Topic #4
ENERGY & MATTER OVERVIEW

OBJECTIVES:

To review basic physical concepts of energy and matter and some key ways in which they interact.

CLASS NOTES: pp 21 - 25

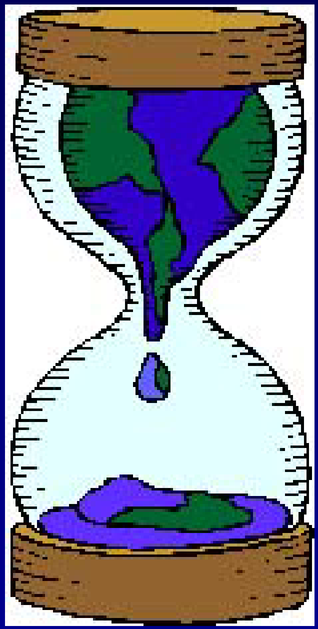
☺

"Science shows us that the visible world is neither matter nor spirit;

the visible world is the invisible organization of energy."

Heinz R. Pagels (b. 1939), U.S. Physicist

LINK TO GLOBAL CHANGE:



These concepts provide the ‘foundation’ for understanding:

a) the important energy fluxes (transfers) in the Sun-Earth-Atmosphere system, and

b) the important moisture fluxes and phase changes of water (H_2O) at the Earth-Atmosphere interface.

QUICK
ENERGY REVIEW

p 21

Energy Terms & Units

Energy (def) = the quality of an object that enables it to do "work;" the ability to do work.

Force (def) - A push or pull that, acting alone, causes a change in acceleration of the object on which it acts.

p 21

Energy Unit Review

Joule (or J) is the physical measurement for work.

One joule equals the work needed to lift one kilogram (2.2 pounds) ten centimeters off the ground. It can also be used to measure heat energy. One kilocalorie, an older energy unit, equals 4.1868 kilojoules.

Calorie (def) = the amount of **heat** required to raise 1 gram of room-temperature water 1 degree Celsius in temperature

1 calorie = 4.186 joules

1 calorie per second = 4.186 watts

(1 “calorie” in nutrition context = 1000 calories = 1 kilogram calorie or kilocalorie (Kcal)

HOW MUCH ENERGY IN A HURRICANE?

http://www.aoml.noaa.gov/hrd/tcfaq/D7.html

V) is done
) is exerted
Work is
at is exerted
over which it

POWER = work done divided by the time it takes to do it:

$$P = W / t$$

The POWER of A Hurricane!

http://www.nhc.noaa.gov/

Different Forms of Energy

- **Kinetic** (KE or KinE) = energy of ***motion***; the ability of a mass to do work.

KE = ½ (mass x $velocity^2$) or KinE = (1/2) ms^2

- **Potential** (PE) = energy a system possess if it is capable of doing work, but is *not* doing work now
  - Includes: **gravitational, elastic, chemical, electrical, magnetic, nuclear, thermal**

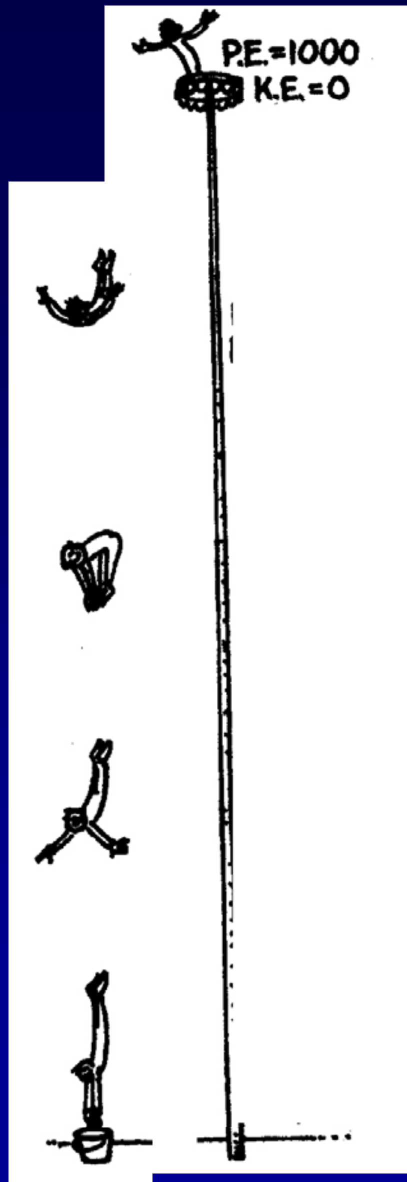
Forms of Energy

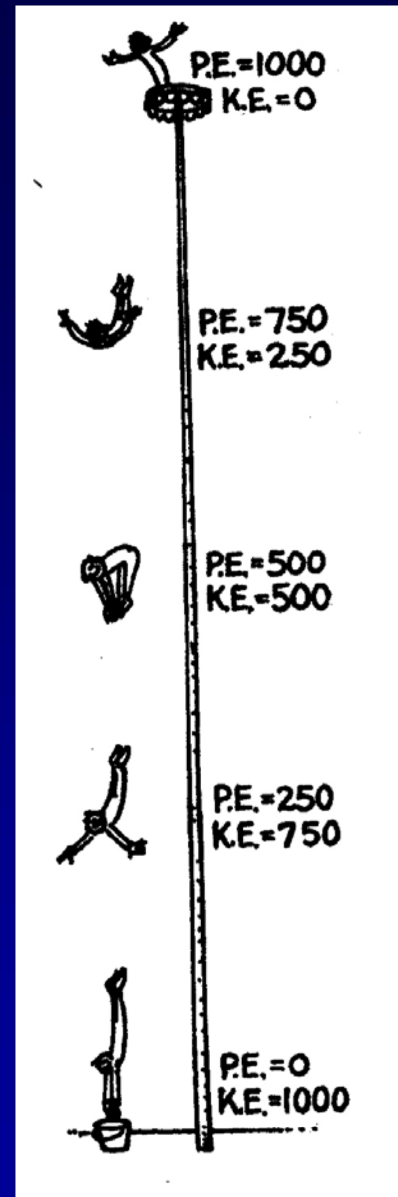
- **Gravitational PE** = energy associated with the position of a mass in a gravitational field, *energy stored by virtue of its position*

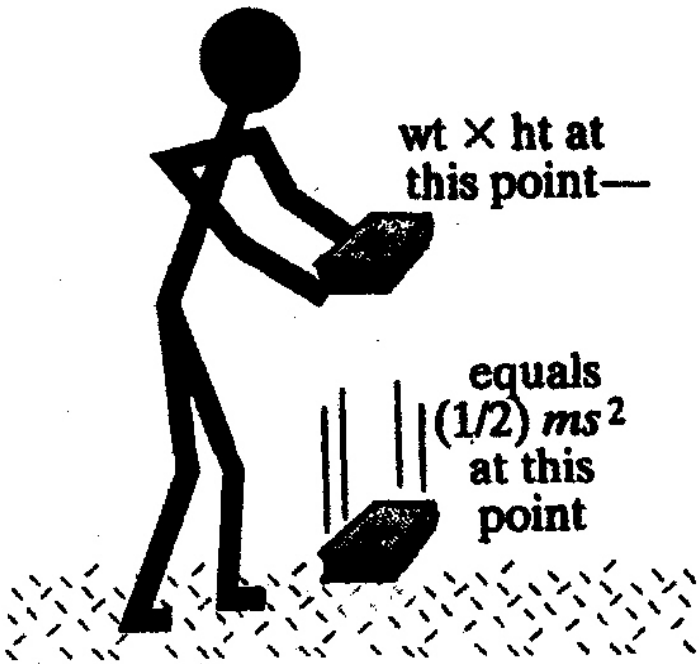
  GravE = weight x height = wt x ht

  Compare with:

  KinE = (1/2) mass x speed ^{2}


P.E.=1000
K.E.=0


P.E.=1000
K.E.=0
P.E.=750
K.E.=250
P.E.=500
K.E.=500
P.E.=250
K.E.=750
P.E.=0
K.E.=1000



An amazing thing: The gravitational energy at the beginning precisely equals the kinetic energy at the end.

