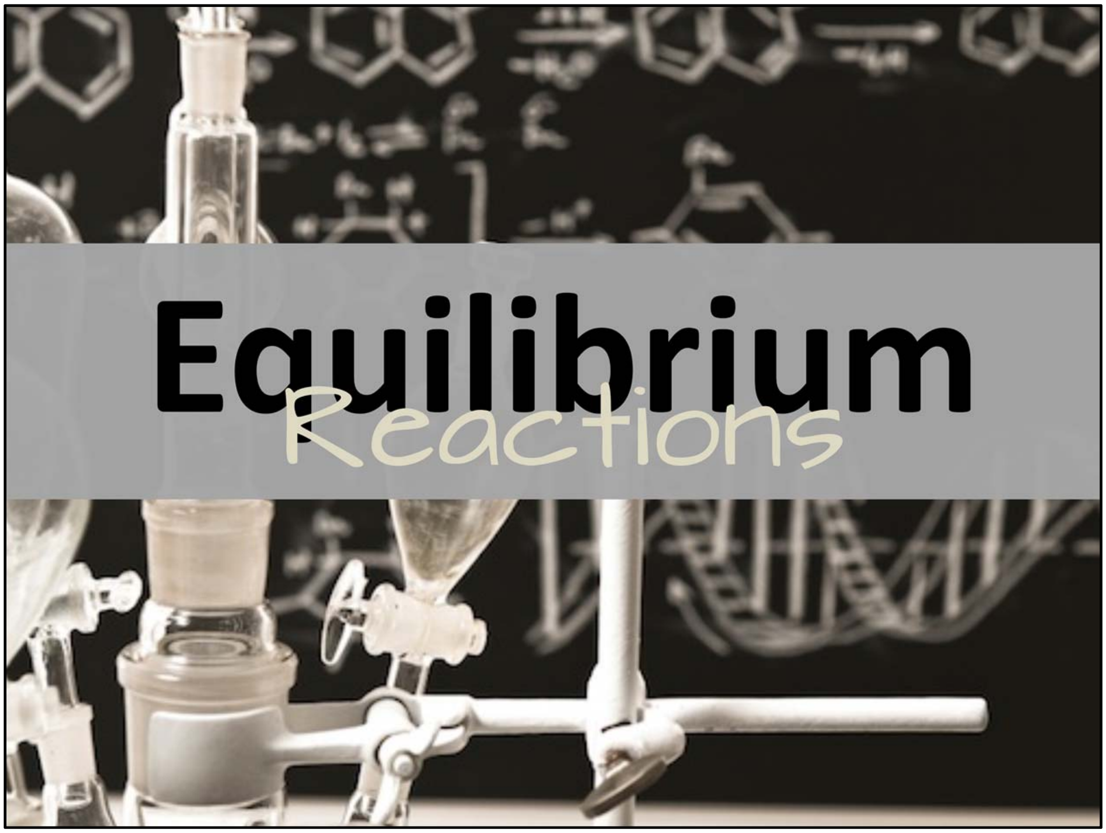
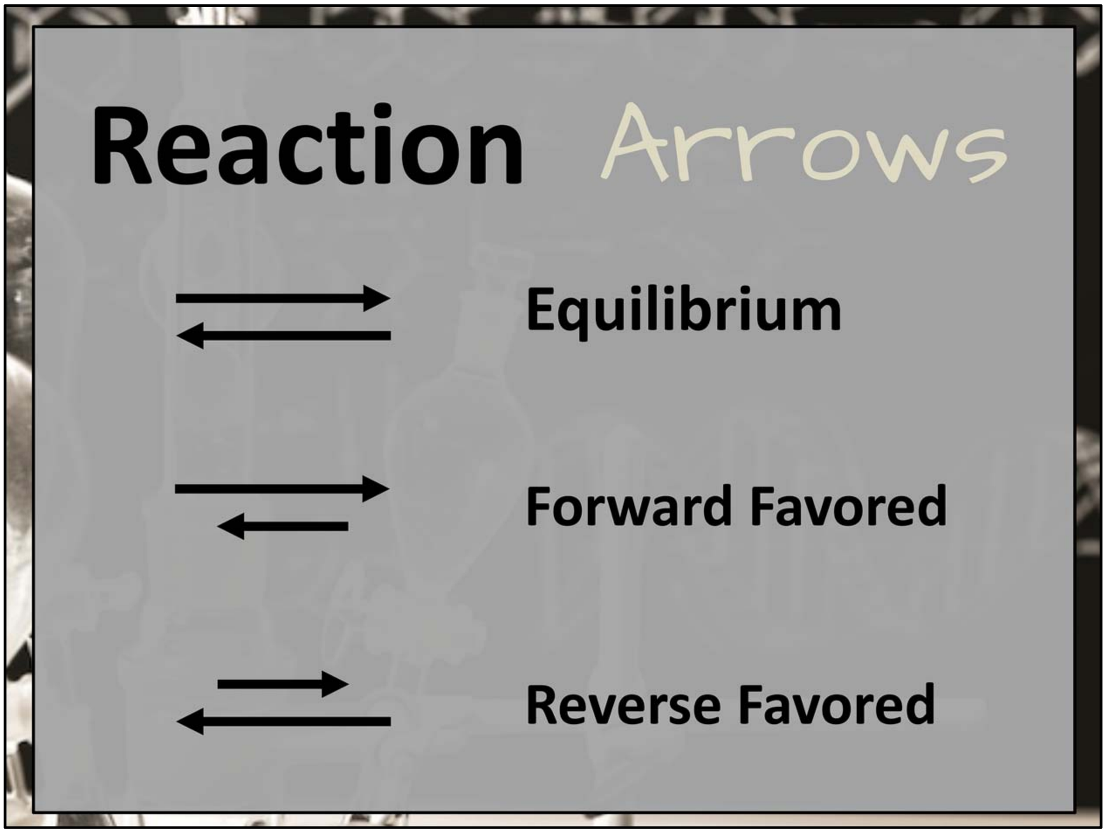
Module 12: Kinetics and Equilibrium
Topic 1 Content: Equilibrium Reactions Presentation Notes



