Table 4.1 Distribution (Mass Percent) of the 18 Most Abundant Elements in the Earth's Crust, Oceans, and Atmosphere

Element	Mass Percent	Element	Mass Percent
oxygen	49.2	titanium	0.58
silicon	25.7	chlorine	0.19
aluminum	7.50	phosphorus	0.11
iron	4.71	manganese	0.09
calcium	3.39	carbon	0.08
sodium	2.63	sulfur	0.06
potassium	2.40	barium	0.04
magnesium	1.93	nitrogen	0.03
hydrogen	0.87	fluorine	0.03
		all others	0.49

Table 4.2 Abundance of Elements in the Human Body

Major Elements	Mass Percent	Trace Elements (in alphabetical order)
oxygen	65.0	arsenic
carbon	18.0	chromium
hydrogen	10.0	cobalt
nitrogen	3.0	copper
calcium	1.4	fluorine
phosphorus	1.0	iodine
magnesium	0.50	manganese
potassium	0.34	molybdenum
sulfur	0.26	nickel
sodium	0.14	selenium
chlorine	0.14	silicon
iron	0.004	vanadium
zinc	0.003	

Table 4.3 The Names and Symbols of the Most Common Elements

Element	Symbol	Element	Symbol
aluminum	Al	lithium	Li
antimony (stibium)*	Sb	magnesium	Mg
argon	Ar	manganese	Mn
arsenic	As	mercury (hydrargyrum)	Hg
barium	Ba	neon	Ne
bismuth	Bi	nickel	Ni
boron	B	nitrogen	N
bromine	Br	oxygen	O
cadmium	Cd	phosphorus	P
calcium	Ca	platinum	Pt
carbon	C	potassium (kalium)	K
chlorine	Cl	radium	Ra
chromium	Cr	silicon	Si
cobalt	Co	silver (argentium)	Ag
copper (cuprum)	Cu	sodium (natrium)	Na
fluorine	F	strontium	Sr
gold (aurum)	Au	sulfur	S
helium	He	tin (stannum)	Sn
hydrogen	H	titanium	Ti
iodine	I	tungsten (wolfram)	W
iron (ferrum)	Fe	uranium	U
lead (plumbum)	Pb	zinc	Zn

*Where appropriate, the original name is shown in parentheses so that you can see where some of the symbols came from.

Dalton's Atomic Theory

1. Elements are composed of atoms

   tiny, hard, unbreakable, spheres

2. All atoms of a given element are identical

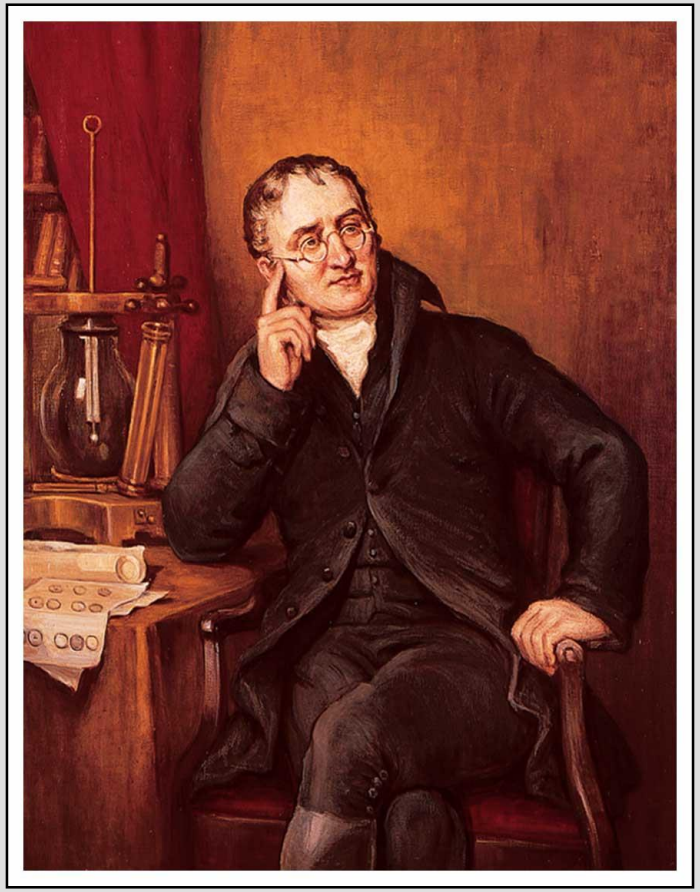
   all carbon atoms have the same chemical and physical properties

3. Atoms of a given element are different from those of any other element

   carbon atoms have different chemical and physical properties than sulfur atoms

Dalton's Atomic Theory

- Atoms of one element combine with atoms of other elements to form compounds.
  - Law of Constant Composition
    - all samples of a compound contain the same proportions (by mass) of the elements
  - Chemical Formulas



Dalton's Atomic Theory

Atoms are indivisible in a chemical process.

