Chemistry 12

II 1 - 3

Equilibrium I

pg. 37-49

Name:
Date:
Block:

1. Enthalpy and Entropy
2. Reverse & Forward Rates

Enthalpy and Entropy

In general, reactions either…

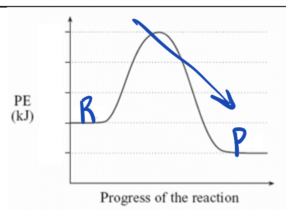
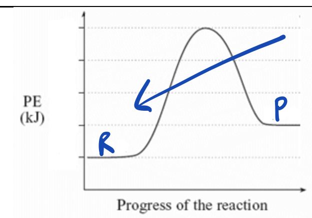
1. Occur
   - The products are favoured.
   - A → B
2. Do not occur
   - The reactants are favoured.
   - A ← B
3. Reach equilibrium
   - ⇋

To determine whether the products or reactants are favoured (preferred), we look at two different factors:

LAZY

1. Enthalpy, H (heat/energy)

- Systems favour low energy states *(i.e.* minimum *enthalpy).*

Exothermic	Endothermic
	
• Products have lower energy. • Products are favoured. • ΔH is negative.	• Reactants have lower energy. • Reactants are favoured. • ΔH is positive.

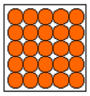
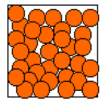
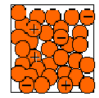
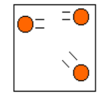
For the following reactions, does **minimum enthalpy** favour the reactants or products?

Reaction:	Which side is favoured? Reactant/Product/Cannot be determined
a) $A_{(g)} + B_{(g)} \overset{?}{\leftrightarrow} C_{(g)}$ + heat (exo)	Products
b) $D_{(s)}$ + heat $\overset{?}{\leftrightarrow} E_{(g)}$ (endo)	Reactants
c) $F_{(aq)} \overset{?}{\leftrightarrow} G_{(aq)}$ ΔH = -10kJ	Products
d) $H_{(s)} \overset{?}{\leftrightarrow} I_{(g)} + J_{(g)}$ ΔH = +10kJ	Reactants
e) $K_{(g)} + L_{(g)} \overset{?}{\leftrightarrow} M_{(g)} + N_{(g)} + O_{(g)}$	Cannot be determined

Messy

2. Entropy, S (randomness)

- Systems favour the side with <u>more</u> disorder (*i.e.* <u>Maximum</u> *entropy*).

Solid	Liquid	Aqueous	Gas
			
Atoms locked in place, vibrating.	Atoms slipping and sliding past each other.	Atoms and ions slipping and sliding past each other.	Atoms zipping and zooming, little contact.
min entropy ⟵			⟶ max entropy

The side with the greater number of molecules with higher entropy will be favoured.

This is why we don't teach our children about entropy until much later...

For the following reactions, does **maximum entropy** favour the reactants or products?

Reaction:	Which side is favoured? Reactant/Product/Cannot be determined
a) $A_{(g)} + B_{(g)} \overset{?}{\leftrightarrow} C_{(g)}$ + heat	Reactants
b) $D_{(s)}$ + heat $\overset{?}{\leftrightarrow} E_{(g)}$	Products
c) $F_{(aq)} \overset{?}{\leftrightarrow} G_{(aq)}$ $\Delta H = -10kJ$	Cannot be determined
d) $H_{(s)} \overset{?}{\leftrightarrow} I_{(g)} + J_{(g)}$ $\Delta H = +10kJ$	Products
e) $K_{(g)} + L_{(g)} \overset{?}{\leftrightarrow} M_{(g)} + N_{(g)} + O_{(g)}$	Products

