How the Sun Works Unit

Week 1 – What is matter? What is energy?

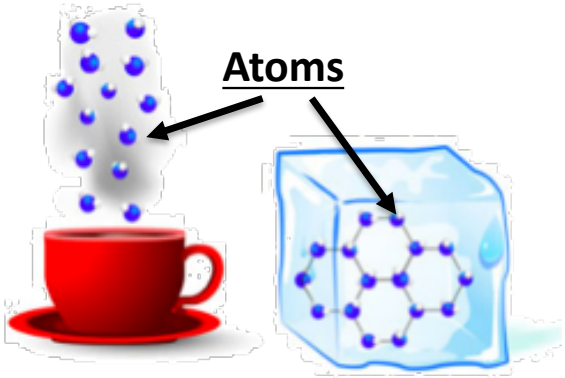
WATERFORD ASTRONOMY

Sun Unit – W1 Driving Question

- **This week's driving question: What happens to matter & energy in a candle during combustion?**
  - What happens to the atoms in molecules during combustion?
  - What happens to energy in molecules during combustion?
  - How does what we can observe during combustion (e.g., heat & light) relate to the changes happening at the molecular level?

Rules of Matter & Energy

- Rule #1: **All solids, liquids, and gases are made of tiny particles called atoms**.
  - The more atoms something has, the more mass it has.
  - Multiple atoms can bond together to form molecules.
  - *For example, water molecules consist of 1 oxygen atom and 2 hydrogen atoms.*



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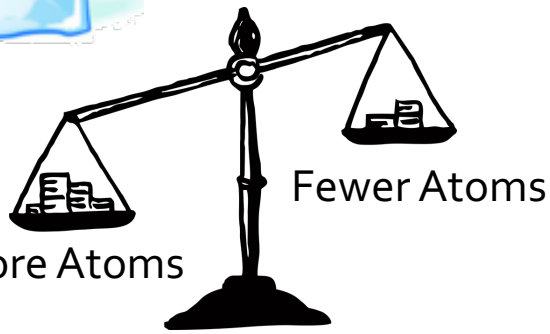
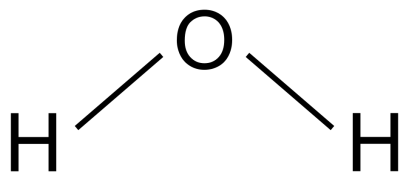
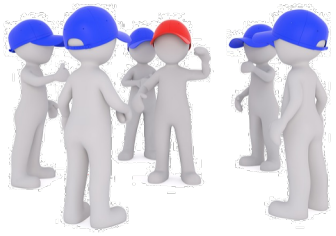


Source: Pixabay

If atoms were like students, a class would be like a molecule.



A group of bonded atoms = a molecule.

