

## Chapter 4: Chemical Foundation: Elements, Atoms and Ions

These Notes are to SUPPLIMENT the Text, They do NOT Replace reading the Text Material.  
Additional material that is in the Text will be on your tests!

To get the most information, READ THE CHAPTER prior to the Lecture, bring in these lecture notes and make comments on these notes. These notes alone are NOT enough to pass any test!

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### Table Data You Need to Memorize

**Table 4.1** 18 Most Abundant Elements in the Earth's Crust      Oxygen 49.2% -> Magnesium 1.93%

**Table 4.2** Elements in the Human Body      Oxygen 65.0% -> Phosphorus 1.0%

**Table 4.4** Mass Charge of E, P, N

**Table 4.5** Diatomic Elements

**Intro** Chemical Elements are important in our daily lives

**Greeks** - all matter was composed of 4 fundamental substances: fire, earth, water and air

**Alchemists tried** to turn cheap metals into gold

**Robert Boyle** in 1600's defined an ELEMENT as a substance was an element unless it could be broken down into two or more simpler substances

We have about 100 different elements

The alphabet has 26 different letters and there are hundreds of thousand words

Oxygen is 21% of the earth atmosphere, 1/3 of the atoms in water is Oxygen

Oxygen forms Oxides with most of the other elements in the earth surface (SiO<sub>2</sub>)

### 9 Elements make up most of those in the Earth:

Oxygen O 49.2%      Silicon Si 25.7%      Aluminum Al 7.50%

Iron Fe 4.71%      Calcium Ca 3.39%      Sodium Na 2.63%

Potassium K 2.40%      Magnesium Mg 1.93%      Hydrogen H 0.87%

### Human Body has

Oxygen 65%      Carbon 18%      Hydrogen 10%      Nitrogen 3%

Calcium 1.5%

- Element:**
1. A Single Atom
  2. Sample of the element large enough to weigh
  3. Macroscopic - Oxygen is O<sub>2</sub>
  4. Generic Element - the body contains Na or Li

### Crucial Trace Elements:

Iodine	thyroid gland
Manganese	helps maintain Ca in bones
Copper	red blood cells
Lithium	treats Manic-Depressive / Bipolar disorder
Cobalt	can control violent behavior
Calcium	in bones, Fluoride in water for teeth

**A substance is an ELEMENT** unless it can be broken down into two or more simpler substances.  
115 known elements, 88 occur naturally

### Symbols for the Elements

Chemical Elements Names come from:

- Greek - Chlorine = Green = Cl, and Iodine = violet - I
- Latin - Gold = Aurum = Au, Lead = Plumbum = Heavy
- German -
- Where Discovered - Francium, Germanium, Californium
- Famous Scientist - Einsteinium, Nobelium

**Abbreviations for the Elements.** - 1st letter is cap, the second is not.

Fluorine - F    Oxygen - O    Silicon - Si    Zinc - Zn

### Dalton's Law of Constant Composition

A given compound always has the same composition regardless of where it comes from  
Salt is NaCl if it comes from the ocean or from a Utah deep mine!

### Dalton's Atomic Theory

1. Most natural materials are mixtures of pure substances
2. Pure substances are either elements or combinations of elements called compounds
3. A given compound ALWAYS contains the same proportions (by mass) of the elements

#### LAW OF CONSTANT COMPOSITION

### DALTON'S ATOMIC THEORY:

1. Elements are made up of tiny particles called atoms
2. All atoms of a given element are identical
3. The atoms of a given element are different from those of any other element
4. Atoms of one element can combine with atoms of another element to form compounds. A given compound always has the same relative numbers of atoms
5. Atoms are indivisible in chemical properties. That is, atoms are not created or destroyed in chemical reactions. A chemical reaction simply changes the way the atoms are grouped together.

**Greenhouse Effect:** car catalytic converter converts CO and NO<sub>2</sub> to nitrous oxide N<sub>2</sub>O. N<sub>2</sub>O absorbs IR causes the earth to retain heat

**The Elements** are comprised of Protons, Neutrons and Electrons

### Formulae of Compounds

**Compound** - a distinct substance that is composed of atoms of 2 or more elements

**Chemical Formula** - types of atoms & the number of each type in each unit - molecule

$H_2O$  = Water = 2 molecules of Hydrogen, one of Oxygen

**Rules for writing formulas**

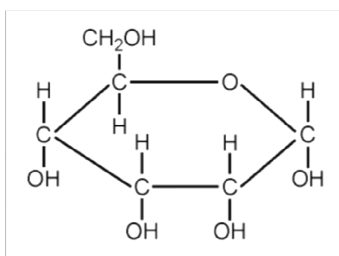
1. Each atom present is represented by its element symbol
2. The number of each type of atom is indicated by a subscript to the right of the symbol
3. When only one atom is present, the subscript 1 is NOT written