Equilibrium Reactions



Different reaction arrows are used to show when a reaction is in equilibrium. When the reaction is in equilibrium, the arrows are of the same length. When the reaction is not at equilibrium the arrows are not the same length. In this case, the size of the arrow will determine if the forward reaction is favored or the reverse reaction is favored.

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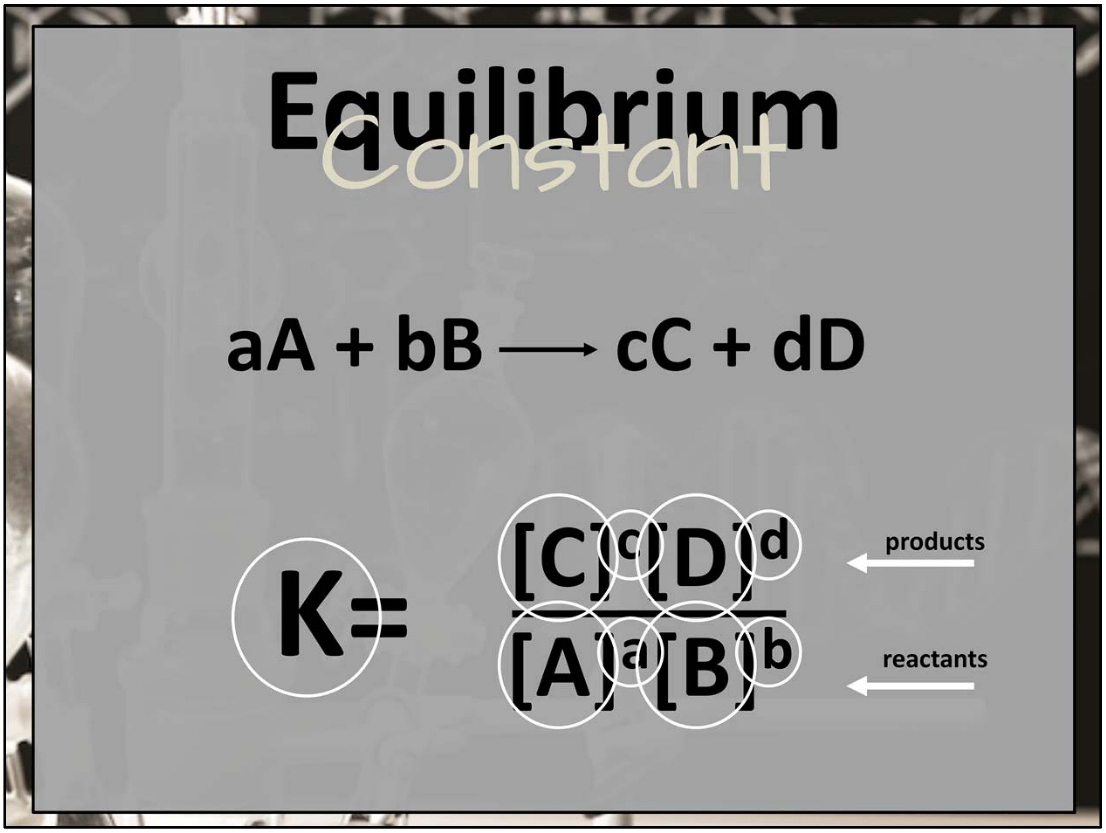

