

Section 5.1: Energy Changes in Chemical and Nuclear Reactions

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1. (a) A stick of dynamite prior to exploding has greater potential energy than kinetic energy.

(b) A space shuttle before launch has greater potential energy than kinetic energy.

(c) The soot rising above a campfire has greater kinetic energy than potential energy.

(d) The chemicals inside a new battery have greater potential energy than kinetic energy.

2. (a) Water evaporating into steam is an endothermic process.

(b) A candle burning is an exothermic reaction.

(c) The combustion of gasoline is an exothermic reaction.

(d) The melting of ice is an endothermic process.

(e) The splitting of a nitrogen molecule, N_2 , into individual atoms is an endothermic reaction.

(f) Dissolving barium hydroxide, $Ba(OH)_2$, in water and observing a temperature decrease in the surroundings is an endothermic process.

3. The statement: “The law of conservation of energy states that energy cannot be created or destroyed. Therefore, when thermal energy is transferred from a system to the surroundings, the quantity of thermal energy lost by the system must be equal to the amount of thermal energy gained by the surroundings.” may not accurately describe what happens to the thermal energy. Energy cannot be created or destroyed; however, it can be transferred from one form to another. So the total energy gained by the surroundings should equal the amount of thermal energy lost by the system. However, all the energy gained by the surroundings may not necessarily be in the form of thermal energy.

4. Answers may vary. Sample answer: Heat is the transfer of thermal energy from a warm object to a cooler object. Thermal Energy is the total potential and kinetic energy of a substance. The quantity of thermal energy of a substance depends on how fast its entities (such as atoms, ions, or molecules) are moving. Temperature is a measure of the average kinetic energy of the entities in a substance. As the average kinetic energy of the substance’s entities increases, the temperature of the substance increases. When a hot burner heats a pot of water on the stove, thermal energy is transferred from the hot material of the pot to the cooler water inside the pot. As water gains thermal energy, its kinetic energy increases and some of its particles move faster, so the temperature of the water increases.

5. Fission is a nuclear reaction in which a neutron collides with a nucleus of high atomic mass and splits it into nuclei with smaller masses. Fusion is a nuclear reaction in which two or more nuclei of low atomic mass combine to form a heavier nucleus.

6. The law of conservation of energy states that energy cannot be created or destroyed. Even though billions of reactions occur in the universe at any given moment, the total energy of the universe must be constant as energy cannot be created or destroyed. So, the law of conservation of energy can be stated as “the total energy of the universe is constant.”

7. Answers may vary. Sample answer: The head of the match (the system) contains potential energy. When the head of the match is struck, the kinetic energy of the strike and the potential energy of the match head are converted to thermal energy, causing a combustion reaction—fire. The initial reaction that lights the match is endothermic, since energy was absorbed from the surroundings by the match head. The combustion reaction itself is exothermic, releasing thermal energy to the surroundings; the match therefore transfers thermal energy to the paper, causing an exothermic combustion reaction in the paper.

8. The average water molecule in the boiling water at 100 °C has more kinetic energy than the average water molecule in the swimming pool at 24 °C. However, the swimming pool contains many more water molecules than a cup of boiling water. Therefore, the total quantity of thermal energy in the swimming pool is greater than in the cup of boiling water.

9. The process of liquid water at 0 °C turning to solid water, ice, is an exothermic process. Thermal energy is the sum of the kinetic and potential energy. As thermal energy is taken away from the system—liquid water, the kinetic energy of the water molecules decreases, making the molecules move slower, so the temperature of water decreases. At 0 °C, the potential energy of the system also decreases during the phase change from liquid to solid. The thermal energy lost by the system is transferred to the surroundings, resulting in the freezing of water, which is thus an exothermic process.