NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ EVERYDAY CHEMISTRY: UNIT 1:

INTRO / MATTER AND ENERGY

The whole of science is nothing more than the refinement of everyday thinking

(Albert Einstein)



Check Out: The Human Element commercial: (oldest version), from DOW Chemical

[**http://www.****youtube.com/watch?v=i3byt7xMSCA**](http://www.youtube.com/watch?v=i3byt7xMSCA)

I) Chemistry is still referred to as, *the central science*. With a few exceptions, **very little** research,

technological development and/or implementation can occur without chemistry. When there is matter

and/or energy involved ... there is chemistry.

What we can study:

chemicals that fuel ... coal, gasoline, hydrogen gas, oil

chemicals that are edible ... carbohydrates, fats, esters, water, sodium chloride, proteins

chemicals that clean ... soap, vinegar, water, ammonia, alcohol, detergent

chemicals that pollute ... coal, soaps, toxins, plastics, phosphates, sulfur dioxide

chemicals that heal ... ibuprofen, aloe, bandages, plastics, Silvadene

chemicals that identify… technetium-99m, fluorine-18, carbon-14, iodine-131

chemicals that build ... steel, cellulose, plastics, silicon, cement, clay

chemicals that decorate ... silver, paint, plastics, dyes, papers, inks

chemicals that run the economy ... oil, gold, copper, silicon, silicone, fluorine, lithium, diamonds

chemicals that conduct electricity ... copper, lithium, gold, electrolyte solutions

chemicals of charm ... perfumes, pheromones, makeup, shampoo, gold, diamonds

chemicals of history ... gunpowder, A-bomb, H-bomb, aniline dyes, steel, radium, salt, oil, gold

chemicals of crime ... arsenic, potassium cyanide, gunpowder, alcohol, luminol, DNA

chemicals of warfare ... iron, bronze, gunpowder, plutonium, phosgene

chemicals of entertainment ... alloys, cellulose, inks, plastics, paint, crayons, xenon gas

chemicals of the brain ... dopamine, serotonin, vasopressin, oxytocin

 For a listing of ideas/topics/possibilities… check out <http://www.chemistryexplained.com/index.html>

Try: What Has Science Done For You Lately? <https://undsci.berkeley.edu/article/0_0_0/whathassciencedone_01>

**Why Study Chemistry1?**

**Carnegie Mellon Researchers Say Use of Switchgrass Could Solve Energy Woes**

Carnegie Mellon University researchers say the use of **switchgrass could help break U.S. dependence on fossil fuels** and curb costly transportation costs.

"Our report indicates the time is right for America to begin a transition to **ethanol derived from switchgrass,**" said Scott Matthews, an assistant professor in the Civil and Environmental Engineering Department. A 25 percent hike in gas prices at the pump since December adds to the researchers' call for more ethanol derived from switchgrass, a perennial tall grass used as forage for livestock. Gasoline prices in the U.S. are approaching an average of $3 a gallon. The Carnegie Mellon findings were published in the May 1 issue of the American Chemical Society's Journal "Environmental Science and Technology."

Matthews, along with W. Michael Griffin, executive director of the Green Design Institute at Carnegie Mellon's Tepper School of Business, and William R. Morrow, a researcher in the university's Department of Civil and Environmental Engineering, said **using switchgrass as a supplement to corn to make ethanol would help ensure the availability of large volumes of inexpensive ethanol to fuel distributors and consumers**.

"We need to be thinking about how **we can make and deliver ethanol once our corn and land resources are maxed out. Switchgrass can be that next step,**" Griffin said.

The Carnegie Mellon report also found that ethanol derived from the dry, brown switchgrass, a cellulosic ethanol, could be made in sufficient quantities to deliver 16 percent ethanol fuel to all consumers in the U.S. Researchers said this would likely lead to significant decreases and stability in the price of gasoline.

"It's a renewable resource," Griffin said. "Rather than taking a depletable resource from the ground, switchgrass can be grown again and again."

**citation: ScienceDaily (May 5, 2006)** [**http://www.sciencedaily.com/releases/2006/05/060505114855.htm**](http://www.sciencedaily.com/releases/2006/05/060505114855.htm)

 Check out: <https://www.youtube.com/watch?v=3p_QAsGyetM> (switchgrass to ethanol)

<https://www.youtube.com/watch?v=i5MO1lAHMVQ> (switchgrass substituting for coal)

**Why Study Chemistry2 ?**

I found this reference while doing a literature review regarding the issue surrounding the problem of ingesting grapefruit juice, with certain medications, some time back. I was not all that surprised to discover that orange juice made from Seville Oranges (a.k.a. Bitter Orange) created the same problem....When you're as old as I am, you begin to wonder about how issues branch .... BUT,

I was surprised, to find the following reference to Seville Orange as a dietary supplement. That was new to me.

And, I thought this was a great example as to why should anyone at a university study a basic chemistry course because, maybe just maybe in order to understand the issues of**: nutrition, dietary supplementation, drug interaction, biochemical/biophysical reactions to chemicals** ……Read on….

**… As an herbal stimulant**

**The extract of bitter orange (and bitter orange peel) has been marketed as dietary supplement purported to act as a weight-loss aid and appetite suppressant.** Bitter orange contains the tyramine metabolites N-methyltyramine, octopamine and synephrine, **substances similar to epinephrine**, which act on the α-1-adrenergic (alpha-1 adrenergic) receptor **to constrict blood vessels and increase blood pressure and heart rate**.

There is no evidence that bitter orange is effective in promoting weight loss.

