17.1 Equilibrium and changing conditions

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS reversible reaction • equilibrium

Objective

Equilibrium and changing conditions. Original classroom practice for IB SL; not an official IB paper.

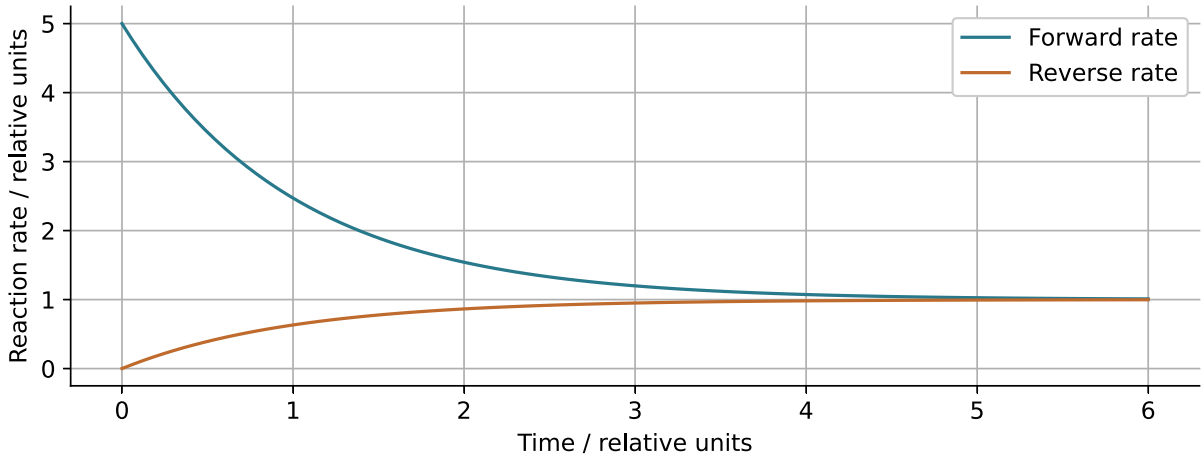
1 Key knowledge and worked examples

■ What would explain this observation?

- A **reversible reaction** can continue in a closed vessel while measured concentrations stay constant. Constant composition does not mean particles have stopped reacting.

■ Build the model

- Dynamic **equilibrium** occurs in a closed system when forward and reverse rates are equal.
- Reactant and product concentrations are constant, but they need not be equal.
- equilibrium: A state with equal forward and reverse reaction rates.
- reversible reaction: A reaction that can proceed in both directions.



Choose evidence that can test it

- A concentration or pressure change disturbs the balance.
- The system responds toward a new equilibrium.
- Temperature changes can also change the equilibrium constant; a catalyst changes how quickly equilibrium is reached.

In the lab: State the balanced equation and whether the forward reaction is exothermic before predicting a temperature effect. Count gas coefficients when considering pressure; pressure has no composition effect when gaseous amounts are equal on both sides.

Work from known quantities

- Known: in $A \rightleftharpoons B$, equilibrium concentrations are $[A] = 0.20$ and $[B] = 0.60$ in the same concentration unit.
- For this stated expression, $K = [B]/[A]$.
- $K = 0.60/0.20 = 3.0$.
- Equal rates do not imply $K = 1$.

Your turn: For $A \rightleftharpoons B$, calculate $[B]/[A]$ when $[B]=0.8$ and $[A]=0.2$.

Check the conclusion and its limits

- Do not use a catalyst to claim a larger equilibrium yield.
- For heterogeneous equilibria, pure solids are omitted from the usual equilibrium expression.

Not true: A catalyst changes the equilibrium constant at a fixed temperature. A catalyst speeds the forward and reverse reactions equally, so equilibrium is reached sooner but the equilibrium constant and final composition at a fixed temperature are unchanged.

Key:

- Dynamic equilibrium occurs in a closed system when forward and reverse rates are equal.
- A concentration or pressure change disturbs the balance.
- Watch for: do not use a catalyst to claim a larger equilibrium yield.

Write from an equilibrium constant of 2.0

- For A in equilibrium with B, the concentration of B is 0.50 and the concentration of A is 0.25, in the same unit.
- Find K for the stated expression $[B]/[A]$. A catalyst does not change K at a fixed temperature.

2 Practice

2.1 What is equal at dynamic equilibrium? Choose one answer.

- **A** Concentrations of all species
- **B** Masses of every reactant and product
- **C** Forward and reverse reaction rates [1]

2.2 For A $\rightleftharpoons$ B, calculate [B]/[A] when [B]=0.8 and [A]=0.2. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: A catalyst speeds the forward and reverse reactions equally, so equilibrium is reached sooner but the equilibrium constant and final composition at a fixed temperature are unchanged. [2]

2.4 A state with equal forward and reverse reaction rates: write the technical term. [1]

3 Exam-style questions

3.1 A⇌B has$K=4$ at fixed temperature. Immediately after adding$A$, the ratio$[B]/[A]=2$. Predict the shift and distinguish reaction rates from equilibrium concentrations. [4]

Solutions

2.1 C At dynamic equilibrium the forward and reverse reactions continue at equal RATES, so concentrations stay constant. The concentrations themselves are usually not equal to each other, and equal rates do not require equal masses.

2.2 For the stated$A \rightleftharpoons B$ expression,$K=[B]/[A]=0.8/0.2=4$.

2.3 True. True. A catalyst speeds the forward and reverse reactions equally, so equilibrium is reached sooner but the equilibrium constant and final composition at a fixed temperature are unchanged.

2.4 equilibrium. equilibrium means A state with equal forward and reverse reaction rates.

3.1 $Q<K$, so net forward change raises the ratio toward4. At equilibrium forward/reverse rates are equal; concentrations need not be equal. Temperature and the stated expression matter.