Chapter 10 Energy

10.1 Energy, Temperature, and Heat

Key Terms

energy	potential energy	kinetic energy
law of conservation of energy	work	state function
temperature	heat	system
surroundings	exothermic	

Summary

Energy is the ability to do *work* (a force acting over a distance) or produce heat. It can be classified as *potential energy* (energy that results from an object's or substance's position or composition) or as *kinetic energy* (energy of motion). The *law of conservation of energy* states that energy can be changed from one form to another but can be neither created nor destroyed.

A *state function* is a property of a *system* (the part of the universe in which a process occurs) that changes independently of its pathway (the specific conditions under which the change occurs). A state function depends only on the beginning and final states of the system. Energy is a state function. Other functions, such as heat and work, depend on the specific pathway followed and are not state functions.

Temperature is a measure of the random motions of the particles that make up a substance. *Heat* is defined as the flow of energy that results from a temperature difference. The thermal energy of an object is the energy content of the object as produced by the random motions of its particles.

In an *exothermic* process, heat flows out of a system into its *surroundings.* In an endothermic process, heat flows from the surroundings into a system. In any exothermic chemical reaction, some of the potential energy stored in the substances' chemical bonds is converted to thermal energy (random kinetic energy) by means of heat.

10.2 The Flow of Energy

Key Terms

thermodynamics	first law of thermodynamics	internal energy
calorie	joule	

Summary

Thermodynamics is the study of energy and its changes. The *first law of thermodynamics* states that the energy of the universe is constant. The *internal energy* (E) of a system is the sum of the kinetic and potential energies of all the particles in the system. The internal energy can be changed by a flow of work, heat, or both.

The heat required to change the temperature of a substance depends on the number of grams of the substance being heated, the temperature change, and the type of substance.

A substance's specific heat is the amount of energy required to change the temperature of one gram of the substance by one degree Celsius. The energy required equals the specific heat capacity times the mass of the sample in grams times the change in temperature in degrees Celsius. This is represented by the equation $Q = s \times m \times \Delta T$.

10.3 Energy and Chemical Reactions

Key Terms

enthalpy	calorimeter	Hess's law

Summary

Enthalpy (*H*) is the heat flow that occurs for a process carried out at constant pressure. For this case, the change in enthalpy equals the energy flow as heat. This is represented by the equation ΔH_p = heat.

Enthalpy is a state function. The change in enthalpy in a particular process is unrelated to the pathway for the process. As a result, during the change from a certain set of reactants to a certain set of products, the change in enthalpy is the same whether the reaction takes place in one step or in a series of steps. This principle is known as *Hess's law.* Hess's law allows chemists to calculate the heat of a reaction from known heats of related reactions.

10.4 Using Energy in the Real World

Key Terms

fossil fuels	petroleum	natural gas
coal	greenhouse effect	energy spread
matter spread	entropy	second law of thermodynamics

Summary

Although energy is conserved in every process, the quality (usefulness) of the energy decreases with each use. Energy is more useful when it is concentrated, such as the energy stored in gasoline.

Our world has many sources of energy. *Petroleum* is made up mostly of compounds called hydrocarbons. *Natural gas* consists mostly of methane. *Coal* was formed when plant material containing cellulose was chemically changed by heat and pressure. All these energy sources are *fossil fuels.*

The use of fossil fuels affects the environment in various ways. As we have burned increasing amounts of fossil fuels, the carbon dioxide concentration in the atmosphere has increased.

Carbon dioxide traps the sun's heat energy near earth's surface, a condition called the *greenhouse effect.* The increase in CO_2 eventually might raise the earth's average temperature enough to cause dramatic changes in climate.

Natural processes occur in the direction that leads to an increase in the *entropy* (*S*), or disorder of the universe. The principal driving forces for processes are energy spread and matter spread. *Energy spread* means that in a given process, concentrated energy is spread out widely. Energy spread occurs in every exothermic process. In *matter spread,* the molecules of a substance are spread out over a larger volume. Energy spread and matter spread lead to greater *entropy.* This fact leads to the *second law of thermodynamics:* The entropy of the universe is always increasing.

Additional Active Reading Questions

1. State the law of conservation of energy.

2. What is the difference between temperature and heat?

3. In what type of process does heat flow out of a system into its surroundings?

4. What is the term for the sum of the kinetic and potential energies of all the particles in a system?

5. What concept is expressed by the equation $Q = s \times m \times \Delta T$?

6. Define *enthalpy.*

7. What law provides a way for chemists to calculate the heat of a reaction from known heats of related reactions?

8. Why is it important to develop sources of energy other than the burning of fossil fuels?

9. What are the relationships among energy spread, matter spread, and entropy?