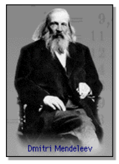
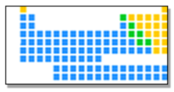
1

How Periodic Table is Arranged

- Properties of elements are periodic functions of their ATOMIC NUMBERS.



- Dmitri Mendeleev developed the modern periodic table. He argued that element properties are ***periodic functions of their atomic weights* - he was wrong.**



Syllabus Learning Outcomes : 5

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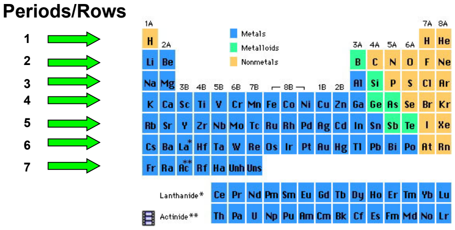
2

7 Periods in the Periodic Table

Periods/Rows

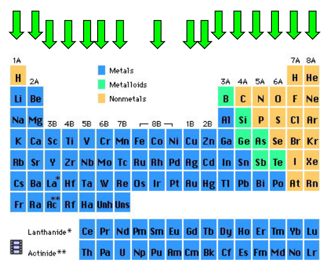


First period has 2 elements

3

16 Groups/Families in the Periodic Table

Elements in groups have similar chemical properties



Group 1A has 7 elements

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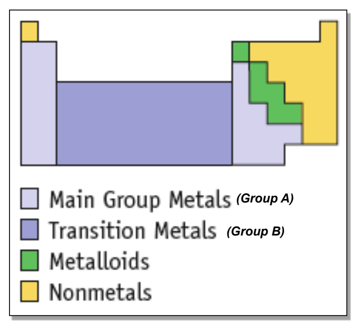
Regions of the Periodic Table



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Periodic Table Explains Chemical Reactivity

Elements have no charge

The next slides show the similar chemical reactivity for elements in Group 1A through Group 8A

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Group 1A: Alkali Metals
H, Li, Na, K, Rb, Cs

- **Metals (malleable, ductile, conduct heat & electricity)**
- **Reactive, exist in nature as compounds**
- **Form alkaline solutions with water**
- **Form +1 ions in compounds**
- **Hydrogen, placed in Group 1, is not a metal, exists naturally as a diatomic gas, H_2, and tends to be +1 in compounds**

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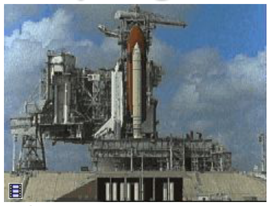
Hydrogen



Shuttle main engines used H_2 and O_2

Usually +1 in compounds

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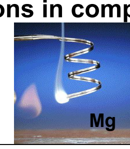
Group 2A: Alkaline Earth Metals

Be, Mg, Ca, Sr, Ba, Ra

- Metals
- Reactive, exist in nature as compounds
- All but Be form alkaline solutions with water
- Form +2 ions in compounds



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Group 3A: B, Al, Ga, In, Tl

- B is a metalloid
- Al, Ga, In, Tl are metals
- B chemistry tends to be different because it is a metalloid
- Tend to be +3 in compounds
- Group 3A forms similar compounds BCl_3, $AlCl_3$

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Group 4A: C, Si, Ge, Sn, Pb

- C is a nonmetal (often +4 or – 4)
- Si and Ge are metalloids (+/- 4)
- Sn and Pb are metals (often +4 ions)
- More variation in elemental properties than other groups
- Form analogous compounds – CO_2, SiO_2, GeO_2, SnO_2, PbO_2
- Carbon allotropes (graphite, graphene buckminsterfullerene, diamond)

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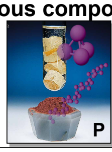
Group 5A: N, P, As, Sb, Bi

- N and P are nonmetals (often -3)
- As and Sb are metalloids (-3/+5)
- Bi is a metal (often +5 ions)
- Nitrogen occurs naturally as a diatomic molecule N_2
- Phosphorous glows in the dark if it is in air and has red and white allotropes
- Form analogous compounds – N_2O_5, P_2O_5, As_2O_5



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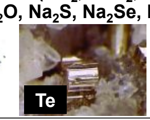
Group 6A: O, S, Se, Te, Po