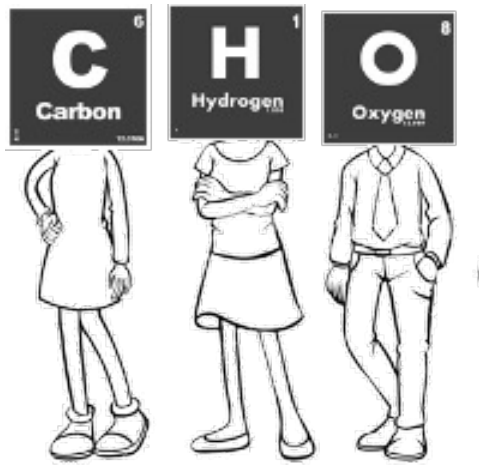


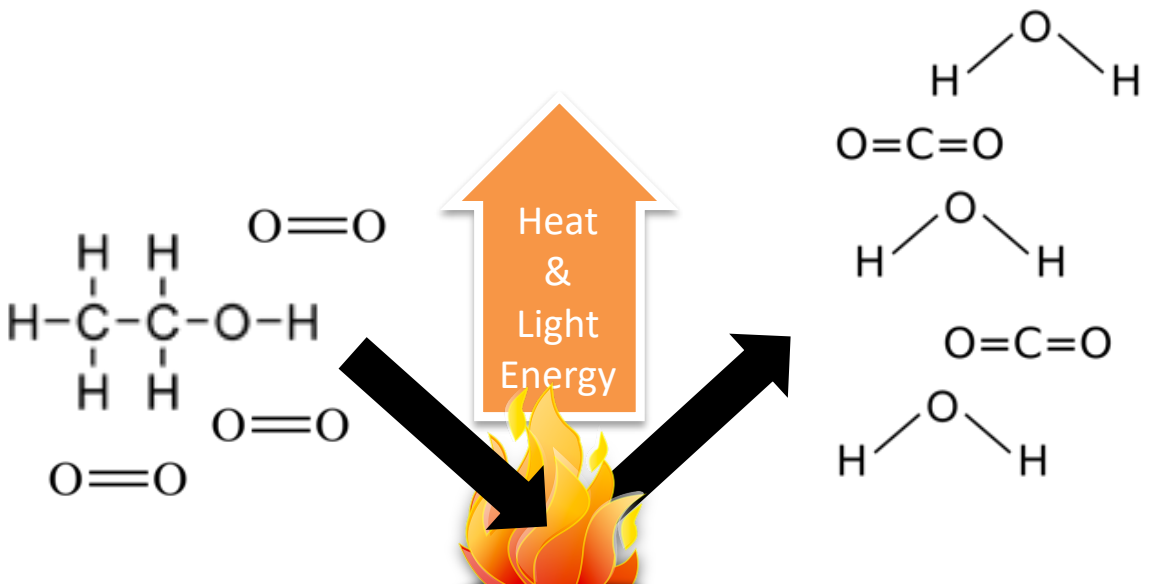
Source: Pixabay

A group of students = a class.

Rules of Matter & Energy

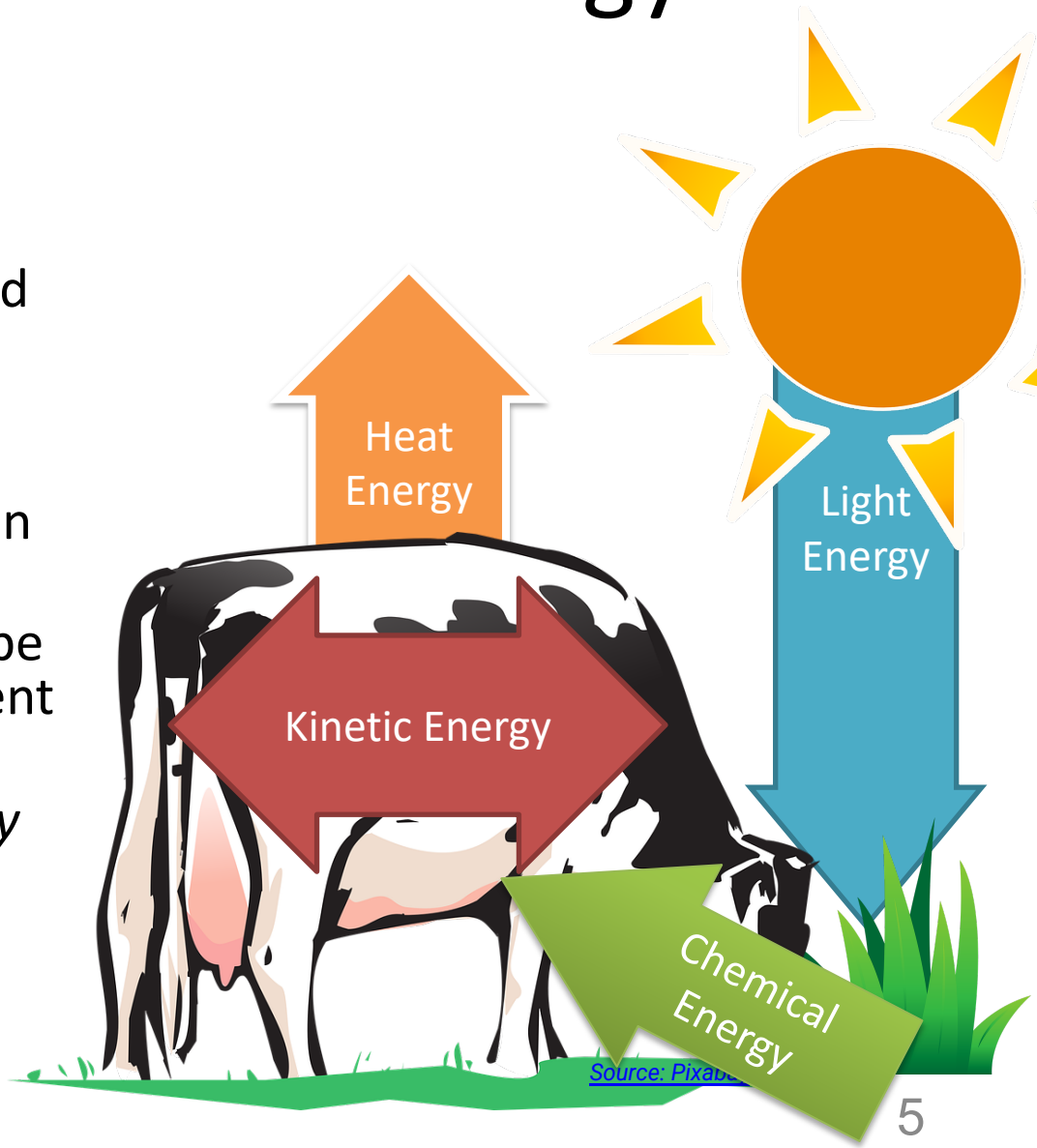
- Rule #2: Atoms found on one molecule can be rearranged to form a new molecule.
  - Different kinds of atoms are called *elements.*