Following bans on the herbal stimulant ephedra in the U.S., Canada, and elsewhere, **bitter orange has been substituted into "ephedra-free" herbal weight-loss products by dietary supplement manufacturers**. Like most dietary supplement ingredients, bitter orange has not undergone formal safety testing, but it is believed to cause the **same spectrum of adverse events as ephedra**. Case reports have linked **bitter orange supplements to strokes, angina, and ischemic colitis**. The U.S. National Center for Complementary and Alternative Medicine found that "**there is currently little evidence that bitter orange is safer to use than ephedra.**"

**Bitter orange may have serious drug interactions with drugs such as statins in a similar way to grapefruit.** Following an incident in which a healthy young man suffered a myocardial infarction (heart attack) linked to bitter orange, a case study found that dietary supplement manufacturers who replaced ephedra with its analogs from "bitter orange" had in effect found a loophole in the ephedra ban, substituting a similarly dangerous substance while labeling the products as "ephedra-free".

citation: <http://en.wikipedia.org/wiki/Bitter_orange>

Read while performing a Boolean search for: Seville orange bergamot grapefruit.

Supporting Literature:

W.L. Stanely et al. *Citrus Coumarins* <http://pubs.acs.org/doi/abs/10.1021/jf60178a007>

[Bouchard](file:///C:\Users\Owner\Documents\01Notes.Quotes.Eq\01Notes%20Past%20Versions\Everyday%20Chem\%20%20Bouchard) N.D. et. al *Ischemic Stroke Associated With Use of an Ephedra-Free Dietary Supplement*

*Containing Synephrine*, Mayo Clinic Proceedings <https://www.mayoclinicproceedings.org/article/S0025-6196(11)63207-2/fulltext>

II) First … Chemistry is a science. So, what is science?

A) Our English term: *science* comes from the Latin word, **scientia**

B) What does the Latin word, (science) mean? \* knowledge

1) \* Knowledge ≠ Information

C) science is concerned with \* prediction & explanation (knowledge)

of a variety of phenomena, ***using*** information. If we can't use something to help predict of to

explain an issue, then it is just data. Information ≠ Knowledge

 This statement by Adler, sort of says it for me…

***The telephone book is full of facts but it doesn't contain a single idea***

(Mortimer Adler)

III) Now, specifically, what is chemistry**?** At its very heart, chemistry is about transforming matter.

Chemistry is the study of:

A) matter: its ***composition, structure, and properties (essentially, chemicals).***

B) the ***reactions***  under which matter goes.

C) the ***energy*** associated with the reactions of matter.

**Historians, Linguists, Artists & Harry Potter fans:** The word Chemistry is from the Greek chemeia**.** The word was used to designate the art of metal working. It actually means *black*.... used possibly due to the black soil of the Nile Valley, known asChemi. (<http://hilltop.bradley.edu/~rbg/Origin.html>) The chemical arts originated in Egypt. The Arabs added the prefix, “al” , and in time, *alchemy* was the name given to the chemical arts up through the Renaissance. (<https://www.ncbi.nlm.nih.gov/pubmed/3064584>) As alchemical arts morphed & disappeared, with the onset of controlled experimentation, math and theory, the field of alchemy became known as ***chemistry****.* (As a side note, there were alchemists right up through the 1920s, even here in the USA...)

D) **There are two huge divisions in chemistry** seen as being closely

associated with physics

Reaction Chemistry Nuclear Chemistry

(our course: inorganic & organic chemistry)

deals with changes\* in the electron deals with changes in the \* nucleus

cloud(s) of the reacting species of the atom (e.g. changes in the number

and / or and energy of protons and neutrons)

the accompanying changes

in the phase of matter Often, there is a conversion between

Matter ↔ Energy

Matter, Energy and Charge are conserved and

**reaction chemistry is really all about the**

**activity (sharing/losing/gaining) of electrons!!!**

Okay ... Wait a minute ... Matter ... Energy .... What do these words mean?

Well, you can know what something ***is*** by what it ***isn't*** . And, in "reaction chemistry" matter and energy

are treated as being relatively different. The terms can blend with nuclear ...but we're not there yet...

**Try This:** **What do you think?** Consider the following terms … are they matter?

1) helium 2) charcoal 3) sound 4) heat 5) temperature

6) water 7) air 8) light 9) sand 10) blood 10) motion

IV) j0290876Thus, what is matter? \*anything which possess mass and volume

Or better …. \*anything you can use to fill a balloon and keep in the balloon for a

period of time.

A) Essentially, *energy* is the ability to create a change or to do work (we will spend a good deal of

time on this a bit later. However, you now know pretty well, the examples of energy from the

prior list, because you know about matter … and you know what something *is, by what it is NOT*!

And now the understanding of ***matter*** and thus energy .... brings us back to the terms: mass, volume and weight

B) Law of the Conservation of Matter, Energy (and Charge):

🌢Matter and energy cannot be created nor destroyed by *ordinary chemical means,*

🌢BUT, energy can be converted into various forms of energy and/or transferred.

So, assuming nothing gets in and nothing gets out of the reaction chamber, the mass of the

chemicals that react must equal the mass of the chemicals produced. The energy-content

of the whole system is also constant ... but the forms of energy may change (chemical energy

may change to light and/or some form of kinetic energy).

Cut to the Chase: Matter, Energy and Charge (meaning electrons and protons are conserved in

reaction chemistry (not necessarily, nuclear chemistry). Essentially, the number

of grams of matter reacted must equal the number of grams produced.

**Think about this metaphor**: **You can't clean something without something else getting dirty**  .....

or **Whatcha' put in .... ya gotta get out** ... It's that straight forward....

Here is a very non-science means of looking at the conservation of matter... and what we mean by

chemical reactions.... Take some notes, as I demonstrate and lecture….

\* DORMITORY → DIRTY ROOM

\* THE MORSE CODE → HERE COME DOTS

\* SNOOZE ALARM → ALAS NO MORE ZS

C) LCME was first articulated, by Antoine Laurent Lavoisier (and his wife, Marie-Anne) .

[](http://www.bc.edu/bc_org/avp/cas/his/CoreArt/art/resourcesb/dav_lavois.jpg)In a **closed system,** the mass of the reacted contents equals the mass of the

contents of the system after the reaction is completed.