- all atoms present at beginning are present at the end
- atoms are not created or destroyed, just rearranged
- atoms of one element cannot change into atoms of another element
  - cannot turn Lead into Gold by a chemical reaction

Are Atoms Really Unbreakable?

- J.J. Thomson investigated a beam called a **cathode ray**
- he determined that the ray was made of tiny negatively charged particles we call **electrons**
- his measurements led him to conclude that these electrons were smaller than a hydrogen atom
- if electrons are smaller than atoms, they must be pieces of atoms
- if atoms have pieces, they must be breakable
- Thomson also found that atoms of different elements all produced these same electrons

The Electron

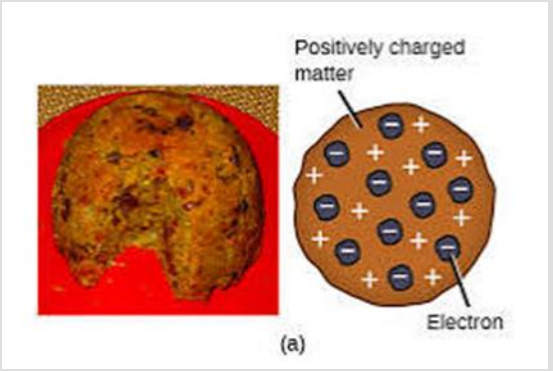
- Tiny, negatively charged particle
- Very light compared to mass of atom
  - $1/1836^{th}$ the mass of a H atom
- Move very rapidly within the atom.

Thomson's Plum Pudding Model1904

negatively-charged electrons embedded within a positively-charged "soup."

- The plum pudding model suggested that an atom consists of a sphere of positive charge, called the pudding, with electrons embedded in it, like plums in a desert. The electrons were arranged in shells and balanced the positive charge of the sphere.

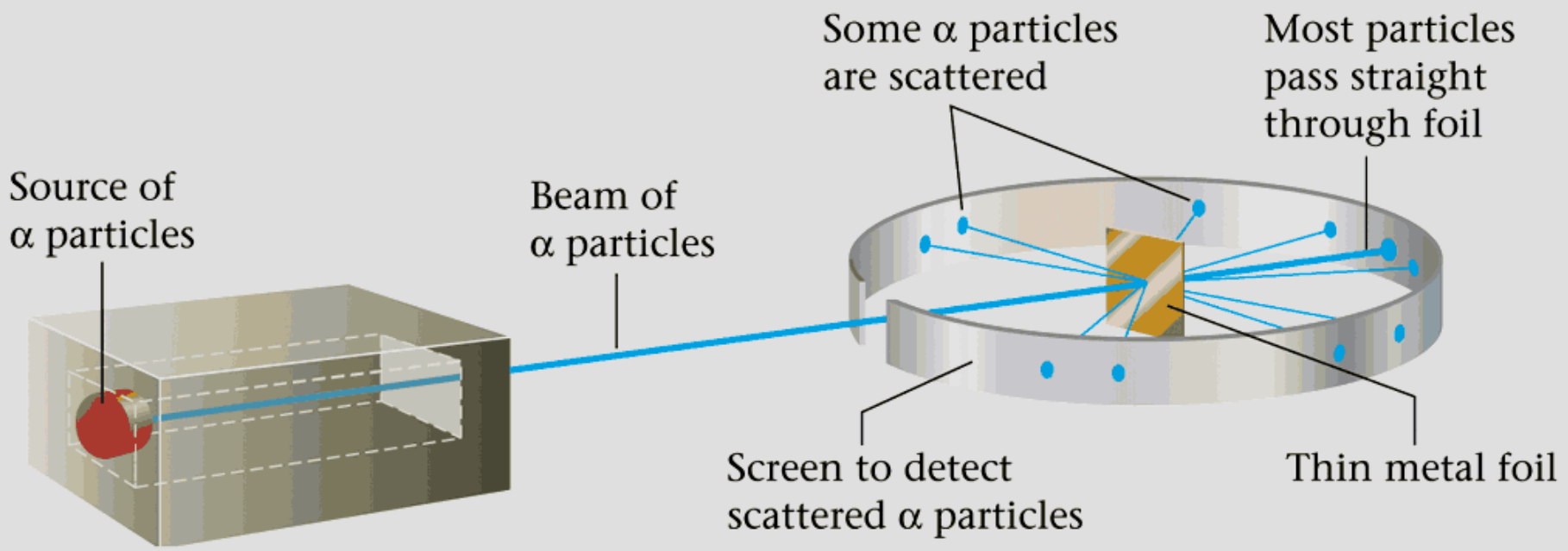
- Atom breakable!!
- Atom has structure
- Electrons suspended in a positively charged electric field
  - must have positive charge to balance negative charge of electrons and make the atom neutral
- mass of atom due to electrons
- atom mostly "empty" space
  - compared size of electron to size of atom



