

## Activity 8 Solutions: Chemical Energy

### 8.1 What is the Composition of Matter?

#### 1) Atoms

- a) What are the building blocks of an atom?

**An atom consists of a positively charged nucleus surrounded by negatively charged electrons.**

- b) What is an atomic nucleus?

**The nucleus is the part of the atom made up of protons and neutrons. The nucleus, which is at the center of the atom, comprises 99.9% of the atom's mass, while it only takes up roughly one ten-thousandth of the volume of a typical atom.**

- c) What is a nucleon?

**A positively charged proton or a neutral neutron**

- d) What holds nucleons together within the nucleus of an atom?

**The strong nuclear force holds together the nucleons (even though the protons are electrically repulsed by each other.)**

- e) How many electrons does an atom have? How many electrons does an ion have?

**An atom has no net electric charge, so the number of electrons surrounding the nucleus equals the number of protons in the nucleus. An ion has a net electric charge, so the number of electrons in an ion is not equal to the number of protons.**

- f) What holds electrons in orbit around the nucleus of an atom?

**As noted above, electrons are negatively charged, protons are positively charged, and neutrons are electrically neutral. The electrostatic force of attraction between the protons and electrons holds the electrons in orbit.**

- g) What is an element?

**An element is matter made up of atoms which all contain the same number of protons. Each element has a name and occupies a place on the periodic table.**

#### 2) An Atomic Model

- a) The two foam balls connected by wires simulate the forces between two protons. What force do the springy wires represent? **electromagnetic force** What force do the magnets represent? **strong nuclear force**

- b) From the model, does the strong nuclear force act over a long or a short range?

**The strong force acts over a very short range.**

- c) Group Discussion Question: How could the model be modified to make it represent a neutron and a proton? How could it be modified to represent two neutrons?

## 8.2 What are Chemical Reactions?

3) **Chemical Compounds** Your instructor will discuss chemical compounds.

- a) The formula for acetic acid, which is found in vinegar, is  $\text{HC}_2\text{H}_3\text{O}_2$ . Which elements make up acetic acid? How many atoms of each element are contained in one molecule?

**A molecule of  $\text{HC}_2\text{H}_3\text{O}_2$  contains 4 hydrogen atoms, two carbon atoms and two oxygen atoms.**

4) **Chemical Equations**

A chemical equation describes a chemical reaction. A balanced equation has the same number of atoms of each element on either side of the arrow.

Are the equations given below balanced? If not, write numbers in the blanks before the substances to indicate the number of molecules of each substance needed to balance the equation.

- a)  $\underline{\quad 2 \quad} \text{H}_2 + \underline{\quad 1 \quad} \text{O}_2 \rightarrow \underline{\quad 2 \quad} \text{H}_2\text{O}$
- b)  $\underline{\quad 6 \quad} \text{CO}_2 + \underline{\quad 6 \quad} \text{H}_2\text{O} \rightarrow \underline{\quad 1 \quad} \text{C}_6\text{H}_{12}\text{O}_6 + \underline{\quad 6 \quad} \text{O}_2$
- c)  $\underline{\quad 1 \quad} \text{Na}_2\text{CO}_3 + \underline{\quad 1 \quad} \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \underline{\quad 1 \quad} \text{NaHCO}_3 + \underline{\quad 1 \quad} \text{NaC}_2\text{H}_3\text{O}_2$
- d)  $\underline{\quad 1 \quad} \text{NaHCO}_3 + \underline{\quad 1 \quad} \text{HC}_2\text{H}_3\text{O}_2 \rightarrow \underline{\quad 1 \quad} \text{H}_2\text{O} + \underline{\quad 1 \quad} \text{CO}_2 + \underline{\quad 1 \quad} \text{NaC}_2\text{H}_3\text{O}_2$

## 8.3 Energy and Chemical Reactions

5) **Endothermic and Exothermic Reactions**

Your instructor will show you how to mix acetic acid and sodium carbonate in a plastic bag.

- a) What do you feel when you touch the outside of the plastic bag? **Heat**
- b) Is this reaction endothermic or exothermic? How do you know?

**The reaction is exothermic because energy (heat) is given off by the reactants.**

Next your instructor will show you how to mix acetic acid with sodium bicarbonate in another plastic bag.

- c) What do you feel when you touch the outside of this plastic bag? **Cold**
- d) Is this reaction endothermic or exothermic? How do you know?

