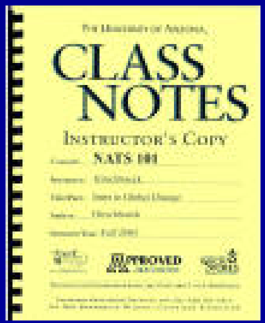
Topic #4
MATTER, ENERGY & HOW THEY RELATE

OBJECTIVES:

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



CLASS NOTES: pp 25 - 33

“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

Matter:

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

Atom:

-- Fundamental building blocks for all matter
-- the smallest representative sample of an element.

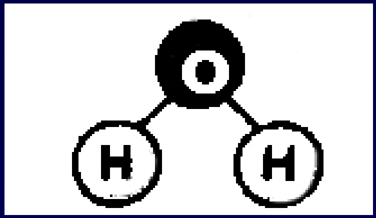
Element:

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*

p 25

Molecule:



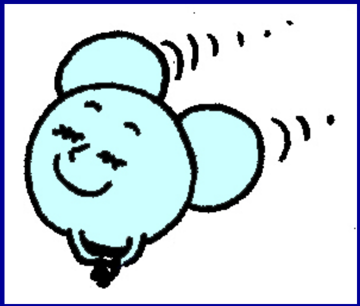
-- Any collection of **two or more atoms bound together**

-- 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

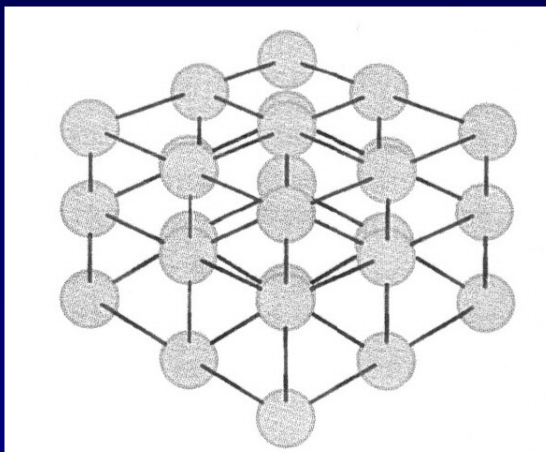
Solid:

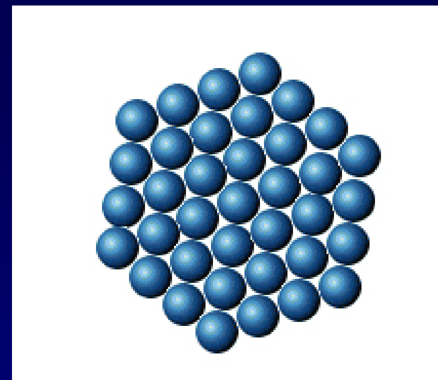
-- a substance that resists changes of shape and volume

-- 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.

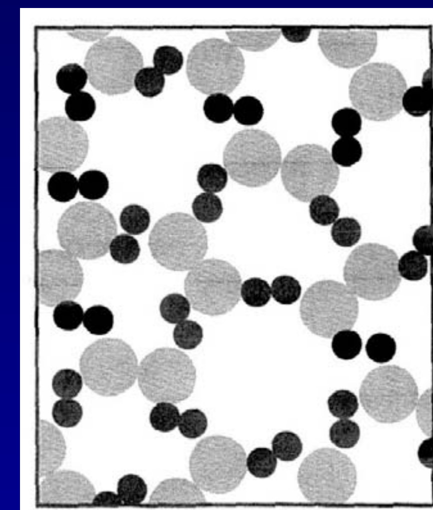
Various Representations of Molecules arranged in a SOLID



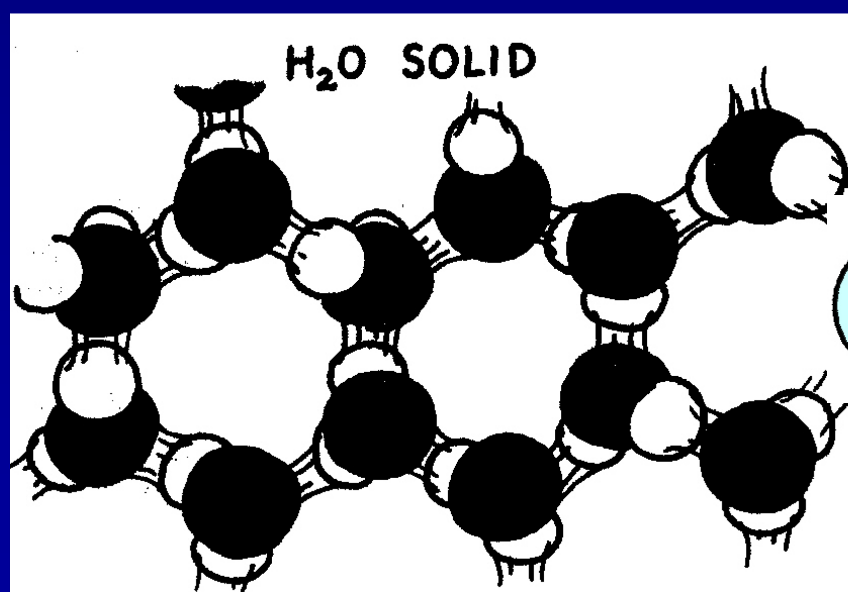


“top down” view of a Neon crystal

“top down” view of water (H_2O) arranged in solid (ice) form



3-D view of a solid crystal structure



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)