Rutherford's Gold Foil Expt 1911

- How can you prove something is empty?
- put something through it
  - use large target atoms
    - use very thin sheets of target so do not absorb "bullet"
  - use very small particle as bullet with very high energy
    - but not so small that electrons will affect it
- bullet = alpha particles, target atoms = gold foil
  - α particles have a mass of 4 amu[#] & charge of +2 c.u.
  - gold has a mass of 197 amu[#] & is very malleable.
  - [#] ***precisely 1/12 the mass of an atom of Carbon-12***

Rutherford's experiment on particle bombardment of metal foil.



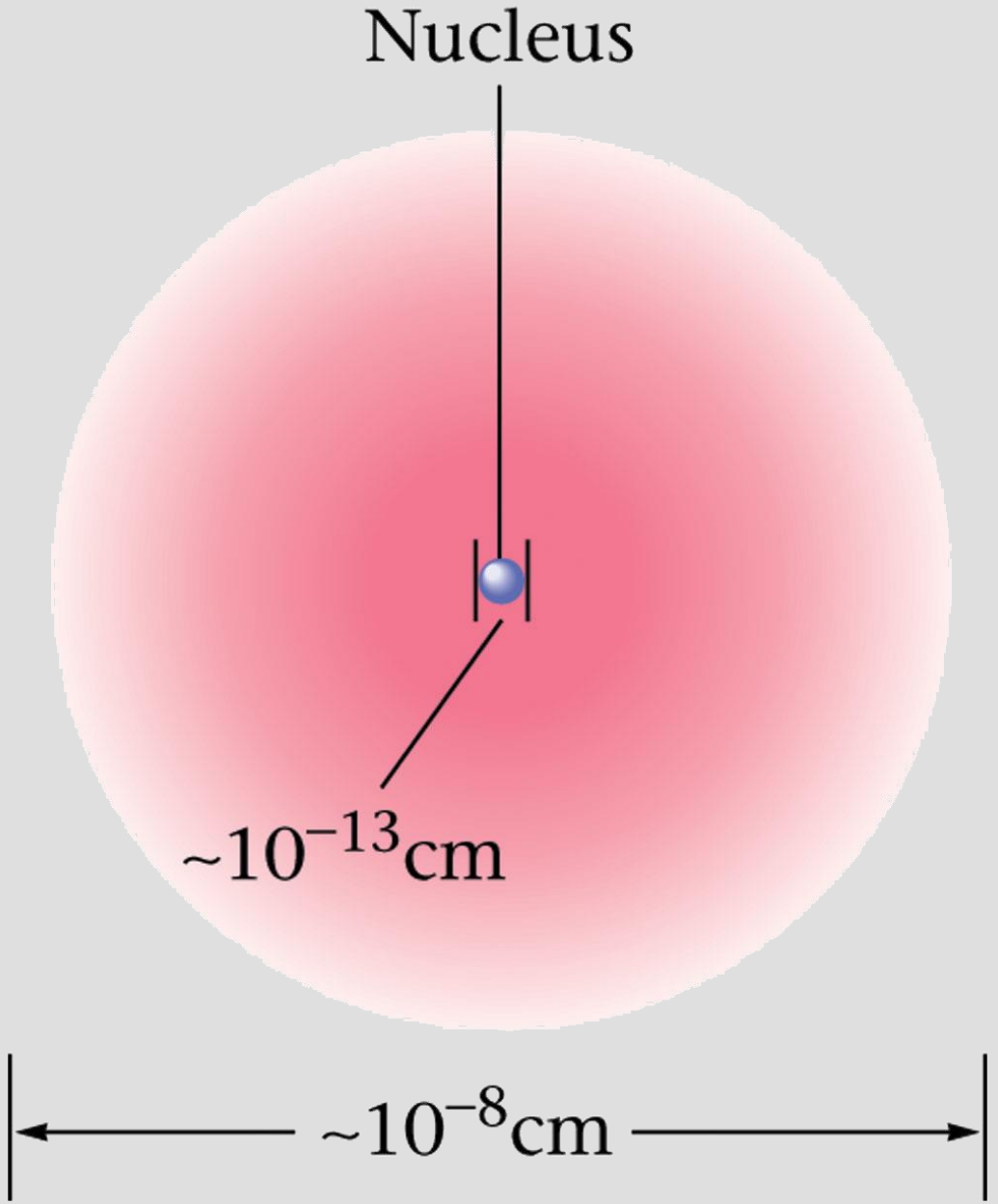
Rutherford's Results

1. Over 98% of the α particles went straight through
2. About 2% of the α particles went through but were deflected by large angles
3. About 0.01% of the α particles bounced off the gold foil

Rutherford's Nuclear Model

1. The atom contains a tiny dense center called the **nucleus**
    1. the volume is about 1/10 trillionth the volume of the atom
2. The nucleus is essentially the entire mass of the atom
3. The nucleus is positively charged
