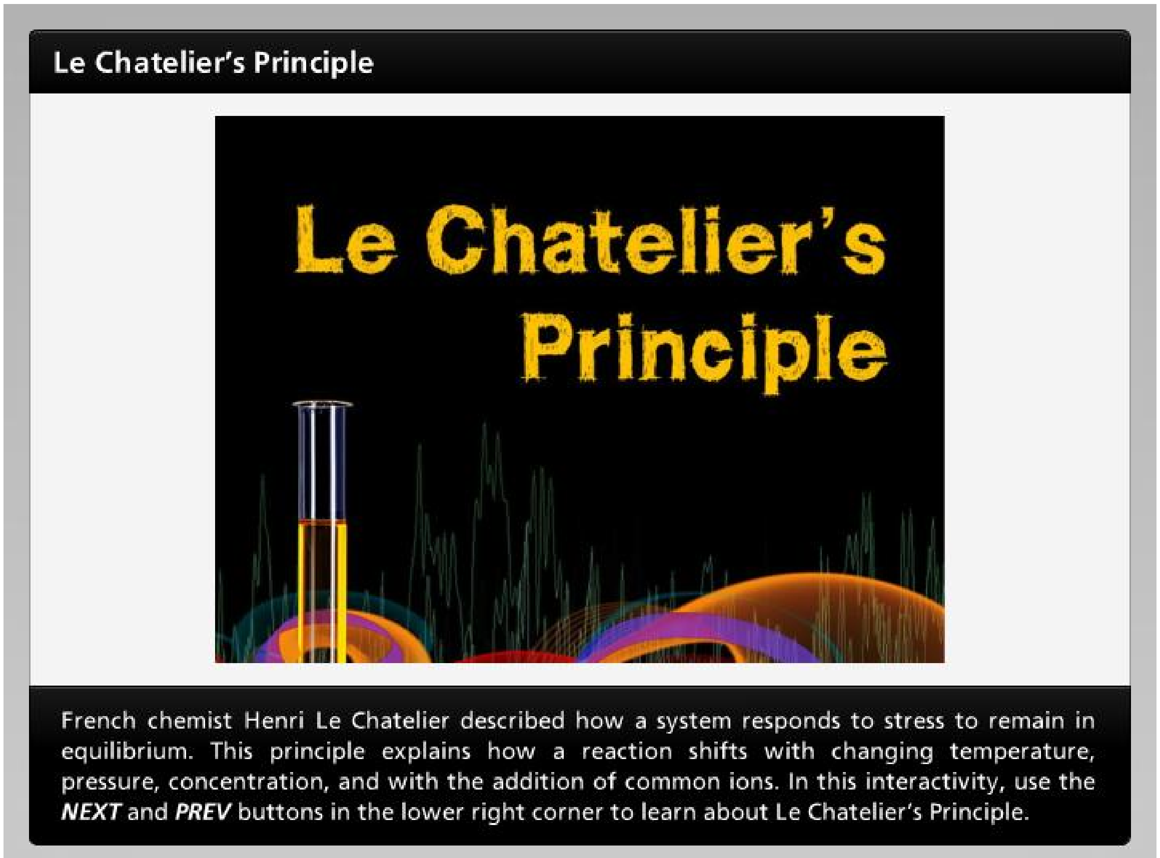
Module 12: Kinetics and Equilibrium
Topic 2 Content: Le Chatelier's Principle Notes



French chemist Henri Le Chatelier described how a system responds to stress to remain in equilibrium. This principle explains how a reaction shifts with changing temperature, pressure, concentration, and with the addition of common ions. In this interactivity, use the ***NEXT*** and ***PREV*** buttons in the lower right corner to learn about Le Chatelier's Principle.