The Lavoisiers carefully massed the reactants (ingredients) and the products

of a chemical reaction. They showed that while the matter may change its

state (e.g. solid reactants may, via new bonds, become gaseous), the total mass of the matter (products) in the reaction chamber, is the same at the end

as the mass of the matter at the beginning of the experiment.

Much later, this idea was expanded to incorporate energy.

David's *Portrait of Monsieur Lavoisier and His Wife*

<http://www.bc.edu/bc_org/avp/cas/his/CoreArt/art/neocl_dav_lavois.html>

1) N.B: The LCME is best applied to issues of **reaction chemistry**, and does not apply at all

times to nuclear reactions, under all circumstances. There are nuclear reactions in which

mass is converted to energy, & vice versa. (e.g. Via nuclear fusion, the Sun, releases energy

as matter is converted to energy (400 million, million, million, million watts of energy/minute

are released by the sun.) *Wonders of the Solar System: Empire of the Sun with Professor Brian Cox [Note: 1 watt = 59.9 joule/minute]*

|  |  |
| --- | --- |
| Component | Mass  (grams/serving) |
| 1 scoop Chocolate Ice Cream | 72.3 |
| 1 scoop Vanilla Ice Cream | 71.5 |
| Hot Fudge | 37.0 |
| Banana | 122.0 |
| Whipped Cream | 2.1 |
| Cherry | 6.7 |

Try These!

1) Use the table of mass to complete this questions

Calculate the mass of a hot fudge banana split sundae made with 2 scoops of vanilla ice cream, 1 scoop of

chocolate ice cream, 3 servings of hot fudge, 1 banana, 2 servings of whipped cream and two cherries.

Math Set Up:

\*2(71.5 grams) + 1(72.3 grams) + 3(37.0 grams) + 1(122.0 grams) + 2(2.1 grams) + 2(6.7 grams)

ans: 465.9 grams

2) Given the balanced equation representing a reaction for the formation of water: 2 H2 + O2 → 2 H2O

What is the total mass of water formed when 8 grams of hydrogen (H2) react completely with 64 grams of

oxygen (O2)?

(1) 18 grams (2) 36 grams (3) 56 grams (4) 72 grams

D) Mass: \* a measure of the quantity of matter an object possesses OR the property of an object that

causes it to have weight in a gravitational field

1) Mass is best described using physics … and that really doesn’t help first-year chemistry

students …. yet it is an elegant description. There is the concept of INERTIA (The tendency

of an object to resist changes in its motion)…

The odds of an object to resist changes in its state of motion varies with its mass. The

greater an object’s inertia, the greater the object’s mass. A more massive object will

have a greater tendency to resist changes in its motion. A less massive object, will have

a relatively lesser tendency to resist changes in it motion (It will be altered or moved,

more easily. Thus, it has less mass.)

2) basic International System (SI) unit = kilograms

Note: 1 kilogram = 1,000 grams

e.g) 1,000 g = 1 kg or 500. g = 0.500 kg



3) Weight: \* pull of gravity on the mass (weight may change, mass does not )

a) SI unit: kg·m/s2 or Newton

English unit: pound (lb)

When we measure an object on a balance, we are measuring against a standard mass. And

while it isn’t surprising that mass and weight are used interchangeably –it is *incorrect* to

do so, really. You see, the concept of “weight” becomes important, **only when the force**

**exerted by gravity is changed.** Since that force is a constant from the balance to your desk

(unless your desk is at the top of Mt. Everest), the term weight is not wholly appropriate.

However, when the gravitational force changes, the **weight** of an object from one point to

another, can change, but its mass (the inertia) is essentially constant.

b) Think of an astronaut weighing 120 lbs here on Earth. We all know that when she gets to the

Moon, she will experience a sense of “weightlessness”, *to some degree*. She can ...jump

higher, hit a golf ball farther.... So, what has happened? Did she lose mass? If so, which part

of her body did she have to cut off? WHAT!? Is there any another explanation?



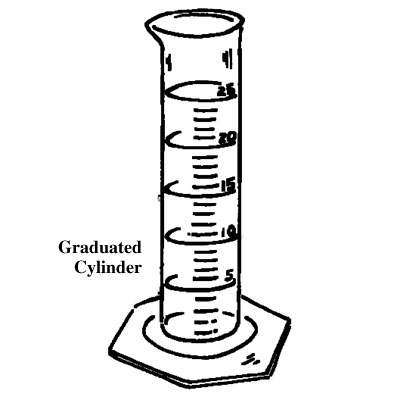
Check out: <http://www.exploratorium.edu/ronh/weight/>

E) Volume: \* the (amount of) space occupied by matter [units: mL or L]

1) regular cube: Length x Width x Height \* e.g. 1 cm x 1 cm x 1 cm = 1 cm3 or 1 cc



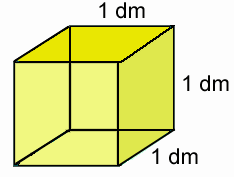
2) Archimedes and Water displacement



3) 1 Liter = 1,000 mL = 1,000 cm3 (cubic centimeter or *cc*)



http://www.squidoo.com/King\_Bidgood



<http://core.ecu.edu/chem/chemlab/equipment/evolumetricflask.htm> cubic decimeter

<http://www.chem.uiuc.edu/webFunChem/volume/volume3.htm> <http://core.ecu.edu/chem/chemlab/equipment/egcylinder.htm>

4) solids and liquids tend to have \* constant volumes

a) If you transfer a solid object from one vessel to a different yet larger vessel,

the volume of the solid \*would remain the same (would be unchanged)

b) When you transfer 100 mL of water from a 400 mL beaker to a 1,000 mL beaker,

the volume of the water (liquid) \* remains the same

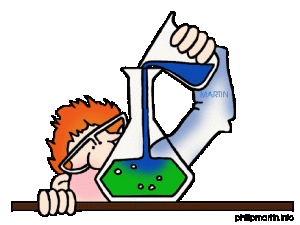
5) gases have no constant volume. The volume of a gas may be reduced or expanded

dramatically, as the conditions of temperature and pressure change.

think: s.c.u.b.a., hot air ballooning, human breathing, ear's popping, home heating

systems, aerosol spray cans, butane lighters , phlebotomy etc...

