

Section 18.2c- Keq

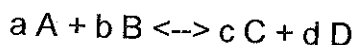
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**Objectives:**

- predict the favourability of reactant or products in a reversible reaction, on the basis of the magnitude of the equilibrium constant.
- write equilibrium constant expressions

Notes There is a mathematical relationship that shows the relationship between reactants and products. This is called the equilibrium constant Keq.

It provides a constant value for a chemical system over a range of concentrations. For the general reaction...



$$K_{eq} = \frac{[\text{products}]}{[\text{reactants}]}$$

[ ] - conc. in mole/L.

The equilibrium law is....

$$K_{eq} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

The equilibrium constant is a ratio of products concentration to reactant concentration at equilibrium.

Keq is a constant for reaction at a given temp.

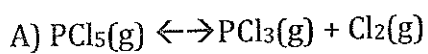
When keq > 1 - products are favored.

When keq < 1 - reactants are favored.

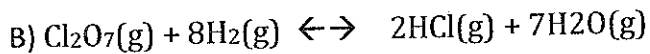
The Equilibrium law can only include substances that can vary in concentration. Hence:

1. All gases, aqueous ions and mixtures of liquids are included.
2. Pure solids & liquids are never included in a Keq.

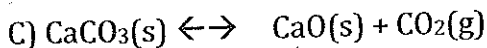
Write the Equilibrium Laws (equilibrium expression) for the following:



$$K_{eq} = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$$

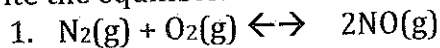


$$K_{eq} = \frac{[\text{HCl}]^2 [\text{H}_2\text{O}]^7}{[\text{Cl}_2\text{O}_7] [\text{H}_2]^8}$$

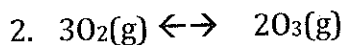


$$K_{eq} = [\text{CO}_2]$$

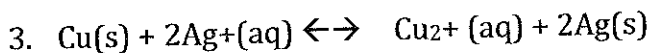
Write the equilibrium laws for each of the following reactions:



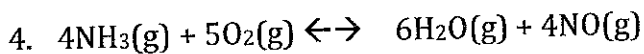
$$K_{eq} = \frac{[\text{NO}]^2}{[\text{N}_2][\text{O}_2]}$$



$$K_{eq} = \frac{[\text{O}_3]^2}{[\text{O}_2]^3}$$



$$K_{eq} = \frac{[\text{Cu}^{2+}]}{[\text{Ag}^+]^2}$$



$$K_{eq} = \frac{[\text{H}_2\text{O}]^6 [\text{NO}]^4}{[\text{NH}_3]^4 [\text{O}_2]^5}$$

Problems:

1. What is the value of  $K_{eq}$  for the reaction of hydrogen and bromine gases to form hydrogen bromide gas? The equilibrium concentrations are:



hydrogen gas: 0.0821 mol/L

bromine gas: 0.0433 mol/L

hydrogen bromide gas: 0.357 mol/L

$$K_{eq} = \frac{[\text{HBr}]^2}{[\text{H}_2][\text{Br}_2]} = \frac{[0.357]^2}{[0.0433][0.0821]} = 35.9$$

2. Industries manufacture methanol by the reaction of hydrogen gas and carbon monoxide gas to produce methanol ( $\text{CH}_3\text{OH}$ ). The equilibrium constant is 10.42 at 479 K. What is the concentration of methanol vapour produced if the equilibrium concentrations of hydrogen gas is 0.478 mol/L and carbon monoxide gas is 0.2289 mol/L?



$$K_{eq} = \frac{[\text{CH}_3\text{OH}]}{[\text{H}_2]^2 [\text{CO}]}$$

$$[\text{CH}_3\text{OH}] = K_{eq} \cdot [\text{H}_2]^2 [\text{CO}]$$

$$[\text{CH}_3\text{OH}] = 10.42 \cdot (0.478)^2 [0.2289] = 0.545 \text{ mol/L}$$