NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ EVERYDAY CHEM: **UNIT 1 (P3)** MATTER & ***ENERGY***

**Okay, we have introduced some of the most important vocabulary dealing with matter such as; the types of compounds, elements, and mixtures, acids/bases etc. We have defined and discussed issues such as: matter, mass, volume, weight, pressure and density. Now, we shall take a longer more involved look at energy.**

I)-VII) See pages 1-50

VIII) Energy: \* The ability to create a change or to do work

 on Earth, it is described as:

 Mechanical Energy (sum of Potential Energy and Kinetic Energy)

 can be divided into 2 big categories.

 Potential Energy can be converted to Kinetic Energy

 defined as defined as

 energy of position of energy of motion (some of the energy possessed by

 between species relative an object in motion)

 to an assumed standard

 examples of kinetic energy

 examples of potential energy

 Electromagnetic Spectrum [Light, Thermal, Microwave];

P.E. is associated with the energy found in bonds.

Bonds have a *length or distance* and thus are their energies are associated closely with potential energy … called chemical energy.

and then there is/are: Sound energy, Moving objects ....

 Chemical

 Bond Energy

acceleration is a change in an object’s speed and/or direction (velocity)

A) Work: W = (force)(distance) where force = (mass)(acceleration)

B) POtential Energy = Energy of \*POsition (or distance between objects, instead of position)

Potential Energy **(Big Idea #2)** is essentially due to a POsition of objects:

***It is the energy (ability to do work) possessed by an object, due to its***

***position relative to some standard (assumed) second position.***

 This is intimately linked to changes in chemical bond energies, phase

 changes, the production of light, and intermolecular forces of attraction(s)

 solid phase vs. gas phase

Important idea: ***Potential Energy applies to chemical bond theory. Chemical bonds, especially covalent***

***bonds, are an interpretation of potential energy.*** Huh?

* Think about it: as a bond is made, the POsition between the atoms, that will bond, must decrease (they must get closer to each other). This “getting closer” must occur if the positive nuclear forces of one atom are to attract the electron(s) of the other atom. As this POsition (POtential) decreases, the LCME states that the change in energy must go somewhere . Often it is converted into thermal energy, and it is released.

As a metaphor for bond making, think of a pen and cap…

* Bonds have a length. Some chemical bonds are short (lower potential energy), while other bonds are longer (they represent a greater energy existing between species)
* Short bonds tend to be “stronger” than longer bonds. It can take more energy to break up a species made

with short, strong bonds, relative to one made up of longer bonds.

Let’s apply potential energy to another idea in chemistry. Try a bow and arrow as a metaphor for learning …some neat connections are about to be made!



<http://clipart.usscouts.org/library/BSA_Cub_Scouts/Cartoons>



 Position of particles in the gas phase

 vs. liquid phase

 The rock on top of a hill



 <https://www.britannica.com/sports/boxing/Weight-divisions>

 Floyd Mayweather Jr. turned and retracted.

C) Review: Law of the Conservation of Matter and Energy: Matter and Energy can NOT be created nor

 destroyed by ordinary chemical means … **BUT, energy can be converted into various**

 **forms of energy and/or energy can be transferred.**

1) As the potential energy between objects decreases, \* it cannot just disappear

 potential energy is often **converted into some form of kinetic energy**



 **ANIMATION**:  [**https://www.youtube.com/watch?v=hx0tSiCQWDc**](https://www.youtube.com/watch?v=hx0tSiCQWDc) (Begin at minute 6 and watch to minute 8)

 a) translation : Moving from place to place (one point to a second point)

 b) rotation : Tumbling

 c) vibration : \*Bending/Stretching of chemical bonds (changes in potential energy)

 D) Kinetic Energy: The ability to create a change or to do work, due to motion (Energy of motion)

1) Generally, the examples of energy with which we are familiar are forms of K.E :(each due

 to the "motion" or change in position of particles … light, radio waves, thermal energy… )

 2) When 2 particles collide the K.E. can be transferred (think of a game of pool…)

[This Photo](https://www.flickr.com/photos/demaiob/4221633260) by Unknown Author is licensed under [CC BY](https://creativecommons.org/licenses/by/3.0/)