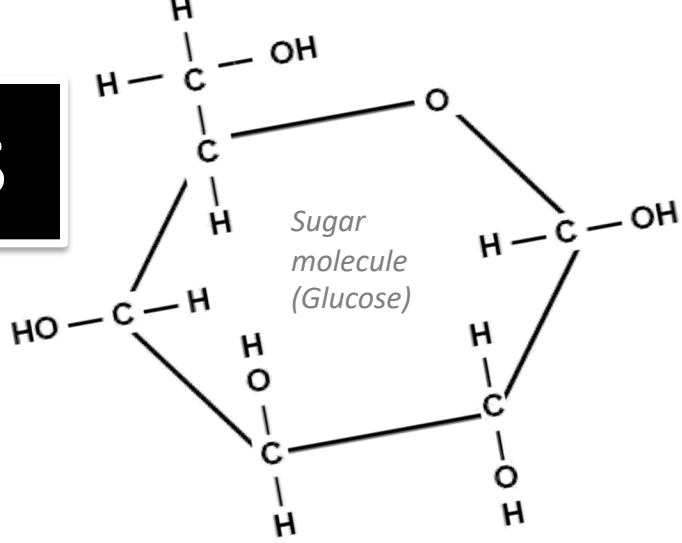
Rules of Matter & Energy

- Rule #3: **Energy lasts forever**.
  - Energy cannot be created or destroyed.
  - Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules.
  - Energy in one form can be transferred into a different form.
  - *For example, light energy can be transformed into heat energy*.

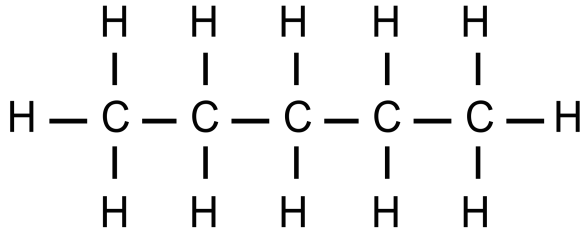


Energy Within Molecules

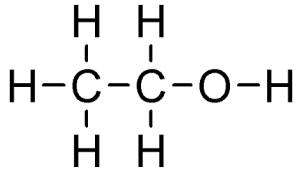
- Molecules can store energy within their chemical bonds.
  - A chemical bond is when two atoms become attracted to each other.
- Carbon-carbon bonds and carbon-hydrogen bonds are high-energy bonds.
  - High-energy bonds store chemical energy.
  - Substances used as fuels (such as sugar, gasoline, ethanol, and fat) tend to have large amounts of C-C and C-H bonds.
- The greater the amount of C-C and C-H bonds, the higher the chemical energy of a substance.