    1. *the amount of positive charge of the nucleus balances the negative charge of the electrons*
4. **The electrons** *move around in the empty space of the atom surrounding the nucleus*

Figure : A nuclear atom viewed in cross section.



Structure of the Nucleus

1. The nucleus was found to be composed of two kinds of particles
2. Some of these particles are called **protons**
    1. charge = +1
    2. mass is about the same as a hydrogen atom
3. Since protons and electrons have the same amount of charge, for the atom to be neutral there must be equal numbers of protons and electrons
4. The other particle is called a **neutron**
    1. has no charge
    2. has a mass slightly more than a proton

The Modern Atom

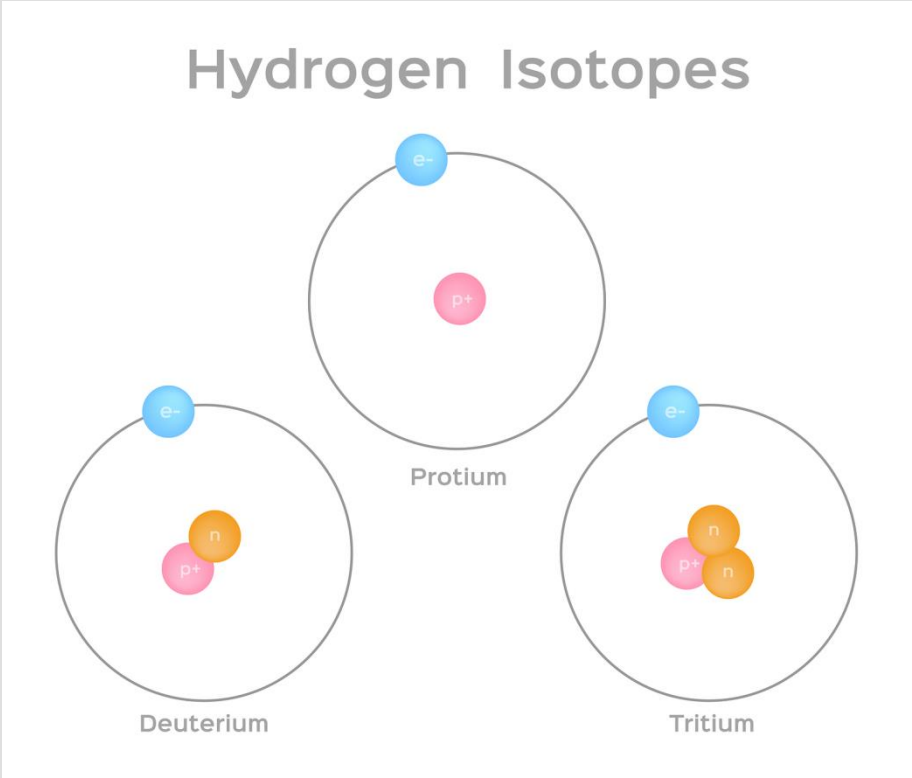
- We know atoms are composed of three main pieces - protons, neutrons and electrons
- The nucleus contains protons and neutrons
- The nucleus is only about 10^{-13} cm in diameter
- The electrons move outside the nucleus with an average distance of about 10^{-8} cm
  - therefore the radius of the atom is about 10^{5} times larger than the radius of the nucleus