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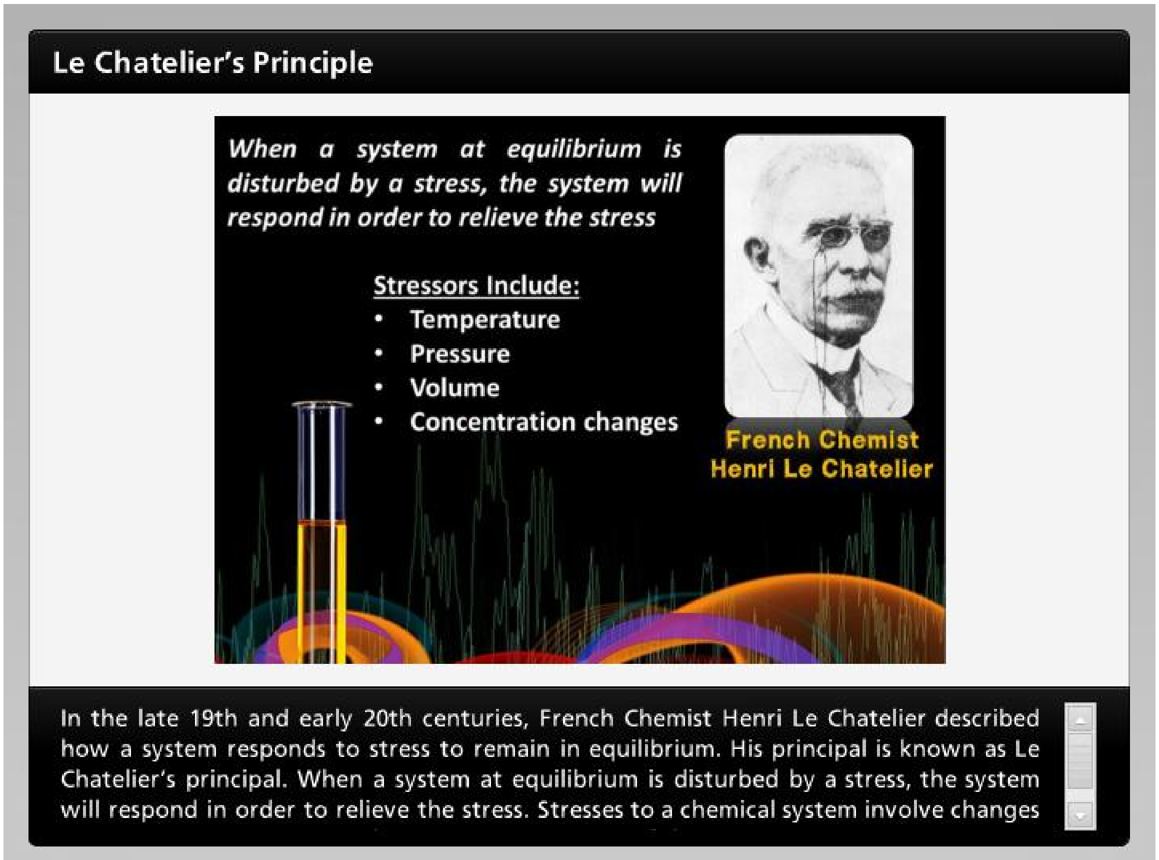

In the late 19th and early 20th centuries, French Chemist Henri Le Chatelier described how a system responds to stress to remain in equilibrium. His principal is known as Le Chatelier's principal. When a system at equilibrium is disturbed by a stress, the system will respond in order to relieve the stress. Stresses to a chemical system involve changes in temperature, pressure, volume, or concentration of the system.

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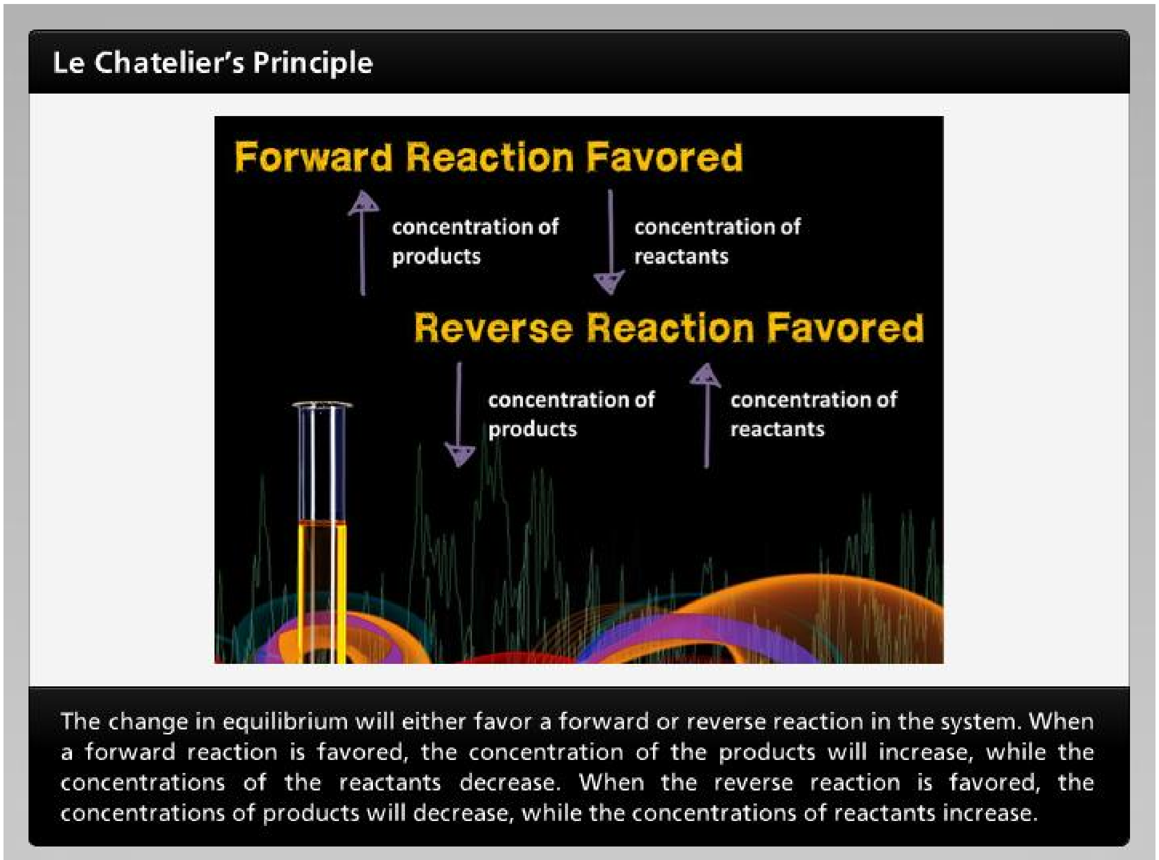