**Writing Formula of Compounds:**

Sulphur TriOxide has 1 atom of Sulphur and 3 of Oxygen -  $SO_3$

DiNitrogen Tetra Oxide has 2 atoms of N and 5 of Oxygen -  $N_2O_5$

Glucose has 6 Carbons, 12 Hydrogens and 6 Oxygen -  $C_6H_{12}O_6$



**PROBLEM Class do:** 4 Phosphorous and 10 Oxygen

1 Uranium and 6 Fluorine

1 Aluminum and 3 Chlorine

**Structure of Atom**

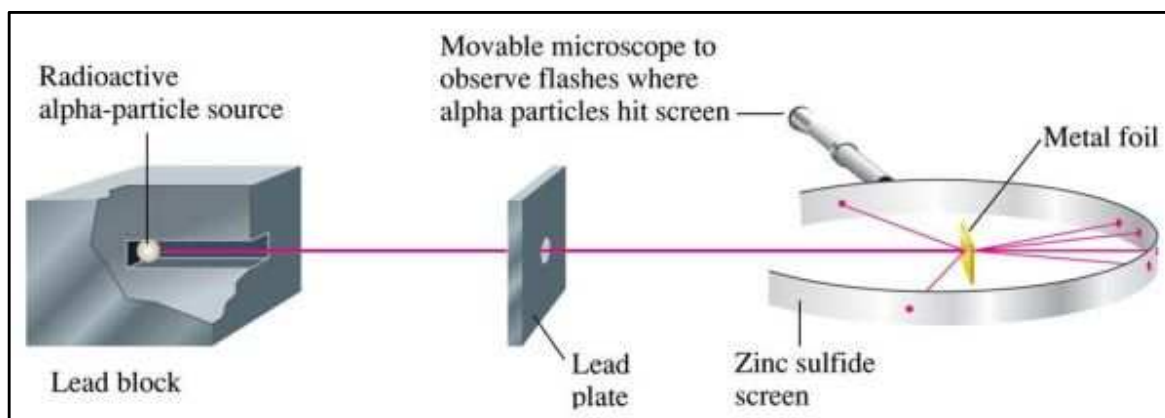
**Elements** consist of atoms

**Compounds** are a specific collection of atoms

But - are atoms like a ball bearing with no internal structure??

Are atoms like a plum pudding (pudding with raisins randomly distributed)

Atoms contain negative particles - **Electrons**. Placed in an electric field, they are repelled by the negative pole



**Rutherford shot Alpha Particles** [ + charge particle 7500 x mass of an electron ] at Al foil with a detector wrapped around the foil. If the plum pudding was correct, the alpha should go through. If there was dense center to the atom, then you'd get some random scattering. Also positive charges deflect from each other.

**Nuclear Atom** - an atom with a dense positive charge - the nucleus.

The center of the atom has a + charge and is densely packed.

The Center + charge balances out the outer - charge from the electron = **Proton**

The Center also has neutral particles - **neutrons**.

Most Massive = Neutron, Proton, Electron

### Modern Atomic Structure

The Nucleus is  $10^{-13}$  cm in dia, so the electrons are  $10^{-8}$  cm away

If the nucleus was the size of a grape, the electron orbit would be about 1 mile away

The space in which the electrons move accounts for most of the atomic volume

The electrons are the parts of the atom that mingle with other atoms

The number of electrons determines chemical behavior

<u>Particle</u>	<u>Relative Mass</u>	<u>Relative Charge</u>
<b>Electron</b>	1	1-
<b>Proton</b>	1836	1+
<b>Neutron</b>	1839	None

## ISOTOPES

Atoms with same number of protons but different numbers of neutrons

**Isotopes** Sodium has 11 protons and 11 neutrons and 12 or 13 neutrons

All atoms of the same element contain the same number of protons and electrons, but atoms of a given element may have different numbers of neutrons.