Isotopes

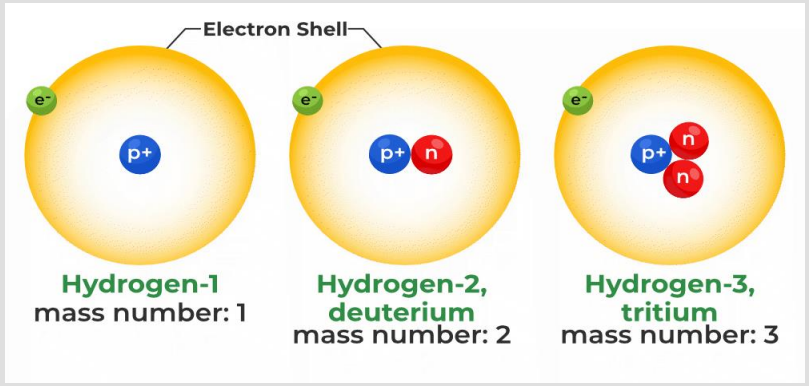
1. All atoms of an element have the same number of protons
2. The number of protons in an atom of a given element is the same as the **atomic number**
    1. **found on the Periodic Table**
3. Atoms of an element with different numbers of neutrons are called **isotopes**
4. All isotopes of an element are chemically identical
    1. **undergo the exact same chemical reactions**
5. Isotopes of an element have different masses
6. Isotopes are identified by their **mass numbers**
    1. **mass number = protons + neutrons**

Isotopes :-

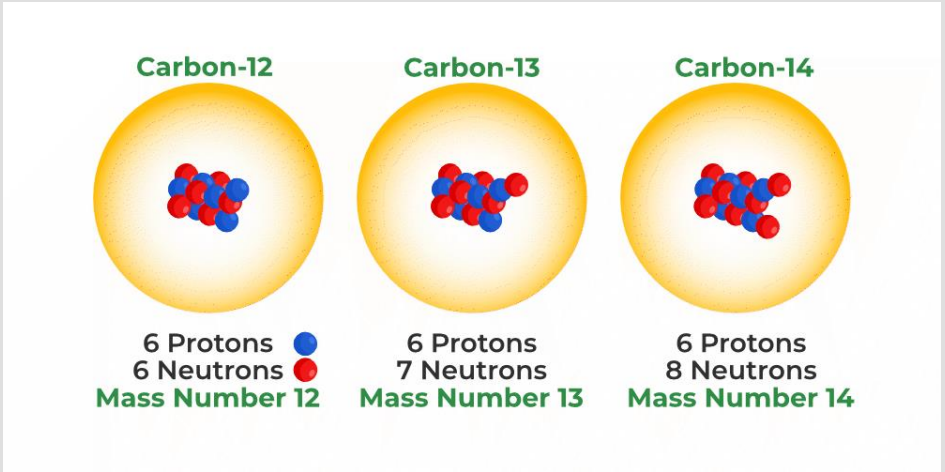
Atoms with the same number of proton but different numbers of neutrons .



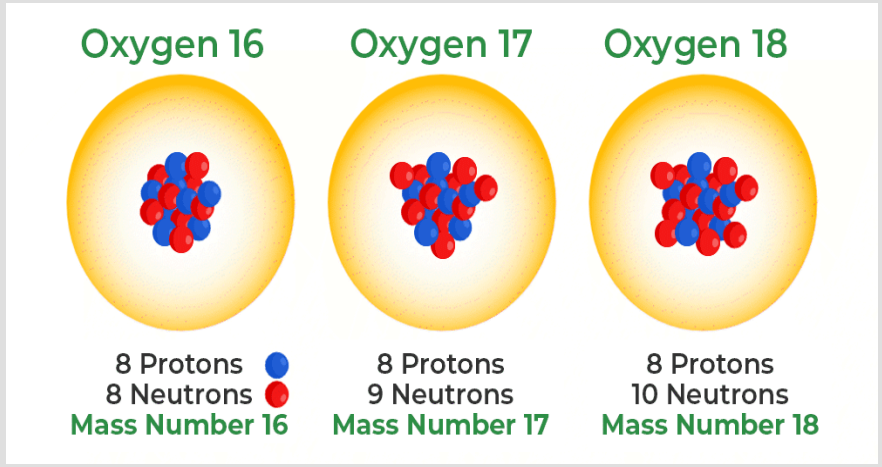
Examples of isotopes.