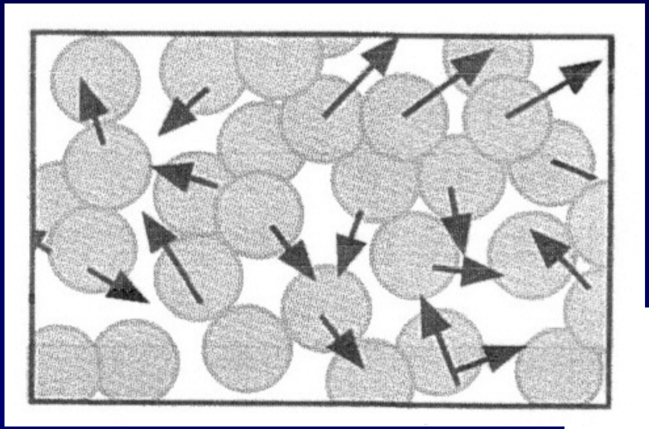
-- **LIQUIDS CAN EXHIBIT PRESSURE**

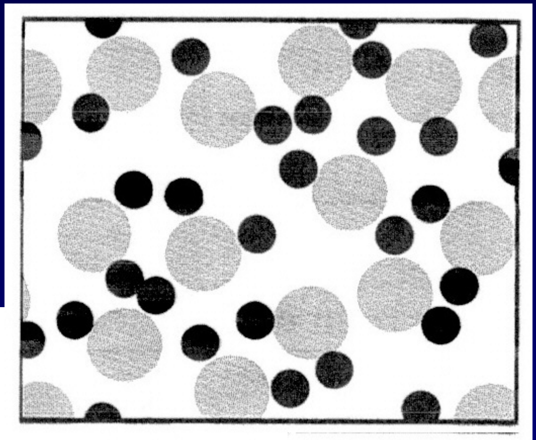
(pressure = a force per unit area)

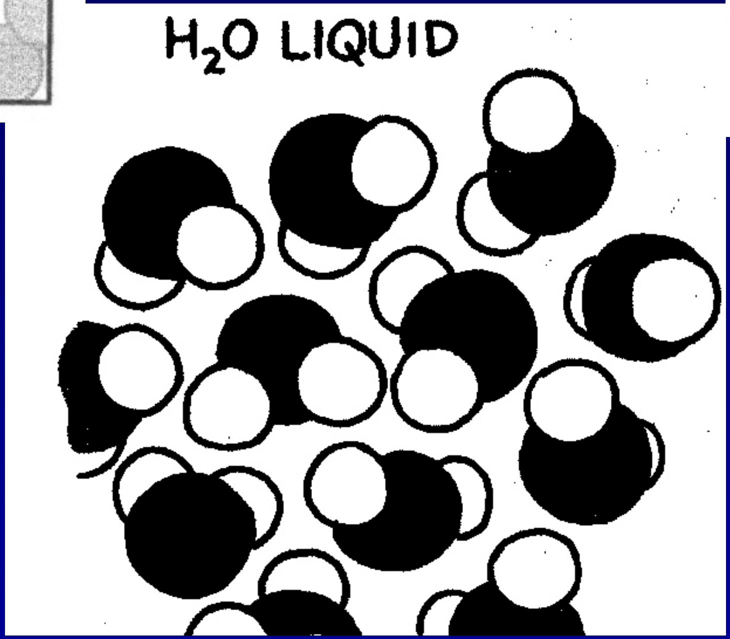
. . . and will take the shape of the container they are in.

p 25

Various Representations of Molecules arranged in a LIQUID







Gas:

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

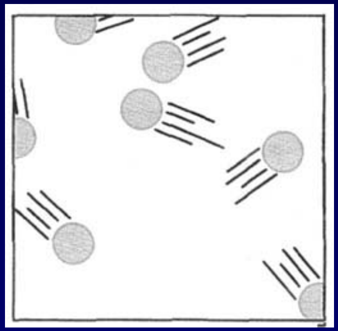
-- fills all space available to it

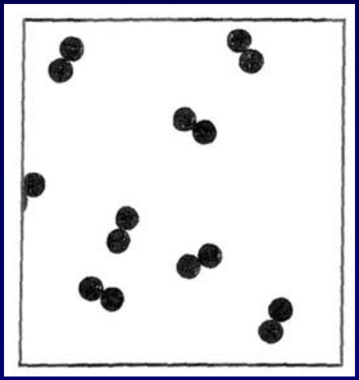
-- takes the shape of its container

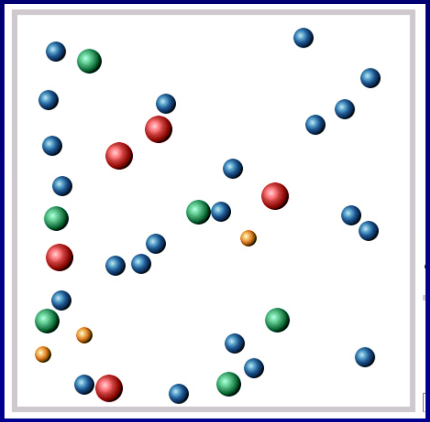
- -- the distance between molecules is such that no cohesive forces exist
- -- atoms or molecules are in high speed motion
- -- many collisions and rebounds occur

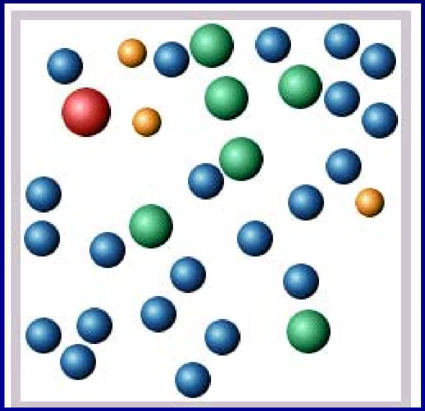
-- **GASES ALSO EXHIBIT PRESSURE**

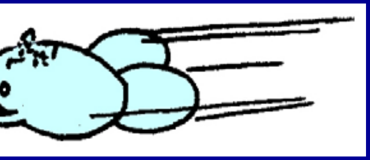
Various Representations of Molecules arranged in a GAS

