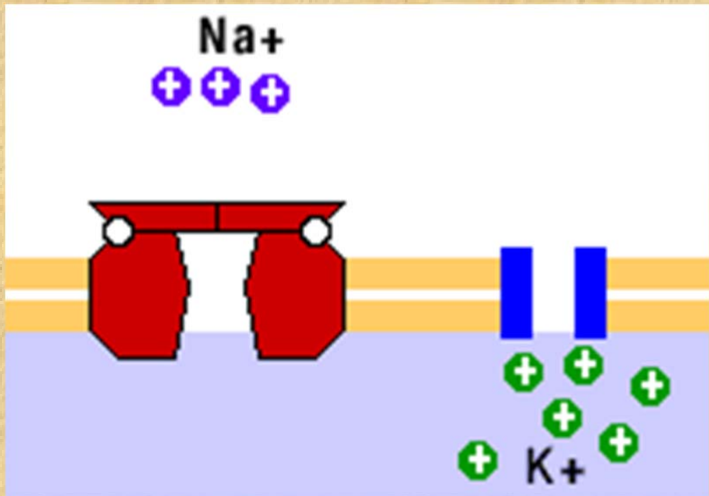
Chemistry Chapter 7

Chemical Formulas and Chemical Compounds



Heart cell rhythm depends on the opening and closing of a complex series of valves on the cell membrane, called **ion channels**. Some valves let certain ions ike potassium (K+) flow out, others let different ions like sodium (Na+) flow in. There are also pumps that actively move ions one direction or another.

Ions

- **Cation**: A positive ion
  - Mg^{2+}, NH_4^+
- **Anion**: A negative ion
  - Cl^-, SO_4^{2-}
- **Ionic Bonding**: Force of attraction between oppositely charged ions.

Predicting Ionic Charges

Group 1: Lose 1 electron to form **1+** ions

H^+ Li^+ Na^+ K^+

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289) (287)		116 (289)		

Predicting Ionic Charges

Group 2: Loses 2 electrons to form 2+ ions

Be^{2+} Mg^{2+} Ca^{2+} Sr^{2+} Ba^{2+}

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
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37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
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Predicting Ionic Charges

Group 13: Loses 3 electrons to form 3+ ions

B^{3+} Al^{3+} Ga^{3+}

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
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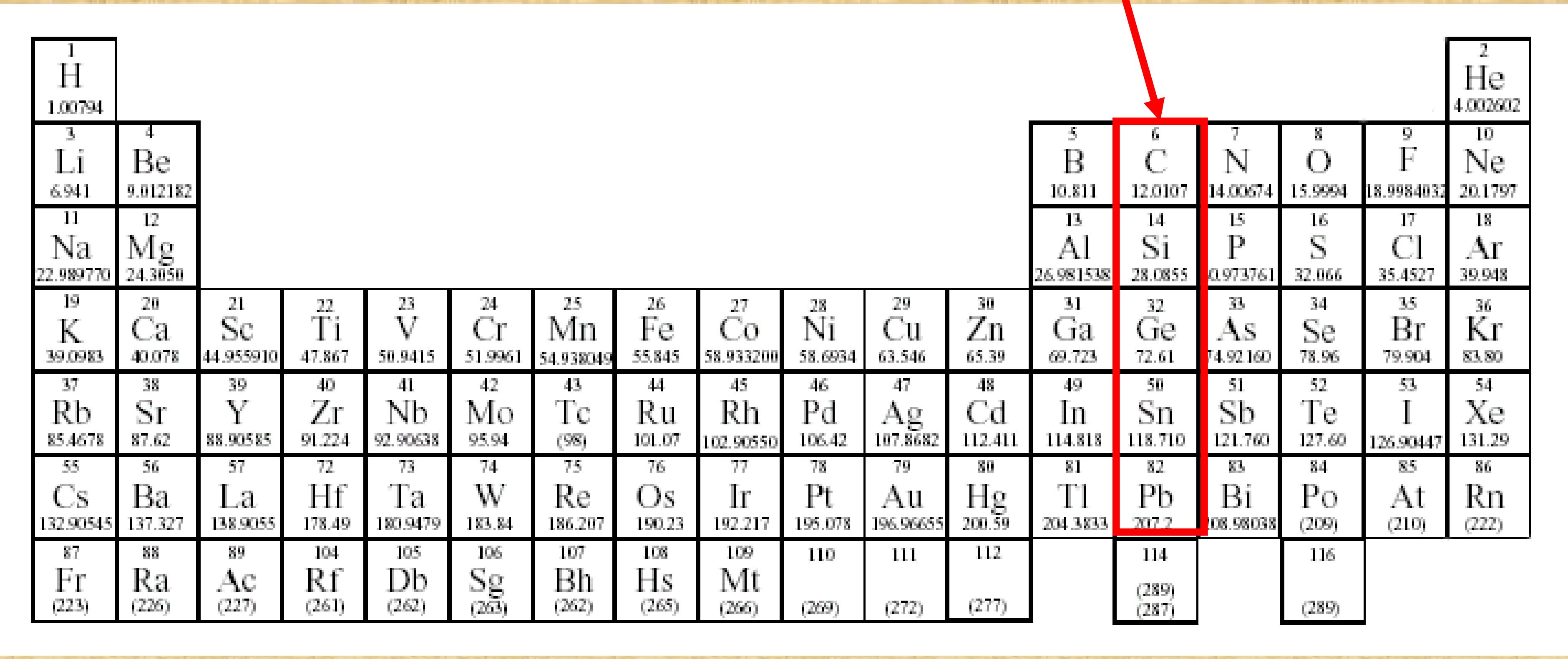
Predicting Ionic Charges

