Effects in reversible exothermic reactions CONTD.

Equilibrium

The fact that a reaction is spontaneous doesn't always mean it happens rapidly. The reactions between the carbon atoms in diamond are spontaneous, but these reactions are so slow that diamonds last a very long time.

Reactions can also reach a state of equilibrium; when two opposite reactions occur at an equal rate, there is no net increase in the amount of the product or the reactants. All of these factors—the change in entropy caused by a reaction, the kinetics of the reaction, and the equilibrium point of the reaction—are important in determining whether a reaction will occur and what it will look like.

What Happens When Hydrogen & Oxygen Combine?

Hydrogen is a highly reactive fuel. Hydrogen molecules violently react with oxygen when the existing molecular bonds break and new bonds are formed between oxygen and hydrogen atoms. As the products of the reaction are at a lower energy level than the reactants, the result is an explosive release of energy and the production of water. But hydrogen does not react with oxygen at room temperature, a source of energy is needed to ignite the mixture.

Hydrogen and Oxygen Mix

Hydrogen and oxygen gases mix at room temperature with no chemical reaction. This is because the speed of the molecules does not provide enough kinetic energy to activate the reaction during collisions between the reactants. A mixture of gases is formed, with the potential to violently react if sufficient energy were introduced to the mixture.

Activation Energy

Introduction of a spark to the mixture results in raised temperatures amongst some of the hydrogen and oxygen molecules. Molecules at higher temperatures travel faster and collide with more energy. If collision energies reach a minimum activation energy sufficient to "break" the bonds between the reactants, then a reaction between hydrogen and oxygen follows. Because hydrogen has a low activation energy only a small spark is needed to trigger a reaction with oxygen.

Exothermic Reaction

Like all fuels, the reactants, in this case hydrogen and oxygen, are at a higher energy level than the products of the reaction. This results in the net release of energy from the reaction, and this is known as an exothermic reaction. After one set of hydrogen and oxygen molecules have reacted, the energy released triggers molecules in the surrounding mixture to react, releasing more energy. The result is an explosive, rapid reaction that releases energy quickly in the form of heat, light and sound.

Electron Behavior

On a sub-molecular level, the reason for the difference in energy levels between the reactants and products, lies with electronic configurations. Hydrogen atoms have one electron each. They combine into molecules of two so that they can share two electrons (one each). This is because the inner-most electron shell is at a lower energy state (and therefore more stable) when occupied by two electrons. Oxygen atoms have eight electrons each. They combine together in molecules of two by sharing four electrons so that their outer-most electron shells are fully occupied by eight electrons each. However, a far more stable alignment of electrons arises when two hydrogen atoms share an electron with one oxygen atom. Only a small amount of energy is needed to "bump" the electrons of the reactants "out" of their orbits so that they can realign in the more energetically stable alignment, forming a new molecule, H2O (Water).

Products

Following the electronic realignment between hydrogen and oxygen to create a new molecule, the product of the reaction is water and heat. The heat can be harnessed to do work, such as driving turbines by heating water. The products are produced quickly due to the exothermic, chain-reaction nature of this chemical reaction. Like all chemical reactions, the reaction is not easily reversible.

What is Chemical Equilibrium?

In the human body, your equilibrium is the body's sense of position and movement including your sense of balance. The chemical term for equilibrium is similar in nature. Chemical equilibrium, also known as a steady state reaction, is when there is no further change in a chemical reaction of the concentration of the reactants or products. It doesn't mean the reaction has stopped occurring, but that the formation and substance consumption are at a balanced condition without further change.

What Is the Law of Chemical Equilibrium?

The law of chemical equilibrium states that at a constant temperature and pressure, the chemical reaction's rate is directly proportional to the concentration of the molecules of the reactants compared to the concentration of the products when both are raised to an equal power as represented by the balanced chemical equations.

What Is the Concept of Chemical Equilibrium?

To understand the law of chemical equilibrium better, consider a reversible reaction. The reactants of A and B form the products C and D.

$A + B = C + D$

After time passes, the concentration of the products of C and D increases and the concentration of the reactants of A and B decrease. Therefore, it indicates an increase in backward reaction and a decrease in the forward reaction at the same time. Eventually, both reaction rates of forward and backward become equal to each other, and the concentrations of the products and reactant remain the same. This is a sample of chemical equilibrium when a visible standstill state is achieved by a chemical reaction. The chemical reactions don't cease, but they proceed at the same rate. The number of moles of the products in the forward reactions is equal to the number of moles of substance that is disappearing per second in the backward reaction. Chemical reactions that continue to proceed with the number of products and reactants remaining the same is dynamic equilibrium.