A CAPSULE OF COVID CHEMISTRY



So, I have given some thought to a few questions:

1) Why is the *minimum* standard alcohol content of hand sanitizer,

generally listed as 70% isopropyl alcohol OR 60% ethanol?

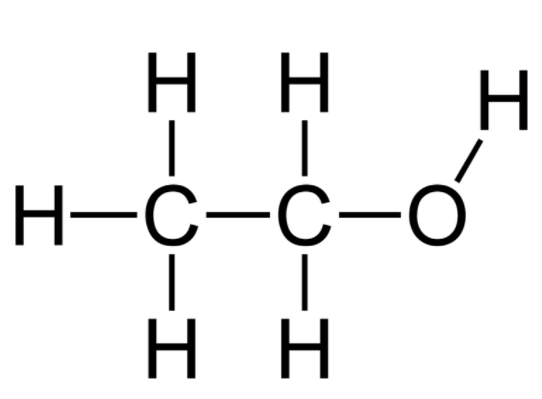
Why are they different percentages?

2) Why is 70% isopropyl alcohol standard? Would using 99.9%

isopropyl alcohol be better than 70% isopropyl alcohol?

A picture containing clock

Description automatically generated



Ethanol Isopropyl alcohol

ethyl alcohol 2-propanol or isopropanol

in liquor in rubbing alcohol

<https://pediaa.com/difference-between-isopropyl-and-ethyl-alcohol/> <https://byjus.com/chemistry/isopropyl-alcohol/>

You may have heard that viruses may be enveloped or nonenveloped. Enveloped viruses are replicas of the original invading virus which tend to be wrapped in lipids (fats) and proteins which often come from the host cell. (<https://www.cancer.gov/publications/dictionaries/cancer-terms/def/enveloped-virus>)

It is believed that this envelope helps to protect the genetic material of the virus by evading the host body’s defense system. Ethanol and Isopropyl alcohol have the ability to unravel and destroy the protective proteins and fats.

Nonenveloped viruses lack this protective feature.

Of the two compounds (ethanol and isopropyl alcohol), ethanol is the better disinfectant, except when dealing with certain fungal infections and bacterial spores. It has a strong ability to kill enveloped viruses (e.g. herpes, influenza virus, and SARS CoV-2 [coronavirus]) as well as nonenveloped viruses (rhinovirus, norovirus )… and even HIV, when ethanol is in concentrations from 60% to 80%. So, the 60% is the minimum concentration that is an effective disinfectant … and 80% is the upper limit.

A mixture of 60% ethanol means that there are 60 mL of ethanol and 40 mL of water, dissolved into each other, in 100 mL of solution. A mixture of 80% ethanol means that there are 80 mL of ethanol and only 20 mL of water, dissolved into each other, in a 100 mL solution.

Of the two compounds, **ethanol is a slightly smaller compound** than isopropyl alcohol. Note that many different words may be used to describe ethanol… such as molecular (molecule) organic, and of course, compound. We will learn what these terms mean, over the course of the semester.

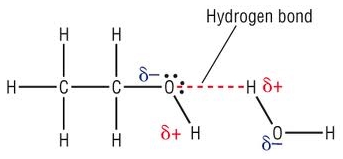
When we do the math, (and we don’t need to do any math here …) there is a massively larger number of **molecules** in a 60% ethanol solution, than in an isopropyl solution of equal concentration. **So, there are more disinfecting molecules in 60% ethanol, due to its smaller mass / size when compared to the same volume of isopropanol.** Hence, you do not NEED a greater concentration of ethanol.

Conversely, the above means that due to the larger size of the isopropyl alcohol (also, an organic, molecular compound), in order to approximate *the same efficacy* of disinfection as 60% ethanol, you need a greater concentration (more molecules per unit volume) of isopropyl alcohol. <https://ehs.umich.edu/wp-content/uploads/2020/05/70-alcohol-FAQs.pdf>

Isopropyl alcohol is not terribly effective against nonenveloped viruses … but fairly effective (in higher concentrations) against enveloped viruses (like SARS CoV-2!) <https://ehs.umich.edu/wp-content/uploads/2020/05/70-alcohol-FAQs.pdf>

Now, you can go to amazon.com and purchase a very concentrated form, of isopropyl alcohol …99.9% !! **However, isopropyl alcohol is NOT a better disinfectant past a 70% concentration (70 mL/100 mL of solution). In fact, it’s worse!!! That is: 70% isopropyl alcohol is a better disinfectant than 99.9%!!!** Hopefully, you are asking….why?

Well, there are 2 reasons. The first is that the 99.9% solution evaporates away too darn quickly. You need the alcohol to linger around to do its damage to the virus. So, the purer stuff needs to mixed it with water, to dilute it, and slow down the rate of evaporation. Many alcohols and water are insanely attracted to each other (It’s due to something called hydrogen bonding). Anyway, the water inhibits the evaporation of the isopropyl alcohol, due to this mutual attraction between the molecules! So, here’s a lesson … more is not always better



<https://sites.google.com/site/chemistryolp/properties-of-alcohols>

The above diagram shows us a number of things … It implies a “mixture” of two different compounds: water and ethanol.

It shows / implies / hints at the:

* structure of ethanol and of water.
* number of covalent bonds in both ethanol and water. Those covalent bonds are drawn as solid lines.
* composition of ethanol (C, H, O) and water (H, O)
* formula for ethanol: C2H5OH or the less frequently used, C2H6O
* formula for water: H2O
* fact that a hydrogen bond (dashed line) is considered to be different than a covalent bond (solid line) and that somehow a slightly negative oxygen of alcohol and a slightly positive hydrogen of water are the cause of it all!!!