The change in equilibrium will either favor a forward or reverse reaction in the system. When a forward reaction is favored, the concentration of the products will increase, while the concentrations of the reactants decrease. When the reverse reaction is favored, the concentrations of products will decrease, while the concentrations of reactants increase.

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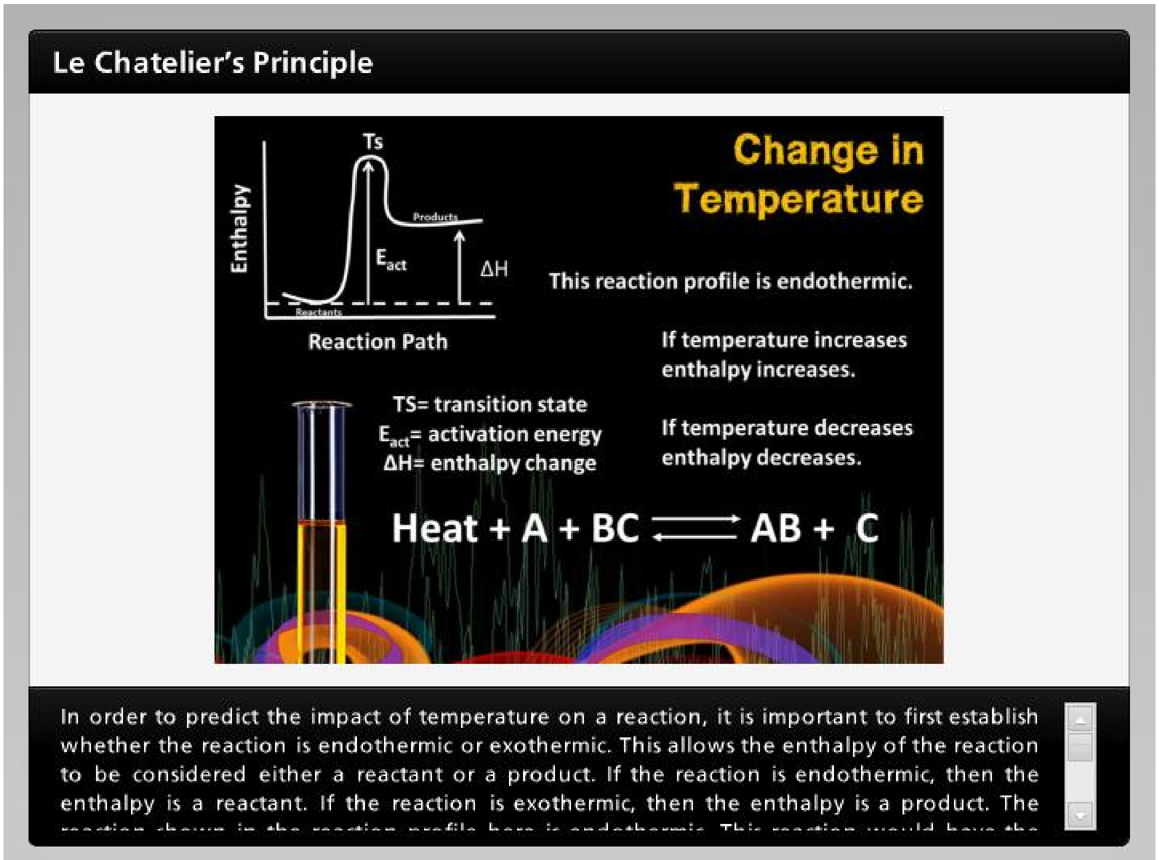
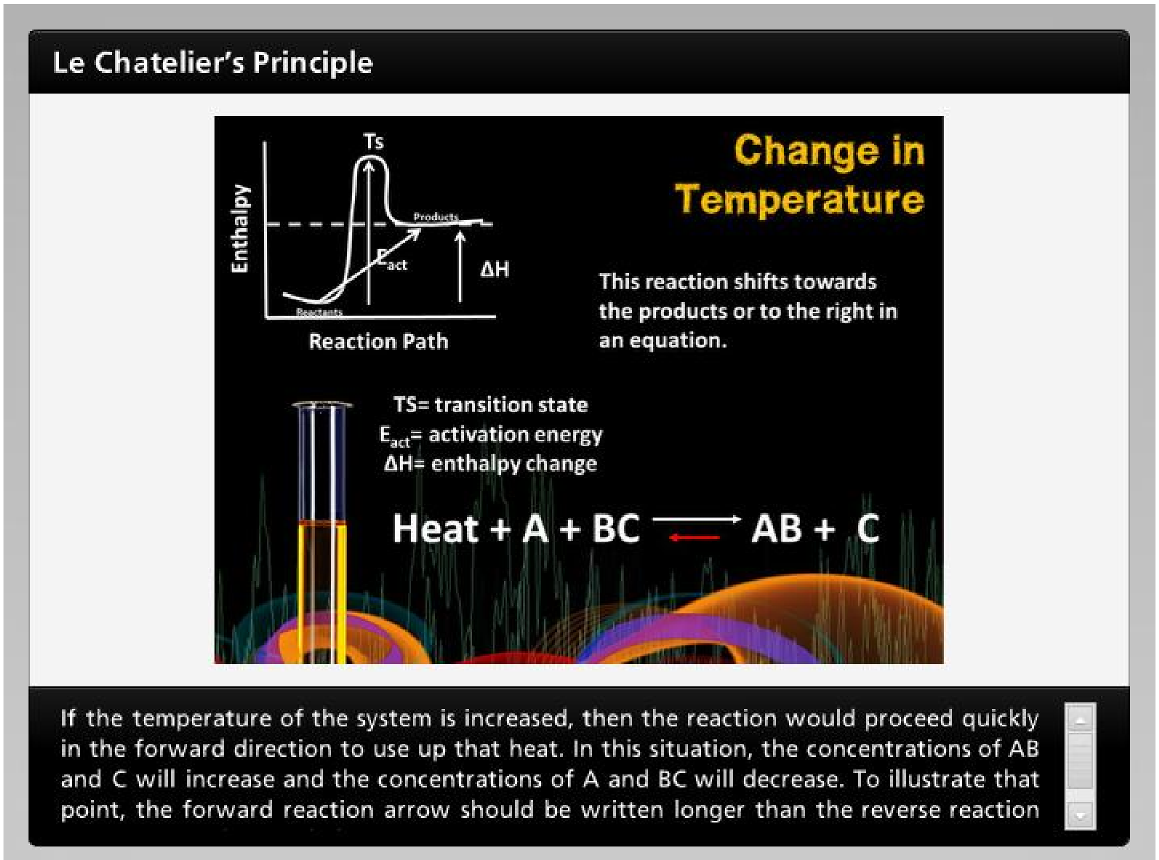


In order to predict the impact of temperature on a reaction, it is important to first establish whether the reaction is endothermic or exothermic. This allows the enthalpy of the reaction to be considered either a reactant or a product. If the reaction is endothermic, then the enthalpy is a reactant. If the reaction is exothermic, then the enthalpy is a product. The reaction shown in the reaction profile here is endothermic. This reaction would have the enthalpy as a reactant. Please take a moment to view how the reaction is written. Notice that the reaction is in equilibrium with neither the forward or reverse reactions favored, as indicated by the arrows. According to Le Chatelier's Principle the reaction rates will shift to favor whichever process will relieve the stress. In the case of temperature change, there are only two ways to "stress" the system. You can either heat it up or cool it down. If you heat it up, then the enthalpy amount is increased and if you cool it down, the enthalpy amount is decreased.



If the temperature of the system is increased, then the reaction would proceed quickly in the forward direction to use up that heat. In this situation, the concentrations of AB and C will increase and the concentrations of A and BC will decrease. To illustrate that point, the forward reaction arrow should be written longer than the reverse reaction arrow. Remember, enthalpy increases as temperature increases.