GravE

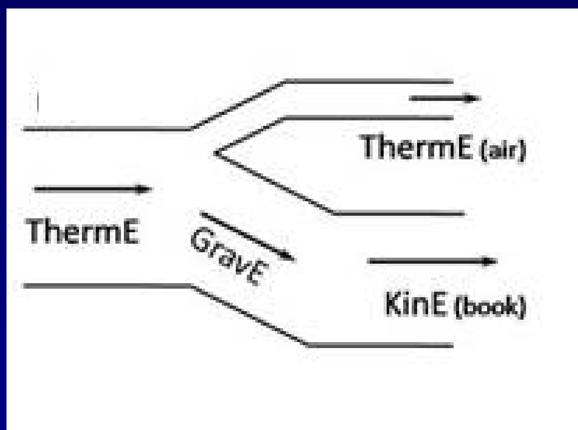
KinE

The total energy is conserved all the way down. The loss in gravitational energy between points 1 and 2 during the fall is precisely balanced

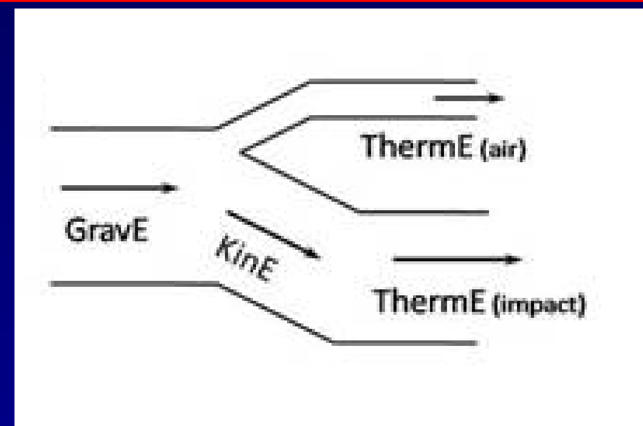
ENERGY IS CONSERVED!

Which figure below depicts an energy flow diagram that properly illustrates the energy transformations that occur with a falling book?

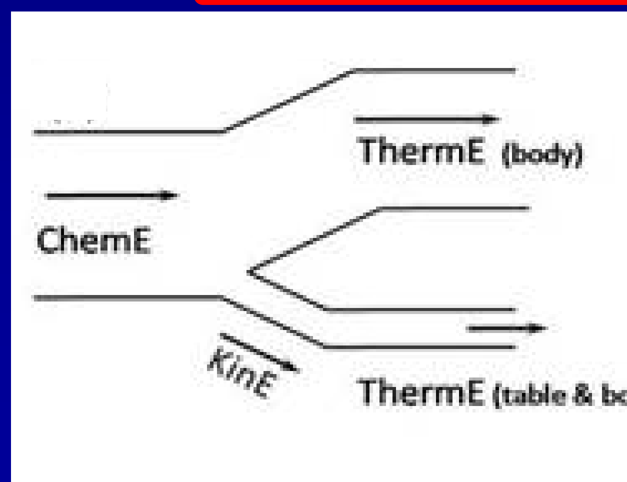
X



Y



Z



THERMAL ENERGY

Thermal energy (internal energy) =

The TOTAL ENERGY (kinetic + potential) of the particles that make up a substance.

Atoms and **molecules** are constantly "jiggling" in some sort of back-and-forth vibratory motion

*(i.e., they have **kinetic energy, KE**)*

The Law of Conservation of Energy:

"energy cannot be created or destroyed; it can be transformed from one form to another but the total amount of energy never changes."

Efficiency:

Although energy may not be destroyed, it can become ***inefficient*** -- i.e., is not easily used or available to do work!

Efficiency = work done / energy used

QUICK
MATTER REVIEW

Matter:

Whatever occupies space & is perceptible to the senses; made up of atoms; matter can be in form of solids, liquids, or gases

p 23

Atom:

-- Fundamental building blocks for all matter

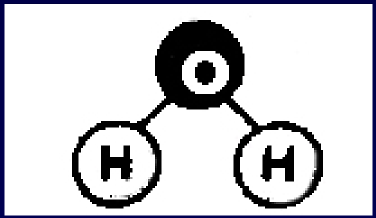
-- the smallest representative sample of an element.

Element:

A chemical substance (material) made from a single type of atom that cannot be broken down any further – and still maintain its identity as that element

. . . as in the *Periodic Table of the Elements*

Molecule:



-- Any collection of **two or more atoms bound together**

-- a cluster of atoms bound together

MOLECULES are the basic constituent of different kinds of materials.

-- the smallest part of any substance that **has all the chemical properties of the substance**

e.g., a water molecule = H_2O

STATES OF MATTER

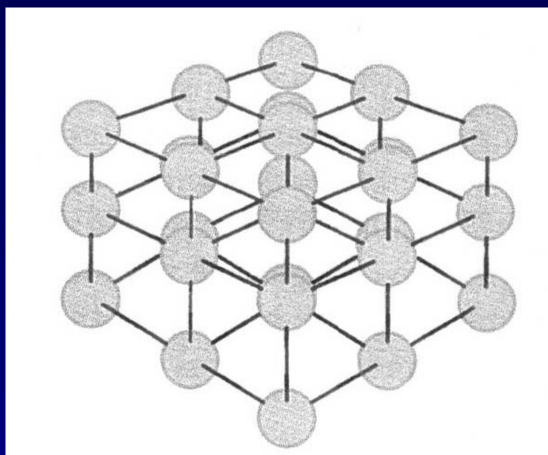
Solid:

-- a substance that resists changes of shape and volume

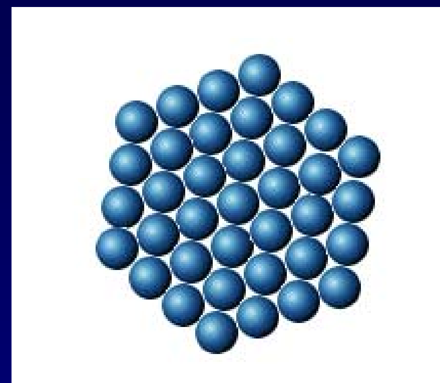
-- characterized by *structure* in the particular order and bonding of atoms that make up the material

Example = a crystal in which the molecules are locked into a strict geometrical order.

Various Representations of Molecules arranged in a SOLID

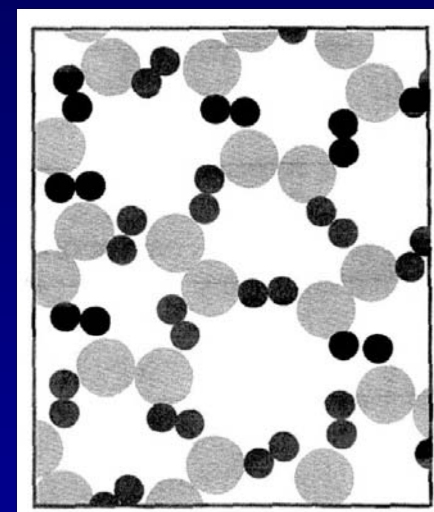


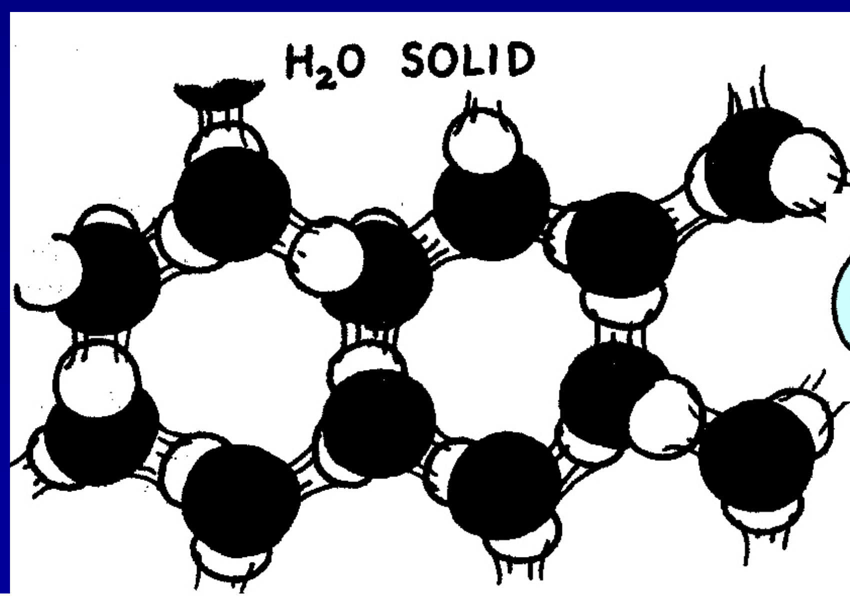
3-D view of a solid crystal structure



“top down” view of a Neon crystal

“top down” view of water (H_2O) arranged in solid (ice) for**m**





Liquid:

-- a substance that flows freely in response to unbalanced forces

-- molecules more or less move freely past one another as individuals or small groups

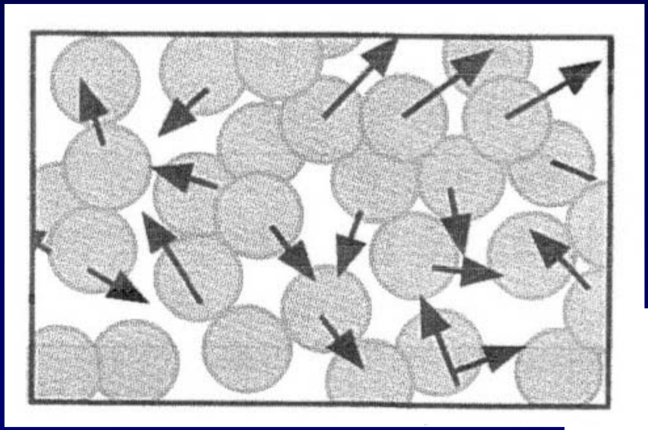
-- are not confined to fixed positions (as in solids)

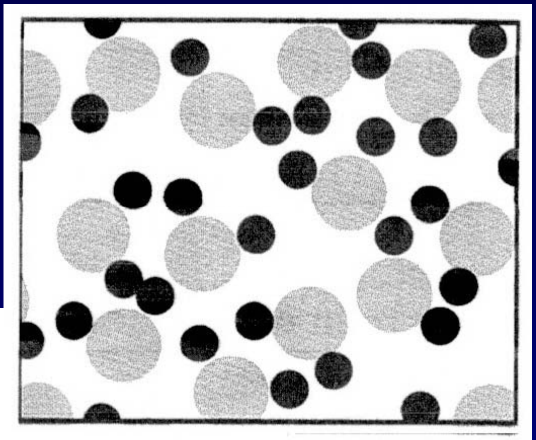
-- LIQUIDS CAN EXHIBIT PRESSURE

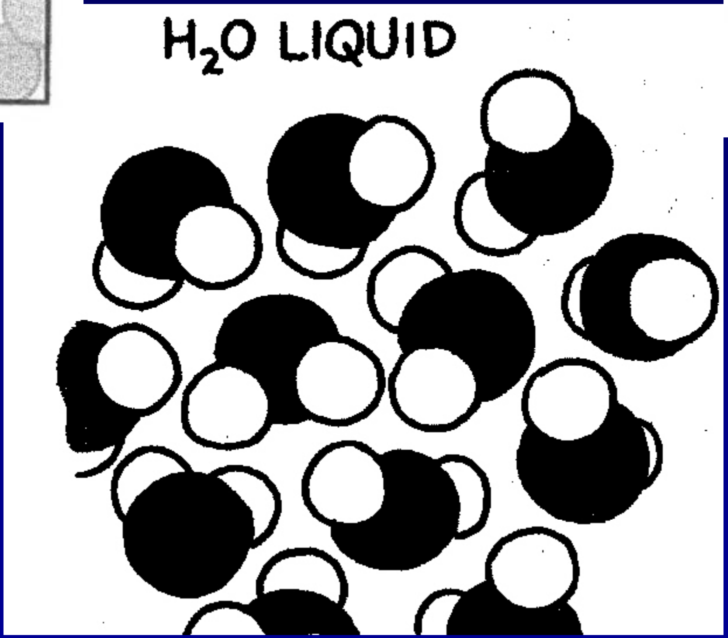
(pressure = a force per unit area)

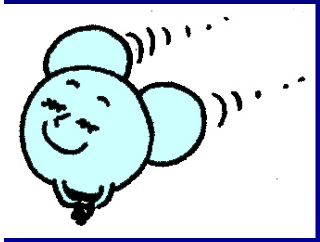
. . . and will take the shape of the container they are in.

Various Representations of Molecules arranged in a LIQUID









Gas:

-- a substance that expands (and contracts) easily, rapidly, and indefinitely

-- fills all space available to it

-- takes the shape of its container

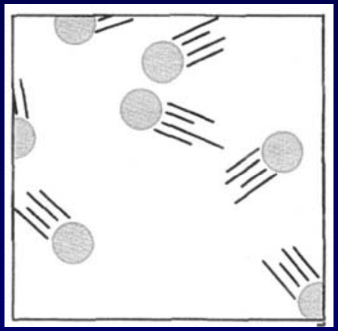
-- the distance between molecules is such that no cohesive forces exist

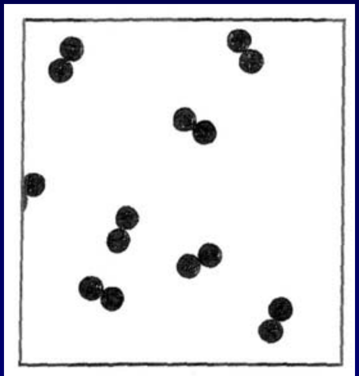
-- atoms or molecules are in high speed motion

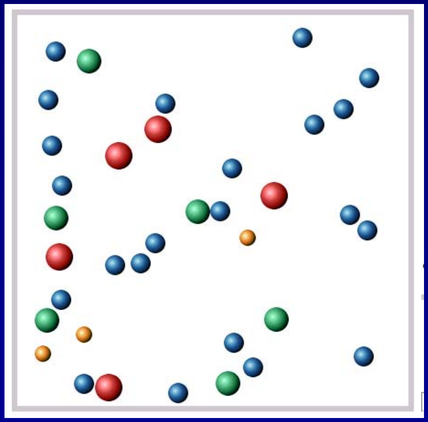
-- many collisions and rebounds occur

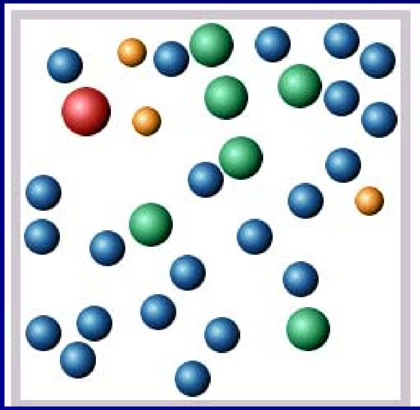
-- **GASES ALSO EXHIBIT PRESSURE**

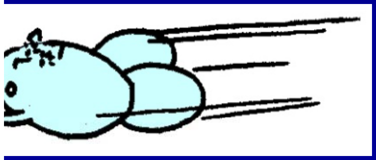
Various Representations of Molecules arranged in a GAS

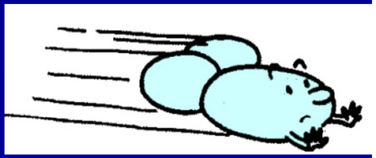








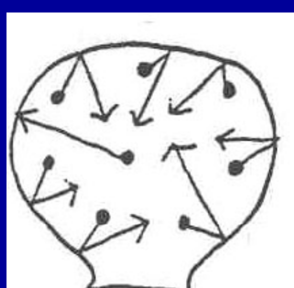




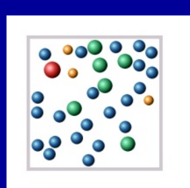
Heat added = increase in total energy
+ work done against outside pressure