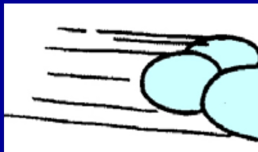






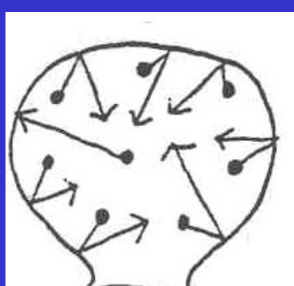




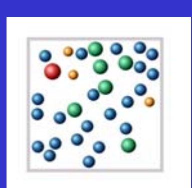


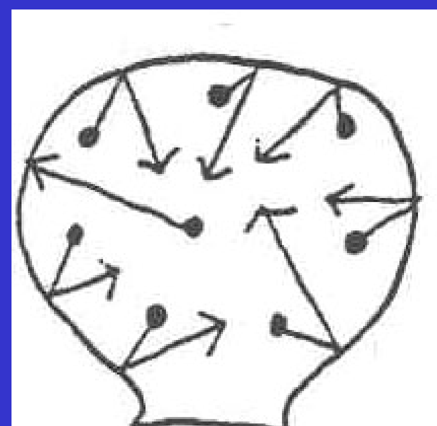
ONE WAY IN WHICH MATTER & ENERGY INTERACT:

Volume increases
& Density decreases→ with
increasing Temperature

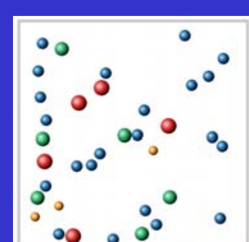


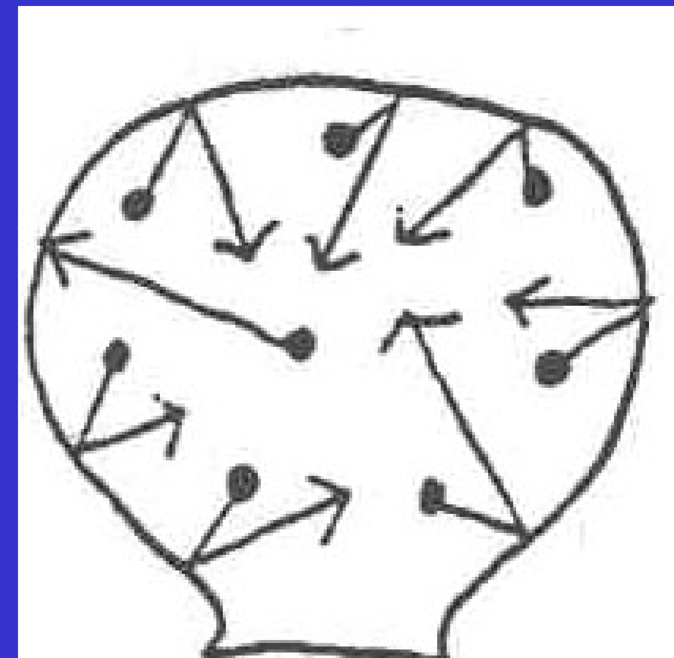
COLD



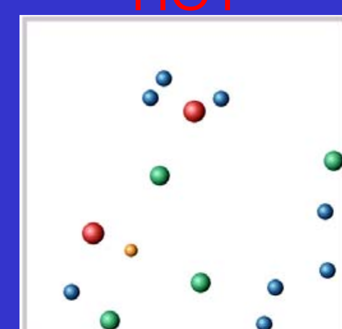


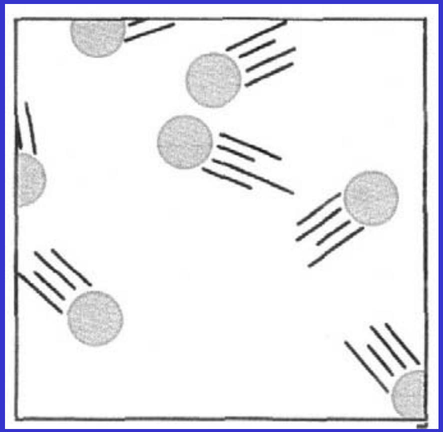
WARM





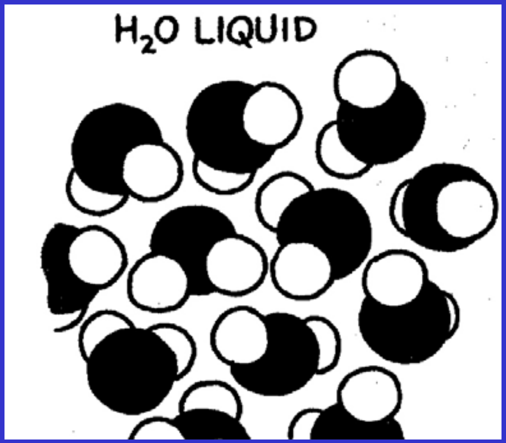
HOT



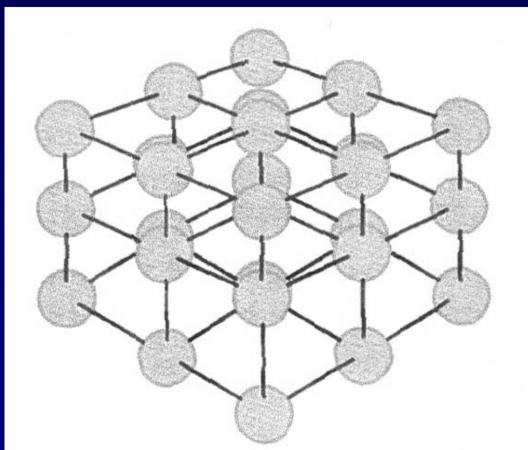


At higher air temperatures, H_2O molecules collide & rebound more frequently, leading to expansion of the air & the water vapor in the air.

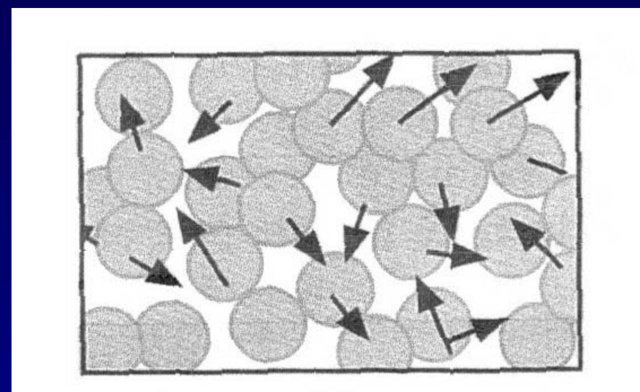
At lower air temperatures as air gets more dense, H_2O molecules are more likely to bond so that a phase change to liquid water or even solid ice can occur.