 3) **Thermal Energy**: unit: joules (J) and kilojoules (kJ)

 a) 1 calorie: The energy required to raise 1 gram of water by 1ºC

 b) 1 calorie is equal to 4.18 Joules (SI Unit)

 c) Heat: (Latin: ***calor***) effectively the physical equivalent of work: James Prescott Joule

 demonstrated that mechanical work, electrical work and chemical work all

 produce a **transfer of energy**. |(The Extraordinary Chemistry of Ordinary Things Snyder 4th ed. p 179)

 i) Heat is the **process**: the ***transfer of energy*** between two areas of different

 energy content. (e.g... We need to "heat up" a cup of cold coffee. It’s a

 transfer of thermal energy really)

 ii) the transfer occurs naturally from areas of \* high energy to areas of

 \* relatively lower energy or from *source to sink: hot to colder*



 iii) And while we’re at it…**there is no such thing as cold energy**

 Cold is the absence of thermal energy … “cold” can indicate a

 lesser average kinetic energy of the molecules.

 **Now, listen very carefully ….**

4) **Temperature ≠ Thermal Energy (or “heat” if you insist...)**

 a) When I say, **temperature**, you think: \* average kinetic energy (& vice versa)

 i) Think about the idea that temperature **≠** thermal energy

 What is/are the unit(s) for measurements of temperature? \* K , °C

 What is the unit for the measurement of energy, in our course? \*joules

 Conclusion? \*They have different units thus they are different concepts.

 ii) temperature measures how frequently and/or how intensely the energy of the

 average molecule(s) of the measured medium affects the energy of the

 molecules of the liquid inside the bulb of a thermometer…

 or, more precisely….

"Temperature reflects the average total kinetic energy of particles in matter. ***Heat* is the transfer of thermal energy; it flows from regions of high temperature to regionsof low temperature.** Thermal energy is stored as [kinetic energy](http://en.wikipedia.org/wiki/Kinetic_energy) in the random modesof translation in monatomic substances, and translations and rotations of polyatomic molecules in gases. Additionally, some thermal energy may be stored as the potential energy associated with higher-energy-modes of vibration, whenever they occur ininteratomic bonds in any substance. Translation, rotation, and the two types of energyin vibration (kinetic and potential) represent the [degrees of freedom](http://en.wikipedia.org/wiki/Degrees_of_freedom_%28physics_and_chemistry%29) of motion whichclassically contribute to the heat capacity of a thermodynamic system." <http://en.wikipedia.org/wiki/Heat_capacity>



 **TRY THIS**: When you feel a "draft" in your house, what ***starts*** the process?

 Is it due to: *cold air moving into the warmer house*, or *warm air moving out of the house to the cold*?

 \* Most probably it is due to warm air moving out of the house, *first*, then being replaced by cold

 air moving into the house. This is most likely due to the rising of warm air, and its lost through

 a roof or cooling up against uninsulated walls or windows.

**TRY THIS**: A cold pack is placed on an injured leg. Identify the direction of the flow of energy

 between the leg and the cold pack. Does the energy flow from your leg to the cold pack or

 does the energy flow from the cold pack to your leg?

 \*leg to cold pack …. area of higher temperature to area of lower temperature

 Describe how the Law of Conservation of Energy applies to the energy exchange that occurs

 between the cold pack and injured leg.

 \*There is an equivalence between the energy lost by the leg and the energy absorbed by the

 cold pack … which is one reason why the cold pack gets warmer.

Now, let’s bring matter and energy together. There are four primary forces associated with matter, per the Standard Model of Particle Physics (some folks may argue 3 forces, and others as of August 2023 may argue 5 – but I am old, and I am sticking with 4 for our work.)

These forces are:

 1) Gravitational Force

 2) Strong Force

 3) Weak Force

 4) Electromagnetic Force

For *our* work, we can almost ignore gravity. On the other hand, the weak force is weirdly important – without it, we don’t exist – but dudes and dudines that is some big time action, and I don’t want to get wrapped up in that for our course. However, I do have a good video re: the weak force on my website, at [www.scientiaestubique.com](http://www.scientiaestubique.com) under the video tab.

The strong force is – well – amazing. If we get the chance to attack it, I will! I do love me some meson transfer.