The second reason 99.9% is not as good a disinfectant as 70%, is how isopropyl disinfects. You see, upon contact, isopropyl alcohol disinfects (kills) by coagulating proteins into a muddled, useless mass (sort of like a rubbery mess of a fried egg). **However, when the concentration is too high (beyond the 70% range)**, the alcohol tends to destroy the top layer of proteins, but this mess of coagulated proteins ends up protecting proteins buried beneath that mass. So, a less potent concentration of isopropyl alcohol, diluted with water is used to allow the isopropyl alcohol to permeate and destroy far more protein-wrapped viral particles. So, 70% isopropyl alcohol is a better disinfectant than 99.9%! Again… more is not always better. Stronger is not always better

The FDA (Food and Drug Administration) has a list of hand sanitizers to avoid (<https://www.fda.gov/drugs/drug-safety-and-availability/fda-updates-hand-sanitizers-consumers-should-not-use#products>.

These 120 or so, different hand sanitizers appear to be contaminated with methanol and/or 1-propanol. You should avoid the use of these products, because methanol can penetrate the skin and be absorbed into the body. Methanol poisoning can cause blindness. 1-propanol is not absorbed through the skin, but its ingestion (or its more probable inhalation) can cause respiratory inflammation (<http://datasheets.scbt.com/sc-213408.pdf>). Chemists at the FDA are worried that were someone with covid-19 to use a 1-propanol sanitizer, their already compromised lungs and/or respiratory system would suffer an even greater degradation.

So the take home message through this all is find hand sanitizers made only with ethanol or isopropanol (both with a proper concentration). Okay??

**Assignment:** Use the preceding reading on ethanol and isopropyl alcohol, and some research to answer

the following questions. Copy and paste these questions into another word document. Email this document with the questions and your responses to me, for as credit-bearing assignment. Some of the answers come directly from the reading. Others will require some online research…Send your document to: [digaetanot@wcsu.edu](mailto:digaetanot@wcsu.edu)

Paradiso: These answers should come from analysis of the reading…

1) What is meant by an enveloped and non-enveloped virus?

2) Record two reasons why 70% isopropyl alcohol is a more efficient disinfectant of the SARS-CoV-2 virus

than 99.9% isopropyl alcohol.

3) What symbol or convention is used to indicate covalent bonds, when drawing a molecular structure?

4) You find a hand sanitizer made with 80% ethanol. Is it okay for you to use? Explain…

Purgatorio: The answers to these questions should involve some pretty straight up research & a touch of work

5) Electrons make covalent bonds (chemical unions between atoms). How many electrons does a single

covalent bond represent?

Inferno: **Hell!** These will require some creative research on your part. They will push you into realms of information and/or

knowledge, with which you are not yet familiar. I use these as primers for further learning and discussion.

6) C2H5OH (ethanol) is an alcohol. CH3OH (methanol) is an alcohol. C4H7OH (1-butanol) is an alcohol .

NaOH (sodium hydroxide) is NOT an alcohol, it is a strong base. KOH (potassium hydroxide) is not an

alcohol, it is also classified as a strong base.

Both alcohols and bases have (OH) groups. However, the chemistry of an alcohol and a base are

wildly different from each other. **Question:** How can you determine when you are looking at the

formula of an alcohol, vs. the formula for a base? (Research and cite your source(s))

7) Identify one side effect, should someone DRINK hand sanitizer made with isopropanol (isopropyl alcohol).

(Research and cite your source(s))

F) Density = Mass

Volume

Maybe the following is a different way of seeing density...

1)Density is a measure of \* the *compactness* with which mass is packed.

Note: \* density ≠ heaviness

a) essentially, at a constant temperature and pressure, the density of a substance is a

constant.

i) as you increase the mass of a substance, the sample become more voluminous

(Volume, scales with the mass)

b) Compression (especially of a gas sample) increases density \*(more compacted)

c) Heating matter, tends to result in the decrease of a material's density

....gases when heated, tend to increase volume (expand).... thus decrease density

....solid metals when heated, tend to increase in volume and thus expand ...

i) in the above cases of heating, the substance becomes \*less compacted

**TRY THIS: ∞**Consider two cubes of pure iron

Barbara has 20 cm3 of iron and Meghan has 60 cm3 of iron, at the same temperature and

pressure. Which statement is FALSE?

\_\_\_ Meghan’s sample has 3 times the density of Barb's sample.

\_\_\_ Meghan's sample has 3 times the volume of Barb’s sample.

\_\_\_ Meghan's sample has 3 times the mass of Barb's sample.

Defend your reasoning: \*The temperature and pressure of the iron samples are the same, thus

the density is the same. Density is a constant. Volume of a sample scales with the mass, thus

M/V is the same.

**TRY THIS: ∞** Which member of the following pairs has the greater density? (Circle one member of each pair

as the answer) One pair is a trick ... in one of the pairs both examples have the same density ... can you

figure it out and why?

pair 1) liquid water (H2O(l)) *or* ice (H2O(s))

pair 2) helium (He(g)) at 0°C and 1 atm *or* air at 0°C and 1 atm

pair 3) olive oil *or* water

pair 4) 25 L of CO2(g) at 0°C and 1 atm *or* 1 L of CO2(g) at 0°C and 1 atm

Identify the “trick pair and defend your thinking as to why it is a "trick pair": Be sure to have a “because”

statement that cites data, a specific theory from your notes, cites an equation or uses an appropriate metaphor.

\* The 4th pair is the trick pair. The densities are the same. The members of the pair are the

same chemical and each is at the same temperature and pressure. They have the same

density *because* density of a chemical is a constant (the same), regardless of volume or

mass, when the conditions of temperature and pressure are the same.

2) Density and Water....

a) Liquid water is the densest at approximately 4 ºC. (really 3.98 ºC ... but, c'mon!)