All reversible chemical reactions progress toward an equilibrium mixture of constant concentrations of reactants and products. At equilibrium, some reactions yield more products than reactants and vice versa. The extent to which reversible reactions proceed toward products before reaching equilibrium is described by the equilibrium constant. The equilibrium constant is the ratio of the concentrations of products to the concentrations of reactants at equilibrium.

In this equilibrium constant equation, the lower-case letters represent the coefficients. These coefficients are very important. When you are writing an equilibrium expression, you will want to make sure you have a balanced equation. The upper-case letters represent the chemical formulas. You should also notice that the products are always in the numerator and the reactants are in the denominator. In this equation, brackets always express the different concentrations. Finally, the equation is set equal to K.

If the state of a reactant or product is aqueous or gaseous, its concentration can change. If its state is solid or liquid, its concentration cannot change. Therefore, solids and liquids are excluded from equilibrium expressions. If either a solid or a liquid is found in the numerator, a value of one is used.

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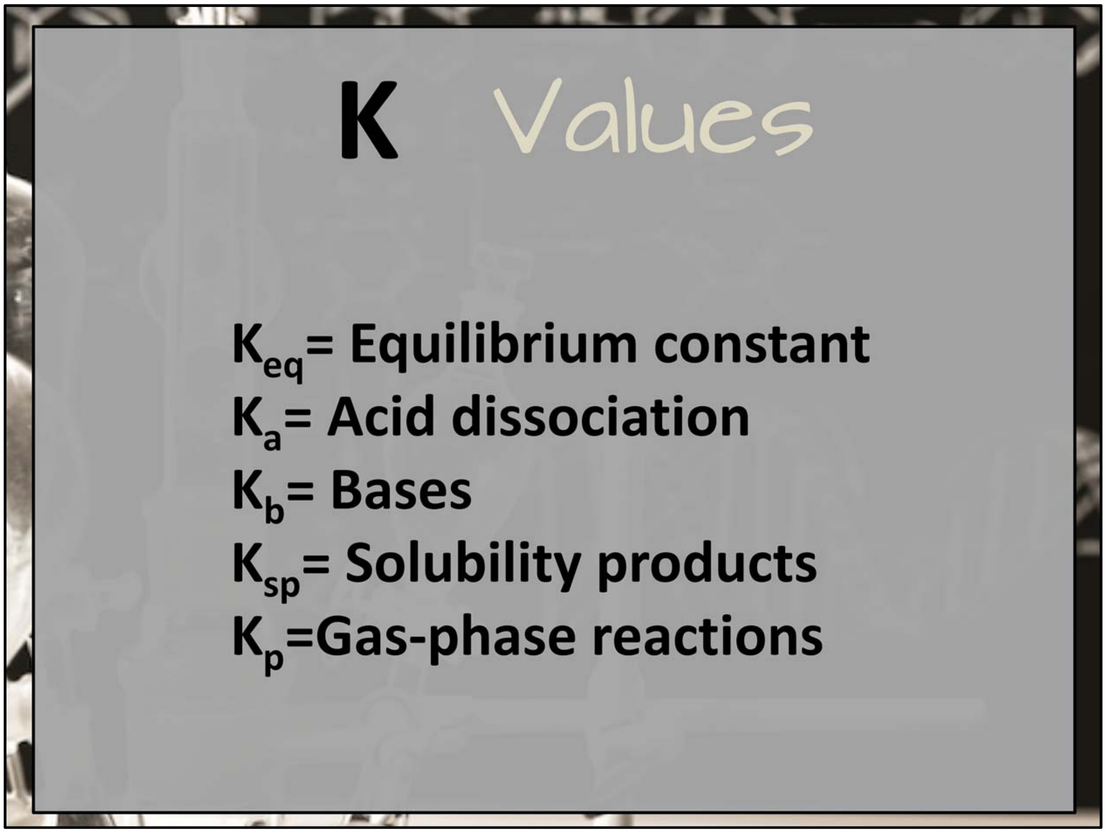
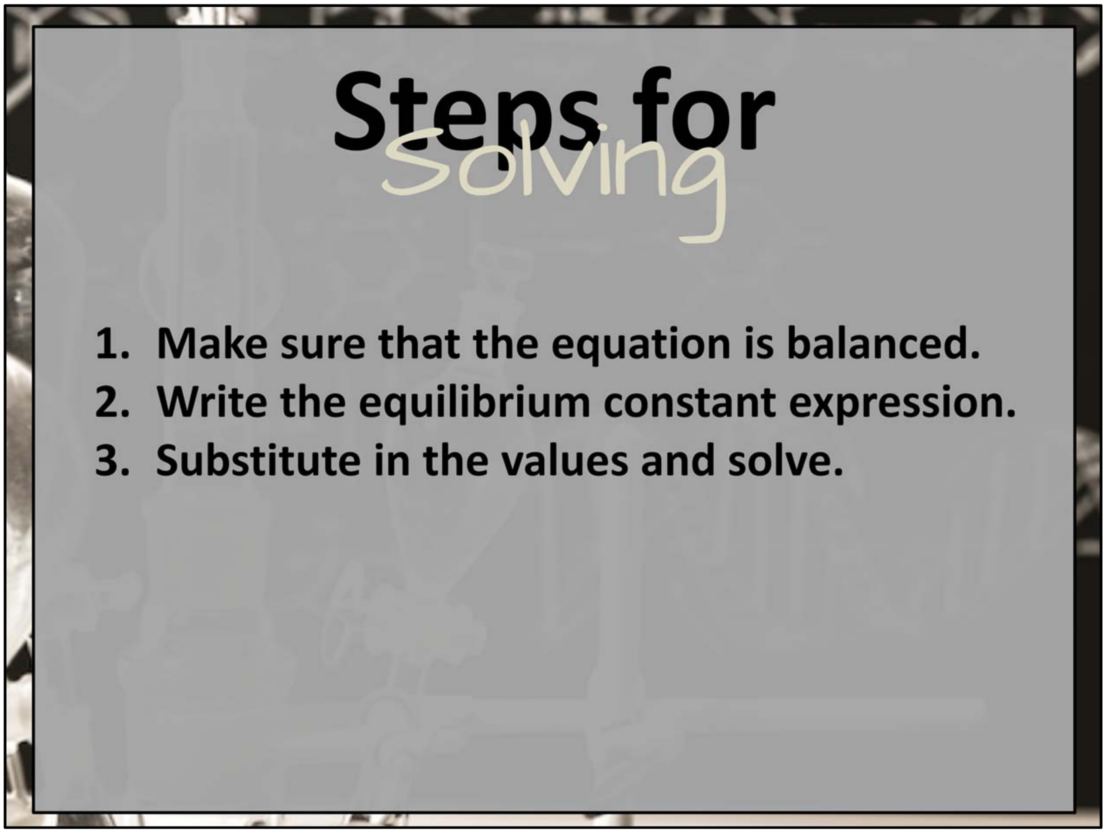
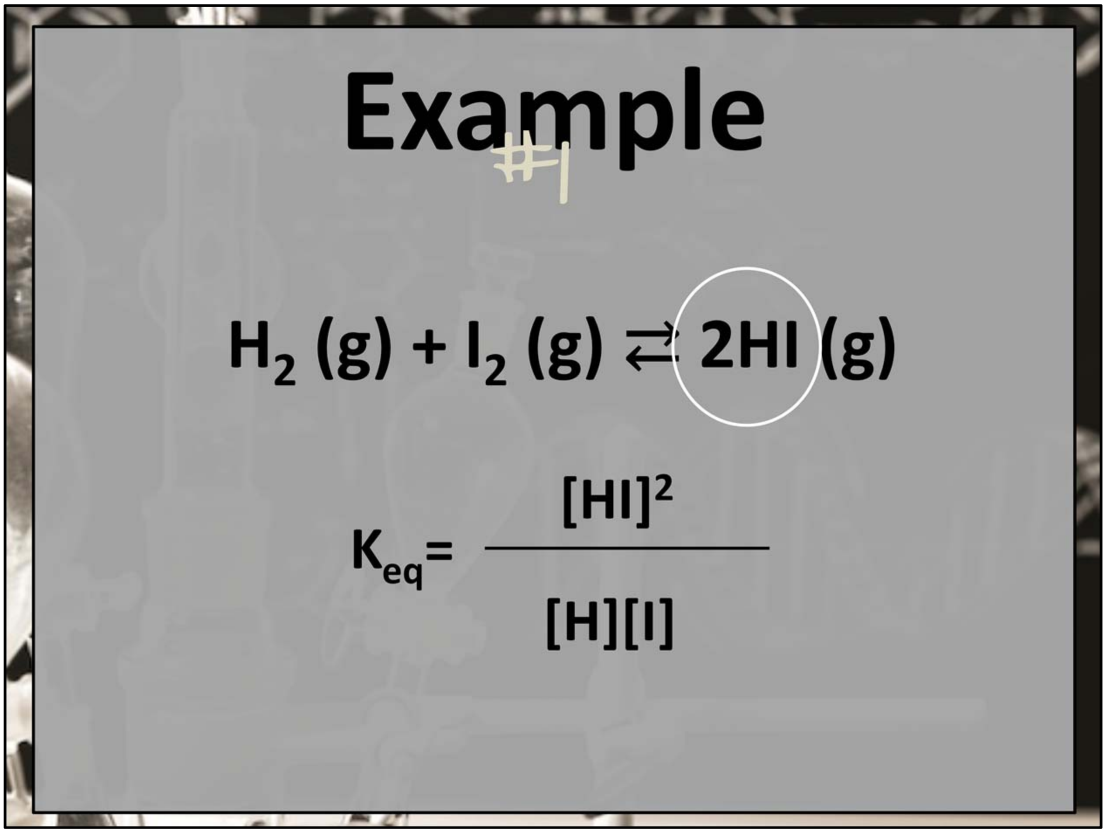