^{1}H ^{2}H ^{3}H



^{12}C ^{13}C ^{14}C



^{16}O ^{17}O ^{18}O

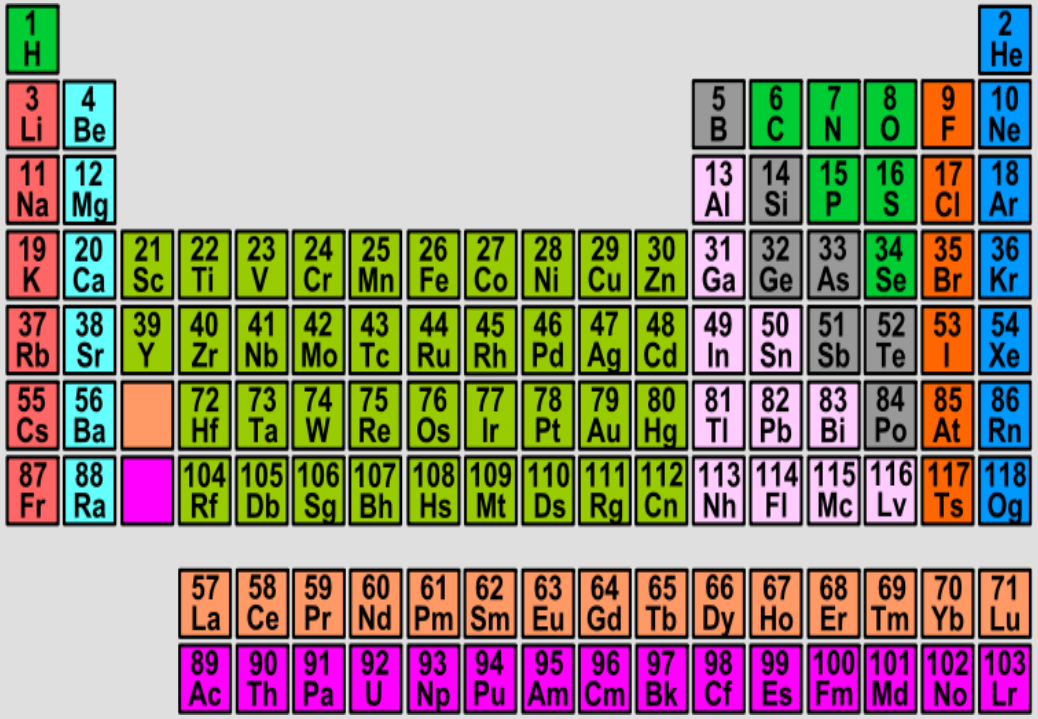
Elements

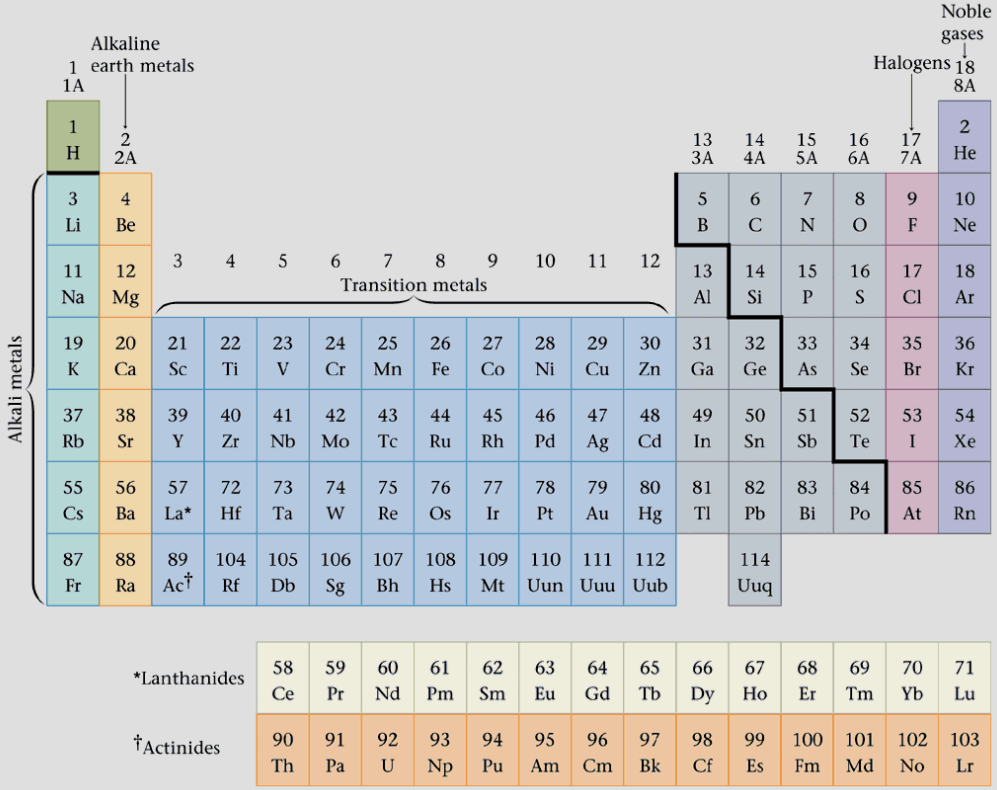
1. Arranged in a pattern called the Periodic Table
2. Position on the table allows us to predict properties of the element
3. Metals
    1. about 75% of all the elements
    2. lustrous, malleable, ductile, conduct heat and electricity
4. Nonmetals
    1. dull, brittle, insulators
5. Metalloids
    1. also know as semi-metals
    2. some properties of both metals & nonmetals

