What is ***Energy***?

One of the most
*fundamental* and *universal* concepts
of science

Not a "thing", but rather *an attribute of matter*

Very **difficult** to define

In this unit we will
review some of the fundamental concepts
of ***energy*** and **heat**
and the relation between them.

***~ Thermodynamics ~***

Let's look at ***energetic aspects of change*** in general

And how these ***apply to chemical change***

Then provide you with tools to
***predict energy changes of chemical processes***.

**Thermodynamics**

Concerned with energy changes
that accompany chemical and physical processes

**Thermochemistry**

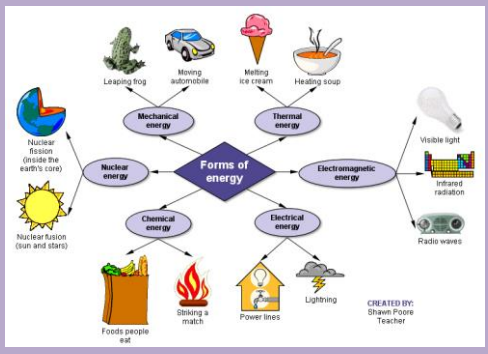
Concerned with the relationship between
chemical reactions and energy changes

***Energy***

The capacity to ***do work*** or ***transfer heat***

That which can ***cause change in matter***

There are ***different forms*** of energy



Energy can be ***converted*** and/or ***transferred***
Life itself depends on the conversion of chemical energy to other forms

## Potential Energy

***Stored energy*** - By virtue of its location

The *attraction/repulsion* of one object for another

Ex: Chemical energy: energy stored in the arrangement of atoms and molecules

**PE= m g h** ← height/distance (m)
↑ gravitational attraction (9.8 m/s$^2$)
mass (kg) ↗

Ex: Find the change in potential energy of a 2.6kg textbook that falls from a table top onto the floor 66cm below.

PE = (2.6kg)(9.8m/s$^2$)(0.66m) = 16.8 J

## Kinetic Energy

Energy of motion

Ex: Thermal energy
Energy due to movement of atoms/molecules

**KE= ½ mv$^2$** ← velocity (m/s)
↑ mass (kg)

Ex: A rifle shoot a 4.25 g bullet at a velocity of 965 m/s. What is its kinetic energy?

KE = ½ (0.00425kg)(965m/s)$^2$ = 1980 J

## Energy Units

| | |
|---|---|
| Joule, J (metric) | 1 J = 1 kg m$^2$/s$^2$ |
| calorie, cal | 1 cal = 4.184 J (exactly) |
| Calorie, Cal | 1 Cal = 1000 cal = 1 kcal |

**Internal Energy, E**

The ***total*** amount of energy in a body - kinetic and potential

But it's the *change in energy* that we are more concerned with.

$$\Delta E = q + w$$

$$\Delta E = q + w$$

**ΔE** = change in energy of a system
q = heat  w = work

**Heat and Work**

These are ***processes*** and ***cannot be stored***
*"energies in transit"*

Measured in energy units of Joules, J

**Heat**

The ***flow of thermal energy***
(KE of all the molecules in a system added together)

**q** = amount of heat added to or removed from the system

***Heat flows*** from one system to another by virtue only of a ***temperature difference***

Heat always transfers from ***hot to cold***

**Endothermic** processes
**q is positive**
**heat is added** to the system

**Exothermic** processes
**q is negative**
**heat is removed** from the system

**Work**

The energy used to
***cause an object to move against a force***

**w** = work done by/on the system
(the change in energy of the mechanical parts)

*If w is **negative**, the system **has done work***
*If w is **positive**, **work was done on** the system*

**W = F x d** ← distance
↖ force

## 1st Law of Thermodynamics

The energy of the universe is constant!

(Law of Conservation of Energy)

$\Delta E_{system} = -\Delta E_{surroundings}$

$(\Delta E = E_{final} - E_{initial})$

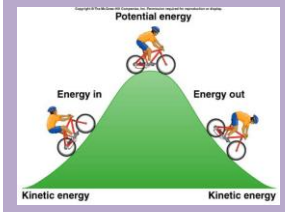
**System**- that part of the universe being studied

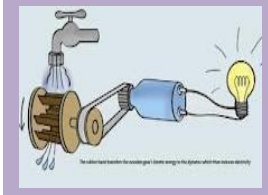
**Surroundings** – everything else

## 1st Law of Thermodynamics

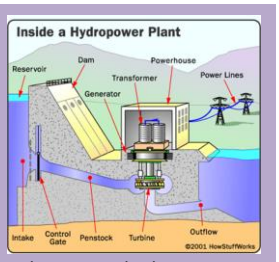
You can't get something for nothing

Even though energy is constant, it can be converted



Much of the potential energy of falling water can be captured by a device that transforms the water's kinetic energy into a useful form.

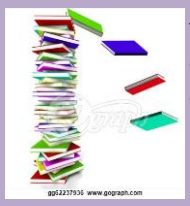



The output of hydroelectric power is directly proportional to the water's height above the generator turbines below. At this point, the kinetic energy of the water is transferred to that of the turbine, most of which (up to 90 percent in the largest installations) is then converted into electrical energy.

Ex: Drop a book

Some PE is converted to KE

↓



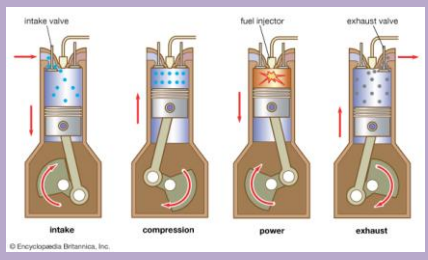
thermal: increased movement of atoms in air and on floor observed as a rise in temperature

Ex: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O +$ energy → heat

Chemical bond energy (PE) of reactants is more than chemical bond energy of products

Ex: Combustion engine

Chemical energy converted to mechanical energy




If a highly exothermic reaction also produces gaseous products, the latter may expand so rapidly that the result is an explosion — a net conversion of chemical energy into kinetic energy (including sound).