Putting it all together…

Reaction	Reaction direction which enthalpy favours? Reactant/Product (Lazy – Min. Enthalpy)	Reaction direction which entropy favours? Reactant/Product (Messy – Max. Entropy)	Spontaneous/ Non-spontaneous/ Equilibrium? (Both products are favoured / Both Reactants are favoured / one of each favoured)
a) $CaCO_{3(s)} + 178\ kJ \overset{?}{\leftrightarrow} CaO_{(s)} + CO_{2(g)}$	← R	P →	Equilibrium
b) $2NO_{(g)} + O_{2(g)} \overset{?}{\leftrightarrow} 2NO_{2(g)} + 113\ kJ$	P →	← R	⇌ E
c) $2C_{(s)} + 2H_{2(g)} \overset{?}{\leftrightarrow} C_2H_{4(g)}$ $\Delta H = +52.3\ kJ$	← R	← R	← NS
d) $2Li_{(s)} + 2H_2O_{(l)} \overset{?}{\leftrightarrow} 2LiOH_{(aq)} + H_{2(g)}$ $\Delta H = -433\ kJ$	P →	P →	S →
d) $KCl_{(s)} \overset{?}{\leftrightarrow} K^+_{(aq)} + Cl^-_{(aq)}$ $\Delta H = -17\ kJ$	P →	P →	S →
f) $Zn_{(s)} + 2Ag^+_{(aq)} \overset{?}{\leftrightarrow} Zn^{+2}_{(aq)} + 2Ag_{(s)} + 169\ kJ$	P →	← R	⇌ E

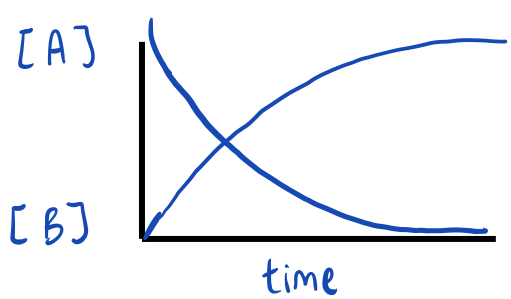
1 solid, 2 aqueous → 1 aqueous, 2 solid

Hebden Pg. 48 #14, 15

Reverse and Forward Rates

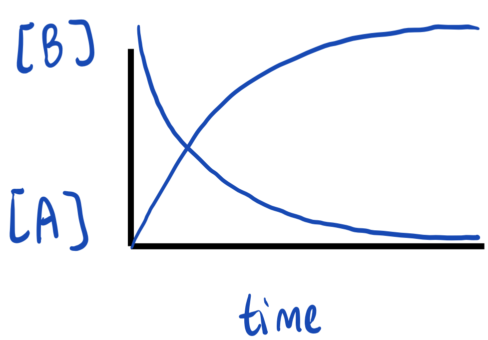
Up until now reactions have been written using a one-sided arrow → to represent the **forward** reaction.

$$A \rightarrow B$$



In the last unit, you learned that some reactions are reversible and ← can be used to represent the **reverse** reaction.

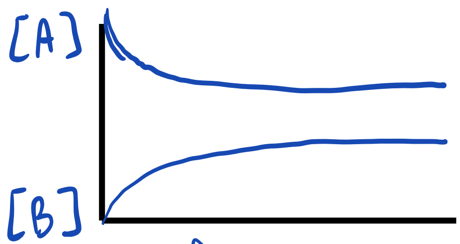
$$A \leftarrow B$$



When both the forward and reverse reaction take place, this is written by using a double-sided arrow.

$$A \leftrightharpoons B$$

- Before equilibrium is reached, A is turning into B very quickly.
    - Forward rate is fast but slows down.
    - Reverse rate is Ø but speed up.



- **As equilibrium is reached, the** forward **rate and** reverse **rate become** equal**.**
- The forward and reverse rate continues to occur.

There are 3 criteria for a system to be at chemical equilibrium:

1. Have constant macroscopic properties.
    - Colour, pH, temperature, pressure remain constant.
    - Minor unobservable changes happen on an atomic or molecular level.
    - Self-perpetuating because the forward and reverse reactions continuously supply each other with reactants.
2. Be Closed.
    - No chemicals entering or leaving the system.
    - Amount of chemicals is held within the system.
3. Shift when conditions change.
    - Results in a change or shift in amount of reactants and products.
    - Equilibrium will be re-established in response to the change.

★ Focus of Next class

<u>Complete Enthalpy and Entropy Worksheet</u>