**This reaction is endothermic because energy (heat) is taken in by the reactants. The bag feels cold because heat is transferred from your hand to the chemicals in the bag.**

- e) Your instructor will begin a demonstration of splitting water molecules into molecules of hydrogen and oxygen gas.
- Is this reaction endothermic or exothermic? endothermic
  - What form of energy is involved in this process?

**Electrical energy is required to split the water molecules.**

- f) Group Discussion Question: What very common endothermic reaction makes possible life on Earth as we know it?

## 5) Batteries

Your instructor will show you how to make a battery.

- Hook your battery to a voltmeter. How much voltage does your battery produce? \_\_\_\_\_
- What causes a voltage difference between the anode and the cathode of the battery?

**Negative charge moves toward the cathode, and positive charge moves toward the anode. The voltage of the battery is the energy per charge of the separated charge, which causes a voltage difference across the anode and cathode. When the cathode and anode are connected to an external circuit, the voltage from the accumulated separated charge causes a current to flow.**

## 6) Electroplating

Your instructor will show you electroplating with carbon and copper rods.

- What happens to the carbon rod?
- In time the carbon rod becomes coated with copper.**
- Why must the copper and carbon rods be connected to batteries?

**The reaction is endothermic. Electrical energy is used to remove positive copper ions from the copper strip. These ions move to the negatively charged carbon rod and attach themselves to the rod.**

## 7) Chemical and Physical Changes

- What is the difference between a chemical reaction and a physical change?

**In a chemical reaction, one or more compounds are partially used up and one or more new compounds are formed.**

**A physical change involves no change in chemical composition. Energy may be absorbed and released in chemical reactions and may also be absorbed or released in physical changes.**

- b) Activate a reusable commercial hot pack. Since the hot pack emits thermal energy, what must be done to the pack before it can be reused?

**The hot pack can be reused if energy is added by placing it in boiling water. This is a physical change, similar to melting or freezing water.**

- c) Activate a commercial cold pack. Does the cold pack emit or absorb energy? How do you know?

**The cold pack feels cold because chemical reactions taking place in the pack absorb thermal energy from your hand.**

## 8) Activation Energy

- a) What is activation energy?

**Activation energy is the energy required to cause two or more substances to begin to react chemically.**

- b) Is activation energy required in endothermic reactions? **Yes**

- c) Is activation energy required in exothermic reactions?

**Yes, although in some cases, the thermal energy of the reactants is sufficient. For example, iron rusts in the presence of oxygen and water because the thermal energy of iron molecules at room temperature is enough energy to begin the reaction.**

## 9) Catalysts

- a) What is the purpose of a catalyst?

**A catalyst reduces the activation energy required for a reaction to take place. In many cases, reducing the required activation energy increases the rate of the reaction. In other cases, reducing the activation energy allows a reaction to occur at a lower temperature. At a lower temperature, the reaction may proceed more slowly.**

- b) Your instructor will demonstrate the effect of a catalyst on hydrogen peroxide ( $\text{H}_2\text{O}_2$ ).

- 1) What is the purpose of adding a piece of platinum to the beaker?

**The platinum acts as a catalyst and increases the speed of the reaction.**

- 2) Is the platinum used up in the reaction? **\_No\_**

- 3) Does the platinum change the outcome of the reaction? **\_No\_**

## 10) Electrolysis of Water

Your instructor will return to the demonstration of the electrolysis of water.

- a) What form of energy was added to this endothermic reaction?

**This endothermic reaction required that electrical energy be continuously added to the reactant (water).**

- b) Is a catalyst used in this reaction?

**Yes, sodium carbonate is added to the water.**

- c) What are the reaction products?

**Water molecules are dissociated into hydrogen gas and oxygen gas.**

### 11) Fuel Cells

- a) The fuel cell demonstrates the opposite of electrolysis of water. Is this reaction endothermic or exothermic?

**The fuel cell is an exothermic reaction that produces electrical energy.**

- b) How is a fuel cell different from a battery?

**Fuel cells are similar to batteries in that they both convert chemical energy directly into electrical energy. A battery is a closed system to which no reactants or products are added or lost. In a fuel cell, the reactants (hydrogen and oxygen gas) must be added and the product (water) given off in a continuous process.**

- c) Group Discussion Question: What are some of the advantages and disadvantages to using fuel cells to power automobiles?