∞ At this temperature, water has a density of 1.00 gram/mL

∞ Below 4 ºC, and above 4 ºC, water is less dense than 1.00 g/mL

b) About **71 percent** of the Earth's surface is water-covered, and the oceans hold

about **96.5 percent** of that water. Use the following graphs to determine what

percent of that 71%:

i) is drinkable (potable) water? \* 3 % and, of that %, what percent

ii) is actually accessible to us? \* < 1 % Of this accessible water, what

iii) percent is due to humidity? \* 9.5 %

A screenshot of a cell phone screen with text

Description automatically generated

From: VanLoon and Duffy: Environmental Chemistry: A Global Perspective 4th ed 2017, p. 226

Source: U.S. Geological Survey <http://ga.water.usgs.gov/edu/waterdistribution.html> , accessed November 2016,

and taken from Gleick, P.H., Water resources, in Encyclopedia of Climate and Weather, ed. Schneider, S H,

Oxford University Press, New York; vol. 2 pp 817-23 1996

c) Water is Weird!

i) The solid phase of most substances is the densest phase ...BUT ...

ii) For water, the solid phase (we call that phase, \* ice ) is

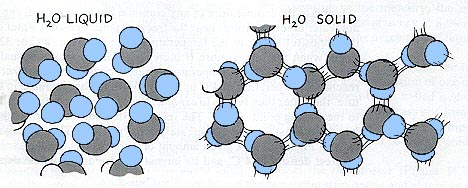
\* less dense than the liquid phase!

Therefore ice floats .... and it's a good thing that it does... Imagine

the consequences (or perhaps, ramifications to life) if it were not to

float…

Or, as Paul Hewitt (the author of Conceptual Physics (2006, p 318) writes ....with some editing by me...



Water molecules in crystal form have an open-structured hexagonal   
 arrangement, so water expands upon freezing (water becomes less dense).

**How Lakes Freeze**

There are 2 key temperatures to remember. **Water is densest around 4°C** but it does not freeze until 0°C ....

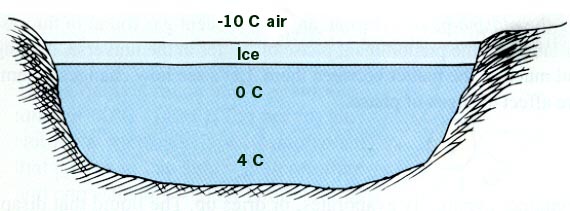
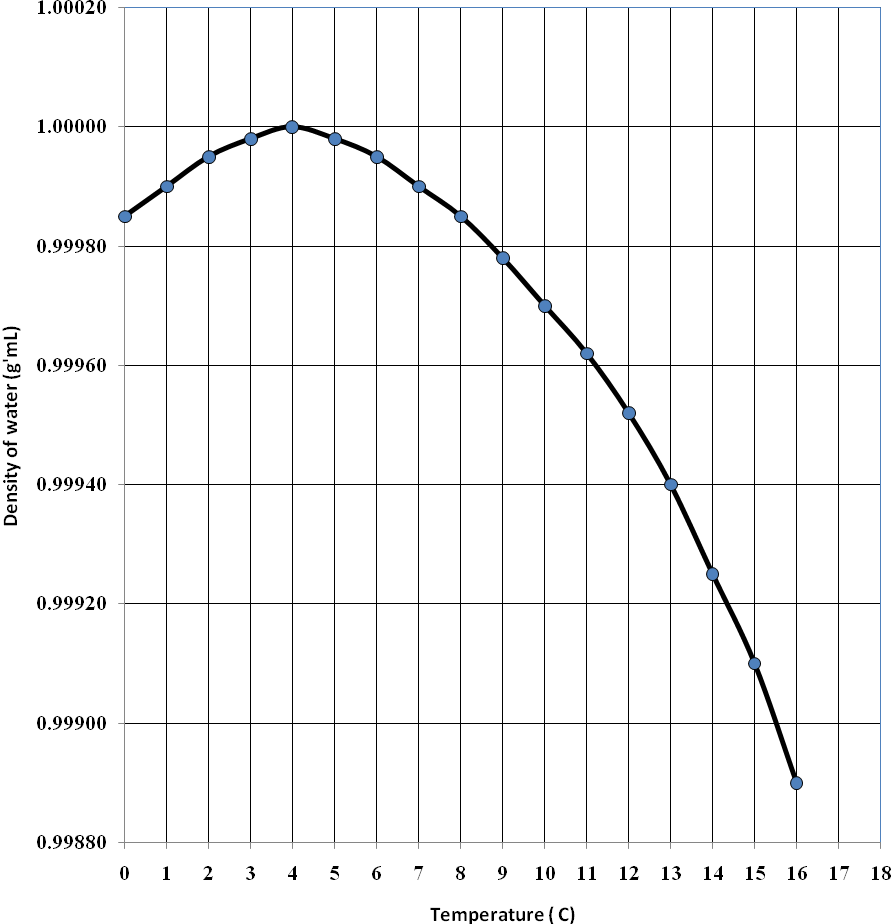
As air above a lake cools, (e.g. from 16°C to 4°C) the water at the top contracts **and becomes denser** than the water below the top layer. This cooler, denser water sinks and **warmer** water rises and takes its place at the top.



This circulation of water, will eventually, bring the vast amount of the lake's water to 4°C. This is as dense as the water can get. Now, think ... water can't become any denser ... but it does become *less* dense ... once it freezes.

Remember, energy moves from high levels to low levels, so as the air continues to cool, (it's winter!!!), the warmer water will continue to lose energy to the air, drop below 4 °C and become *less* dense ... The UPPERMOST (top) layer of water *is especially vulnerable* to this temperature change and drop in density, because the top layer is *less insulated* from changes in air temperature.