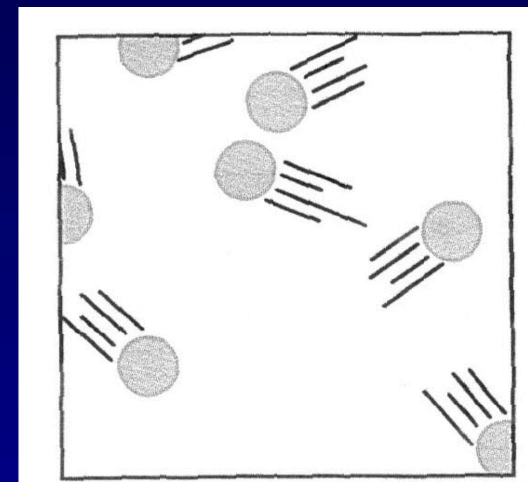
SUMMARY:



SOLID



LIQUID



GAS

KEY CONCEPT #1:

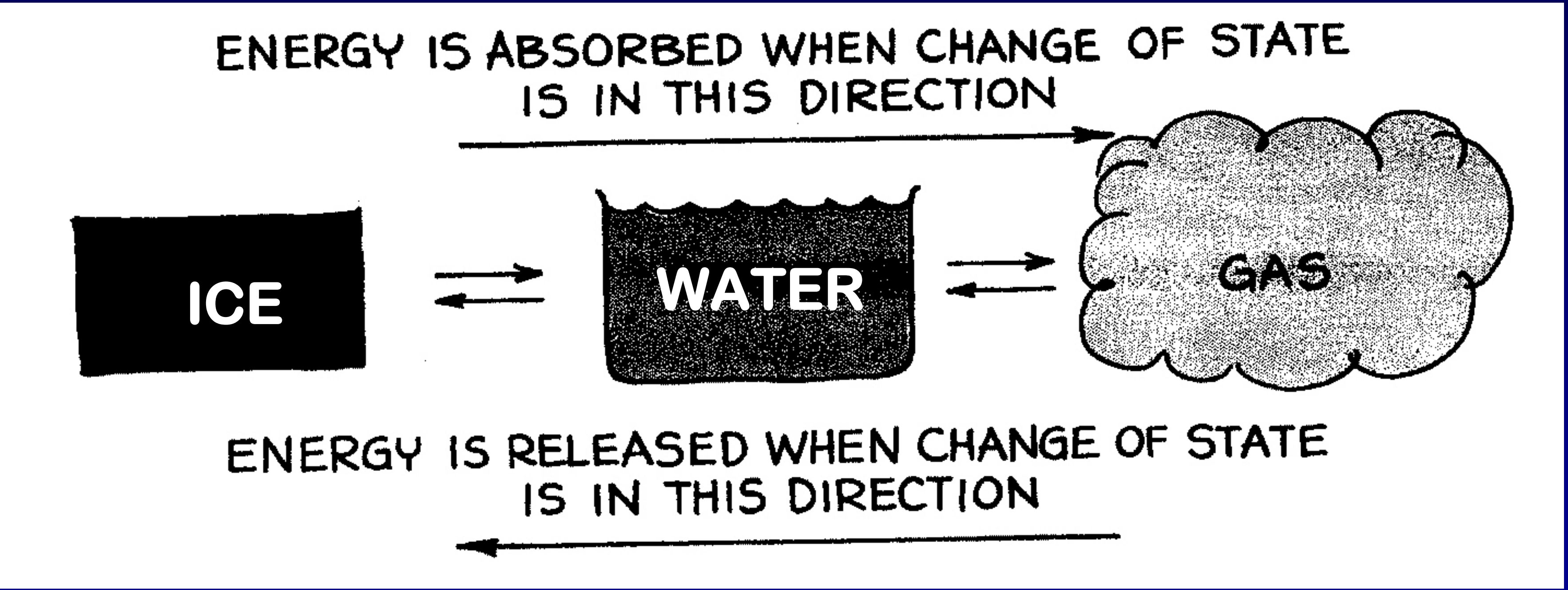
ENERGY & MATTER INTERACT

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.

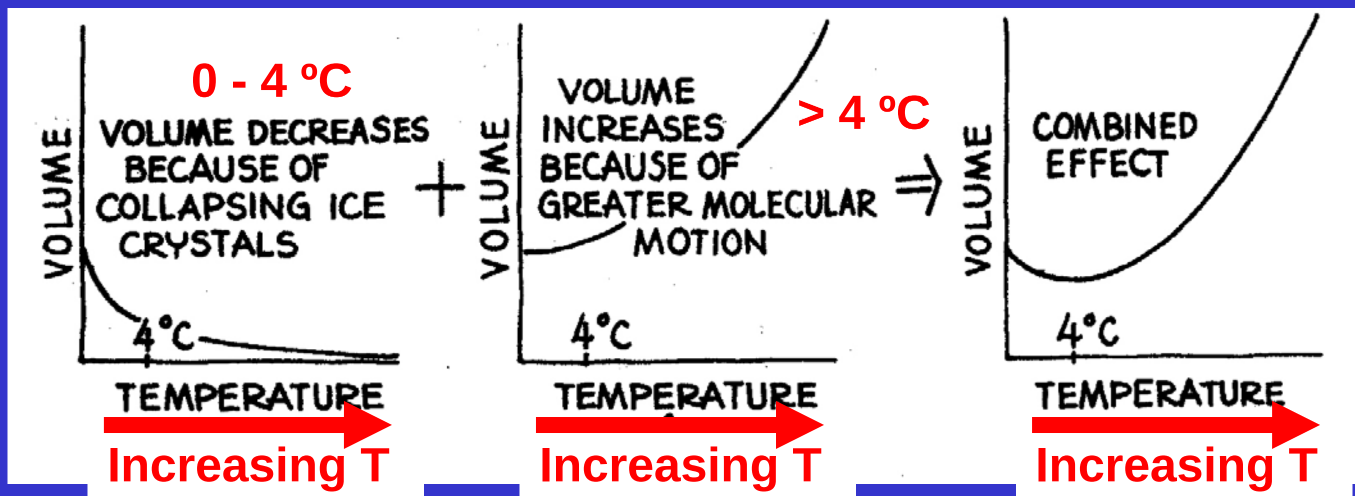
Thermal energy is involved in phase changes.