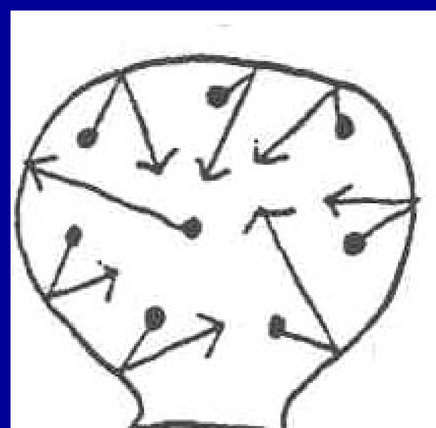
With increasing T (temperature)

→ Volume increases &
Density decreases

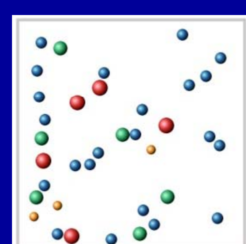


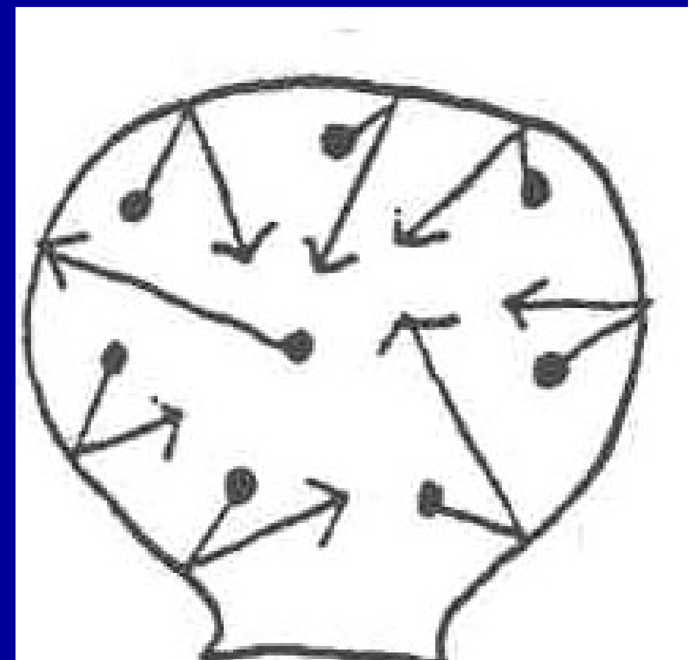
COLD



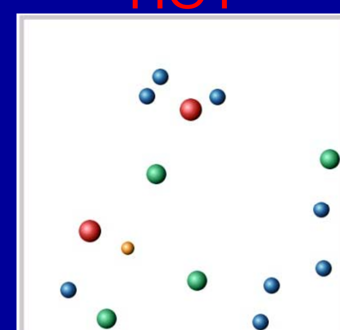


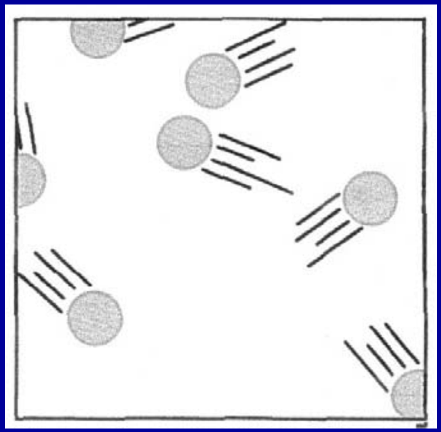
WARM





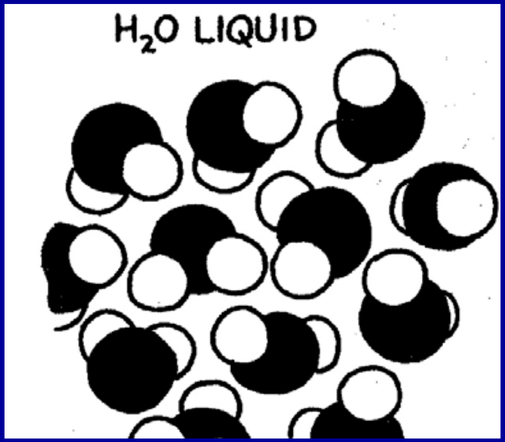
HOT



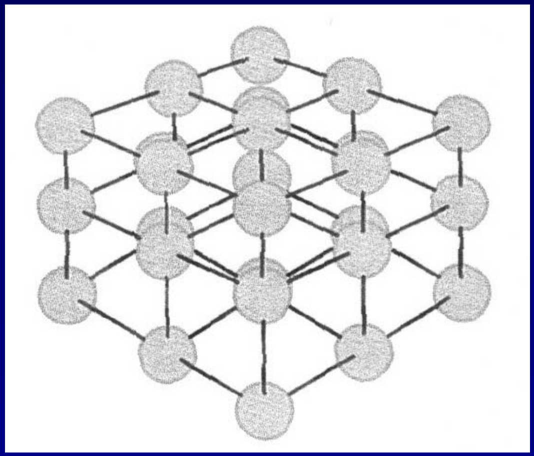


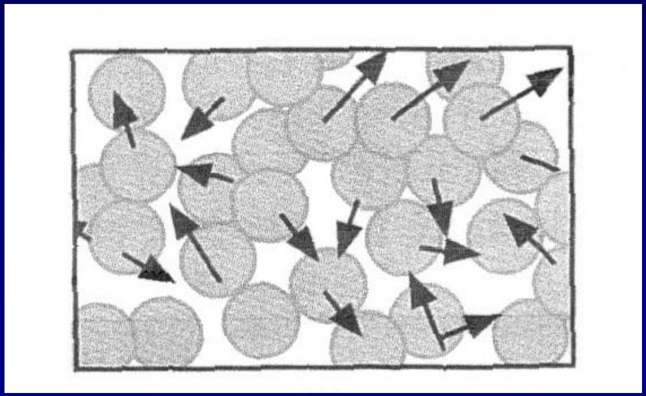
At higher air temperatures, H_2O molecules collide & rebound more frequently, leading to expansion of the air & the water vapor in the air.

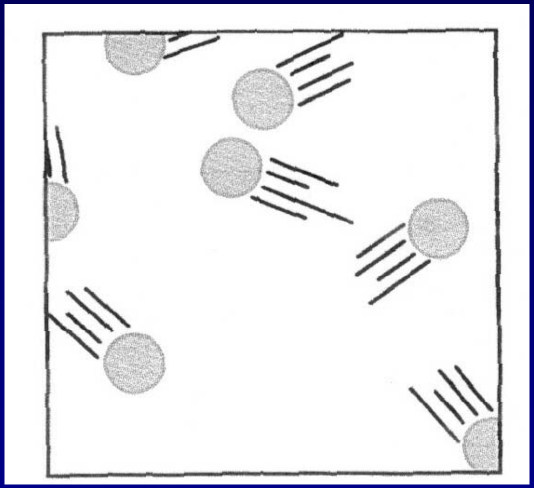
At lower air temperatures as air gets more dense, H_2O molecules are more likely to bond so that a phase change to liquid water or even solid ice can occur.