So, as the top water layer cools below 4°C, the water incurs a *further decrease* in (water) density. Because the top layer of water is becoming less dense, the matter must be "spreading out", increasing its volume (EXPANDING!) Thus an expansion of the top layer's volume (same mass, with lower density = greater volume). So, the (colder) top layer becomes less dense than the water below. The water at the top stays on top, and ultimately freezes at 0°C and lower.

 Density as a function of Temperature

from: *Conceptual Physics* p 319 (Paul Hewitt)

Question: Use the graph on the preceding page. Consider that climate change is a real issue, and that the

temperature of the Earth’s atmosphere and water is increase.

As water warms, what happens to its density? \*decreases .

As this change in density occurs, using D=M/V what must then happen to the water’s

volume (space occupied)? \*increases

As this happens, what will happen to the depth/height of sea level? \*increase

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

**Okay, so through a bit of meandering … we have defined matter, energy, mass, volume, weight,**

**and density. Earlier in the notes, I used the word, chemicals, …. So,**

V) What are chemicals? Essentially, a “chemical” is matter classified as a substance (any element or

compound), OR any mixture of substances.

A) Substances

1) Substances are homogeneous (pure, uniform throughout) chemicals, in which samples

are made of only 1 specific element **or** 1 specific compound, in the **solid, liquid or gas**

**phase**.

2) Ideally, substances are unvarying in their physical characteristics … Hence, a substance is

expected to have a single (constant) melting point, one normal boiling point, a constant

density (at specific temperatures and pressures).

3) There are 2 different categories of **substances**

a) Elements: a sample of matter (a chemical) in which all of the atoms in the sample,

have the same atomic number. The matter on the periodic table …

i) recognition skill: \* only one type of capital letter in the symbol, and

a true (s), (l) or (g)

ii) Elements cannot be decomposed into any simpler substance.

N.B. The atoms of an element can be “smashed” into protons neutrons and electrons …

but these are subatomic particles …not substances…. (Ah, vocabulary!)

Metaphor: Think of an element, like a single letter of the American alphabet.

b) Compounds: a sample of matter (a chemical) made of 2 or more different elements

that have been combined via chemical bonds, in a definite proportion.

i) recognition skill: \* 2 or more different capital letters with (s), (l), (g)

ii) Compounds have a definite proportion between the components. This ratio

is represented by the subscripts. These subscripts cannot be changed for the

specific compound.

iii) Compounds can be chemically decomposed into simpler compounds or back

to their elements.

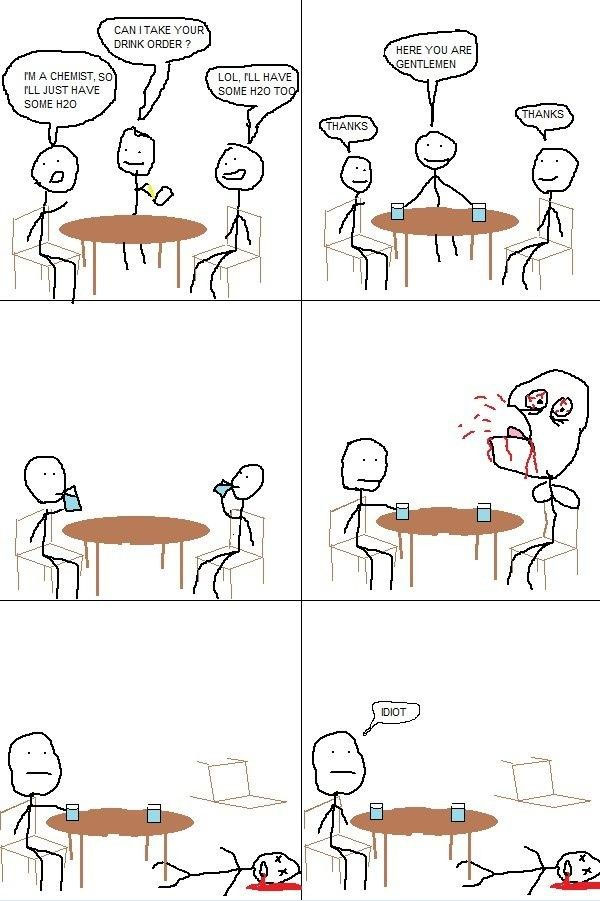
CdCO3(s) → CdO(s) + CO2(g) or 2 H2O → 2 H2(g) + O2(g)

Metaphor: Think of a compound as a unified group of letters, forming a word. Change a letter of

the word or the number of a letter, you change the word. Thus, if you were to change

any one of the elements or the number of a specific element of a compound, you

change it to a different compound!



<https://www.chemistryjokes.com/jokes/can-i-take-your-drink-order/>

B) Mixture: \*a physical combination of at least 2 different substances, in varying proportions,

in which the component substances generally keep their physical characteristics.

1) Properties of Mixtures

a) The composition may be varied.

b) Mixtures are not *true* solids liquids or gases. Many are dissolved in water, and are

called aqueous solutions. An aqueous solution often has (aq). e.g. NaCl(aq)

c) The physical characteristics of a mixture depend upon the components and their

concentrations

d) The components of a mixture can be separated from each other, via physical means,

such as filtration, chromatography, evaporation, distillation etc…

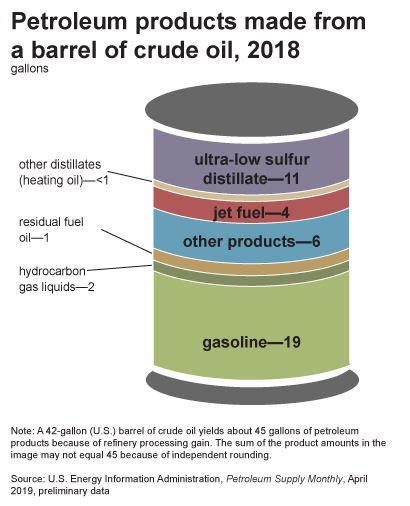
e) Mixtures may be homogeneous or heterogeneous