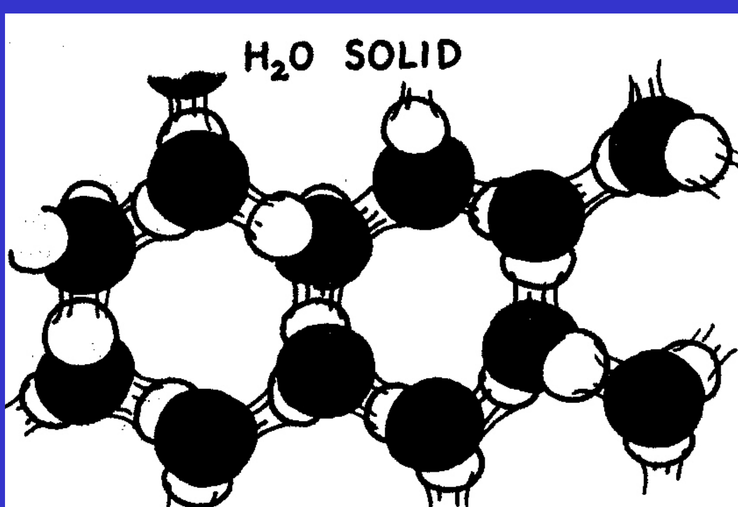
PHASE CHANGES IN H_2O



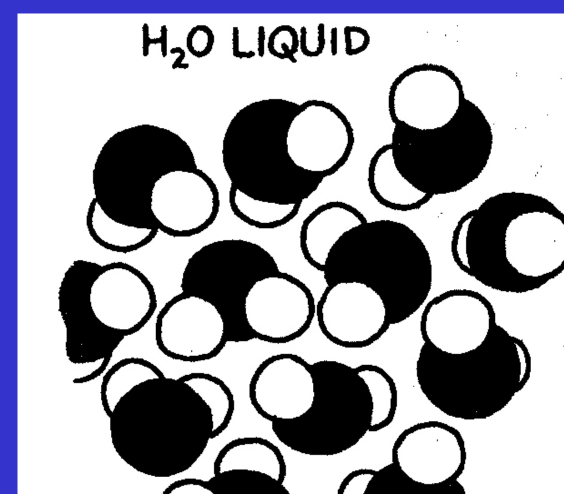
(more on this later in the semester)

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





PHASE CHANGE



ANIMATION / DEMO. . . . .

WHAT DOES THIS HAVE TO DO WITH MY DAILY LIFE ?????

THE
GC-SAVVY
COMSUMER!

Arizona Daily Star
www.dailystar.com www.azstarnet.com

Published: 08.31.2006

Today's newspaper!

Ariz. heat cheats drivers at gas pump

Federal 60-degree standard not enforced, costing $115M yearly in state, study says

By Andrea Kelly

ARIZONA DAILY STAR

Arizona drivers are spending about $115 million more a year on gasoline and diesel fuel than they would if fuel temperatures were regulated to the federal standard, according to a newspaper study.

FEDERAL STANDARD:

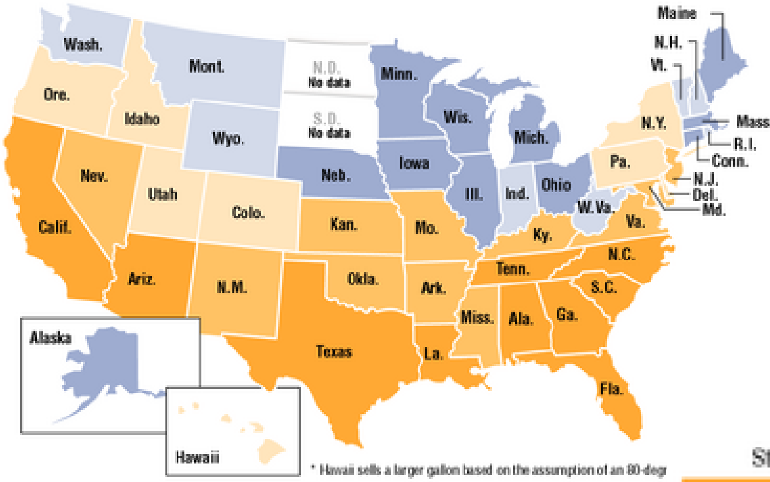
Fuel at gas pump should be dispensed into a vehicle's tank at a temperature of 60 º F

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

☺

The colder the better – for the consumer

U.S. drivers, especially those in the hot South and Southwest, are buying more than 750 million additional gallons of gasoline because fuel pumps do not account for expansion of hot fuel.



* Hawaii sells a larger gallon based on the assumption of an 80-degr

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	State	Average fuel temp.	Effect on retail gas consumption in millions of gallons	Consumers' gain or loss in millions of dollars
Paying $50 million or more	California	75°	158	-$509
	Texas	78°	143	-$416
	Florida	82°	122	-$367
	Arizona	82°	39	-$115
	Georgia	72°	41	-$123
	Louisiana	77°	28	-$81
	North Carolina	69°	25	-$74
	Alabama	72°	22	-$63
	South Carolina	73°	22	-$61
	Tennessee	70°	21	-$60
Paying $10 million to $50 million more	Virginia	66°	16	-$46
	Mississippi	74°	16	-$46
	Nevada	75°	10	-$31
	Arkansas	71°	11	-$32
	Oklahoma	69°	11	-$31
	New Jersey	63°	8	-$22
	Maryland	64°	7	-$22
	New Mexico	69°	6	-$17
	Kentucky	63°	5	-$14
	Missouri	62°	5	-$15
	Kansas	65°	4	-$12
	Oregon	63°	3.5	-$10
	New York	61°	3	-$9
	Utah	63°	3	-$7
	Colorado	62°	2	-$7

