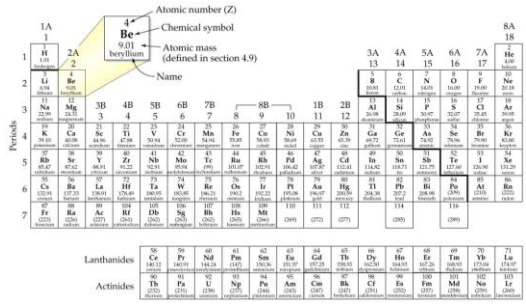
4.5 Elements

- each element has a unique number of protons in its nucleus
- the number of protons in the nucleus of an atom is called the **atomic number**
- each element has a unique name and symbol

The Periodic Table of Elements



4.6 Mendeleev and the Periodic Law

- order elements by atomic mass
- saw a repeating pattern of properties
- **Periodic Law** – When the elements are arranged in order of increasing relative mass, certain sets of properties recur periodically
- used pattern to predict properties of undiscovered elements

Periodic Pattern

nm H_2O a/b H 1 H_2

m Li_2O Li b 7 LiH	m/nm BeO Be a/b 9 BeH_2	nm B_2O_3 B a 11 $(BH_3)_n$	nm CO_2 C a 12 CH_4	nm N_2O_5 N a 14 NH_3	nm O_2 O 16 H_2O	nm OF_2 F 19 HF

Periodic Pattern

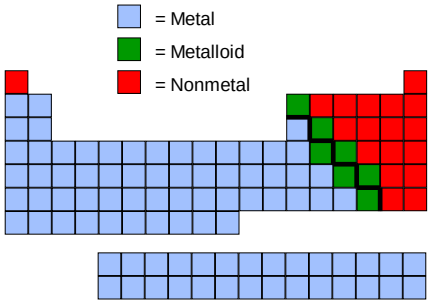
nm H_2O a/b H 1 H_2

m Li_2O Li b 7 LiH	m/nm BeO Be a/b 9 BeH_2	nm B_2O_3 B a 11 $(BH_3)_n$	nm CO_2 C a 12 CH_4	nm N_2O_5 N a 14 NH_3	nm O_2 O 16 H_2O	nm OF_2 F 19 HF
m Na_2O Na b 23 NaH	m MgO Mg b 24 MgH_2	m Al_2O_3 Al a/b 27 $(AlH_3)_n$	nm/m SiO_2 Si a 28 SiH_4	nm P_4O_{10} P a 31 PH_3	nm SO_3 S a 32 H_2S	nm Cl_2O_7 Cl a 35.5 HCl

Mendeleev's Predictions for Ekasilicon (Germanium)

Property	***Silicon's Props***	***Tin's Props***	***Predicted Value***	***Measured Value***
Atomic Mass	28	118	72	72.6
Color	Grey	White metal	Grey	Grey-White
Density	2.32	7.28	5.5	5.4
Reaction w/ Acid & Base	Resists Acid, Reacts Base	Reacts Acid, Resists Base	Resists Both	Resists Both
Oxide	SiO_2	SnO_2	Eks_1O_2	GeO_2

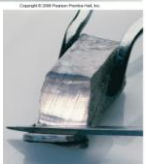
Periodicity



PerTable Movie

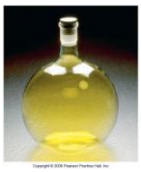
Metals

- solids at room temperature, except Hg
- shiny
- conduct heat
- conduct electricity
- malleable
- ductile
- about 75% of the elements are metals
- lower left on the table



Nonmetals

- found in all 3 states
- poor conductors of heat
- poor conductors of electricity
- solids are brittle
- upper right on the table



Metalloids

- show properties of metals and some of nonmetals
- also known as semiconductors

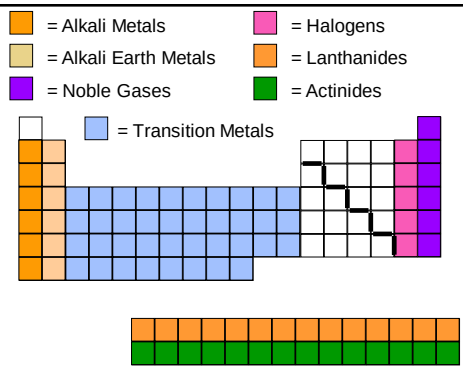
Properties of Silicon
shiny
conducts electricity
does not conduct heat well
brittle

The Modern Periodic Table

- Elements with similar chemical and physical properties are in the same column (**Groups** or **Families)**
- Rows are called **Periods**

The Modern Periodic Table

- Main Group = Representative Elements = 'A' groups
- Transition Elements = 'B' groups
- Bottom rows = Inner Transition Elements = Rare Earth Elements



