Reversible Reactions

Consider the following two reactions:

ICE → WATER

WATER → ICE

- Both reactions can occur; that is, they are both spontaneous reactions (although the temperature has to be different)
- The above reaction is called a reversible reaction
- A reversible reaction is a reaction in which both the forward and reverse reactions are spontaneous
- Not all reactions are reversible

For example, consider the following reaction:

A + B → C where $\Delta H = (-)$ and $\Delta S = (+)$

We know that this reaction is __________ spontaneous at _________ temperature.

However, consider its reverse reaction:

C → A + B

We know that for this reaction, $\Delta H = (\ )$ and $\Delta S = (\ )$ and therefore it is __________ spontaneous at _________ temperature.

We can therefore conclude that the reaction A + B → C is NOT a reversible reaction.

RECALL: In the previous unit, we learned

1) That if ΔH is negative in one direction, it will be _______________ in the reverse direction. The same holds true for ΔS and ΔG.
2) That for a reaction to be spontaneous, ΔG must be ______________.

- Some reactions are reversible at the <u>same temperature</u>; that is, unlike the example of ice and water, both reactions are spontaneous at the same temperature.

$$A + B \rightarrow C \text{ at } 30^\circ C \quad \text{and} \quad C \rightarrow A + B \text{ at } 30^\circ C$$

- This means that ΔG must be ______________ for both reactions. This isn't possible, therefore ΔG = _____________ for this type of reaction.
- Since both reactions are occurring at the same time, we can write the reaction as: $A + B \Leftrightarrow C$ and is called an equilibrium reaction.

Equilibrium Reactions

The equilibrium reaction below was studied at 448°C:

$$H_{2(g)} + I_{2(g)} \leftrightarrow 2HI_{(g)}$$

Purple colourless

The following observations were made:

- The purple colour never completely disappears
- The same intensity of purple is present at the end of the reaction regardless of whether the reaction starts with, for example, 1 mole each of H_2 and I_2 or it starts with 2 moles of HI.
- The following relationship exists between the final concentrations of H_2, I_2, and HI regardless of starting concentrations:

$$\frac{[HI]^2}{[H_2][I_2]} = 49.5 \leftarrow \text{this value changes if T changes}$$

- 49.5 is called the equilibrium constant K_{eq} and the relationship is called the equilibrium expression.
- The equilibrium expression can easily be derived for any equilibrium reaction – the products go in the numerator, the reactants in the denominator and the coefficients become the exponents.

$$2A + 3B \leftrightarrow C$$

$$K_{eq} = \frac{[C]}{[A]^2[B]^3}$$