	State	Avg. fuel temp.	Effect on retail gas consumption in millions of gallons	Consumers' gain or loss in millions of dollars
Paying $0 to $10 million more	Hawaii *	86°	2	-$6
	Delaware	64°	1	-$3
	Pennsylvania	60.3°	1	-$3
	Washington, D.C.	66°	0.7	-$2
	Idaho	60.5°	0.2	-$0.6
Paying $0 to $5 million less	Rhode Island	59.8°	-0.05	$0.1
	West Virginia	59.6°	-0.2	$0.6
	Indiana	59.9°	-0.3	$0.9
	Wyoming	55°	-1	$3
	Washington	59.5°	-1	$3
	Montana	57°	-0.9	$3
	New Hampshire	58°	-1	$4
	Vermont	54°	-1.4	$4
Paying $5 to $40 million less	Alaska	47°	-2	$7
	Massachusetts	59°	-2	$7
	Maine	55°	-2.5	$7
	Connecticut	59°	-3	$8
	Nebraska	54°	-3	$10
	Iowa	57°	-4	$11
	Ohio	59°	-4	$12
	Illinois	57°	-9	$29
	Wisconsin	55°	-9.3	$29
	Michigan	57°	-10	$29
	Minnesota	53°	-13	$37

Sources: Tank temperatures from National Institute of Standards and Technology. The effect on retail gas consumption was calculated using information from National Institute of Standards and Technology and Energy Information Administration. Cost in dollars calculated using AAA average cost of regular gas for each state on July 31, 2006.

Graphic: The Kansas City Star

FEDERAL STANDARD:

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

☺

It works this way:

As a liquid, gasoline expands and contracts depending on temperature. At the 60-degree standard, the 231-cubic-inch American gallon puts out a certain amount of energy. But that same amount of gas expands to more than 235 cubic inches at 90 degrees, even though consumers still only get 231 cubic inches at the pump.

Put simply, every degree over the 60-degree standard diminishes the energy a 231-cubic-inch gallon delivers to the nation's fleet of vehicles — and forces drivers to use more fuel and pay more.

Basic physics rules mean that, depending on the temperature, the difference can amount to just a few cents per gallon. But it adds up to big money — coming straight out of consumers' pockets.

Rules of physics cost us money !!

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

p 26

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.

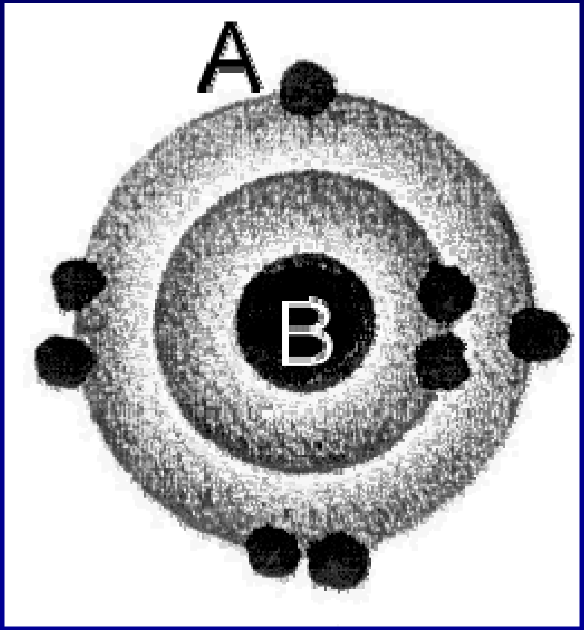
NEUTRON: Electrically neutral nuclear particle, approximately equal in mass to a proton.

