

Reversible Reactions

Consider the following two reactions:



- 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:



We know that this reaction is _____ spontaneous at _____ temperature.

However, consider its reverse reaction:



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 $A + B \rightarrow C$ 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 _____.

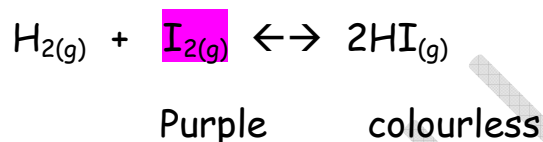
- Some reactions are reversible at the same temperature; that is, unlike the example of ice and water, both reactions are spontaneous at the same temperature.



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

Equilibrium Reactions

The equilibrium reaction below was studied at 448°C:



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:

$$\frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = 49.5 \leftarrow \text{this value changes if } T \text{ changes}$$

- 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.



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