Resorting balance

Science, Chemistry

Chemical equilibrium is a true balancing act. What happens when the balance is disturbed? The purpose of this lab is to observe the effects of concentration and temperature on equilibrium and to visualize how balance can be restored based on LeChâtelier's Principle.

Background Not all chemical reactions proceed to completion, that is, to give 100% yield of products. In fact, most chemical reactions are reversible. In the forward direction, reactants interact to make products, while in the reverse direction the products revert back to reactants. This idea is represented symbolically using double arrows.

In a closed system, any reversible reaction will eventually reach a dynamic balance between the forward and reverse reactions. A system is said to reach chemical equilibrium when the rate of the forward reaction equals the rate of the reverse reaction. At this point, no further changes will be observed in the amounts of either the reactants or products. Chemical equilibrium can be further defined, therefore, as the state where the concentrations of reactants and products remain constant with time. This does not mean the concentration of reactants and products are equal. The forward and reverse reactions create an equal balance of opposing rates.

What happens when the balance is disturbed—due to the addition of more reactants or products or due to changes in the temperature or pressure? LeChâtelier's Principle predicts how equilibrium can be restored: " If an equilibrium system is subjected to a stress,

the system will react in such a way as to reduce the stress."

Any change that is made to a system at equilibrium is considered a stress—this includes adding or removing reagents or changing the temperature. To reduce the stress, one of two things can happen. A reversible reaction can shift in the forward direction and make more products, thus using up some of the reactants. Alternatively, the reaction can shift in the reverse direction and re-form the reactants, thus using up some of the products.

The effect of temperature on a system at equilibrium depends on whether a reaction is endothermic (absorbs heat) or exothermic (produces heat). If a reaction is endothermic, heat appears on the reactant side in the chemical equation. Increasing the temperature of an endothermic reaction shifts the equilibrium in the forward direction, to consume some of the excess energy and make more products. The opposite effect is observed for exothermic reactions. In the case of an exothermic reaction, heat appears on the product side in the chemical equation. Increasing the temperature of an exothermic reaction shifts the equilibrium in the reverse direction.

Experiment Overview The purpose of this experiment is to investigate the effect of reaction conditions on the reversible formation of cobalt complex ions. When cobalt chloride hexahydrate (CoCl2•6H2O) is dissolved in ethyl alcohol, three different solute species are present: Co2+ cations, Cl- anions, and water molecules. These can react to form two different complex ions, Co(H2O)62+ , where the cobalt ion is surrounded by six water molecules, and CoCl42-, in which the metal ion is surrounded by four chloride ions.