![](data:None;base64,) **GIMME A METAPHOR!!**

Think of: \*a tossed salad

![](data:None;base64,)

2) Take for instance, everything chemistry provides us from one 42-gallon barrel♦ of petroleum.



|  |
| --- |
| The vast amount of oil is used to produce fuels of some sort (the most being gasoline) |
| Approximately 6.5 gallons of each bbl♦ makes our: |
| Aspirin |
| Plastics (et. al.) skis, helmets, cleats, fishing lines, polishes, shoes, vinyl, basketballs, faucet washers, dice, bandages, toilet seats, PVC piping, plastic wrap …. |
| Paints |
| Rubber for gaskets, tires, wiper blades |
| Nylon / Yarn |
| Polymer Fibers for Slacks / Dresses |
| Perfumes |
| Detergents / Ammonia / Deodorants |
| Inks |
| Hair Coloring Dyes / Clothing Dyes |
| Dashboards / Vinyl Siding |
| Roofing Shingles |
| Cortisone / Antihistamines |
| Antiseptics |
| Makeup: lipstick, foundation, mascara |
| Fertilizers / Insecticides / Pesticides |
| Candles |
| Hand Lotion |
| Contact lenses / TV screens |
| Shaving cream |
| Shampoo |
| Latex: condoms, balloons  <https://www.ranken-energy.com/index.php/products-made-from-petroleum/> |

<http://www.eia.doe.gov/kids/energy.cfm?page=oil_home-basics>

According to the above website, a 42-U.S. gallon barrel of crude oil provides

about 45 gallons of petroleum products. This gain from processing the crude

oil is approximately 7%.

This probably is due to changes in intermolecular forces of attraction

(see bonding unit) Smaller/Less massive hydrocarbons tend to exert weaker

intermolecular forces and have a lesser "pull" on surrounding molecules,

giving a less dense (and possibly more voluminous) mass of molecules.

♦The unit, bbl., is used to designate the standardized 42- gallon barrel, in which the crude

oil was shipped. The unit bbl. may have been used to avoid confusion with the unit

bl (for bale). There is a myth out there that it began with John D. Rockefeller, who

supposedly sealed every barrel of Standard Oil with a blue lid. However, the unit bbl.

was in use for about 1 century prior to JD Rockefeller and the oil boom of 1880s.



Data: <https://www.eia.gov/totalenergy/data/monthly/#petroleum>

VI) 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 really 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

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

B) POtential Energy = Energy of \* POsition (or distance between objects, if you wish...)

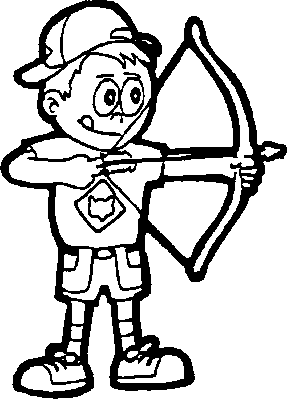
POtential Energy is essentially due to a POsition of objects: It is the energy (ability to do work) possessed by an object, due to its position relative to some standard (assumed) second position.

This is intimately linked to changes in chemical bond energies, phase changes, the production of light, and intermolecular forces of attraction(s)

This applies to bond theory, because 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 energy must go somewhere …. Often it is converted into thermal energy and it is released.

Vs.

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>

/



Vs.

Snap!!

Lower Energy

Higher

Energy

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**



Check it out: How CO2(g) affects Climate Change:

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

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

1) Generally, the examples o f 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…)



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)

<http://tinyurl.com/3ja8uft>

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**. In Joule’s own words: “The amount of heat

produced by friction is proportional to the work done and independent of the

nature of the rubbing surfaces” (The Extraordinary Chemistry of Ordinary Things Snyder 4th ed. p 179)

i) Heat is the **process** re: 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**

 **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? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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_(physics_and_chemistry)) of motion whichclassically contribute to the heat capacity of a thermodynamic system." <http://en.wikipedia.org/wiki/Heat_capacity>

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



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

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

(think source to sink)

\* 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?

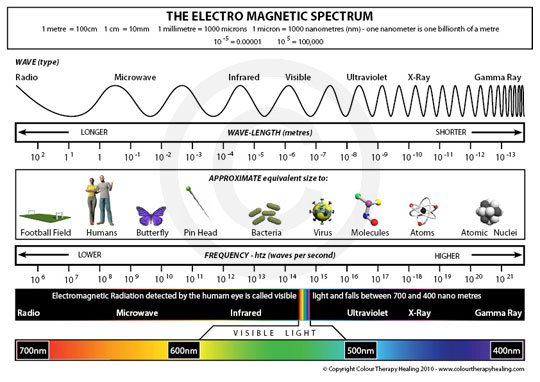
\*leg to cold pack …. area of higher temperature to area of lower temperature

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 the cold pack gets warmer.

VII) 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 a number of different types of radiation …but each related to the

movement of electrons.

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

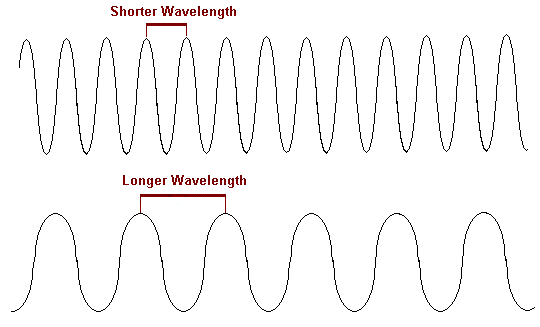
called **quanta**. A **quantum** of energy is the amount of energy required to move an electron from

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

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)

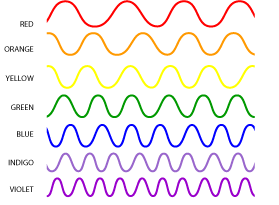


a) shorter wavelength, thus: greater frequency

b) longer wavelength, thus: lower frequency

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

**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>



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