- O, S and Se are nonmetals (often -2)
- Te is a metalloid
- Po is a metal
- Oxygen occurs naturally as a diatomic molecule O_2 and has an allotrope, Ozone - O_3
- S, Se, and Te are known as chalcogens because of presence in most Cu ores
- Polonium is radioactive.
- Form similar oxides (SO_2, SeO_2, TeO_2) and sodium compounds (Na_2O, Na_2S, Na_2Se, Na_2Te)



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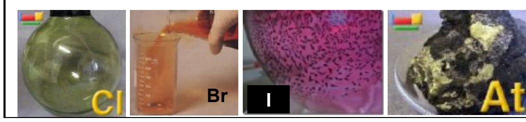
Group 7A: Halogens
F, Cl, Br, I, At

- F, Cl, Br, I and At are nonmetals
- Often -1 in compounds
- Fluorine, chlorine, bromine and iodine occur naturally as diatomic molecules
- Halogens are reactive
  - combine violently with alkali metals.
  - React with other metals and most nonmetals
- At room temperature, F_2 and Cl_2 are gases, Br_2 is a liquid, and I_2 is a solid.



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Group 8A: Noble Gases
He, Ne, Ar, Kr, Xe, Rn

Ne

- He, Ne, Ar, Kr, Xe, and Rn are nonmetals
- Tend not to form compounds
- Least reactive elements
- All are gases
- None are abundant
- Known as noble, inert or rare gases

He

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Diatomic Elements

- Remember HONClBrIF (Honclbrif)
- Represents H_2, O_2, N_2, Cl_2, Br_2, I_2, F_2
- Iodine is a solid, bromine is a liquid and the rest are gases at room temperature
- When they form compounds, they are no longer diatomic (NaCl)

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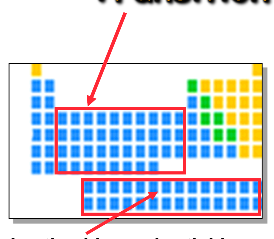
Transition Elements

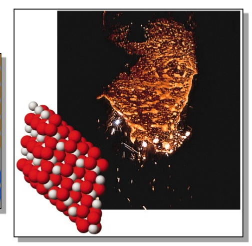


Lanthanides and actinides

Groups 1B-8B

Fe, Co, Ni groups are all 8B

Cu is 1B, Zn is 2B, Sc is 3B



Iron in air gives iron(III) oxide

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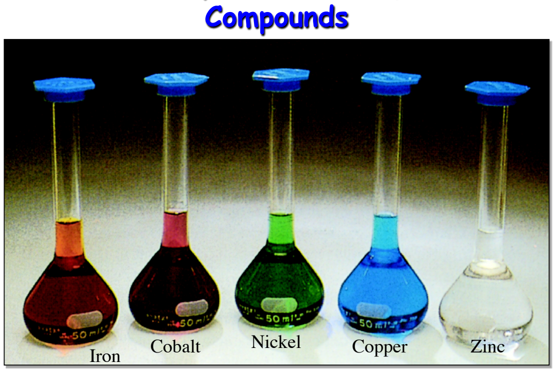
Colors of Transition Metal Compounds



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Group 1B to 8B: Transition Metals

- All are metals
- Most have commercial uses
- Most occur naturally in combination with other elements
- Silver (Ag), gold (Au), and platinum (Pt) are much less reactive and can be found in nature as pure elements

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Essential Elements

- The elements C, H, N and O account for 99% of the total composition of elements in biological systems.
- Water, H_2O is a major component of biological systems
- Na, K, Ca, Mg, P, S and Cl account for 0.9%
- Many trace elements (<0.1%) are also biologically important:
- Fe (hemoglobin), Co (Vitamin B12), Cu, I, Zn, Se

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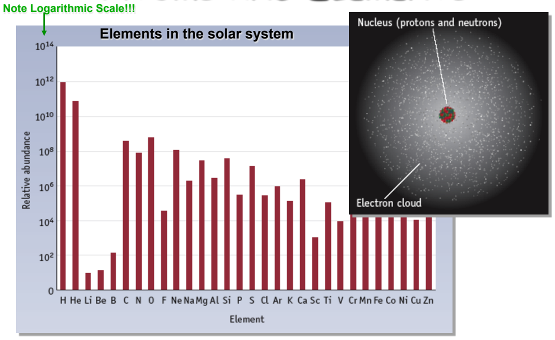
Atoms and Elements

Note Logarithmic Scale!!!