However, the brass ring of the four forces, for *our* course, is the electromagnetic force. The electromagnetic force is all about ***chemical bonds, bond energy, electrons, light*** … Oh it’s grand. You definitely want to use some of the blank pages provided, to take some extra notes. **Let’s Go!**

IX) Visible Light Energy and Thermal Energy are both forms of the Electromagnetic Spectrum

 <http://www.colourtherapyhealing.com/colour/electromagnetic_spectrum.php>

A) The electromagnetic spectrum represents several different types of radiation …but each related

 to the \*movement of electrons relative to a nucleus

 1) Radiation is and energy which is emitted and/or travels in the form of waves or particles

 ("particles" of light are called photons)

 Please understand that light is a form of radiation. Most people think of radiation as *nuclear radiation* only.

 For the most part, nuclear radiation is a limited part of the electromagnetic spectrum (e.g., gamma radiation).

 B) **So, What Do We Mean By Light?**

 With the work of scientists such as Albert Einstein and Prince Louis de Broglie, it is fairly

 common to consider energy and matter to have both wave-like properties and particle-like

 properties.

 Einstein called a light particle, **a photon.** A photon comes in little discrete packages of energy

 called **quanta**. A **quantum** of energy is the amount of energy required to move an electron from

 one energy level to another energy level … The electron’s energy is said to be quantized.

 1) ***Visible*** Light is just one form of electromagnetic energy. We see only visible light, but

 other animals can see other forms of electromagnetic energy.

 a) Visible Light is only ONE portion of the electromagnetic spectrum. Other examples

 are: Microwaves, Radio Waves (NOT sound waves), X-Rays, Infrared Waves

 i) Some birds and bees can see polarized light

 2) Visible (as a whole) or White Light is a combination of wavelengths: **ROYGB**I**V**

 a) The I (for indigo) is sort of the, Pluto of the wavelength family. It is no longer

 considered to be a separate wavelength – but rather the border between blue

 and violet. Sorry – Not Sorry.

 3) Two terms become important: **Wavelength and Frequency**

 Wavelength: The "size" or distance from crest to crest

 Frequency: The number of waves that pass a certain point, in 1 second (unit: Hertz)

 Generally, the higher the frequency (shorter wavelength) the more powerful the light.



 a) shorter wavelength, thus: greater frequency

 b) longer wavelength, thus: lower frequency

<http://www.qrg.northwestern.edu/projects/vss/docs/Communications/1-what-is-wavelength.html>



 Check Out: For a good idea of frequency watch a steel ball on an anvil:

 <https://www.youtube.com/watch?v=fcFY3ywqurM>

 **Check Out:** [**https://www.youtube.com/watch?v=Ve8iqkgAl9s&t=53s**](https://www.youtube.com/watch?v=Ve8iqkgAl9s&t=53s) **Wavelength vs. Frequency (Not Bad!)**

 **Relative Wavelengths of Visible Light**



 **longest wavelength, thus lowest frequency**

 **shortest wavelength, thus, greatest frequency**

 <http://science.hq.nasa.gov/kids/imagers/ems/visible.html>

 c) Inference: Study the diagram of visible wavelengths (above). Compare Red to Blue.

Which has the shorter wavelength? \*Blue

 This means that \*blue light has a greater / lower frequency.

(Choose 1)

 **Thus, we may conclude that \*blue light transfers \*more energy**

 d) Sidenote: As light attenuates (stretches) due to traveling farther, it red shifts

5) **Application**: Subtractive color: The electrons of dyes and pigments (e.g. lake pigments and

 other organic compounds such as chlorophyll) absorb certain frequencies of visible light

 (\*ROYGBIV ). The energy NOT absorbed by the electrons is \*reflected.

 That \*reflected light energy is what we see as color. Color is essentially

 our interpretation of the energy which has been \*subtracted from ROYGBIV

 a) e.g. The electrons of the molecules of the pigments found in something like a

 yellow banana \*absorb all of ROYGBIV, *except* for the yellow! Yellow wavelengths

 (somewhere close to 570 to 580 nm wavelengths) are reflected.



 So here is a wonderful application <https://www.youtube.com/watch?v=X96d1YEN_fQ>

 **(Sci Show: Why are plants green? an example of subtractive color)**

 Why do some scientists believe the reflection of green light to be adaptative?

 6) **Application:** Photochromic Lenses (e.g., Transition Lenses): Light can create a chemical

 change.