Neither! Group 13 elements rarely form ions.

Group 14: Lose 4 electrons or gain 4 electrons?



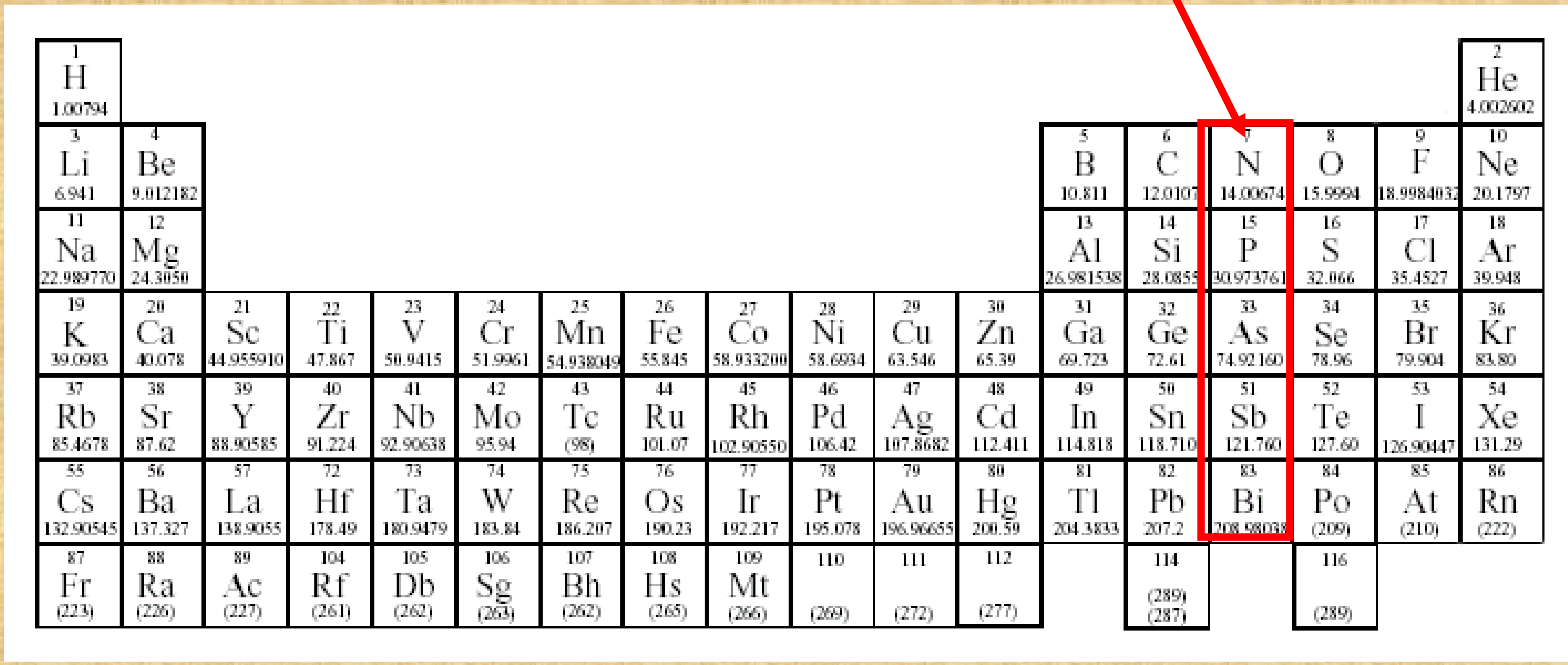
Predicting Ionic Charges

N^{3-} Nitride

P^{3-} Phosphide

As^{3-} Arsenide

Group 15: Gains 3 electrons to form 3- ions



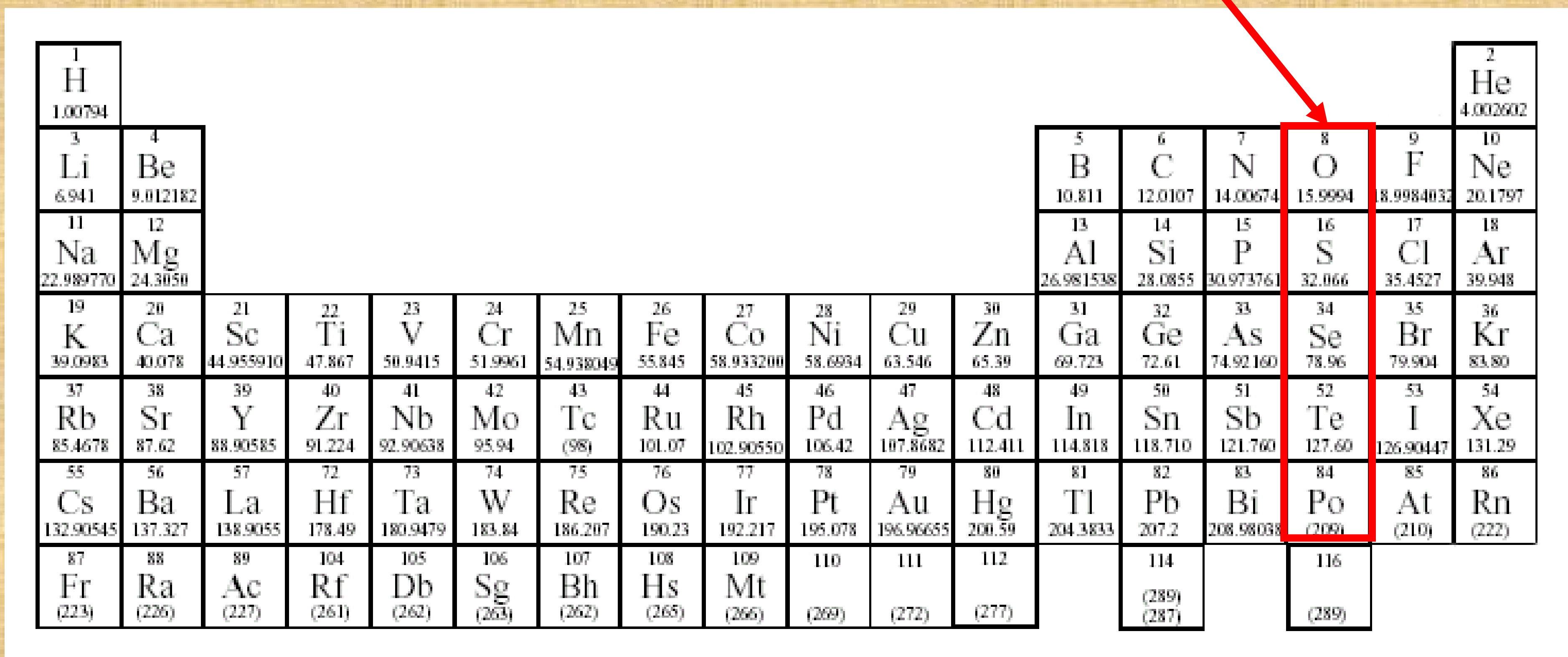
