

Equilibrium and Thermodynamics Worksheet
CHEM 212

1. Write a generalized equilibrium expression for the following reaction.



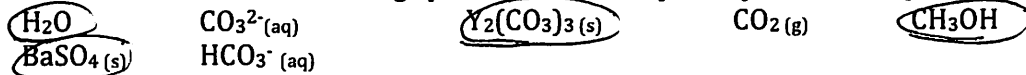
$$K = \frac{\text{products}}{\text{reactants}} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

2. State the units for each phase below necessary for the equilibrium expression. If a phase does not participate, explain why.

Phase	units
Gas	f or pressure
Aqueous	Molarity
Liquid	⊖
solid	⊖

liquids & solids don't participate in equilibrium expressions

3. Circle each of the following species that do not participate in the equilibrium expression.



What do the circled answers have in common?

solid or liquid

Manipulating Equilibrium constants

Forward and reverse reactions



Write each equilibrium expression for each equation.

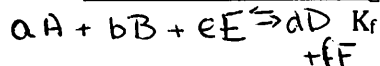
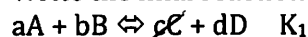
$$K_f = \frac{[C]^c [D]^d}{[A]^a [B]^b} \quad K_r = \frac{[A]^a [B]^b}{[C]^c [D]^d}$$

What is the relationship between equilibrium constants (Ks)?

$$K_f = \frac{1}{K_r}$$

Adding reactions

Write the final reaction and equilibrium expression for each reaction.



$$K_1 = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

$$K_2 = \frac{[F]^f}{[C]^c [D]^d}$$

$$K_f = \frac{[D]^d [F]^f}{[A]^a [B]^b [E]^e}$$

What is the relationship between the Ks?

$$K_f = K_1 \cdot K_2$$

Thermodynamics

Define the following terms in words and state if positive or negative is favorable:

enthalpy

change of heat during a reaction from bonds made/broken during rxn.

+ ΔH , heat absorbed, endothermic, not favored
 entropy - ΔH , heat released, exothermic, favored

a measure of disorder. Increased entropy means disorder has increased, which is favorable.

Gibb's free energy

A measure of the spontaneity of a reaction.

- ΔG is favorable, if rxn will proceed spontaneously.

Spontaneous?

Spontaneity is predicted by: $\Delta G_r = \Delta H_r - T\Delta S_r$

Complete the table and predict if the reaction would be spontaneous.

ΔH_r	ΔS_r	ΔG_r	Spontaneous?
+	+	not clear	entropy favored
+	-	+	no!
-	+	-	yes! most favorable
-	-	not clear	enthalpy favored

What is the equation relating the equilibrium constant and Free energy

$$K = e^{-\frac{\Delta G}{RT}} \quad \text{or} \quad \Delta G = -RT \ln K$$

$$R = 8.314 \text{ J/K}\cdot\text{mol}$$

$$T = K$$

$$\Delta G = \text{J/mol}$$

What is Le Châtlier's principle in words?

Le Châtlier's principle means that if you push on either the reactants or products side of an rxn, the rxn will proceed away from that pressure

When can heat be considered as a reactant or product?

when a reaction is endothermic, heat is a reactant

when exothermic, heat is a product.

In which direction is a reaction spontaneous?

Q is the reaction quotient and can be used in nonequilibrium situations to determine the direction in which a reaction will be spontaneous. K is Q at equilibrium.

Equilibrium is a lowest energy state predicted using thermodynamic data. However, it does not say if a reaction will happen or how fast. If a reaction will really happen also depends on kinetics, which is not discussed in this course.

react / prod
Δ