Chemical and Physical Equilibrium

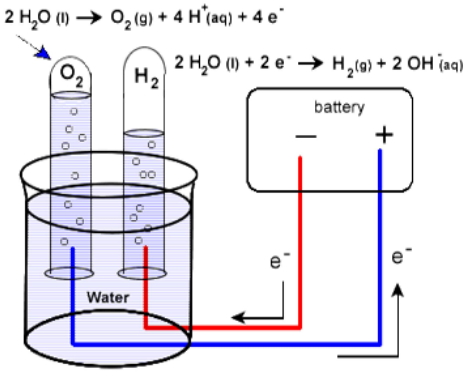
Reversible Reactions

= go both ways
= exo in 1 dir & endo in the other

In theory, every rxn pathway can be transversed in both directions—but some are harder than others to reverse

e.g. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$ LST → exo

To reverse this rxn would require a temperature of 3000 °C or an electric current (hydrolysis of water/electrolysis of water/decomposition of water = endothermic).



endo

$2H_2O(l) + elect \rightarrow 2H_2(g) + 1O_2(g)$

Equilibrium

- When the rate of the forward rxn = the rate of the reverse rxn
- Both rxns continue but there is no net change in the composition of the system 80R : 20P
- It has to be a closed system
- It is a dynamic state
  - ↳ moving

Reactions are driven to a lower enthalpy and a higher entropy.

exo more chaos
more randomness

At equilibrium, the driving force of the energy change factor (lower enthalpy, exo rxn) is balanced by the driving force of the entropy change factor (increased randomness). Sometimes they work together.

e.g. $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq) + 44.2\ kJ$

S → ions → exo

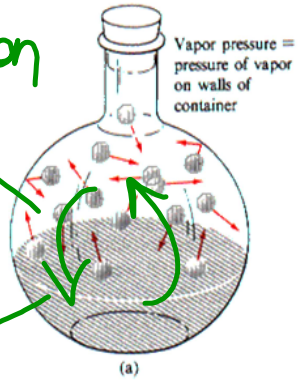
Physical Equilibria

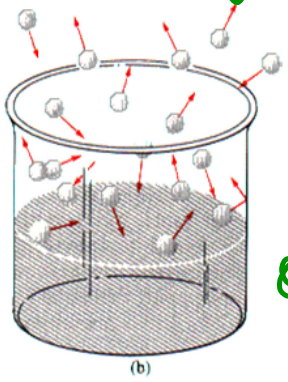
1) **liquid—vapour equilibrium**

l ⇋ g rate evap = rate conden

Dalton gas

liq





open = particles are escaping

2) **solution equilibrium**

saturated = "closed"

rate diss ⇋ rate crypt

$I_{2(s)} \leftrightharpoons I_{2(aq)}$

s ⇋ aq

3) **ionic equilibrium**

saturated

$NaCl_{(s)} \leftrightharpoons Na^+_{(aq)} + Cl^-_{(aq)}$

s ⇋ ions

Factors That Disturb Equilibrium

Any change that alters the rate of either the forward or reverse reaction disturbs the original equilibrium.

Remember! The Rate Can Be Changed By:

8OR ↔ 2OP

- the nature of the reactants
- the concentration of the reactants
- the surface area
- temperature change
- presence of a **catalyst** = this alters **BOTH** rates therefore no change in the equilibrium

"Vector Chemistry" = magnitude and direction of ⇆

Le Chatelier's Principle left 8OP ⇆ 2OP

If a system at equilibrium is subjected to a stress, the equilibrium is shifted in the direction that relieves the stress.

If you stress a system, the system will want to reduce the stress. It will shift either right or left to eliminate the stress.

Stress 1 **Concentration Change** ⇒ for G or aq

If you ↑ [R] = shifts to the right = to produce more products and ↓ [R]

stress ↑[A] add A

A(g) + B(g) ↔ C(g) + D(g)

If you ↑ [P] = shifts to the left = to produce more R and ↓ [P]

↑[D]

A(g) + B(g) ↔ C(g) + D(g)

↓ [R] =

↓ [P] =

The "Rule" is:

S Stress??

W Want??

S Shift??

Stress 2 **Change in Pressure** = a change in concentration of a **GAS** only NOT (l) or (s) or (aq)

If you ↑ P = ↑ [gases]

- has an effect only if gases are involved
- if you ↑ **P** then the system will shift to the side with the fewer number of moles of gas because:

* P is caused by: the # parts hitting the sides

So if you want to ↓ P then you need to ↓ the # of gas parts

3 n gas ⇌ 2 n gas + 2 D(s)

2 A(g) + B(g) ↔ 2 C(g)

Stress ↑P

Want ↓P

Shift right

Stress 3 **Change in Volume** = actually a pressure change

Stress 4 **Temperature Change**

Reversible rxns are exo in one direction and endo in the other.

* Addition of heat energy shifts the equilibrium so that heat is absorbed

therefore the endo rxn is favoured.

Removal of heat energy favours the exo rxn.

A(g) + B(g) ↔ C(g) + D(g) + HE

Stress = ↑HE

Want = ↓HE

Shift = left to absorb HE into the bonds of the R