

# Chem 111

## Lecture 4



# Announcements

- My Office is LGRT- 503, room of cubicles, all the way in the back.

# Homework

- Finishing Up Reading Chapter 2
- OWL online homework.

# Recap

- Error
- Scientific Notation
- Significant Figures
- Dimensional Analysis
- Atomic Structure

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# Atomic Structure

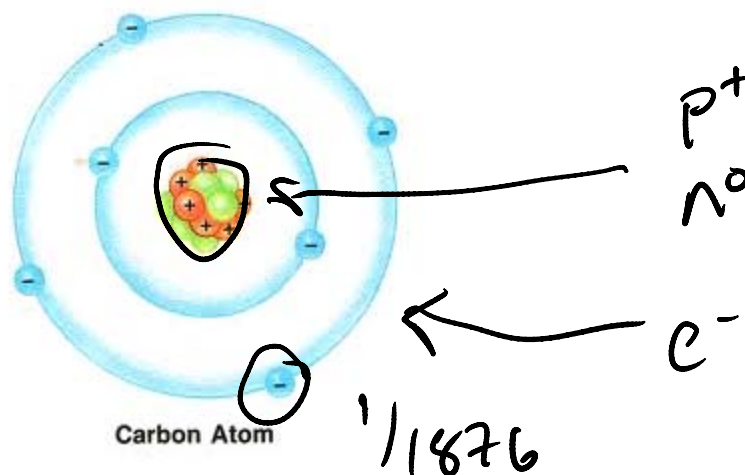
All atoms of an element have the same number of protons in the nucleus.

Elements are distinguished from one another by the number of protons or **Atomic Number (Z)**.

**Isotopes** are atoms of a given element that differ in the number of neutrons (and mass).

**Mass Number (A)**, is the total number of protons plus neutrons.

# Atomic Structure



	Change
Protons	New Element
Neutrons	New Isotope
Electrons	New Ion

# Symbolic Representation

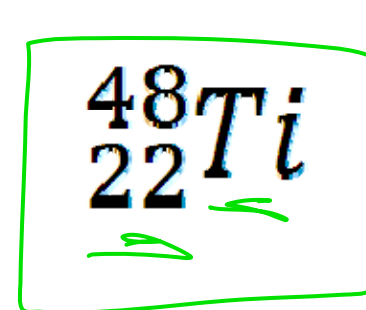
48 Ti

Mass Number

$\begin{matrix} A \\ Z \end{matrix} E$

Symbol for the element

Atomic Number



ATOMIC  
NUMBER

ATOMIC  
WEIGHT

= avg mass #  
(196)

22

47.90

Ti

SYMBOL

(Ar)3d<sup>2</sup>4s<sup>2</sup>

Titanium

ELECTRON  
CONFIGURATION

NAME

$$48 - 22 = 26$$

n°

# Abundance

$$100\% \times \frac{99 \text{ zero neutron atoms}}{100} = 99\%$$

$$\text{percent abundance} = \frac{\text{\# of atoms in a given isotope}}{\text{total \# of atoms of all isotopes}} \times 100\%$$

**Atomic weight** - is the weighted average mass *numbers*.

*atomic weight*

$$= \left( \frac{\% \text{ abundance isotope 1}}{100} \right) (\text{mass of isotope 1}) + \left( \frac{\% \text{ abundance isotope 2}}{100} \right) (\text{mass of isotope 2}) + \dots$$

$$99\% \times 1 + 1\% \times 2 =$$



# Periodic Table

Handwritten notes above the table:

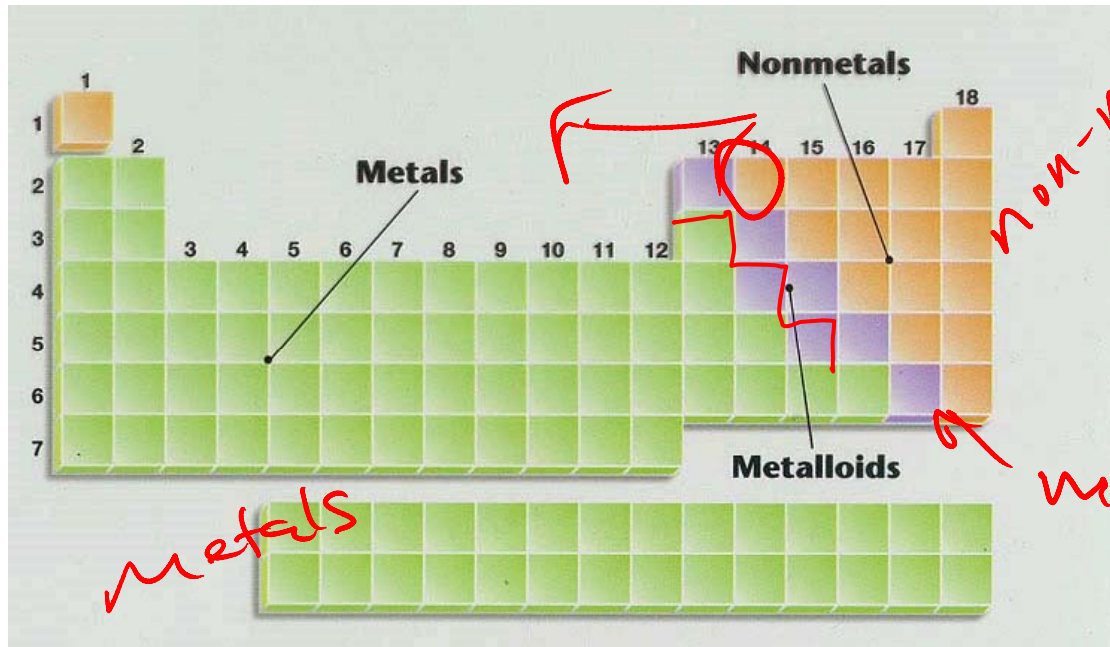
- $CH_4$  and  $SiX_4$  with a red arrow pointing to Group 14.
- $NX_3$  and  $PH_3$  with a green arrow pointing to Group 15.

Handwritten annotations on the table:

- A red arrow points to Group 1 (labeled IA).
- A green arrow labeled "period" points to the first row (Period 1).
- Red circles highlight Group 1 (IA), Group 2 (IIA), Group 13 (IIIA), Group 14 (IVA), Group 15 (VA), and Group 16 (VIA).
- A green circle highlights Germanium (Ge) in Period 4, Group 14.
- A green arrow labeled "group" points down the right side of the table.

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	1 H (IA)																	2 He (VIIIA)
Period 2	3 Li (IA)	4 Be (IIA)											5 B (IIIA)	6 C (IVA)	7 N (VA)	8 O (VIA)	9 F (VIIA)	10 Ne (VIIIA)
Period 3	11 Na (IA)	12 Mg (IIA)											13 Al (IIIA)	14 Si (IVA)	15 P (VA)	16 S (VIA)	17 Cl (VIIA)	18 Ar (VIIIA)
Period 4	19 K (IA)	20 Ca (IIA)	21 Sc (IIIB)	22 Ti (IVB)	23 V (VB)	24 Cr (VIB)	25 Mn (VIIB)	26 Fe (VIII)	27 Co (VIII)	28 Ni (VIII)	29 Cu (IB)	30 Zn (IIB)	31 Ga (IIIA)	32 Ge (IVA)	33 As (VA)	34 Se (VIA)	35 Br (VIIA)	36 Kr (VIIIA)
Period 5	37 Rb (IA)	38 Sr (IIA)	39 Y (IIIB)	40 Zr (IVB)	41 Nb (VB)	42 Mo (VIB)	43 Tc (VIIB)	44 Ru (VIII)	45 Rh (VIII)	46 Pd (VIII)	47 Ag (IB)	48 Cd (IIB)	49 In (IIIA)	50 Sn (IVA)	51 Sb (VA)	52 Te (VIA)	53 I (VIIA)	54 Xe (VIIIA)
Period 6	55 Cs (IA)	56 Ba (IIA)	57 *	72 Hf (IVB)	73 Ta (VB)	74 W (VIB)	75 Re (VIIB)	76 Os (VIII)	77 Ir (VIII)	78 Pt (VIII)	79 Au (IB)	80 Hg (IIB)	81 Tl (IIIA)	82 Pb (IVA)	83 Bi (VA)	84 Po (VIA)	85 At (VIIA)	86 Rn (VIIIA)
Period 7	87 Fr (IA)	88 Ra (IIA)	89 +	104 Rf (IVB)	105 Ha (VB)	106 Sg (VIB)	107 Bh (VIIB)	108 Hs (VIII)	109 Mt (VIII)	110 Ds (VIII)	111 Rg (IB)	112 Uub (IIB)	113 Uut (IIIA)	114 Uuq (IVA)	115 Uup (VA)	116 Uuh (VIA)	117 Uus (VIIA)	118 Uuo (VIIIA)
s-block		d-block										p-block						
f-block	Lanthanide Series		57 *La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
	Actinide Series		89 +Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