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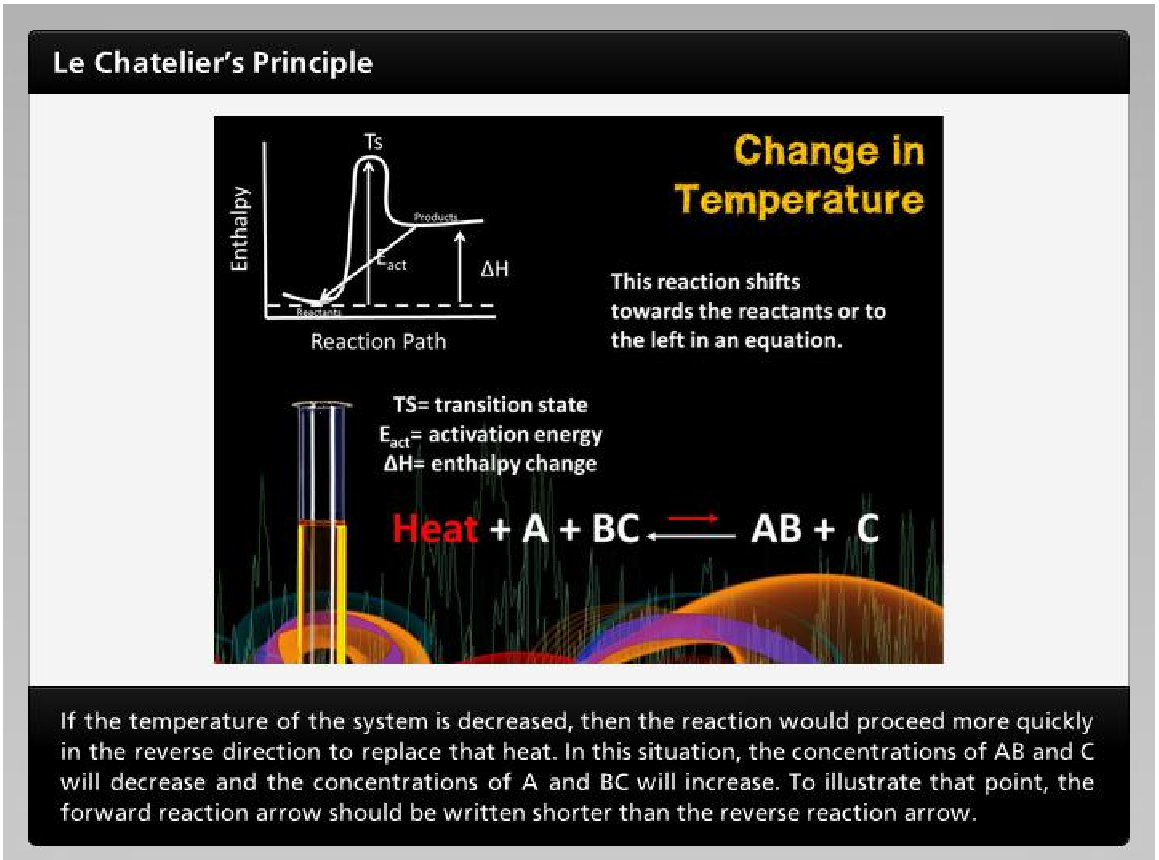

If the temperature of the system is decreased, then the reaction would proceed more quickly in the reverse direction to replace that heat. In this situation, the concentrations of AB and C will decrease and the concentrations of A and BC will increase. To illustrate that point, the forward reaction arrow should be written shorter than the reverse reaction arrow.