The Modern Periodic Table

1. Elements with similar chemical and physical properties are in the same column
2. Columns are called **Groups** or **Families**
3. Rows are called **Periods**
4. Each period shows the pattern of properties repeated in the next period

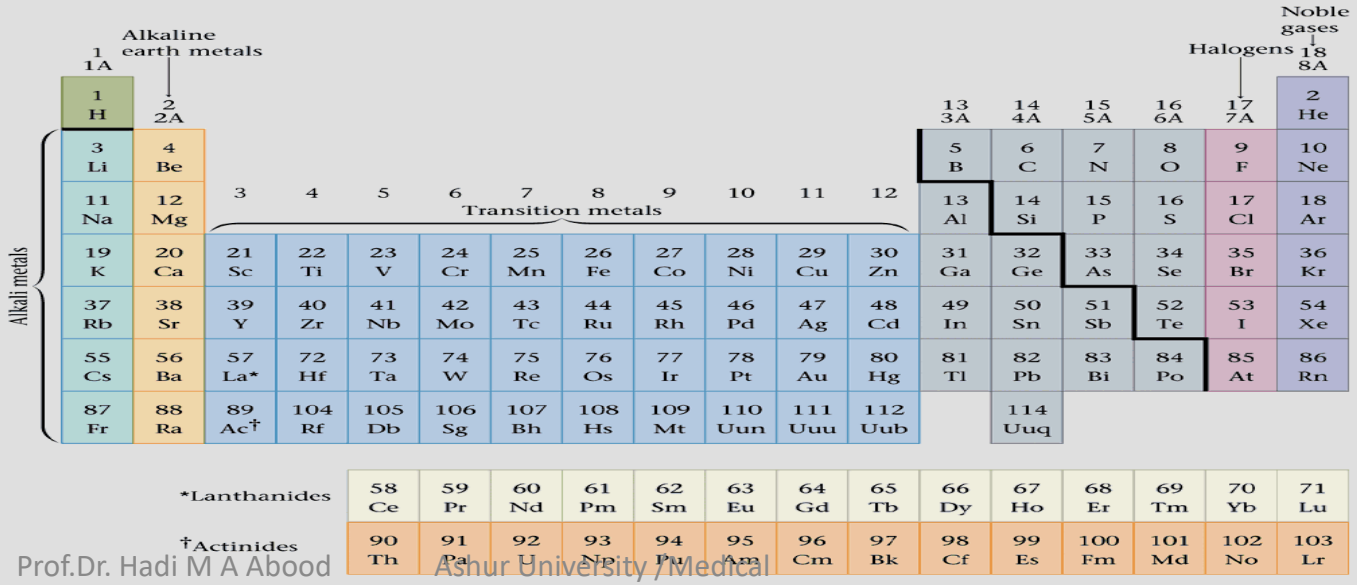
Figure : The periodic table.





