Chemistry 12

Equilibrium I

Name:
Date:
Block:

1. **Enthalpy and Entropy**
2. **Reverse & Forward Rates**

Enthalpy and Entropy

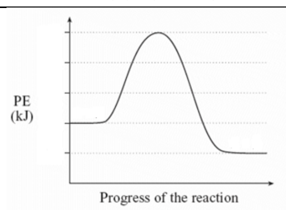
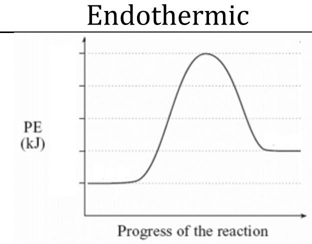
In general, reactions either…

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

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

1. Enthalpy, H (heat/energy)

- Systems favour ____________ energy states *(i.e. ________________ enthalpy).*

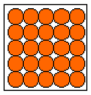
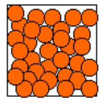
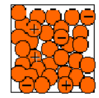
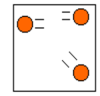
Exothermic	Endothermic
	
• _____________ have lower energy. • _____________ are favoured. • ΔH is _____________.	• _____________ have lower energy. • _____________ are favoured. • ΔH is _____________.

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

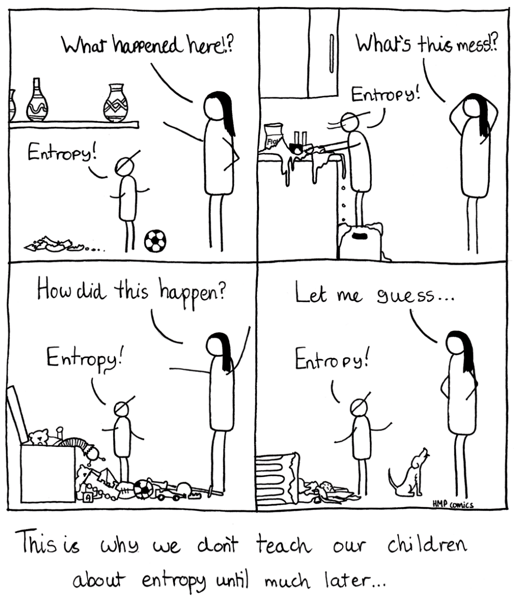
Reaction:	Which side is favoured? Reactant/Product/Cannot be determined
a) $A_{(g)} + B_{(g)} \overset{?}{\leftrightarrow} C_{(g)}$ + heat	
b) $D_{(s)}$ + heat $\overset{?}{\leftrightarrow} E_{(g)}$	
c) $F_{(aq)} \overset{?}{\leftrightarrow} G_{(aq)}$ $\Delta H = -10kJ$	
d) $H_{(s)} \overset{?}{\leftrightarrow}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

2. Entropy, S (randomness)

- Systems favour the side with ____________ disorder *(i.e. ________________ 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.

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



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

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

Putting it all together…

Reaction	Reaction direction which enthalpy favours? Reactant/Product	Reaction direction which entropy favours? Reactant/Product	Spontaneous/ Non-spontaneous/ Equilibrium?
a) $CaCO_{3(s)} + 178\text{ kJ} \overset{?}{\leftrightarrow} CaO_{(s)} + CO_{2(g)}$			
b) $2NO_{(g)} + O_{2(g)} \overset{?}{\leftrightarrow} 2NO_{2(g)} + 113\text{ kJ}$			
c) $2C_{(s)} + 2H_{2(g)} \overset{?}{\leftrightarrow} C_2H_{4(g)}$ $\Delta H = +52.3\text{ kJ}$			
d) $2Li_{(s)} + 2H_2O_{(l)} \overset{?}{\leftrightarrow} 2LiOH_{(aq)} + H_{2(g)}$ $\Delta H = -433\text{ kJ}$			
d) $KCl_{(s)} \overset{?}{\leftrightarrow} K^+_{(aq)} + Cl^-_{(aq)}$ $\Delta H = -17\text{ kJ}$			
f) $Zn_{(s)} + 2Ag^+_{(aq)} \overset{?}{\leftrightarrow} Zn^{+2}_{(aq)} + 2Ag_{(s)} + 169\text{ kJ}$			

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 ________________ but ______________________.
  - Reverse rate is ________________ but _______________________.

- **As equilibrium is reached, the ___________________ rate and ___________________ rate become ________________________.**
- 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.
   - _________________________ because the forward and reverse reactions continuously supply each other with reactants.
2. Be __________________.
   - No chemicals entering or leaving the system.
   - Amount of chemicals is held within the system.
3. __________________ 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.

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