What Are the Types of Chemical Equilibrium?

Two types of chemical equilibrium exist: homogeneous and heterogeneous. In homogeneous equilibrium, it's a reaction when the reactants and products are in the same phase. Heterogeneous equilibrium is when the reactants and products are each in a different phase from each other.

What Terms Need to Be Satisfied?

Four items must be met in order to classify any reaction as a chemical equilibrium:

The properties that you can measure, such as concentration, density, color or pressure remain constant at a given temperature. Chemical equilibrium may be attained from either side of the equation being forward or backward reactions.

When a catalyst is present, chemical equilibrium may be attained in a shorter amount of time. A catalyst doesn't change the equilibrium as it affects both the forward and backward reactions in the same extent.

A chemical equilibrium is always dynamic.

What Factors Can Affect Chemical Equilibrium?

Several factors can make the equilibrium shift and change the outcome of the products or reactants including changes in pressure, concentration, temperature, adding a catalyst or adding an inert gas. Any of these items may throw the results out of equilibrium.

If you add more reactant or product or change the concentration of one, it will affect equilibrium. The addition of reactant makes more product form, and adding more product makes more reactants form.

When the temperature is changed, it has an altering effect on equilibrium. An increase in temperature shifts an equilibrium in the direction of the endothermic reaction, and a decrease shifts it to the exothermic reaction's direction.

Pressure changes affect the equilibrium because decreasing the volume of a gas actually increases the pressure, which in turn increases the concentration of the products and reactants. The net reaction of this process causes the concentration of gas molecules to go down.

What Happens to Chemical Bonds During Chemical Reactions

During chemical reactions, the bonds that hold molecules together break apart and form new bonds, rearranging atoms into different substances. Each bond requires a distinct amount of energy to either break or form; without this energy, the reaction cannot take place, and the reactants remain as they were. When a reaction is finished, it might have taken energy from the surrounding environment, or put more energy into it.

Chemical reactions break and reform the bonds that hold molecules together.

Types of Chemical Bonds

Chemical bonds are bundles of electric forces that hold atoms and molecules together. Chemistry involves several different kinds of bonds. For example, the hydrogen bond is a relatively weak attraction involving a hydrogen-bearing molecule, such as water. The hydrogen bond accounts for the shape of snowflakes and other properties of water molecules. Covalent bonds form when atoms share electrons, and the resulting combination is more chemically stable than the atoms are by themselves. Metallic bonds occur between atoms of metal, such as the copper in a penny. The electrons in metal move easily between atoms; this makes metals good conductors of electricity and heat.

Conservation of Energy

In all chemical reactions, energy is conserved; it is neither created nor destroyed but comes from the bonds that already exist or the environment. Conservation of Energy is a well-established law of physics and chemistry. For every chemical reaction, you must account for the energy present in the environment, the bonds of the reactants, the bonds of the products, and the temperature of the products and environment. The total energy present before and after the reaction must be the same. For example, when a car engine burns gasoline, the reaction combines the gasoline with oxygen to form carbon dioxide and other products. It doesn’t create energy from thin air; it releases the energy stored in the bonds of molecules in the gasoline.

Endothermic vs. Exothermic Reactions

When you keep track of the energy in a chemical reaction, you will find out if the reaction releases heat or consumes it. In the previous example of burning gasoline, the reaction releases heat and increases the temperature of its surroundings. Other reactions, such as dissolving table salt in water, consume heat, so the temperature of the water is slightly lower after the salt dissolves. Chemists call heat-producing reactions exothermic, and heat-consuming reactions endothermic. Because endothermic reactions require heat, they cannot take place unless enough heat is present when the reaction starts.

Activation Energy: Kickstarting the Reaction

Some reactions, even exothermic ones, require energy just to get started. Chemists call this the activation energy. It is like an energy hill that the molecules must climb before the reaction is set into motion; after it starts, going downhill is easy. Going back to the example of burning gasoline, the car engine must first make a spark; without it, not much happens to the gasoline. The spark provides the activation energy for the gasoline to combine with oxygen.

Catalysts and Enzymes

Catalysts are chemical substances that reduce the activation energy of a reaction. Platinum and similar metals, for example, are excellent catalysts. The catalytic converter in a car's exhaust system has a catalyst like platinum inside. As exhaust gases pass through it, the catalyst increases chemical reactions in harmful carbon monoxide and nitrogen compounds, turning them into safer emissions. Because reactions don't use up a catalyst, a catalytic converter can do its job for many years. In biology, enzymes are molecules that catalyze chemical reactions in living organisms. They fit into other molecules so reactions can take place more easily.