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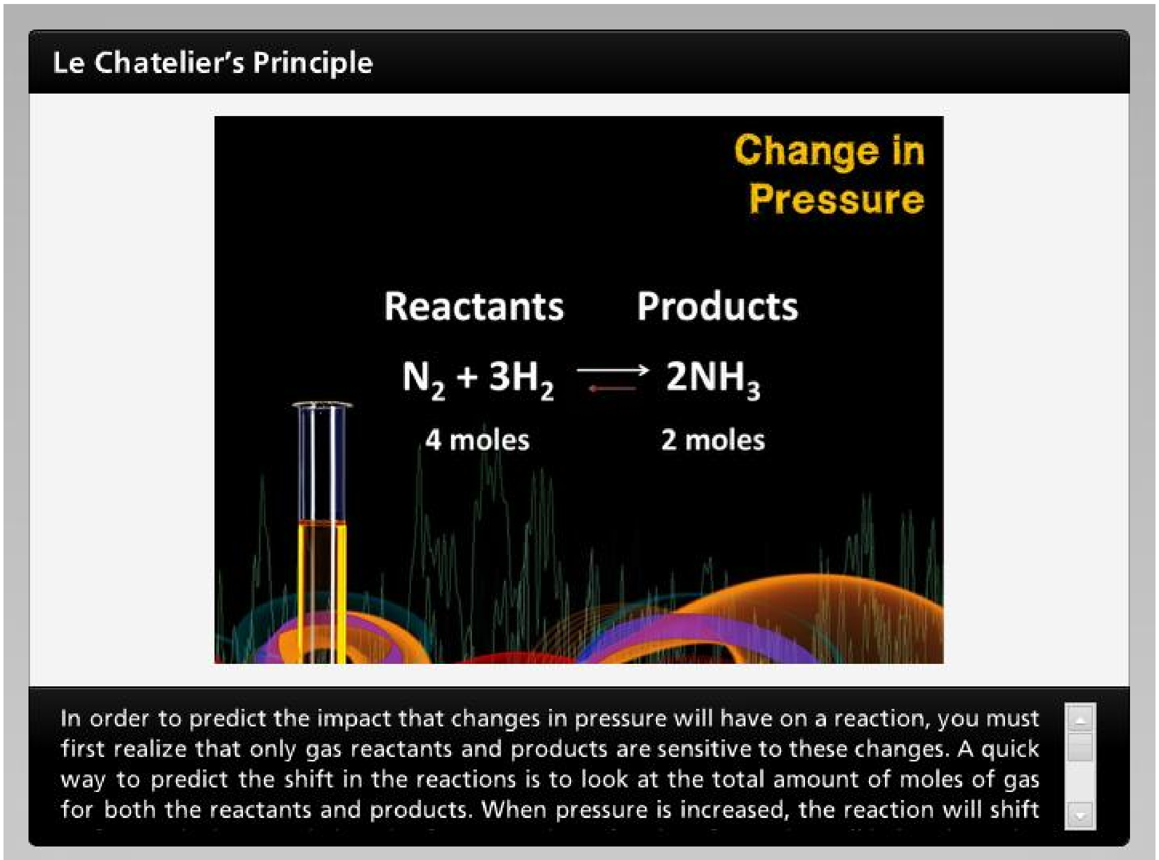

In order to predict the impact that changes in pressure will have on a reaction, you must first realize that only gas reactants and products are sensitive to these changes. A quick way to predict the shift in the reactions is to look at the total amount of moles of gas for both the reactants and products. When pressure is increased, the reaction will shift to favor whichever side has the fewer number of moles of gas. This will help relieve the pressure. In the reaction shown here, there are four moles of gas on the reactant side. There are only two moles of gas on the product side. An increase in pressure will cause the reaction to shift right, or toward the products. How is a change in the pressure of a gas created? When the pressure of a gas is changed, it is normally the result of a change in volume. The gas laws explain that adding more gas, or decreasing the volume in which gases are stored, creates an increase in pressure.