SUMMARY:







SOLID LIQUID GAS

KEY CONCEPT #1:

ENERGY & MATTER INTERACT

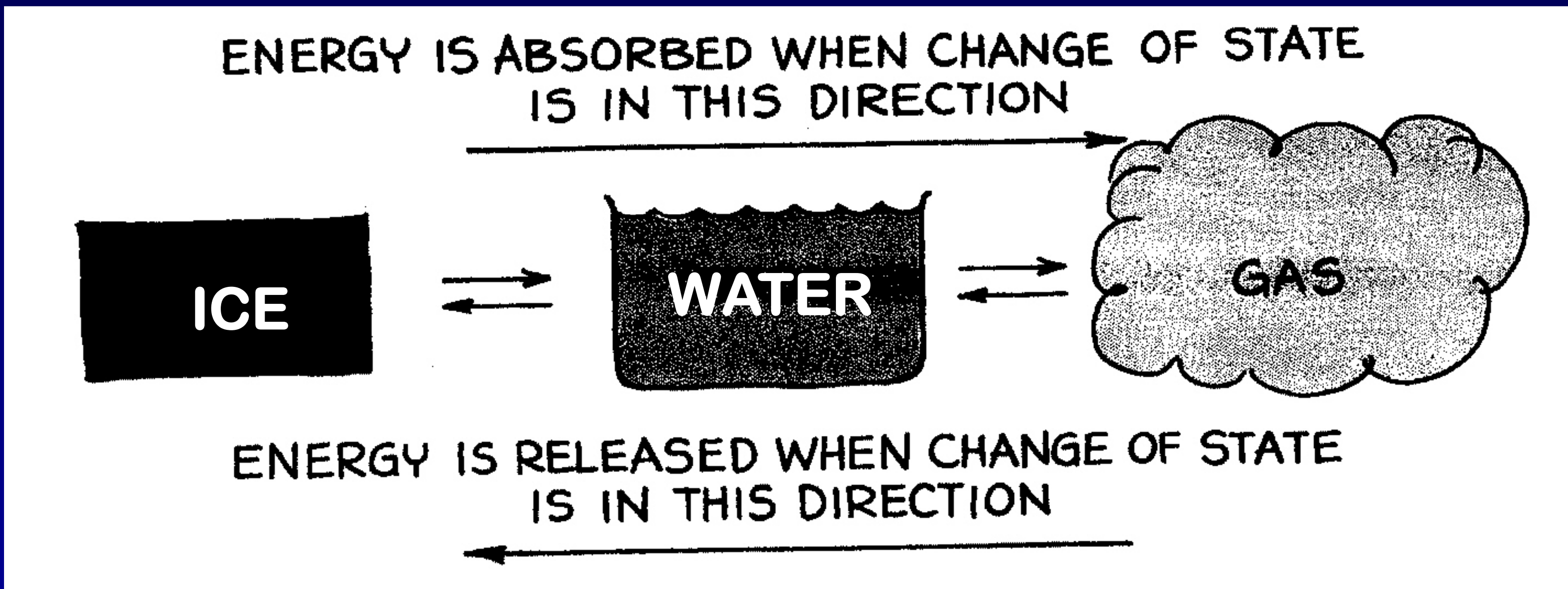
The change in the state of a substance
- from a solid to a liquid form, or
- from a liquid to a gaseous form,
(or vice versa)

is called a CHANGE OF STATE or PHASE CHANGE.

Thermal energy* *is involved in phase changes.

p 21

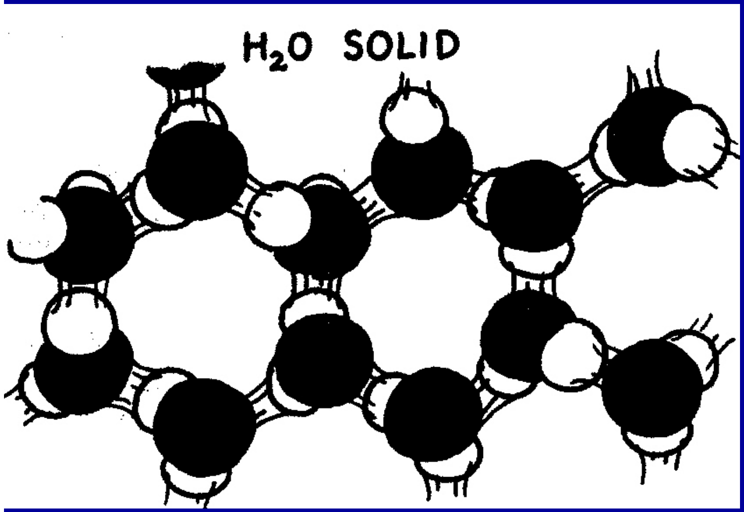
PHASE CHANGES in H_2O



(more on this later in the semester)

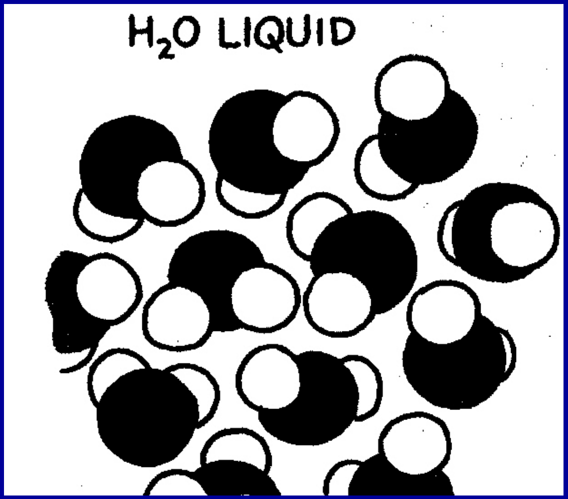
☺

H_2O's UNIQUE EXCEPTION at ~ 0º-4 ºC to "rule" of: heating → expansion cooling → contraction



ice → water

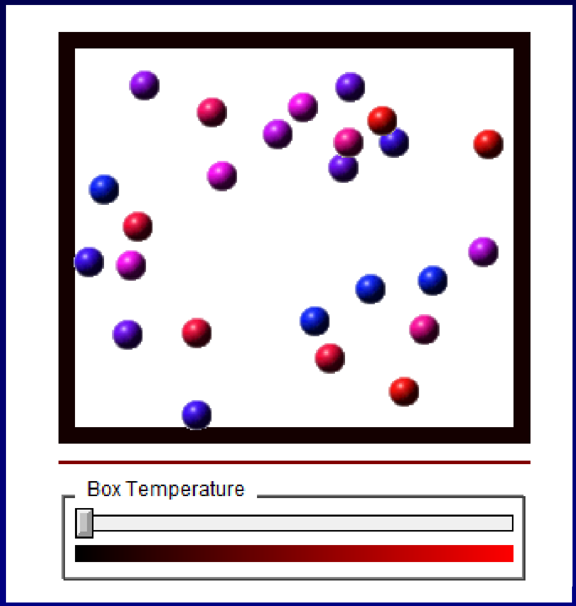
PHASE CHANGE



Volume <u>decreases</u> upon heating (in a short range of temperatures) when the phase change occurs from ice to liquid water (due to collapsing ice crystals)

☺

A Simple Demo :



http://www.colorado.edu/physics/2000/bec/temperature.html

WHAT DOES THIS HAVE TO DO WITH GLOBAL CHANGE & MY DAILY LIFE ?????

☺

Arizona Daily Star

www.dailystar.com @www.azstarnet.com

Published: 08.31.2006

Ariz. heat cheats drivers at gas pump

standard not enforced, costing $115M yearly in state, study says

spending about $115 million more a year on gasoline and diesel fuel

uel temperatures were regulated to the federal standard, according to

LAT Home | My LATimes | Print Edition | All Sections

FEDERAL STANDARD:

Fuel at gas pump should be dispensed into a vehicle's tank at a temperature of 60 ºF

If temperature is not 60 º F, the cost of a gallon should be adjusted to reflect the volume of fuel at 60 º F.

"It's a significant number, and one that we shouldn't be paying," said Judy Dugan, research director at Santa Monica-based Consumer Watchdog, formerly called the Foundation for Taxpayer and Consumer Rights. "With every rise in the price of gas, hot fuel becomes a more important issue."

The U.S. government defined volume of a gallon of gas:

At 60 degrees, a gallon is 231 cubic inches.

But when fuel is warmer than 60 degrees, the liquid expands, yielding less energy per gallon.