Sugar molecule (Glucose)



Gasoline molecule



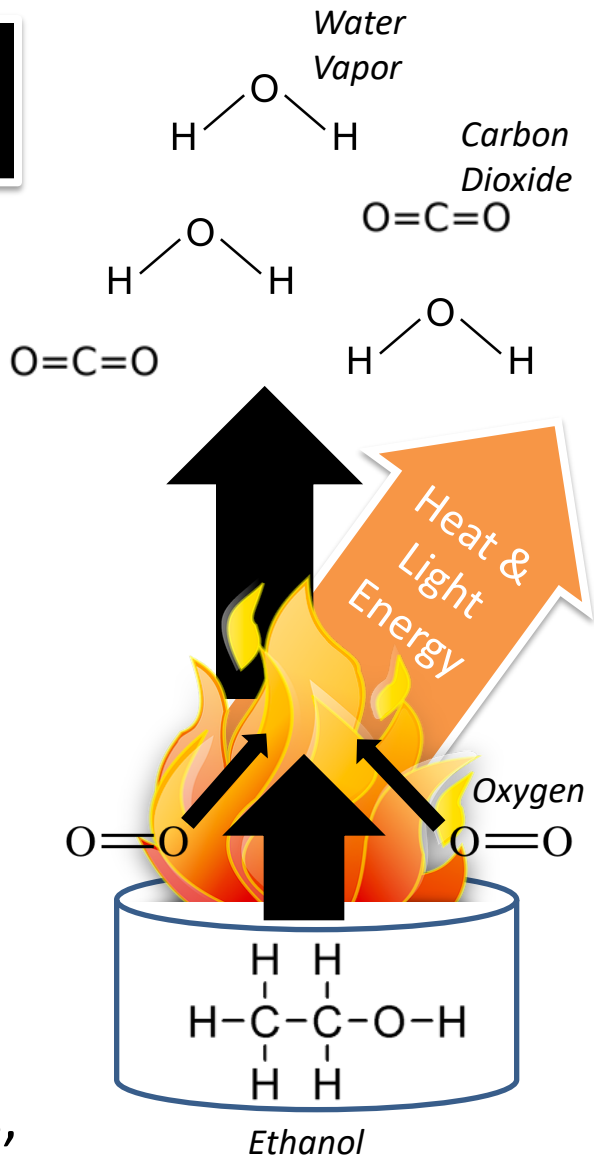
Ethanol molecule

Gasoline, ethanol, and sugar molecules have large amounts of high-energy C-C and C-H bonds.

Rearrangement Reactions

- **However, the energy within C-C and C-H bonds is "stored energy".**
  - The chemical energy stored in these molecules cannot be used.
  - To make this energy available for use, the atoms of these molecules must be "rearranged" into new molecules.

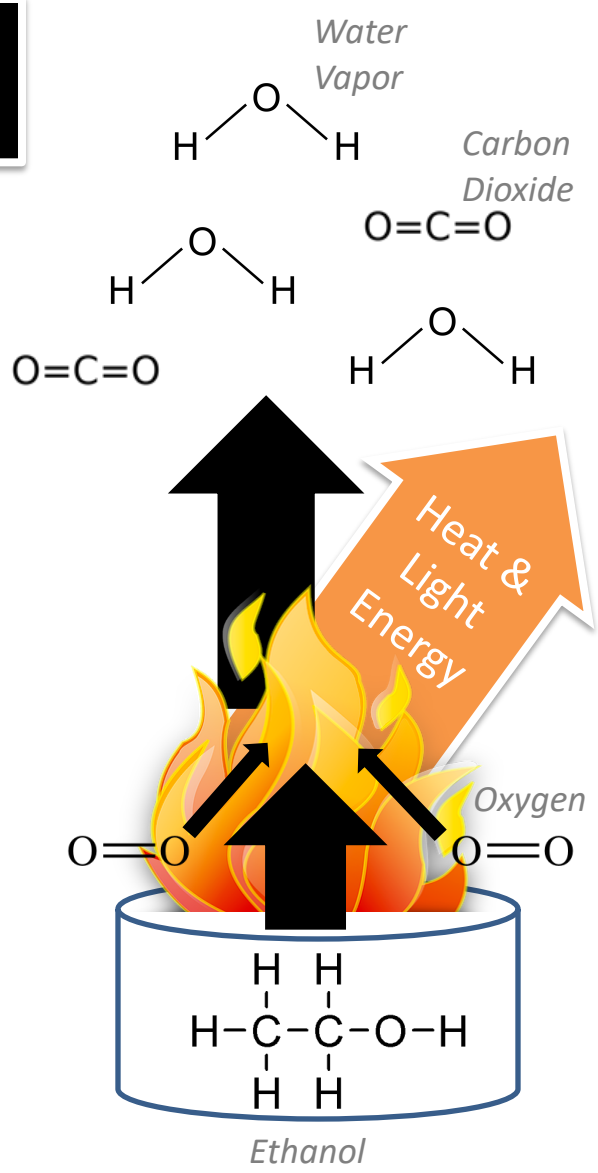
- **Combustion is a "rearrangement reaction".**
  - During combustion, the atoms of ethanol and oxygen (O_2) are rearranged to form CO_2 and H_2O.
  - Note that CO_2 and H_2O lack high energy bonds, which explains why they aren't combustible.