The Modern Periodic Table

- Main Group = Representative Elements
  - "A" columns
- Transition Elements
  - all metals
- Bottom rows = Inner Transition Elements = Rare Earth Elements
  - belong in Period 6 & 7



Important Groups

- Group 8 = Noble Gases
- He, Ne, Ar, Kr, Xe, Rn

1. *all colorless gases at room temperature*
2. *very non-reactive, practically inert*
3. *found in nature as a collection of separate atoms uncombined with other atoms*

- Noble Metals
- Ag, Au, Pt

1. *all solids at room temperature*
2. *least reactive metals*
3. *found in nature uncombined with other atoms*

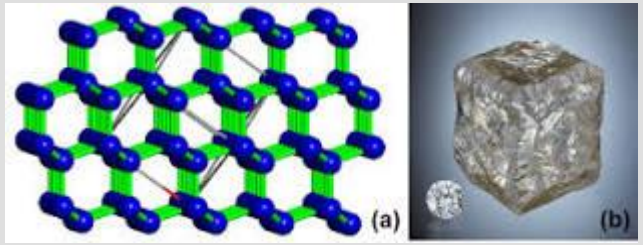
Important Groups - Halogens

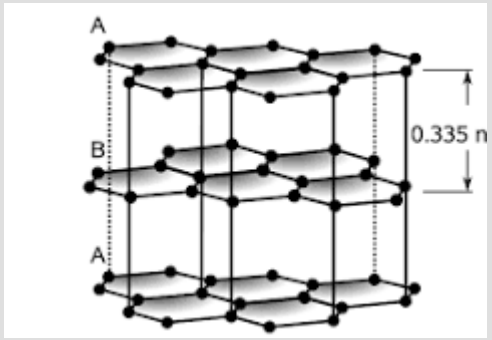
- Group 7A = Halogens
- *very reactive nonmetals*
- *react with metals to form ionic compounds*
- *HX all acids*

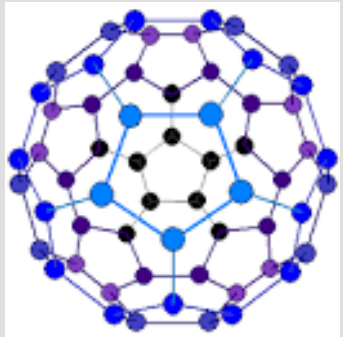
- Fluorine = F_2
  - pale yellow gas
- Chlorine = Cl_2
  - pale green gas
- Bromine = Br_2
  - brown liquid that has lots of brown vapor over it
  - Only other liquid element at room conditions is the metal Hg
- Iodine = I_2
  - lustrous, purple solid

Allotropes

- *Are solid nonmetallic elements exist in different forms with different physical properties*
- *the different physical properties arise from the different arrangements of the atoms in the solid*
- Allotropes of Carbon include
  - diamond
  - graphite
  - buckminsterfullerene







Electrical Nature of Matter

- Most common pure substances are very poor conductors of electricity
  - with the exception of metals and graphite
  - Water is a very poor electrical conductor
- Some substances dissolve in water to form a solution that conducts well - these are called **electrolytes**
- When dissolved in water, electrolyte compounds break up into component **ions**
  - ***ions** are atoms or groups of atoms that have an electrical charge*

Ions

1. ions that have a positive charge are called **cations**
    1. form when an atom loses electrons
2. ions that have a negative charge are called **anions**
    1. form when an atom gains electrons
3. *ions with opposite charges attract*
    1. therefore cations and anions attract each other
4. moving ions conduct electricity
5. compound must have no total charge, therefore we must balance the numbers of cations and anions in a compound to get 0 total charge

Atomic Structures of Ions

- Metals form cations
- For each positive charge the ion has 1 less electron than the neutral atom
  - Na = 11 e^-, Na^+ = 10 e^-
  - Ca = 20 e^-, Ca^{+2} = 18 e^-
- Cations are named the same as the metal

sodium	$Na \rightarrow Na^+ + 1e^-$	sodium ion
calcium	$Ca \rightarrow Ca^{+2} + 2e^-$	calcium ion

- The charge on a cation can be determined from the Group number on the Periodic Table for Groups IA, IIA, IIIA
  - Group 1A $\Rightarrow$ +1, Group 2A $\Rightarrow$ +2, (Al, Ga, In) $\Rightarrow$ +3

Atomic Structures of Ions

- Nonmetals form anions
- For each negative charge the ion has 1 more electron than the neutral atom
  - F = 9 e^-, F^- = 10 e^-
  - P = 15 e^-, P^{3-} = 18 e^-
- Anions are named by changing the ending of the name to ***-ide***

fluorine	$F + 1e^- \rightarrow F^-$	fluoride ion
oxygen	$O + 2e^- \rightarrow O^{2-}$	oxide ion

- The charge on an anion can be determined from the Group number on the Periodic Table
  - Group 7A $\Rightarrow$ -1, Group 6A $\Rightarrow$ -2