**Z = ATOMIC NUMBER**

The number of protons in a nucleus

**A = MASS NUMBER**

Sum of the number of neutrons and protons

The Number of Neutrons = MASS NUMBER - ATOMIC NUMBER

### Nuclide Symbol

How many PROTONS, NEUTRONS AND ELECTRONS IN EACH:

$^{23}_{11}\text{Na}$  = Sodium 23 because it's mass is 23    What is  $^{24}_{11}\text{Na}$

$^{12}_6\text{C}$      $^{13}_6\text{C}$      $^{14}_6\text{C}$     **Isotopes of Carbon**

$^{90}_{38}\text{Sr}$  = Strontium- 90     $^{201}_{80}\text{Hg}$

Magnesium 24 =  $^{24}_{12}\text{Mg}$

What is the Mass Number for Silver 108?     $^{108}_{47}\text{Ag}$

**Isotopes:** Elements with the same number of protons, but different number of neutrons

$^{12}_6\text{C}$      $^{14}_6\text{C}$      $^{14}_7\text{N}$      $^{15}_7\text{N}$

$^{14}\text{C}$  /  $^{12}\text{C}$  ratio is carbon dating.     $^{15}\text{N}$  /  $^{14}\text{N}$  is for nitrogen dating.

# Periodic Table of Elements

										Alkaline earth metals										Noble gases ↓ 8A																																																																																		
										1A		2A												7A	4.003																																																																													
1	1	H	1.008																	2	He	4.003																																																																																
2	3	Li	6.941	4	Be	9.012																	5	B	10.81	6	C	12.01	7	N	14.01	8	O	16.00	9	F	19.00	10	Ne	20.18																																																														
3	11	Na	22.99	12	Mg	24.31	Transition metals										13	Al	26.98	14	Si	28.09	15	P	30.97	16	S	32.07	17	Cl	35.45	18	Ar	39.95																																																																				
4	19	K	39.10	20	Ca	40.08	21	Sc	44.96	22	Ti	47.88	23	V	50.94	24	Cr	52.00	25	Mn	54.94	26	Fe	55.85	27	Co	58.93	28	Ni	58.69	29	Cu	63.55	30	Zn	65.38	31	Ga	69.72	32	Ge	72.59	33	As	74.92	34	Se	78.96	35	Br	79.90	36	Kr	83.80																																																
5	37	Rb	85.47	38	Sr	87.62	39	Y	88.91	40	Zr	91.22	41	Nb	92.91	42	Mo	95.94	43	Tc	(98)	44	Ru	101.1	45	Rh	102.9	46	Pd	106.4	47	Ag	107.9	48	Cd	112.4	49	In	114.8	50	Sn	118.7	51	Sb	121.8	52	Te	127.6	53	I	126.9	54	Xe	131.3																																																
6	55	Cs	132.9	56	Ba	137.3	57	La*	138.9	58	Ce	140.1	59	Pr	140.9	60	Nd	144.2	61	Pm	(145)	62	Sm	150.4	63	Eu	152.0	64	Gd	157.3	65	Tb	158.9	66	Dy	162.5	67	Ho	164.9	68	Er	167.3	69	Tm	168.9	70	Yb	173.0	71	Lu	174.9	72	Hf	178.5	73	Ta	180.9	74	W	183.8	75	Re	186.2	76	Os	190.2	77	Ir	192.2	78	Pt	195.1	79	Au	197.0	80	Hg	200.6	81	Tl	204.4	82	Pb	207.2	83	Bi	209.0	84	Po	(209)	85	At	(210)	86	Rn	(222)						
7	87	Fr	(223)	88	Ra	226	89	Ac**	(227)	90	Th	232.0	91	Pa	231.0	92	U	238.0	93	Np	(237)	94	Pu	(244)	95	Am	(243)	96	Cm	(247)	97	Bk	(247)	98	Cf	(251)	99	Es	(252)	100	Fm	(257)	101	Md	(258)	102	Nh	(289)	103	Ds	(285)	104	Rg	(281)	105	Uue	(285)	106	Uuq	(289)	107	Uup	(288)	108	Uub	(294)	109	Uuq	(293)	110	Uup	(293)	111	Uub	(294)	112	Uuq	(293)	113	Uut	(290)	114	Uuq	(289)	115	Uup	(288)	116	Uuq	(288)	117	Uut	(293)	118	Uuq	(293)	119	Uut	(293)	120	Uuq	(293)
Alkali metals																	metals	nonmetals																																																																																				