Predicting Ionic Charges

O^{2-} Oxide

S^{2-} Sulfide

Se^{2-} Selenide

Group 16: Gains 2 electrons to form 2- ions



Predicting Ionic Charges

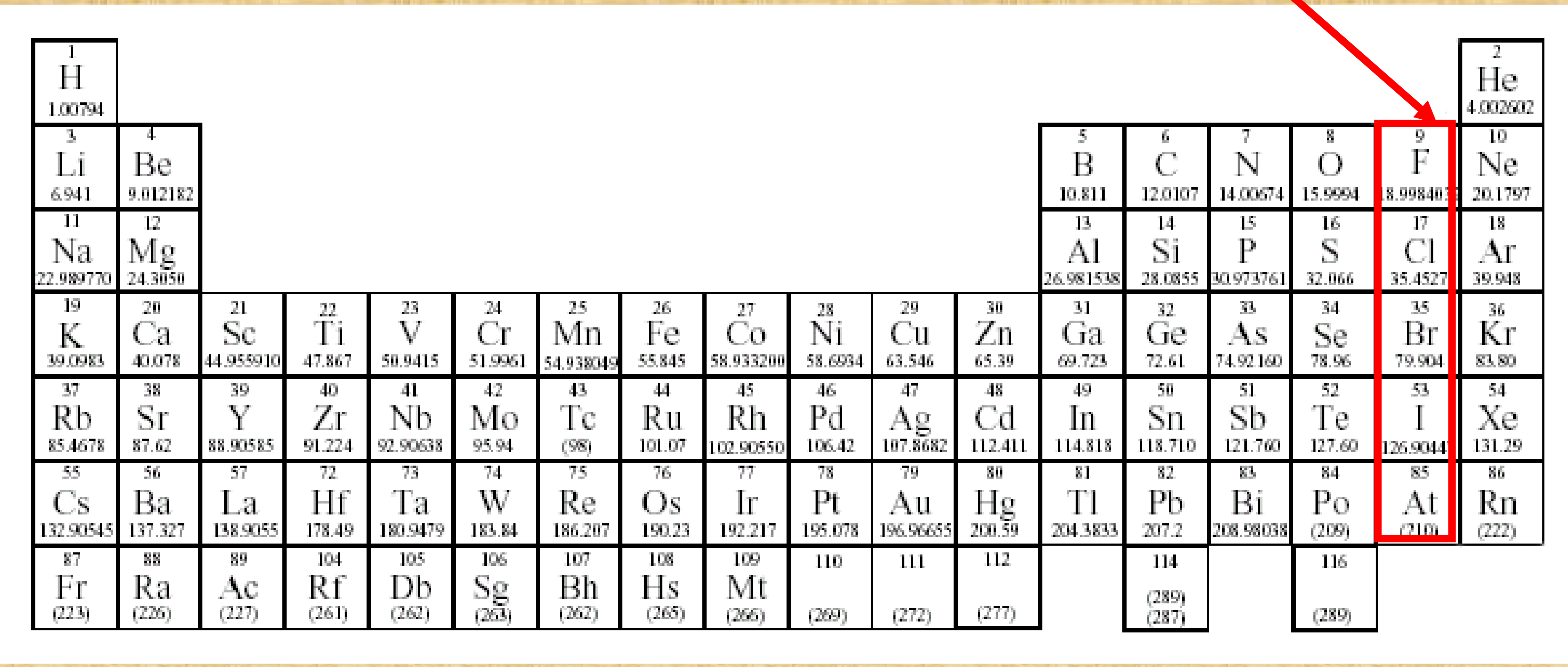
F^{1-} Fluoride

Br^{1-} Bromide

Cl^{1-} Chloride

I^{1-} Iodide

Group 17: Gains 1 electron to form $1-$ ions



Predicting Ionic Charges

Group 18: Stable Noble gases **do not** form ions!

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Predicting Ionic Charges

<u>Groups 3 - 12</u>: Many transition elements have more than one possible oxidation state.