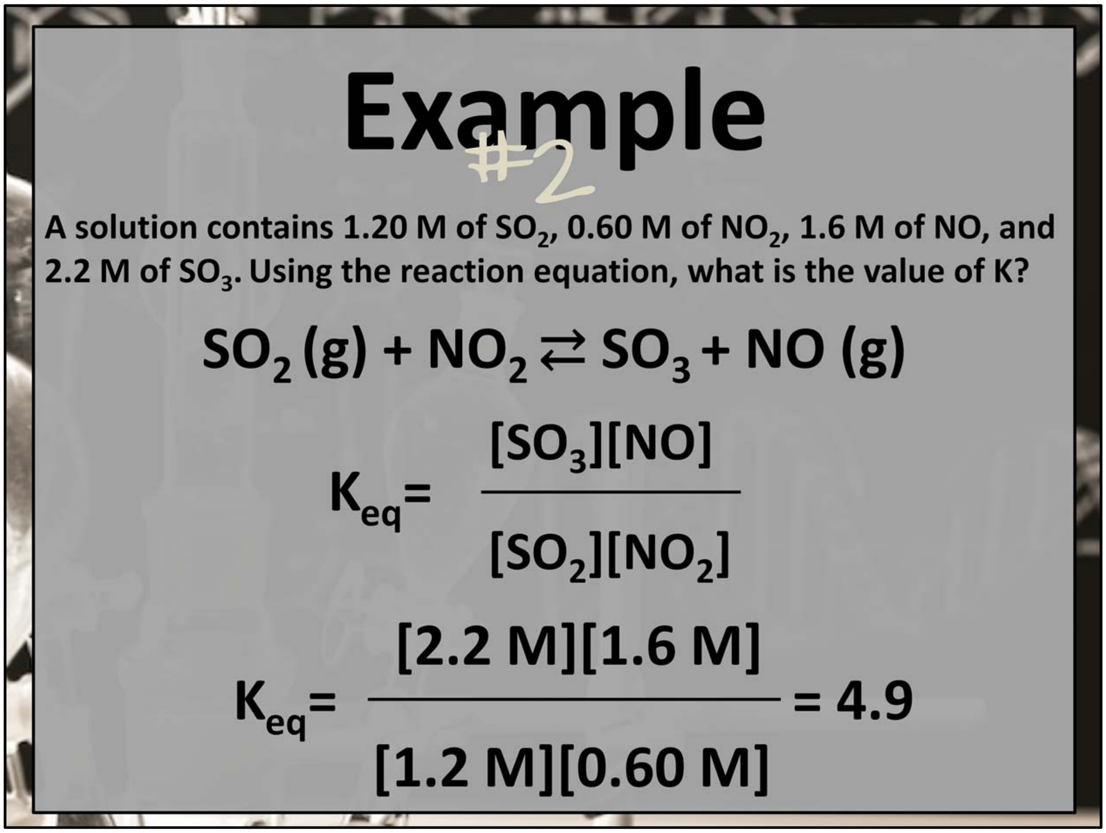
It is important to note that K can represent different reactions. K_{eq} represents the equilibrium constant for a chemical reaction. K_a is the constant for an acid dissociation reaction. K_b is the constant for bases. K_{sp} is the constant for solubility products. And finally, K_p is the constant for gas-phase reactions that use units of partial pressure. These indicate that the constant describes a specific type of reaction, but they operate exactly the same as any other equilibrium constant.



Writing the equilibrium constant expression is very straightforward. But, how do you solve a problem when you are given concentrations for each of the products and reactants? The first step is to make sure that the equation is balanced. Then, write the equilibrium constant expression. Finally, substitute in the values and solve.



Look at this reaction between hydrogen gas and iodine gas. The product for this reaction is hydrogen iodide. How would you write the equilibrium expression for this reaction? Remember, the products are placed in the numerator, while the reactants are in the denominator. The coefficients for the reactants are both one. The coefficient for hydrogen iodide is two. The equilibrium expression is set equal to K_{eq} as this reaction is in equilibrium.



Try to solve this example problem:

A solution contains 1.20 M of SO_2, 0.60 M of NO_2, 1.6 M of NO, and 2.2 M of SO_3. Using the reaction equation, what is the value of K?

In this example, sulfur dioxide and nitrogen dioxide produce sulfur trioxide and nitrogen monoxide. The first step in solving for concentration is to write the equilibrium constant expression. Finally, substitute in the known values to solve. The equilibrium constant is equal to 2.2 M times 1.6 M divided by 1.2 M times 0.60 M. In this specific problem, the concentration constant is 4.9. This equation indicates that there are more products then reactants. This shows that the products are favored in this reaction.