(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 26



A = ELECTRON

B = NUCLEUS

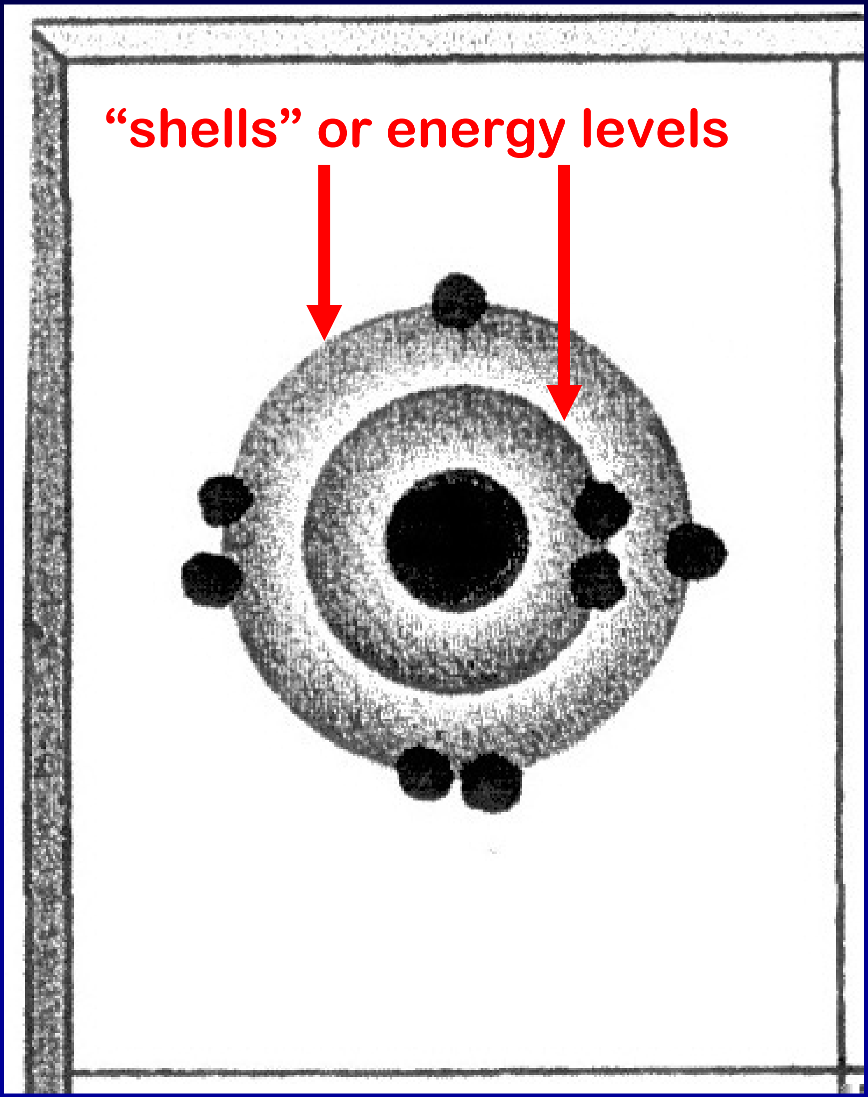
electrons = 8

protons = 8

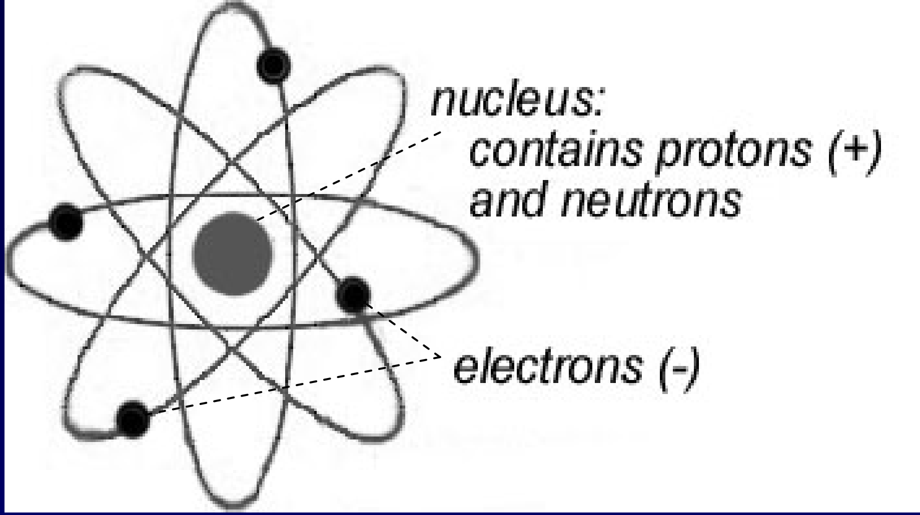
neutrons = 8

atomic # = 8

Another schematic "dot" diagram depiction of an Oxygen atom



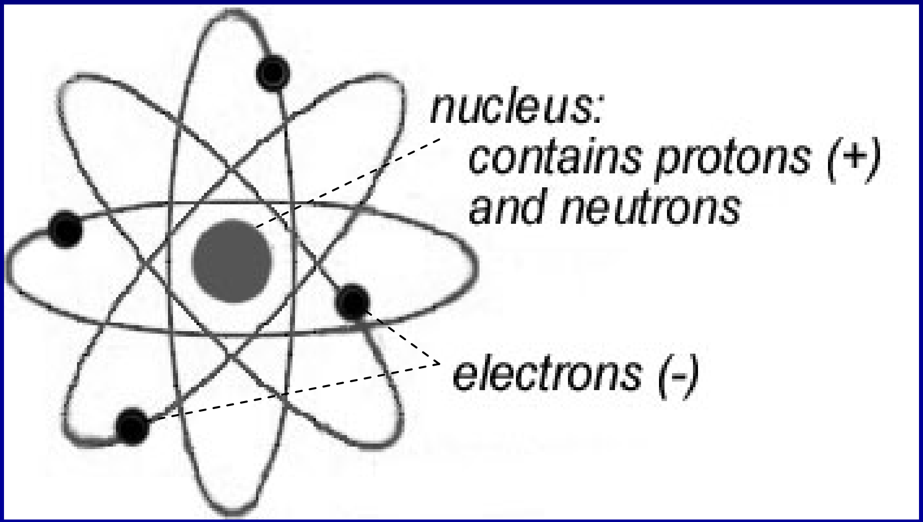
One Model of the Atom: THE PLANETARY MODEL



- Familiar representation / compares an atom to solar system
- Neutrons & protons occupy dense central region = nucleus
- Electrons orbit the nucleus like planets orbiting the Sun (but orbits are not confined to a plane as in Solar System).
- In an actual atom the radius of the nucleus is about 100,000 times smaller than the radius of the entire atom
- In an actual atom, electrons have little mass; are really more like "point" particles without a physical extent

On models and theories of atoms:

A nucleus with orbiting electrons (the planetary model of the atom) is a useful theory that explains a lot of observed behavior of matter at microscopic and smaller scales.



Not only is the universe stranger than we imagine,
it is stranger than we can imagine.
~Arthur Eddington

More recent experiments require the planetary model to be replaced by the **QUANTUM THEORY** of the atom.

The term "quantum" means "a small, discrete quantity" and the theory of quantum mechanics describes the behavior of matter on a microscopic scale – molecules and smaller.

The ENERGY state of the particles (electrons) is **restricted to certain discrete values**

-- certain orbits are allowed
-- other orbits don't exist.

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 planetary model).

-- There are only certain **"allowed orbits"** (shells) 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.

p 27

- These fixed energy states are designated by numbers (quantum numbers) n = 1,2,3, etc.
- An electron in the lowest available energy level is said to be in the n = 1 state called the **ground state**
- All energy levels above the ground state (n = 2 or higher) are called excited states.

