Equilibrium and Le Chatelier's principle

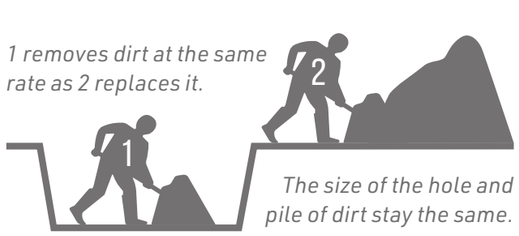
COMPOUND INTEREST

Reversible chemical reactions reach equilibrium in closed systems (no substances added or lost). Here's how different conditions affect that equilibrium.

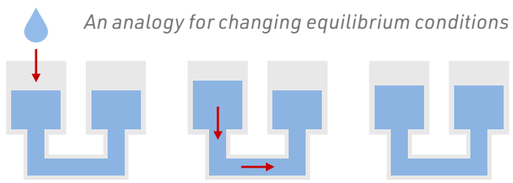
Equilibrium

$$A + B \rightleftharpoons C + D$$

In reversible reactions products of the reaction can react to produce the original reactants. At dynamic equilibrium the rates of the forwards and backwards reactions are equal; the concentrations of the reactants and products don't change.



Le Chatelier's principle



Le Chatelier's principle states that when a change is made to the conditions of a dynamic equilibrium, the system moves to counteract the change, causing changes in quantities of reactants and products.

Concentration

Reactant concentration increased

↓

The equilibrium position shifts to reduce the reactant concentration.

↓

Reaction forming products favoured

In the example below the new equilibrium mixture will contain a higher concentration of C and D.

REDUCES REACTANT CONCENTRATION

$$A + 2B \rightleftharpoons C + D$$

REDUCES PRODUCT CONCENTRATION

Increasing concentration of one side favours the other.

Product concentration increased

↓

The equilibrium position shifts to reduce the product concentration.

↓

Reaction forming reactants favoured

In the example above the new equilibrium mixture will contain a higher concentration of A and B.

Temperature

Temperature increased

↓

The equilibrium position shifts to reduce the temperature.

↓

The endothermic reaction will be favoured

In the example below the new equilibrium mixture will contain more A and B, and less C and D.

ENDO

EXOTHERMIC

(increases temperature)

$$A + 2B \rightleftharpoons C + D$$

(decreases temperature)

ENDOTHERMIC

If the forward reaction is exothermic, the backward reaction will be endothermic, and vice versa.

Temperature decreased

↓

The equilibrium position shifts to increase the temperature.

↓

The exothermic reaction will be favoured

In the example above the new equilibrium mixture will contain more C and D, and less A and B.

EXO

Pressure

Pressure increased

↓

The equilibrium position shifts to reduce the pressure.

↓

Side of reaction with fewer gas molecules favoured

In the example below the new equilibrium mixture will contain more C and D, and less A and B.

DECREASES PRESSURE

(fewer gas molecules on right)

$$A + 2B \rightleftharpoons C + D$$

(more gas molecules on left)

INCREASES PRESSURE

If the number of gas molecules is the same on either side, then changing pressure will have no effect.

Pressure decreased

↓

The equilibrium position shifts to increase the pressure.

↓

Side of reaction with more gas molecules favoured

In the example above the new equilibrium mixture will contain more A and B, and less C and D.

Note: using a catalyst increases the rate of both the forwards and backwards reactions but doesn't change the equilibrium position.