CHEMICAL EQUILIBRIUM

VISUAL CHEM CARDS

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Chemical Equilibrium

Some chemical reactions are reversible, ie products can react together to produce the original reactants:

$$aA + bB \rightleftharpoons cC + dD$$

Left (L) **Right (R)**

Forward reaction $\longrightarrow$

Backward reaction $\longleftarrow$

$\rightleftharpoons$ reversible reactions

Reversible reaction mixtures contain both reactants and products.

Position of equilibrium is given by K – an equilibrium. Under a given set of temperature and pressure conditions, K is a **constant**,

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

[ ] = concentration (M)

reaction coefficients

If K is large, equilibrium lies to the **R**– ie high proportion of products.

If K is small, equilibrium lies to the **L**– ie high proportion of reactants.

Chemical Equilibrium

Le Chatelier's principle if the reaction conditions of a system in dynamic equilibrium are changed, the position of equilibrium will shift to counteract the changes in order to re-establish equilibrium.

So, any changes made to reaction conditions will cause the equilibrium to move in a direction (left or right) to offset the change.

$$aA + bB \rightleftharpoons cC + dD$$

Left **Right**

Changing Concentration

Increase [A] or [B]	Equilibrium shifts **R**
Decrease [A] or [B]	Equilibrium shifts **L**
Increase [C] or [D]	Equilibrium shifts **L**
Decrease [C] or [D]	Equilibrium shifts **R**

Chemical Equilibrium

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Changing Pressure

Changing the pressure will have no impact on reactions that involve only solids or liquids.

Pressure only has an effect when the number of gaseous reactant and product molecules differs.

$$X_{2(g)} + 3Y_{2(g)} \rightleftharpoons 2XY_{3\,(g)}$$

reactants **products**

1 + 3 = 4 molecules 2 molecules

Increase Pressure	Equilibrium shifts R
Decrease Pressure	Equilibrium shifts L

Chemical Equilibrium

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So, any changes made to reaction conditions will cause the equilibrium to move in a direction (left or right) to offset the change.

Changing Temperature

Exothermic reactions

$$aA + bB \rightleftharpoons cC + dD + heat$$

Increase Temperature	Equilibrium shifts L
Decrease Temperature	Equilibrium shifts R

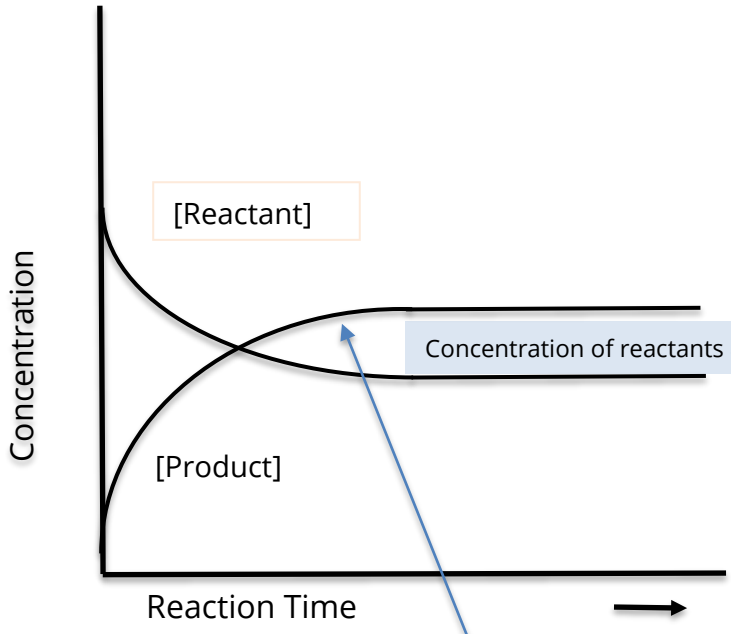
Endothermic reactions

$$aA + bB + heat \rightleftharpoons cC + dD$$

Increase Temperature	Equilibrium shifts R
Decrease Temperature	Equilibrium shifts L