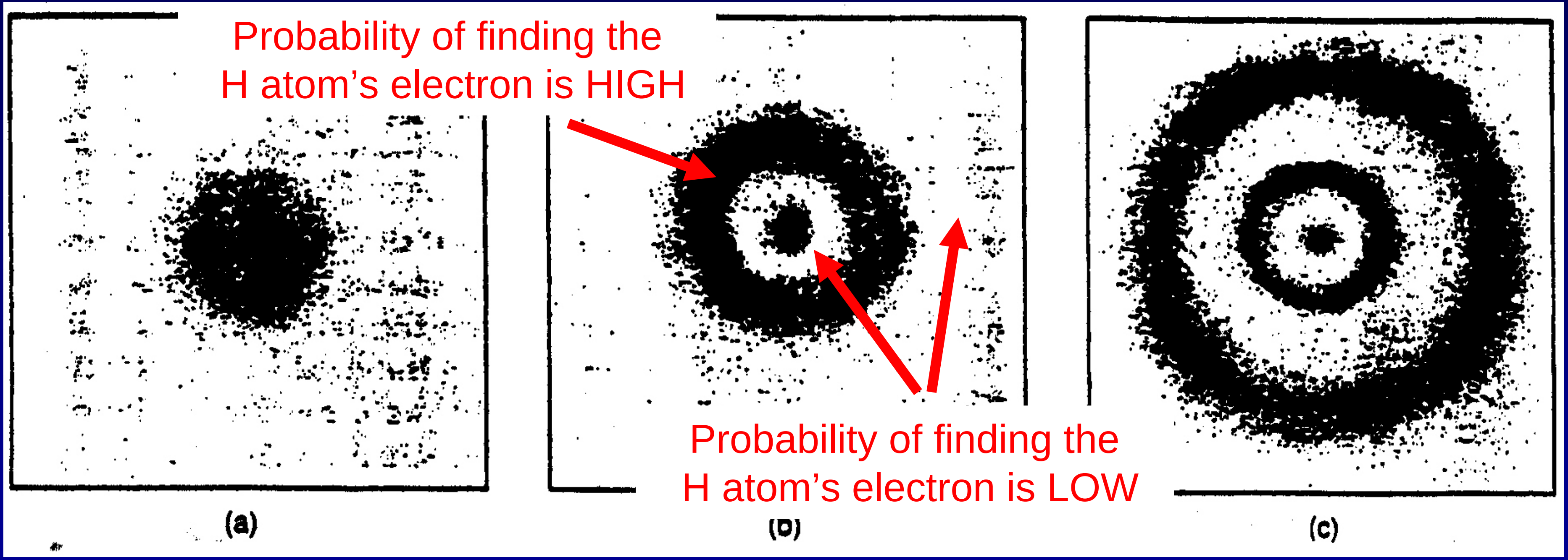
(1st excited state, 2nd excited state, etc.)

-- Each electron energy level can accommodate only a limited number of electrons, then it is "full"

-- The electrons at a given energy level make up an "electron shell"

-- The higher the shell number (n) the more distant are its electrons from the nucleus and the greater the energy of the electrons.
(The electrons that can be separated most easily from its atom is therefore an electron in the highest shell.)

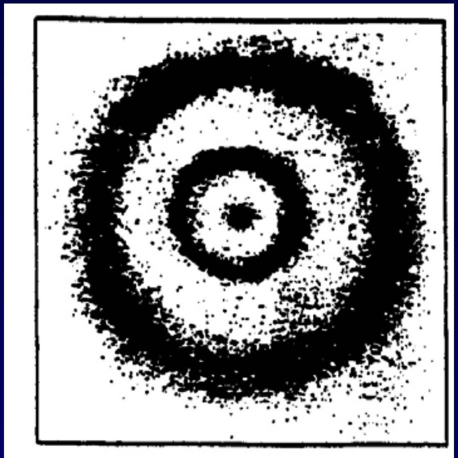
SCHEMATIC DIAGRAMS REPRESENTING ELECTRON ENERGY STATES (SHELLS) for Hydrogen H in the Bohr Model:



Electron "cloud" in GROUND State

Electron "cloud" in Excited State 1

Electron "cloud" in Excited State 2



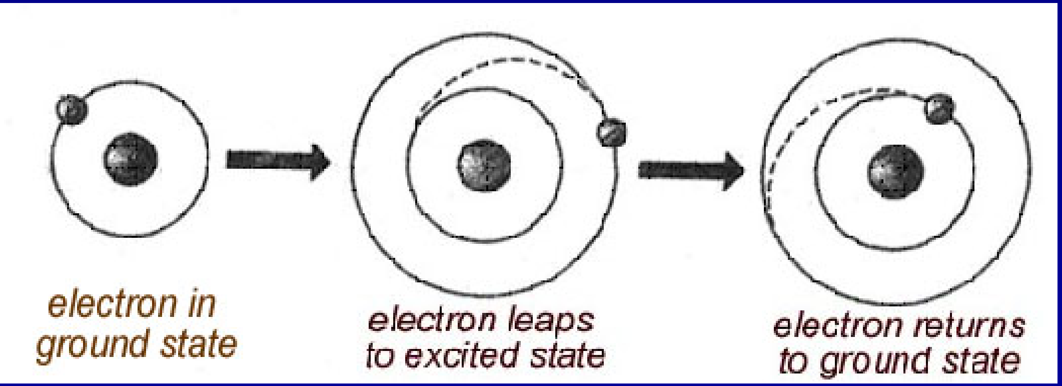
-- The "empty" spaces represent areas with *little likelihood* of finding an electron

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

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

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

-- but according to quantum mechanics.



p 28

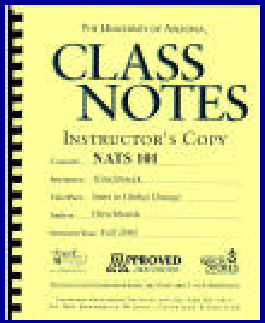
-- Electrons can make transitions between the orbits allowed by quantum mechanics by absorbing or emitting (giving off) EXACTLY the energy difference between the two orbits

--- The energy that is absorbed or emitted during the quantum leaps is called electromagnetic energy – which can be viewed as pulses of energy traveling in waves or as bundles of particle-like energy called PHOTONS.

G-2 ORGANIZING THE PERIODIC TABLE ACTIVITY

- Worth 5 GROUP points for a perfect paper!
- Within your group, you'll work first in subgroups of 2 – then prepare one final GROUP ANSWER FORM
- One envelope per subgroup (contains cutouts of atoms on p 145)
- PLEASE DO NOT WRITE ON THE ATOM CUTOUTS IN THE ENVELOPES !!!!

Dr H recycles ☺



Class Notes Appendix p 141-145

Have a great Labor Day weekend
and come back refreshed
and ready to learn
all about the very exciting
RADIATION LAWS !

Whoppee!