☺

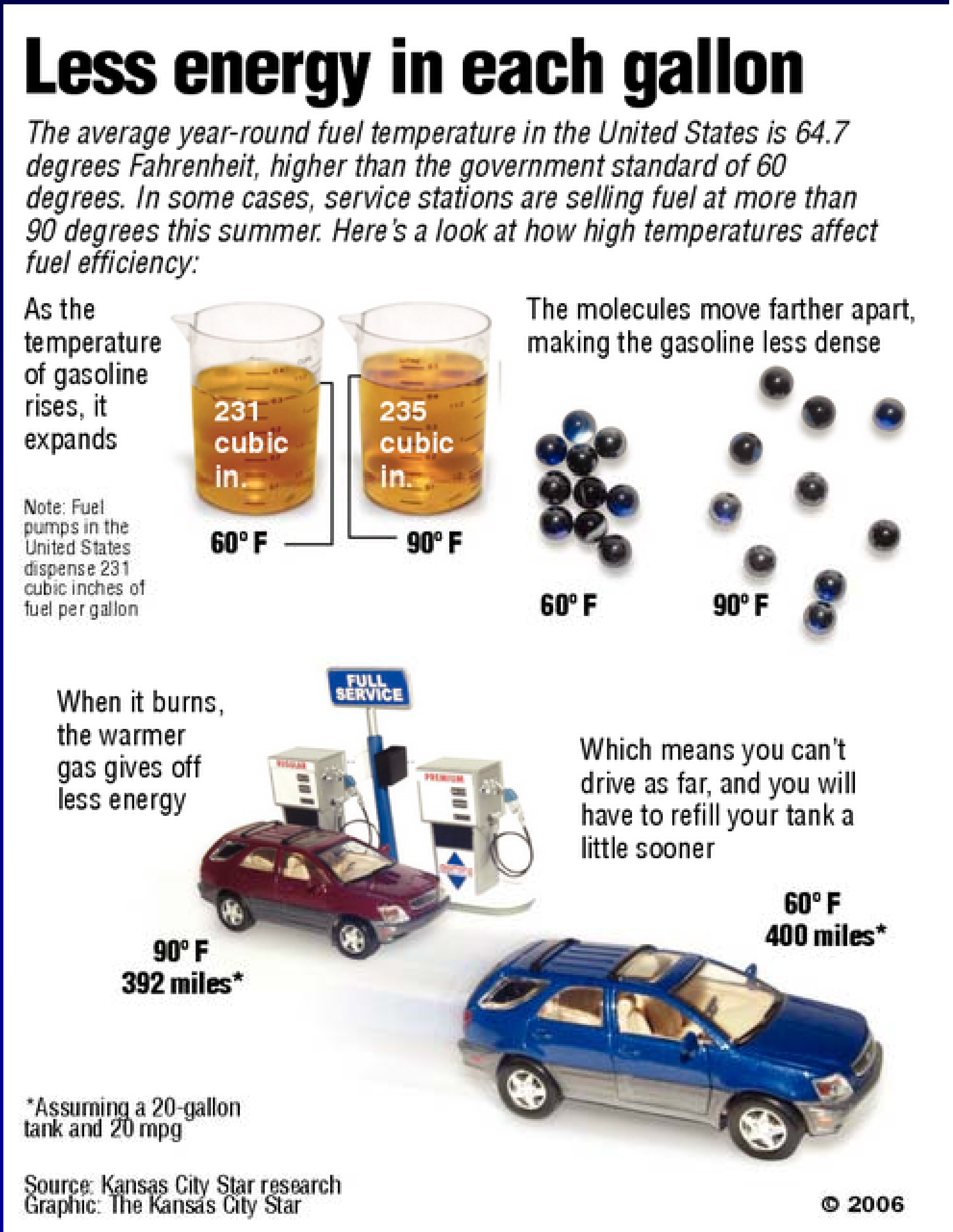
http://articles.latimes.com/2008/may/23/business/fi-hotfuel23

Rules of physics cost us money !!

Basic physics!

Depending on the temperature, the difference can amount to a few cents per gallon . . . .

. . . . But it adds up to big money — coming straight out of consumers' pockets.



Now let's focus on the atoms themselves and their internal structure . . .


I'VE DONE IT— I'VE FOUND THE MOST BASIC PARTICLE!
I'VE FOUND THE PARTICLE THAT MAKES UP THAT BASIC PARTICLE!
I'VE FOUND THE PARTICLES THAT MAKE UP THE PARTICLES...
S. Harris

ATOMIC STRUCTURE:

Electron

Nucleus

Proton

Neutron

ELECTRON:

Tiny negatively charged particles that circle in orbits around a positively charged nucleus of an atom.

The electron is an atomic particle with a negative charge and very low mass.

NUCLEUS:

The small, massive central part of an atom; it is made up of elementary particles that are even smaller ➔

PROTON: Positively charged nuclear particle.

The ***atomic number*** of an atom is the number of protons, or units of positive charge, in the nucleus. If the atom is neutral -- the atomic number is also equivalent to the number of electrons.

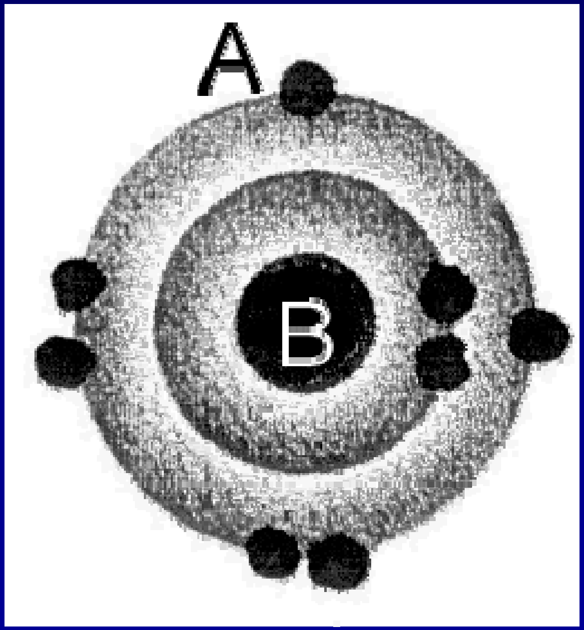
NEUTRON: Electrically neutral nuclear particle, approximately equal in mass to a proton.

(Both protons and neutrons have much greater relative mass than electrons.)

The ***mass number*** of an atom is the total number of protons and neutrons in the nucleus of the atom.