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Radioactivity

- One of the pieces of evidence for the fact that atoms are made of smaller particles came from the work of **Marie Curie** (1876-1934).
- She discovered **radioactivity**, the spontaneous disintegration of some elements into smaller pieces.

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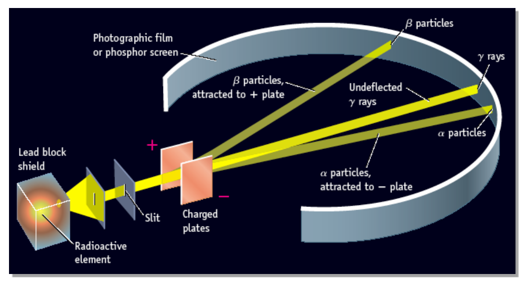
Types of Radioactive Emissions



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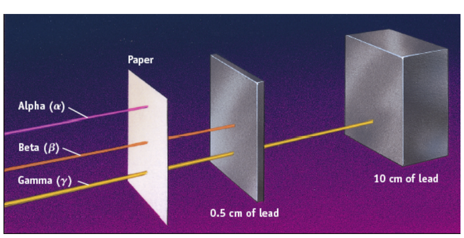
Types of Radioactive Emissions



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Atomic Discoveries

- J.J. Thompson determined the charge to mass ratio of an electron by passing electrons through an electromagnetic field (1896-1897).
- R.A. Millikan determined the charge on an electron in 1909 as 1.60 x10^{-19} C allowing the mass of an electron to be calculated.
- The mass of an electron is 9.109383x10^{-28} g

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Atomic Discoveries

The modern view of the atom was developed by **Ernest Rutherford** of New Zealand (1871-1937).

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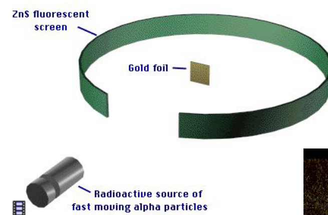
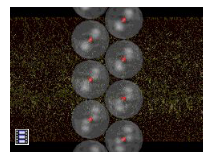
The modern view of the atom was developed by **Ernest Rutherford** (1871-1937).





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ATOMIC COMPOSITION

- **Protons**
  - +1 electrical charge
  - mass = 1.672623 x 10^{-24} g
  - relative mass = 1.00 atomic mass units (u)
- **Electrons**
  - -1 electrical charge
  - relative mass = 0.0005 u
- **Neutrons**
  - no electrical charge
  - mass = 1.00 u

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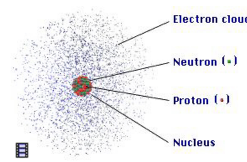
ATOM COMPOSITION

The atom is mostly empty space

•Protons and neutrons are located in the dense nucleus



•The number of electrons is equal to the number of protons.

•Electrons occupy space around the nucleus.

•Atoms are extremely small. One teaspoon of water has 3 times as many atoms as the Atlantic Ocean has teaspoons of water.

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Atomic Number, Z

All atoms of the same element have the same number of protons in the nucleus, Z

13	Atomic number, Z
Al	Atom symbol
26.981	Atomic mass

Atomic mass on periodic table is an average for all isotopes

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Atomic Mass

- This tells us the mass of one atom of an element relative to one atom of another element.
- OR — the mass of 1000 atoms of one relative to 1000 atoms of another.
- For example, an O atom (15.9994 u) is approximately 16 times heavier than an H atom (1.0079 u). u = atomic mass units.
- Define one element as the standard against which all others are measured
- Standard = carbon (1 u = 1/12th of the mass of 1 atom of carbon with 6 protons and 6 neutrons. This C atom's mass is 12.000 u.

1 u = 1.661x10^{-24}g, Calculate g using 6.022 x10^{23}

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Mass Number, A

- Mass Number (A) - Not on Periodic Table
- A = # protons + # neutrons
- Boron atoms (Z=5) can have A = 5 p + 5 n = 10 u

$^{10}_{5}B$ — A ⟶ 10, Z ⟶ 5

- C atom with 6 protons and 6 neutrons is the mass standard (Z=6 and A=12)
- = 12 atomic mass units (u)

$^{12}_{6}C$

Isotopes of carbon and boron

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Boron in Death Valley

•Death Valley has been a major source of borax and other boron-containing minerals.
•Borax was transported out of Death Valley in wagons pulled by teams of 20 mules.