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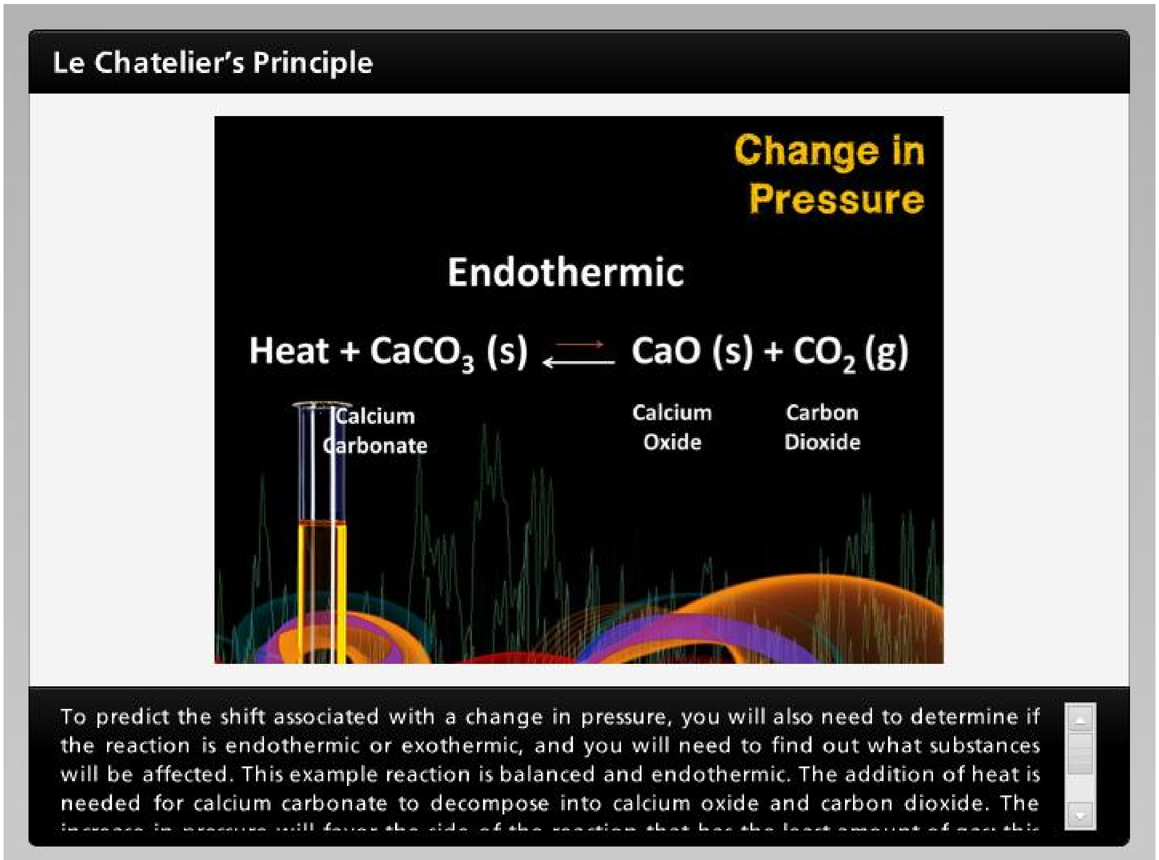