Schematic "dot" diagram of an oxygen atom

Fill in blanks on p 24



A = ELECTRON

B = NUCLEUS

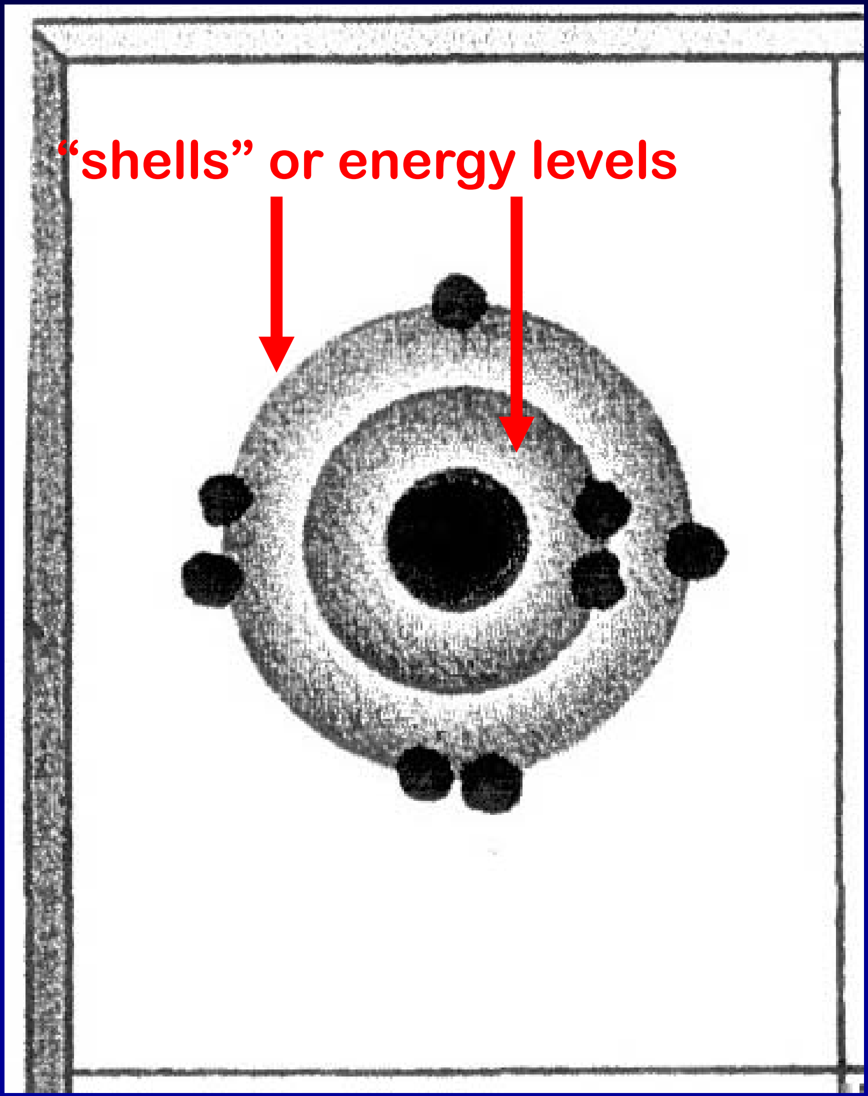
 # electrons = 8

 # protons = 8

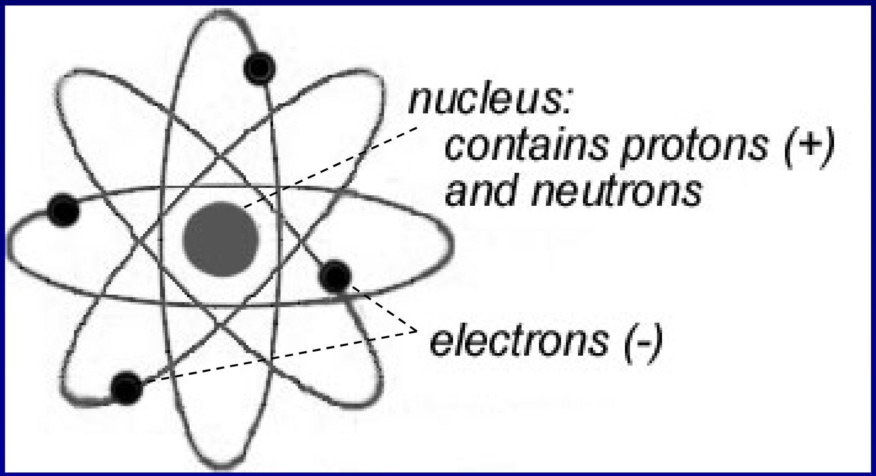
 # neutrons = 8

atomic # = 8

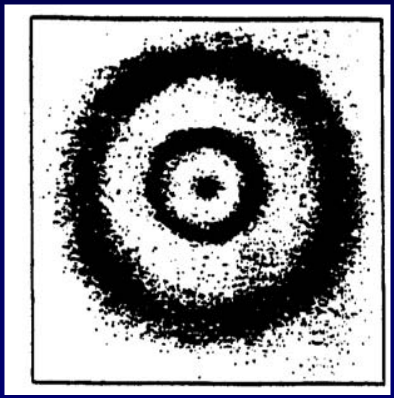
Review the details about “shells” and “energy levels” on p 25 (on your own later if necessary)



THE PLANETARY MODEL OF THE ATOM



The BOHR MODEL OF THE ATOM:



According to Neils Bohr's model of the atom,

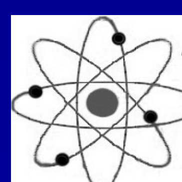
electrons circling the nucleus cannot maintain their orbits at just *any* distance from the center of the atom (the early model).

p 25
(1st bullet)

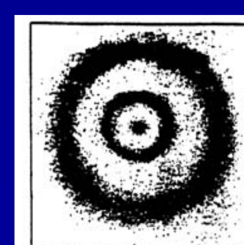
There are only certain "allowed orbits"

- in which an electron can exist for long periods of time without giving off radiation.

- As long as the electron remains at one of these distances, its energy is fixed.

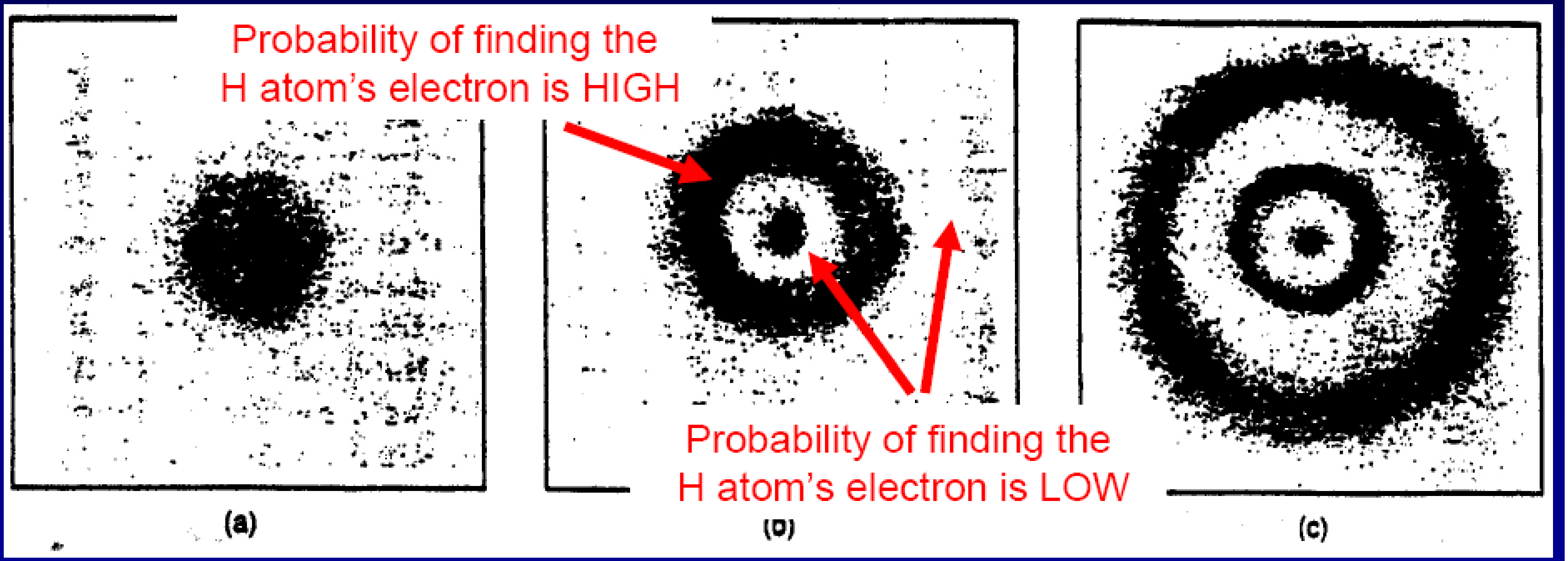


vs.

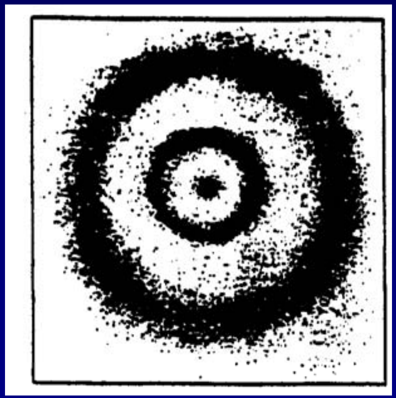


p 25

Schematic Diagrams representing ELECTRON ENERGY STATES (Shells) for Hydrogen H in the Bohr model :



GROUND State **Excited State 1** **Excited State 2**



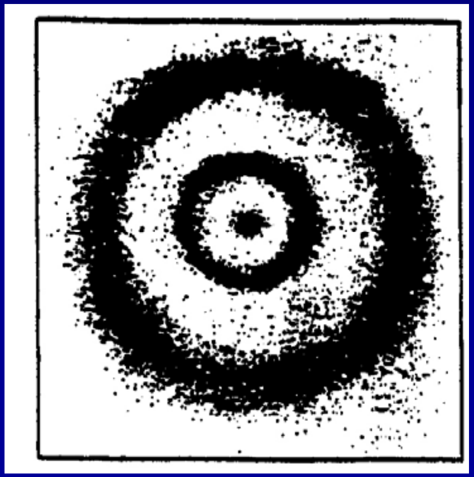
-- The "empty" spaces represent areas with *little likelihood* of finding an electron

-- Dark areas represent places (or energy levels) where electrons are "allowed" to be

. . . but how do they get from one level to another???