Flames = "Leftover Energy"

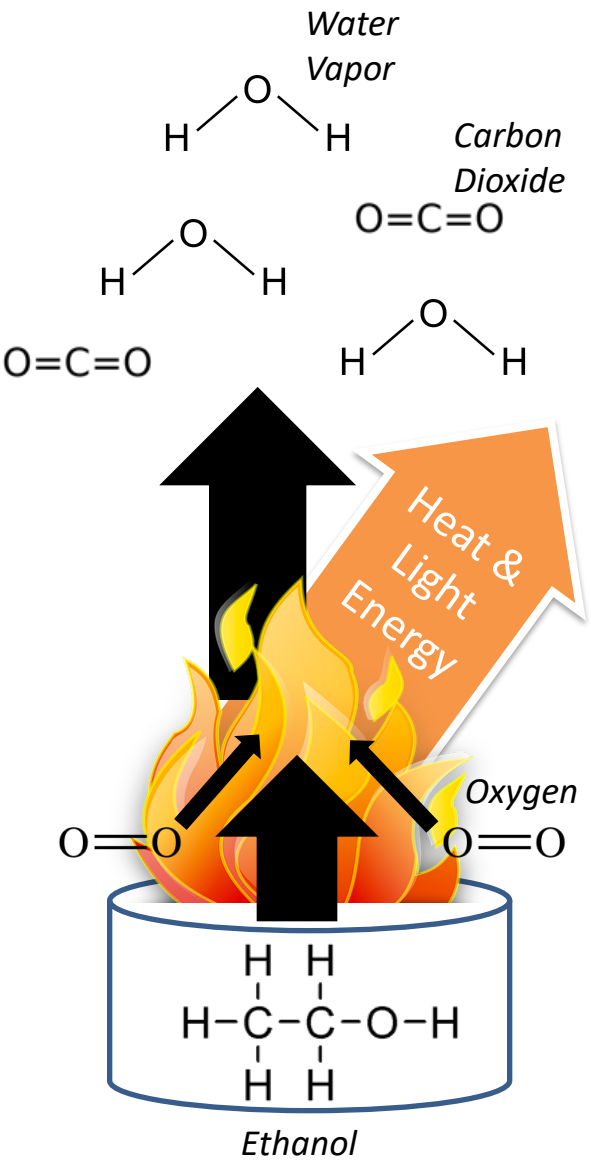
- **There are no C-C or C-H bonds on either carbon dioxide or water.**
  - However, there are 6 high energy bonds within an ethanol molecule.
  - This means that there is "leftover energy" when ethanol and oxygen are rearranged into carbon dioxide and water molecules.

- **This "leftover energy" can be observed as the heat, light, and motion of the flame.**
  - The flames of a fire are literally the release of energy that occurs when ethanol and oxygen are rearranged into carbon dioxide and water.



The 3 "Rules"

- **Note how this aligns to our three rules of matter and energy.**
  - ***Rule 1 - All matter is made of atoms***: all the substances in a combustion reaction can be described based on the atoms they contain.
  - ***Rule 2 - Atoms can form new molecules***: all the atoms prior to combustion can be traced to specific molecules after burning.
  - ***Rule 3 – Energy lasts forever***: all the energy within the C-C and C-H bonds of ethanol can be observed as heat, light, and motion.
    - Eventually all this energy becomes heat and dissipates away into space.



Part 1 Revision

Can we now improve our claims about the data above?