Citation: What’s That Stuff? Self-Darkening Eyeglasses C&EN 6 April 2009 Volume 87 Issue 15 by Britt E. Erickson

 a) Plastic photochromic lenses work differently than glass photochromic lenses.

 But we will focus just on only the plastic lenses which change color as you

 enter or leave sunlight.

 b) According to Chris Baldy in “What’s that Stuff? when photochromic

 dye (layered into/onto/between) plastic, is exposed to UV radiation (like the UV

 rays which cause us to tan…) , the dye absorbs that UV radiation, and a bond is

 broken, in the dye. (See the reddish line representing a covalent bond)

 c) This opens the dye molecule and changes the absorption of the molecule. It

 absorbs at the *longer wavelengths of visible light.* This means that the lens will

 darken (When light is absorbed, but not released, the color is “black” or at least

 darker) What’s That Stuff? Self-Darkening Eyeglasses C&EN 6 April 2009 Volume 87 Issue 15 by Britt E. Erickson

 **Demo: Light as Energy…. Which form carries the most energy?**

 AgNO3(aq) + NaCl(aq) 🡪 NaNO3(aq) + AgCl(s) ↓ (white precipitate)

|  |  |
| --- | --- |
|  |  |
|  |  |

light energy

 AgCl(s) → Cl2(g) + Ag(s) a black-looking solid



 Check out: Color Change in Leaves: [The Chemicals Behind the Colors of Autumn Leaves – Compound Interest (compoundchem.com)](https://www.compoundchem.com/2014/09/11/autumnleaves/)

 What pigment decomposes first?

 What is the source of the gold and yellow pigments?

 Why might a leaf be bright red on one side but dull green/gray on the other side?



 **Fun Fact**☺ Check Out: **Why is the sky blue?** <http://www.sciencemadesimple.com/sky_blue.html>

 What causes the sky to be blue?

 Water appears blue for a slightly different reason….

**Try This!** In the Autumn of 2022, there was a Blood Moon. A Blood Moon is a special sort of Lunar Eclipse (when the Earth is between the Sun and Moon), in which the moon looks reddish. What is causing a Blood Moon, to appear red in color?

 <https://www.timeanddate.com/eclipse/total-lunar-eclipse.html>

\* As light is attenuated (stretched) is tends to shift to a red wavelength. The red color is essentially the long red wavelengths of sunset being reflected onto the moon.

 How CO2(g) and other greenhouse gases affect Climate Change:

 <https://scied.ucar.edu/carbon-dioxide-absorbs-and-re-emits-infrared-radiation>



 By A loose necktie - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=80356809>

 Watch: The great Dr. Carl Sagan in 1985 <https://www.youtube.com/watch?v=Wp-WiNXH6hI>

* The names, Climate Change & Greenhouse Effect are just ever so slightly different in meaning to me.

We first referred to this phenomenon as the greenhouse effect – but the term is a bit misleading. As the

atmosphere of the Earth warms, climate will change unequally around the world.

* The Greenhouse Effect is one of the reasons there is life on this planet. Rather than having the energy

of the Sun totally reflected off the Earth’s surface, and thus bounced right back out into space, certain chemicals in the atmosphere absorbed and re-radiated that energy back to Earth.

* The result of reflecting solar energy back to the Earth’s surface was that \*the Earth was warmed. This warming in turn helped to develop life.
* Climate Change is a relatively new term which generally refers to the effects that an \*excess of these various chemicals in the atmosphere are having on the Earth’s temperature.
* It is sort of an issue of “Too much of a good thing….”

**Test Question: How do greenhouse gases contribute to changes in the temperature of the Earth?**

According to chemists at Elmhurst University (<http://chemistry.elmhurst.edu/vchembook/globalwarmA5.html>)

Carbon dioxide and water vapor are two greenhouse gas molecules. They are shown in the next series

of figures along with the IR spectra (infrared spectra) and the **bending and vibrations** (changes in potential energy) caused by absorbing the IR radiation.

* The arrows on the molecules indicate the direction of the bends and vibrations of the bonds.
* The IR spectra indicates the specific energies at certain wavelengths which are absorbed.
* Radiation that is 100% transmittance is not blocked but travels straight through the sample and

returns to space.

* **The dips in the lines** are caused by the absorption of energy, by the molecules, hence only 10% of the energy is transmitted back to space, in the case of CO2(g). 90% is retained.