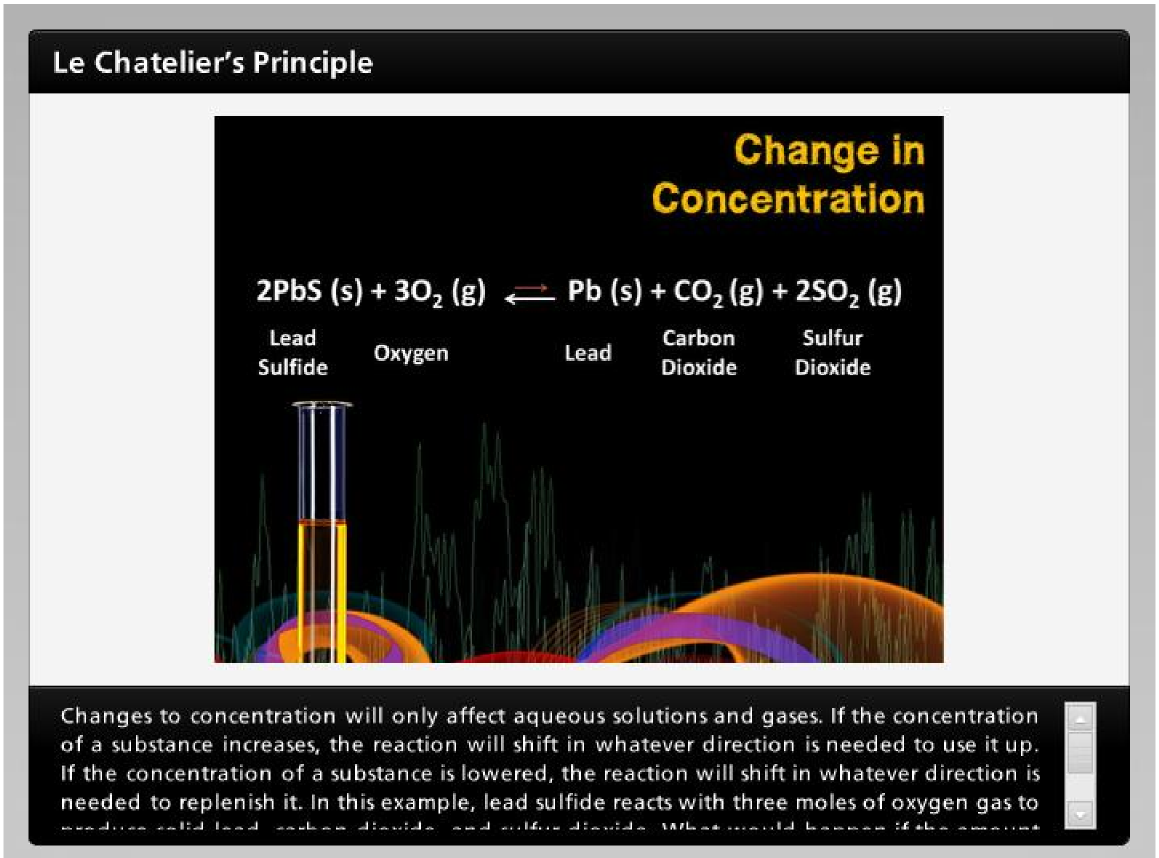
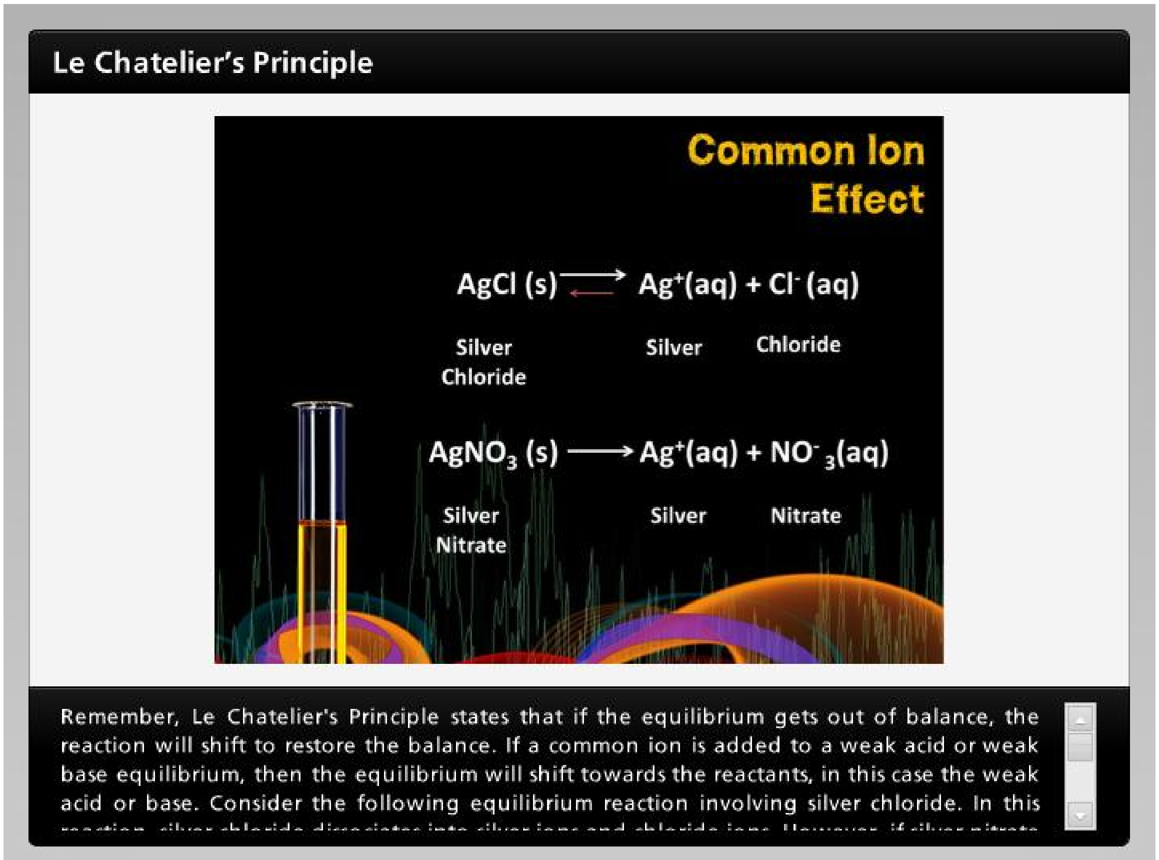