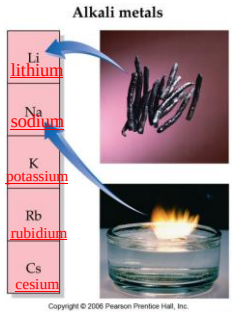
Important Groups - Hydrogen

- nonmetal
- colorless, diatomic gas
- reacts with nonmetals to form molecular compounds
- reacts with metals to form hydrides
- Many compounds form acids in water

Important Groups – IA, Alkali Metals

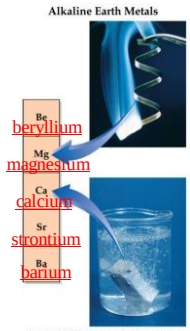
- hydrogen doesn't belong
- soft, low melting points,low density
- very reactive, never find uncombined in nature
- tend to form water soluble compounds
- react with water to form basic (alkaline) solutions and H_2

Alkali metals and water



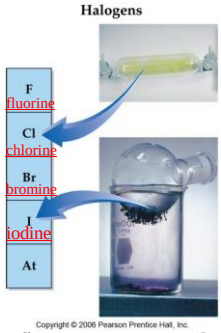
Important Groups – IIA, Alkali Earth Metals

- harder, higher melting, and denser than alkali metals
- reactive, but less than corresponding alkali metal
- form stable, insoluble oxides
- oxides are basic
- react with water to form H_2



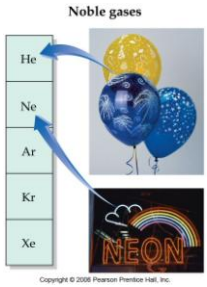
Important Groups – VIIA, Halogens

- nonmetals
- very reactive
- Cl_2, Br_2 react slowly with water
- react with metals to form ionic compounds
- Forms acid when combined with hydrogen
  - ✓HF weak < HCl < HBr < HI



Important Groups – VIIIA, Noble Gases

- all gases at room temperature,
- very unreactive, practically inert



4.7 Ions

- Atoms acquire a charge by gaining or losing electrons
- Ion Charge = # protons – # electrons
- ions with a + charge are called **cations**
- ions with a – charge are called **anions**

Atomic Structures of Ions

- Metals form cations
- Cations are named the same as the metal

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

Atomic Structures of Ions

- Nonmetals form anions
- 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

Example 4.5: Determining the Number of Protons and Electrons in an Ion

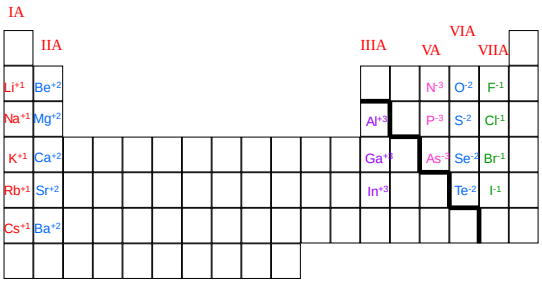
Find the number of protons and electrons in the Ca^{2+} ion

Atomic Structures of Ions

Ion	p^{+}	e^{-}
Cl^{-1}		
K^{+1}		
S^{-2}		
Sr^{+2}		

Ion Charge & the Periodic Table

- metals are always positive ions
  - ✓for many main group metals, the charge = the group number
- nonmetals are negative ions
  - ✓for nonmetals, the charge = the group number - 8



4.8 Isotopes

- The same element can have atoms with different masses, called **isotopes**
- The observed mass is a weighted average of the weights of all the naturally occurring **isotopes**

- all isotopes of an element are chemically identical
- all isotopes of an element have the same number of protons
- isotopes of an element have different numbers of neutrons
- isotopes are identified by their **mass numbers**

Neon

Symbol	Number of Protons	Number of Neutrons	A, Mass Number	Percent Natural Abundance
Ne-20 or $^{20}_{10}Ne$	10	10	20	90.48%
Ne-21 or $^{21}_{10}Ne$	10	11	21	0.27%
Ne-22 or $^{22}_{10}Ne$	10	12	22	9.25%

Example 4.8: Determining the Number of Protons and Neutrons from Isotope Symbols

How many protons and neutrons in the chromium-52

Practice - Complete the following table

	Atomic Number	Mass Number	Number of Protons	Number of Electrons	Number of Neutrons
Calcium-40					
Carbon-13					
Aluminum-27^{+3}					

4.9 Atomic Mass

- Mass Number is Not the Same as Atomic Mass

Calculating Atomic Mass

Gallium has two naturally occurring isotopes: Ga-69 with mass 68.9256 amu and a natural abundance of 60.11% and Ga-71 with mass 70.9247 amu and a natural abundance of 39.89%. Calculate the atomic mass of gallium.