Unit 4: Energy Transformations

1. Kinetic, Potential and Thermal Energies.

* A general introduction to the three main forms of energy.
* In this unit kinetic, potential and thermal energy will be discussed qualitatively rather than quantitatively.

1. Chemical and Nuclear Potential Energy.

* Endo and exothermic reactions.
* Reaction rate and activation energy and catalysts.
* Chemical/Nuclear potential energy diagrams.
* Energy and mass-defect.

1. Electricity production.

* Coal Power
* Nuclear Power
* “Greener” alternatives like hydro, wind, solar…

Energy

Energy is a difficult thing to define, but that does not mean that it isn’t well understood or important. It is similar to music in that way. Everything in the observable universe is either matter or energy, or some combination.

In a very simplistic definition, energy is the ability to move or cause motion, including molecular motion. Another helpful way to think about energy is: If something can hurt you, it probably has energy. The more it will hurt, the more energy it has.

Examples:

One other very, very, very, very important aspect of energy is that it is a *conserved quantity***.** This means that you cannot make energy or use energy up, you can only change its form. The total amount of energy (and mass) in the universe now is the same as the amount of energy that was present at the time of the Big Bang! This is known as The Law of Conservation of Energy, and it one the most important most fundamental laws of nature.

**The Law of Conservation of Energy**

***Energy can neither be created nor destroyed, but can only change form.***

Kinetic, Potential and Thermal Energy

**Kinetic energy** is the purest and simplest form of energy to understand. If an object is moving it has kinetic energy. The faster it goes and the more mass it has, the more kinetic energy it will have. In fact we can calculate kinetic energy from the following formula:

However, we will save the calculations for the next unit. But qualitatively this makes sense, the larger an object is and the faster it is moving, the more it can hurt you.

Examples:

**Potential energy** is a bit more abstract. Potential energy is the *potential* of a group of objects to get kinetic energy. Potential energy is the energy of position. A group of objects has potential energy if, because of their relative positions, they can apply forces (like gravity and electrical and spring) to each other. These forces can then make the objects move and give them kinetic energy. A single object cannot have potential energy. Potential energy is always shared by a group of at least two objects. Because there are many types of potential energy, there is no single simple formula to calculate it.

Examples:

**Thermal energy** is the energy of the motion of the atoms of a substance. In actuality it is really just kinetic energy, but because atoms are so tiny and there are so many of them we usually take a sort of average of the energy of the molecules. There are some important terms to define and keep clear:

* **Thermal Energy**: The total kinetic energy of ALL OF THE MOLECULES of a substance.
* **Temperature:** A measure of the average kinetic energy of the molecules of a substance. Temperature, in science, may be measured in degrees Celcius (oC) or in Kelvin (K).
* **Heat:** The transfer of thermal energy within an object or between objects. Heat natuarally flows from

Chemical Potential Energy:

Remember that atoms are made up of protons, neutrons and electrons. Protons and electrons have charge and can therefor apply forces to one another.

proton – proton: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

electron – electron: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

proton – electron: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)

Because of this chemical compounds have energy stored up within the bonds between atoms. Some reactions require energy to create bonds, other reactions release energy by the breaking of bonds. In general larger molecules store more energy than smaller ones.

Chemical reactions always involve the breaking and/or forming of bonds and so energy is always involved. There are two basic types of chemical reaction, classified according to energy:

**Endothermic Reactions** are reactions in which the *chemical potential energy of the products is greater than the chemical potential energy of the reactants*. In other words this reaction has absorbed energy from the surroundings. Remember, energy cannot be created, so the extra energy stored in the products had to come from somewhere. In most cases, this means the reaction will cause the surroundings to get colder. An instant cold pack is an example of an endothermic reaction.

**Exothermic Reactions** are reactions in which the *chemical potential energy of the reactants is greater than the chemical potential energy of the products*. In other words this reaction has released energy to the surroundings. In most cases, this means the reaction will cause the surroundings to get warmer. In highly exothermic reactions there may also be a release of light and sound. An explosion is an example of a highly exothermic reaction.

**Activation Energy:** In order for a chemical reaction to occur, the molecules must collide. Furthermore, they must collide with enough *energy* ; that is they need to hit hard enough. How much energy the molecules need to hit is called the activation energy.