To predict the shift associated with a change in pressure, you will also need to determine if the reaction is endothermic or exothermic, and you will need to find out what substances will be affected. This example reaction is balanced and endothermic. The addition of heat is needed for calcium carbonate to decompose into calcium oxide and carbon dioxide. The increase in pressure will favor the side of the reaction that has the least amount of gas; this will cause a shift toward the reactants. The amount of carbon dioxide should decrease in order to eliminate the stress. Remember, you are only looking at the gaseous substances.



Changes to concentration will only affect aqueous solutions and gases. If the concentration of a substance increases, the reaction will shift in whatever direction is needed to use it up. If the concentration of a substance is lowered, the reaction will shift in whatever direction is needed to replenish it. In this example, lead sulfide reacts with three moles of oxygen gas to produce solid lead, carbon dioxide, and sulfur dioxide. What would happen if the amount of carbon dioxide gas was increased? In this case, the reaction would shift to the left to use up the carbon dioxide.



Remember, Le Chatelier's Principle states that if the equilibrium gets out of balance, the reaction will shift to restore the balance. If a common ion is added to a weak acid or weak base equilibrium, then the equilibrium will shift towards the reactants, in this case the weak acid or base. Consider the following equilibrium reaction involving silver chloride. In this reaction, silver chloride dissociates into silver ions and chloride ions. However, if silver nitrate was added to the equation, the solubility of silver chloride decreases. Why does this happen? The addition of silver nitrate causes an increase in silver ions. The amount of collisions between silver and nitrate ions also increases. This causes more solid silver chloride to form. According to Le Chatelier's principal, this results in a shift of equilibrium from right to left.