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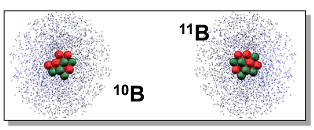
Isotopes

- Atoms of the same element (same Z) but different mass number (A).
- Boron-10 has 5 p and 5 n: $^{10}_{5}B$
- Boron-11 has 5 p and 6 n: $^{11}_{5}B$



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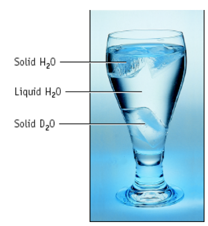
Hydrogen Isotopes

Hydrogen has _____ isotopes

$^{1}_{1}H$ 1 proton and 0 neutrons, protium

$^{2}_{1}H$ 1 proton and 1 neutron, deuterium

$^{3}_{1}H$ 1 proton and 2 neutrons, tritium
radioactive



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Isotope Composition

Isotope	Electrons	Protons	Neutrons
$^{32}_{16}S$			
$^{79}_{35}Br$			

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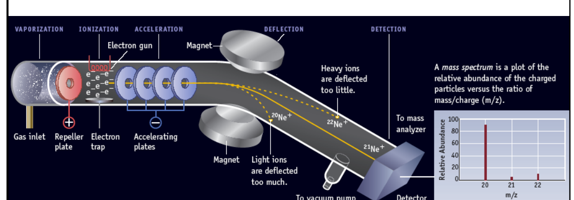
Masses of Isotopes

determined with a mass spectrometer



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Isotopes & Atomic Mass

- Because of the existence of isotopes, the mass of a collection of atoms has an average value.
- ^{6}Li = 7.5% abundant and ^{7}Li = 92.5%
  - –Atomic mass of Li = ______________
- ^{28}Si = 92.23%, ^{29}Si = 4.67%, ^{30}Si = 3.10%
  - –Atomic mass of Si = ______________

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Three Isotopes

What is the atomic mass of magnesium given these data?

^{24}Mg mass = 23.985042 u; % abundance= 78.99%

^{25}Mg mass = 24.985837 u; % abundance = 10.00%

^{26}Mg mass = 25.982593 u; % abundance = 11.01%

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Three Isotopes

What is the atomic mass of magnesium given these data?

^{24}Mg mass = 23.985042 u; % abundance = 78.99%

^{25}Mg mass = 24.985837 u; % abundance = 10.00%

^{26}Mg mass = 25.982593 u; % abundance = 11.01%

atomic weight of Mg =

(^{24}Mg mass)(% abundance) +

(^{25}Mg mass)(% abundance) +

(^{26}Mg mass)(% abundance) =

(23.985 u)(0.7899) + (24.986 u)(0.1000) + (25.983 u)(0.1101)

= 24.31 u

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Calculate % Abundance

- Calculate the percent abundance of each isotope given that copper has 2 isotopes ^{63}Cu with mass 62.9298 u and ^{65}Cu with mass 64.9278 u

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Calculate % Abundance

- Calculate the percent abundance of each isotope given that copper has 2 isotopes ^{63}Cu with mass 62.9298 u and ^{65}Cu with mass 64.9278 u
- Need atomic mass of Cu = 63.546 u (Periodic Table).
- The percent abundances of each isotope times the atomic masses must equal the atomic mass for copper
- Note that the percentages of both isotopes must total 100% or 1.
- So, if the fraction of ^{63}Cu is X, the fraction of ^{65}Cu must be 1-X
- Set up relationship and solve for X, the fraction of ^{63}Cu

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Calculate % Abundance

- Calculate the percent abundance of each isotope given that copper has 2 isotopes ^{63}Cu with mass 62.9298 u and ^{65}Cu with mass 64.9278 u

- 62.9298 u (X) + 64.9278 u (1-X) = 63.546 u
- X = fraction of ^{63}Cu = 0.6916
- 1-X = fraction of ^{65}Cu = 0.3084
- % ^{63}Cu = 0.6916 * 100% = 69.16%
- % ^{65}Cu = 0.3084 * 100% = 30.84%

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Summary

- Determine **atomic weight** from **isotope abundance**.
- Calculate **isotope abundance** from **atomic weight**.

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End