# Periodic Table



**Metals** – luster, high electrical and thermal conductivity, ductile and malleable.

**Nonmetals** – various colors, brittle, poor conductors, low mp

**Metalloids** – Have properties that fall in between those of metals and nonmetals

# Periodic Table

reactive

Periodic Table of Elements																		
© AllAboutGemstones.com																		
Period																		
Group																		
IA																		
IIA																		
IIIA																		
IVA																		
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1	H	He																He
2	Li	Be																Ne
3	Na	Mg																Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra		Rf	Ha	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
s-block			d-block										p-block					
f-block																		
Lanthanide Series			57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	
Actinide Series			89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	

Alkali Metals

Alkali Earth Metals





# Periodic Table

→ complexes = color

Group 1																		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Transition Metals



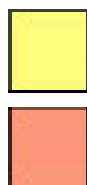
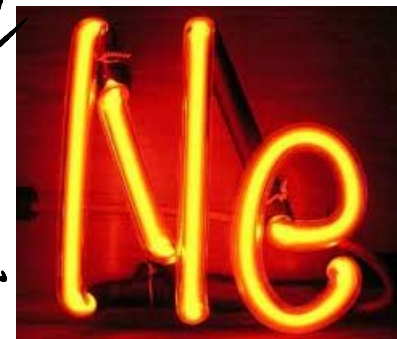
Rare Earth Metals



# Periodic Table

Handwritten annotations: "s" with arrows pointing to groups 1 and 2; "main group" with an arrow pointing to groups 13-18; "p" with an arrow pointing to groups 13-18.

Group 1																			Group 2																			Group 3																			Group 4																			Group 5																			Group 6																			Group 7																			Group 8																			Group 9																			Group 10																			Group 11																			Group 12																			Group 13																			Group 14																			Group 15																			Group 16																			Group 17																			Group 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Halogens

Noble Gasses

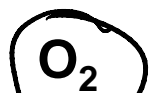
Chalogens



# Molecules

**Molecules** – are assemblies of two or more atoms tightly bound together. This “package” of atoms behaves like a single distinct object.

Pure substance.



Dioxygen

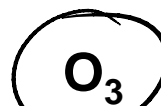
diatomic

odorless

gas – colorless

mp/bp = 54.36 K / 90.20 K

v



Ozone

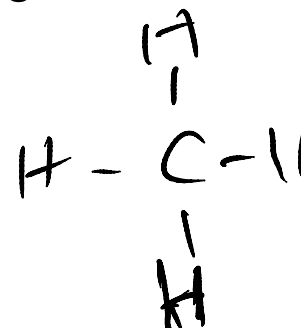
triatomic

pungent smell

gas – pale blue

mp/bp = 80.7 K / 161.3 K

much more reactive



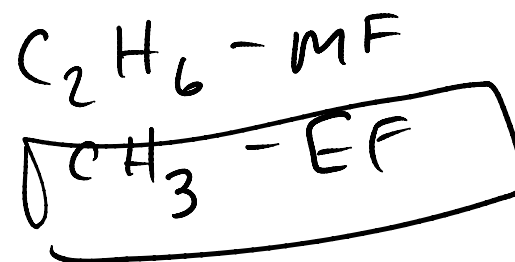
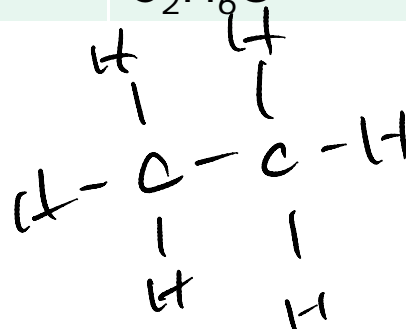
# Formulas

**Empirical (or simplest) formula** – gives only the **relative** number of atoms of each type in a molecule.

**Molecular formula** – the **actual** numbers and types of atom in a molecule

Name	Empirical	Molecular
Water	H <sub>2</sub> O	H <sub>2</sub> O
Peroxide	HO	H <sub>2</sub> O <sub>2</sub>
Ethanol	C <sub>2</sub> H <sub>6</sub> O	C <sub>2</sub> H <sub>6</sub> O
Dimethyl Ether	C <sub>2</sub> H <sub>6</sub> O	C <sub>2</sub> H <sub>6</sub> O

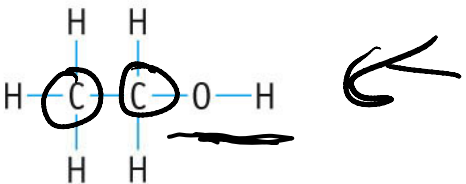
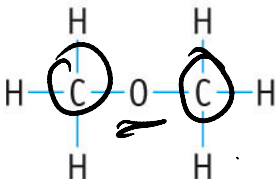
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# Formulas