The quantum model of the atom states that:

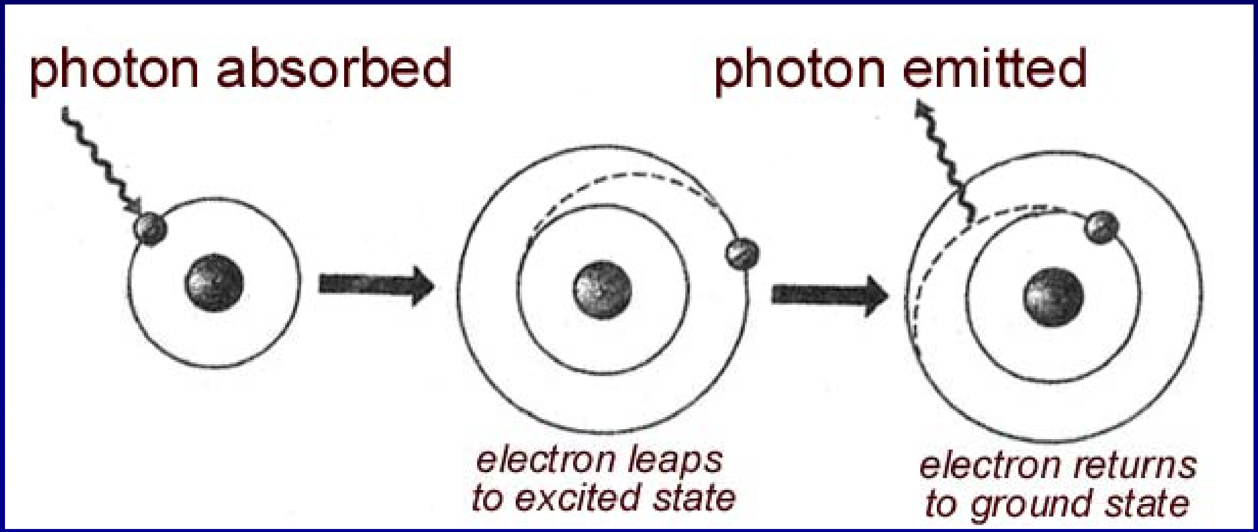
electrons can exist only in discrete allowed places within shells (or energy levels) and not in between.



p 24

The electrons move -- NOT according to Newtonian laws of motion

-- but according to quantum mechanics.



MORE on how this happens and what it has to do with GLOBAL CLIMATE CHANGE next week!!

A little rusty on atoms, elements, shells, and the Periodic Table?

See pp 109-113 in Class Notes

This is an ungraded "on your own" review activity – answers will be posted this weekend. You may need to know this for a future test . . . So do the review if you need it!

Class Notes Appendix
p 109 - 113

GROUP ACTIVITY

G-1 GROUP ECOLOGICAL FOOTPRINT

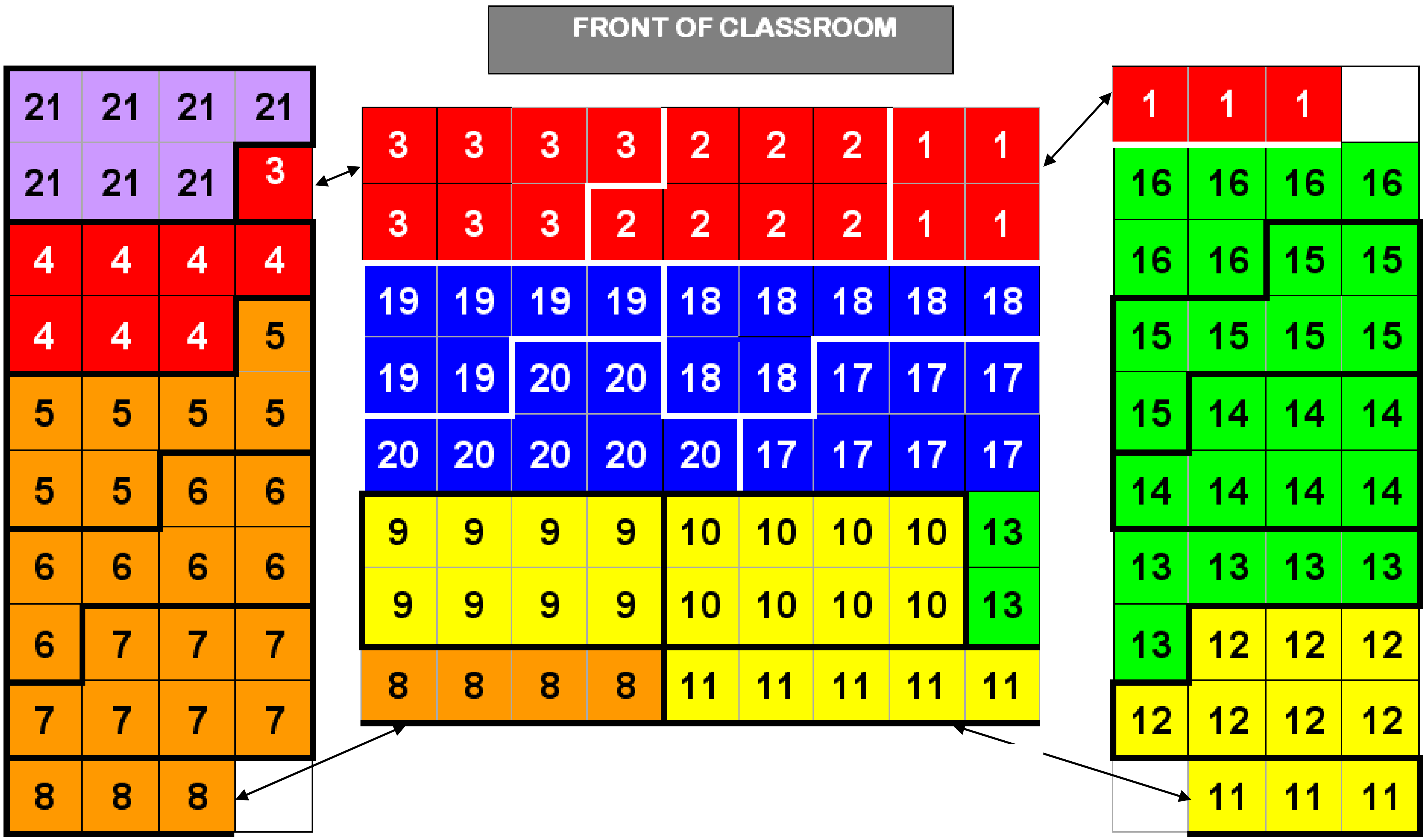
ASSIGNMENT G-1
GROUP ECOLOGICAL FOOTPRINTS

- **GET GROUP FOLDER (color coded)**
- **EVERYONE SIGN YOUR NAME <u>inside</u> the GROUP FOLDER**
- **First in alphabet in your group is TODAY's GROUP LEADER.**

Your job is to keep the discussion going and get assignment done!

- **GO AROUND THE CIRCLE AND INTRODUCE YOURSELF:**
  - **where from, major (if known)**
  - **Ecological Footprint!**
- **WORK ON G-1 TOGETHER – GROUP LEADER appoints a RECORDER, who is responsible for getting all the info on the form, although each student will write in something!**
- **REPORT BACK TO CLASS ON GROUP'S TOTAL FOOTPRINT.**
- **NOTE: Leave your I-1's in the folder and submit G-1 by leaving it in your group folder.**

NEVER TAKE YOUR GROUP FOLDERS OUT OF THE CLASSROOM!



Here's the Group Seating Arrangment

RE-CAP of ANNOUNCEMENTS

- **RQ-1 was cutoff at 30 minutes before class TODAY.**
  Missed the cutoff deadline? See FAQ #22

- **Be sure you have submitted the Practice RQ on the Syllabus & FAQ with a perfect score of 7/7 by midnight tonight to earn one point on Assignment I-1**

- **OFFICE HOURS are now in operation for Dr H and the GTA's See the hours on the TEACHING TEAM link.**

- **RQ-2 is due next Thursday (Sep 10) 30 minutes before class begins.**
  (For those still without textbooks, if necessary, I will post the required chapter in a password-protected PDF next week)

Have a Great Weekend . . .

GO CATS!