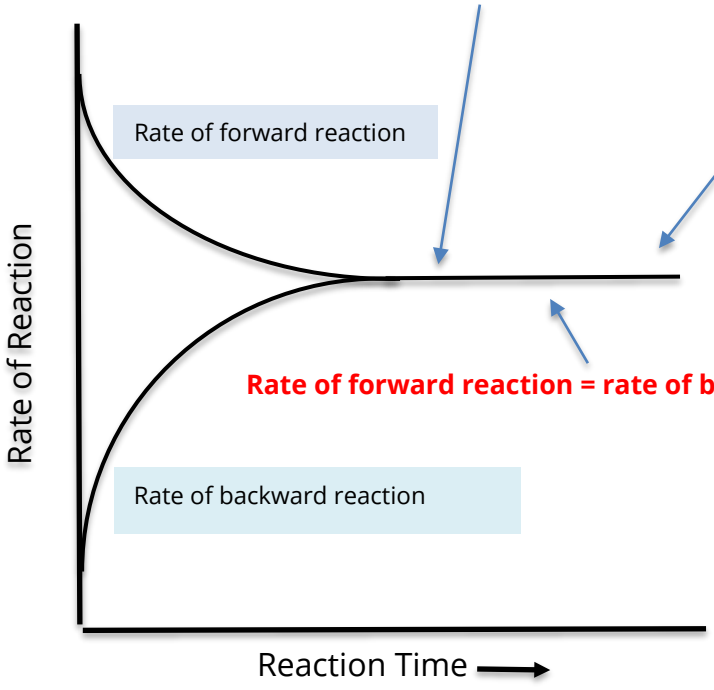
Chemical Equilibrium

Reactants ⇌ Products



Concentration of reactants and products remain constant

Dynamic equilibrium



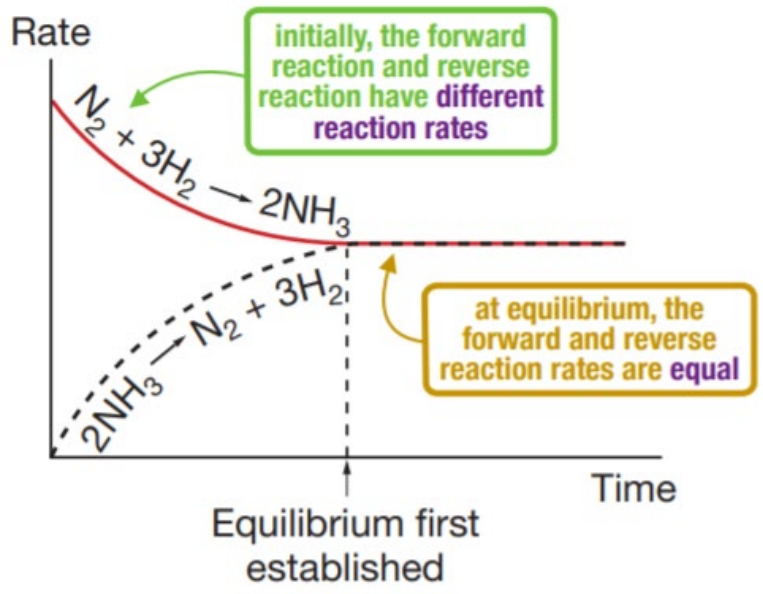
Rate of forward reaction = rate of backward reaction

At equilibrium:

- rate of the forward reaction = rate of the backward reaction,
- amounts of the reactants and products at equilibrium do not change with time,
- equilibrium is dynamic, i.e., both forward and backward reactions do not stop and continue to take place, but at equal rates,
- catalyst do not change the position of equilibrium, but reduce the time taken for equilibrium to be established.

Chemical Equilibrium

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$



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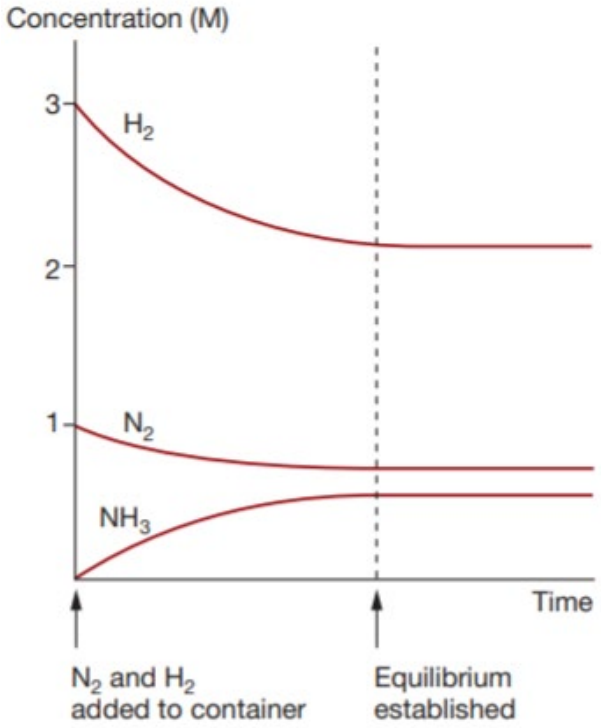

At Dynamic Equilibrium

constant concentrations
constant temperature
constant total gas pressure
the reaction is incomplete

(all substances are present in the equilibrium mixture)