**Periodic Table** Shows all the known elements and info on each

**PERIODIC TABLE** Is ordered by the INCREASE IN ATOMIC NUMBER

Number above the element symbol is the ATOMIC NUMBER = number of Protons

**GROUP** are Vertical Columns. They have similar chemical properties

Group 7 The Halogens, F, Cl, Br, I form very reactive gas's

Group 1 Alkali Metals: Na, K behave very similar - NaCl, KCl

Group 2 Alkaline Earth Metals

Group 7 Halogens

Group 8 Nobel Gases

Collection spanning vertical columns - Transition Metals

Most of the elements are **METALS** - Physical Properties

1. Efficient conduction of heat and electricity
2. Malleable - can be hammered into sheets
3. Ductile - can be pulled into wires
4. Lustrous - shiny appearance

**METALS** All elements to the left and below the stair step  
 Metals are solid at room temperature.

**NONMETALS** All elements to the right of the stair step  
 Many NONMETALS are GAS OR LIQUID

**SEMIMETALS OR METALLOIDS** All Elements close to the stair step  
 Silicon, Germanium, Arsenic, Antimony and Tellurium"

**PROBLEM:** Give Symbol, Atomic Number and Mass of

Iodine Magnesium Gold Lithium Argon Chlorine Barium Cesium

**Natural State of the Elements:** Matter consists of mixtures of compounds which are mixtures of elements.

**Most elements are REACTIVE**

EXCEPT FOR SOME GASES, GOLD, SILVER AND PLATINUM

**Noble Gases:** Helium, Neon, Argon, Krypton, Xenon and Radon DONOT READILY COMBINE

**DIATOMIC MOLECULES:** Oxygen and Nitrogen and Hydrogen form 2 atoms per molecule



**Group 7 - The Halogens** form Diatomic Molecules - Fluorine, Chlorine, Bromine, Iodine

**Noble Gases** form Individual Atoms - are NOT Diatomic

2 Elements are liquid at room temp - Bromine and Mercury

All other elements are solids at 25 deg C

Solid Non-Metals are more varied than Metals.

**ALLOTROPES:** Different forms of an element

Carbon - Diamond, Graphite and Buckminsterfullerene - different physical and chem prop

An **Ion** is a charged particle formed by removing an electron (s)

Na 11 metal  $\rightarrow \text{Na}^{+1}$  plus 1 Electron

A **Cation** is a Positive Ion, from the removal of one or more electrons from a neutral atom

Mg  $\rightarrow \text{Mg}^{+2}$  plus 2 Electrons Aluminum  $\rightarrow \text{Al}^{+3}$  plus 3 Electrons

Cation is named from the Parent Atom - Sodium Ion, Aluminum Ion

**Anion** is a Negative charged Ion, from the addition of an electron (s) to a neutral atom

Chlorine plus 1 Electron  $\rightarrow \text{Cl}^{-1}$  Cl 17  $\rightarrow$  Cl 17 plus 18 electrons

Anions are named from the root name of the atom and changing the ending

Cl  $\rightarrow$  Chloride add ide F, Br, I

$\text{Cl}^{-1}$  = Chloride, Fluoride, Bromide, Iodide

Anions that add 2 electrons

Oxygen plus 2 electrons =  $O^{2-}$  Oxide

Sulfur plus 2 electrons  $\rightarrow S^{2-}$  Sulfide

Ions are formed from the addition or subtraction of Electrons - do not change the # of protons

Ion Charges

Group 1 Metals  $\rightarrow +1$  Ions ( $M^+$ )

Group 2 Metals  $\rightarrow +2$  Ions ( $M^{++}$  or  $M^{+2}$ )

Group 3 Metals  $\rightarrow +3$  Ions ( $M^{+++}$  or  $M^{+3}$ )

Transition Elements for Cations have various positive charges

Metals lose electrons and form **POSITIVE IONS**



Non-Metals gain electrons and form **NEGATIVE CHARGED IONS**

Group 7 Atoms gain 1 electron  $\rightarrow A^{-1}$

Group 6 Atoms gain 2 electrons  $\rightarrow A^{-2}$

Compounds that contain Ions

Ions combine to form **NEUTRAL COMPOUNDS**

Salt - NaCl melts at 800 deg C and then conducts electricity

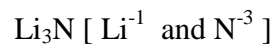
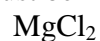
But will dissolve in water to conduct also.

The Salt in water **IONIZES** to  $Na^+$  and  $Cl^-$

**Ionic Compounds** are Compounds formed between a metal and non-metal

1. There must be both positive & negative ions

2. The net charge must be zero



**Formula for Ionic Compounds**