.2

2.1 State the **two** features of a system at dynamic equilibrium. [2]

2.2 Write the K_c expression for $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$. [1]

Exercises 2.1·2.2

2.1 State the **two** features of a system at dynamic equilibrium. [2]

2.1

- the forward and reverse rates are equal; the concentrations of reactants and products stay constant

2.2 Write the K_c expression for $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$. [1]

2.2

- $$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

Exercises 3.1·3.2

3.1 For an **exothermic** equilibrium, increasing the temperature:

[1]

☐

A shifts it towards the products

B shifts it towards the reactants (the endothermic direction)

C has no effect

D increases the value of K_c towards products

3.2 Adding a catalyst to a system at equilibrium:

[1]

☐

A shifts it towards the products

B shifts it towards the reactants

C does not change the position of equilibrium

D increases K_c

Exercises 3.1·3.2

3.1 For an **exothermic** equilibrium, increasing the temperature:

[1]

☐

A shifts it towards the products

B shifts it towards the reactants (the endothermic direction)

C has no effect

D increases the value of K_c towards products

3.1 B

- Raising T shifts an exothermic equilibrium towards the reactants (endothermic direction)

3.2 Adding a catalyst to a system at equilibrium:

[1]

☐

A shifts it towards the products

B shifts it towards the reactants

C does not change the position of equilibrium

D increases K_c

3.2 C

- A catalyst speeds both directions equally – no shift

Exercise 3.3 (a)

3.3 At equilibrium, $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ has $[\text{N}_2\text{O}_4] = 0.10$ and $[\text{NO}_2] = 0.20 \text{ mol dm}^{-3}$.

(a) Write the expression for K_c and calculate its value (give units). [3]

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(a) Write the expression for K_c and calculate its value (give units). [3]

(a)

- $$K_c = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{0.20^2}{0.10} = 0.40 \text{ mol dm}^{-3}$$

Exercise 3.3 (b)

3.3 At equilibrium, $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ has $[\text{N}_2\text{O}_4] = 0.10$ and $[\text{NO}_2] = 0.20 \text{ mol dm}^{-3}$.

(b) State the effect on the **value** of K_c of increasing the pressure. [1]

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(b) State the effect on the **value** of K_c of increasing the pressure. [1]

(b)

- no change – only temperature changes K_c

Exercise 3.4

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3.4

- total moles = 4.0; mole fraction of SO_2 = $3.0/4.0 = 0.75$; $p(\text{SO}_2) = 0.75 \times 400 = 300$ kPa