**Condensed formula** – show atoms in **relation** (how they are grouped) to each other without showing the bonds.

**Structural formula** – is a **graphical depiction** of the molecular structure.

NAME	MOLECULAR FORMULA	CONDENSED FORMULA	STRUCTURAL FORMULA
Ethanol	$C_2H_6O$	$CH_3CH_2OH$	
Dimethyl ether	$C_2H_6O$	$CH_3OCH_3$	

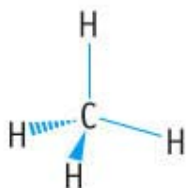
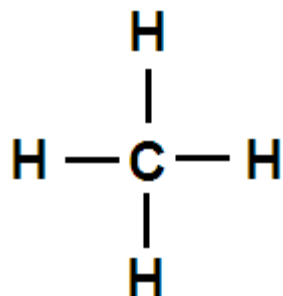
© Brooks/Cole, Cengage Learning

Fig. 2-13, p. 68



# Models

## Methane



Simple perspective drawing

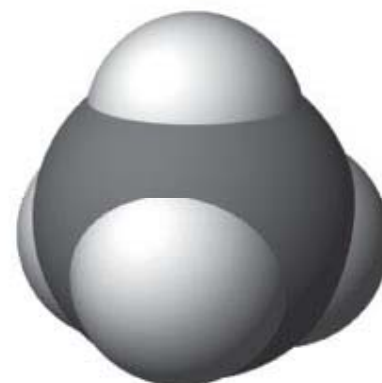
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Plastic model



Ball-and-stick model



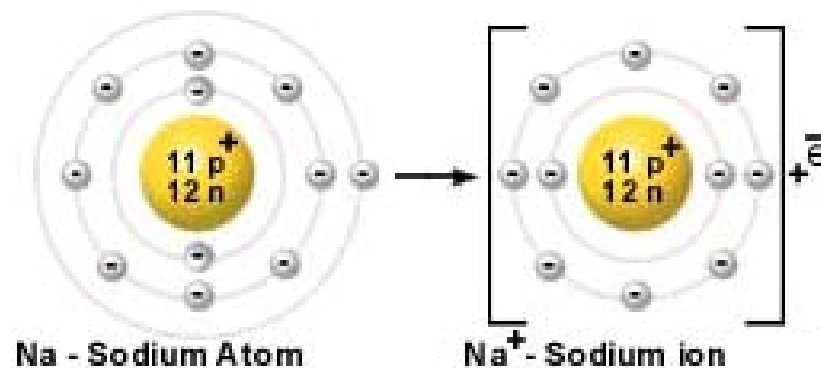
Space-filling model



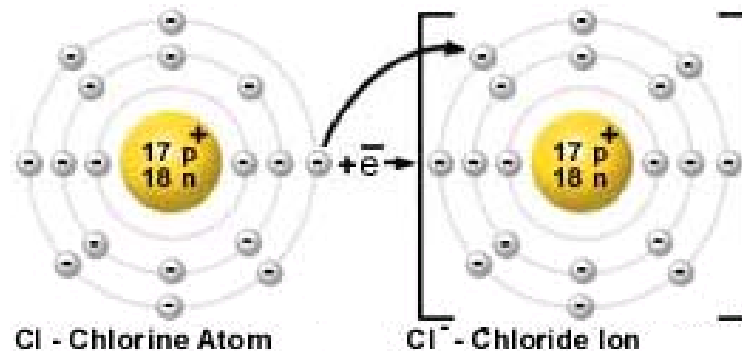
# Ions

**Ions** – are charged particles. Occur when electrons are removed or added to a neutral atom or molecule.

**Cation** – an ion with a positive charge.



**Anion** – an ion with a negative charge.



# Monatomic Ions

- Metals generally lose electrons and form cations.
- Nonmetals generally gain electrons and form anions.
- Groups 1A – 3A  $\rightarrow$  Lose electrons = Group Number
- Groups non-metals  $\rightarrow$  Gain electrons =  $8 - \text{group number}$

**Fig. 2-18, p. 72**

Legend:

- Metals
- Transition metals
- Metalloids
- Nonmetals

1A	2A											3A	4A	5A	6A	7A	8A
H <sup>+</sup>																H <sup>-</sup>	
Li <sup>+</sup>														N <sup>3-</sup>	O <sup>2-</sup>	F <sup>-</sup>	
Na <sup>+</sup>	Mg <sup>2+</sup>	3B	4B	5B	6B	7B	8B		1B	2B	Al <sup>3+</sup>		P <sup>3-</sup>	S <sup>2-</sup>	Cl <sup>-</sup>		
K <sup>+</sup>	Ca <sup>2+</sup>		Ti <sup>4+</sup>		Cr <sup>2+</sup>	Mn <sup>2+</sup>	Fe <sup>2+</sup>	Co <sup>2+</sup>	Ni <sup>2+</sup>	Cu <sup>+</sup>							
					Cr <sup>3+</sup>		Fe <sup>3+</sup>	Co <sup>3+</sup>		Cu <sup>2+</sup>	Zn <sup>2+</sup>				Se <sup>2-</sup>	Br <sup>-</sup>	
Rb <sup>+</sup>	Sr <sup>2+</sup>									Ag <sup>+</sup>	Cd <sup>2+</sup>						
															Te <sup>2-</sup>	I <sup>-</sup>	
Cs <sup>+</sup>	Ba <sup>2+</sup>										Hg <sub>2</sub> <sup>2+</sup>						
											Hg <sup>2+</sup>		Pb <sup>2+</sup>	Bi <sup>3+</sup>			

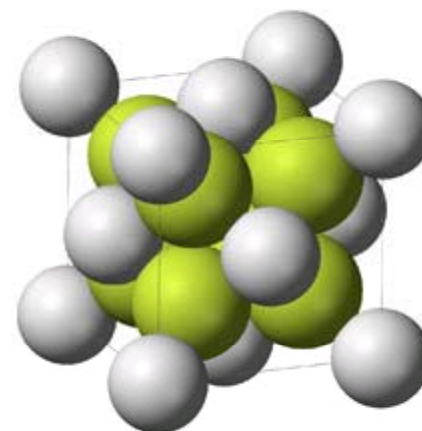
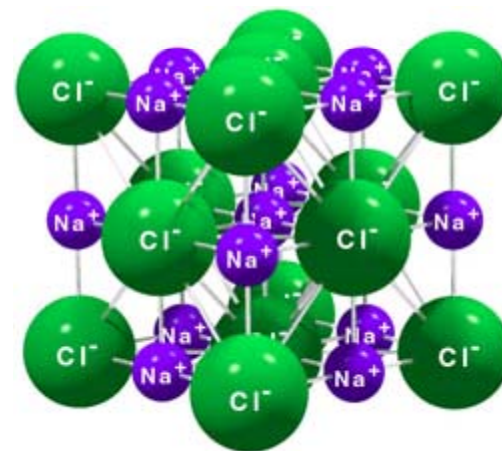
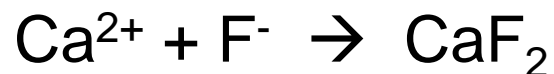
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# Ionic Compounds

**Ionic Compounds** - are compounds that contain positively charged ions and negatively charged ions.



Metals + Nonmetals  $\rightarrow$  Ionic Compounds



# Polyatomic Ions

**Polyatomic Ion** - is a charged compound composed of two or more atoms bonded together.

**TABLE 2.4** Formulas and Names of Some Common Polyatomic Ions

Formula	Name	Formula	Name
<b>CATION: Positive Ion</b>			
$\text{NH}_4^+$	ammonium ion		
<b>ANIONS: Negative Ions</b>			
<b>Based on a Group 4A element</b>		<b>Based on a Group 7A element</b>	
$\text{CN}^-$	cyanide ion	$\text{ClO}^-$	hypochlorite ion
$\text{CH}_3\text{CO}_2^-$	acetate ion	$\text{ClO}_2^-$	chlorite ion
$\text{CO}_3^{2-}$	carbonate ion	$\text{ClO}_3^-$	chlorate ion
$\text{HCO}_3^-$	hydrogen carbonate ion (or bicarbonate ion)	$\text{ClO}_4^-$	perchlorate ion
<b>Based on a Group 5A element</b>		<b>Based on a Group 6A element</b>	
$\text{NO}_2^-$	nitrite ion	$\text{OH}^-$	hydroxide ion
$\text{NO}_3^-$	nitrate ion	$\text{SO}_3^{2-}$	sulfite ion
$\text{PO}_4^{3-}$	phosphate ion	$\text{SO}_4^{2-}$	sulfate ion
$\text{HPO}_4^{2-}$	hydrogen phosphate ion	$\text{HSO}_4^-$	hydrogen sulfate ion (or bisulfate ion)
$\text{H}_2\text{PO}_4^-$	dihydrogen phosphate ion		

Table 2-4, p. 74