Iron(II) = Fe^{2+} Iron(III) = Fe^{3+}

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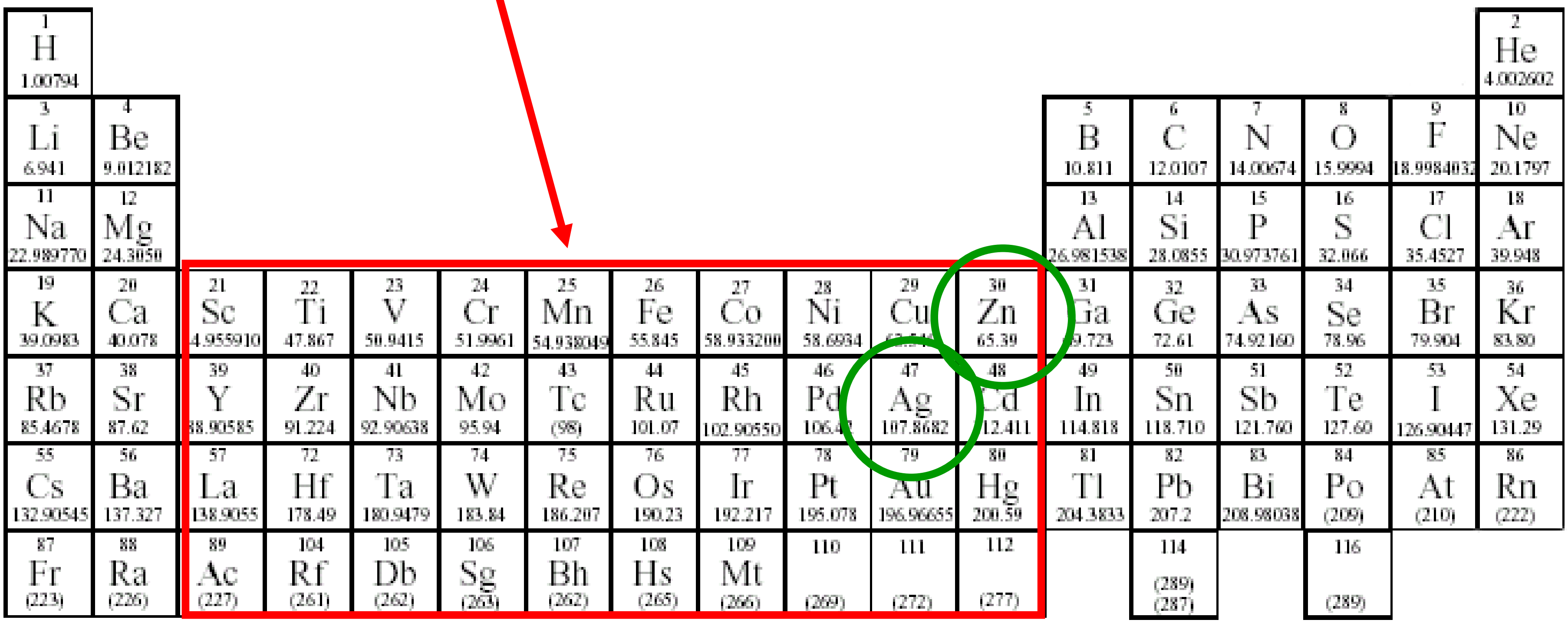
Predicting Ionic Charges

Groups 3 - 12: Some transition elements have only one possible oxidation state.

Zinc = Zn^{2+} Silver = Ag^{+}



Writing Ionic Compound Formulas

Example: Barium nitrate

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

$Ba^{2+}(NO_3^-)_2$

Not balanced!

3. Balance charges , if necessary, using subscripts. Use parentheses if you need more than one of a polyatomic ion.

Writing Ionic Compound Formulas

Example: Ammonium sulfate

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

3. Balance charges , if necessary, using subscripts. Use parentheses if you need more than one of a polyatomic ion.

$(NH_4^{+})_2SO_4^{2-}$

Not balanced!

Writing Ionic Compound Formulas

Example: Iron(III) chloride

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

3. Balance charges , if necessary, using subscripts. Use parentheses if you need more than one of a polyatomic ion.

$Fe^{3+}\ Cl^{-}{}_{3}$

Not balanced!

Writing Ionic Compound Formulas

Example: Aluminum sulfide

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

3. Balance charges , if necessary, using subscripts. Use parentheses if you need more than one of a polyatomic ion.

Al^{3+}_{2} S^{2-}_{3}

Not balanced!

Writing Ionic Compound Formulas

Example: Magnesium carbonate

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

Mg^{2+} CO_3^{2-}

They are balanced!

Writing Ionic Compound Formulas

Example: Zinc hydroxide

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

3. Balance charges , if necessary, using subscripts. Use parentheses if you need more than one of a polyatomic ion.

$Zn^{2+}(OH^{-})_2$

Not balanced!

Writing Ionic Compound Formulas

Example: Aluminum phosphate

1. Write the formulas for the cation and anion, including CHARGES!

2. Check to see if charges are balanced.

Al^{3+} PO_4^{3-}

They ARE balanced!

Naming Ionic Compounds

- 1. Cation first, then anion
- 2. Monatomic cation = name of the element
  - Ca^{2+} = calcium ion
- 3. Monatomic anion = root + -ide
  - Cl^{-} = chloride
  - $CaCl_2$ = calcium chloride

Naming Ionic Compounds
(continued)

Metals with multiple oxidation states

- - some metal forms more than one cation
- - use Roman numeral in name

- $PbCl_2$
- Pb^{2+} is cation
- $PbCl_2$ = lead(II) chloride

Naming Binary Compounds

- \- Compounds between two nonmetals
- \- First element in the formula is named first.
- \- Second element is named as if it were an anion.
- \- Use prefixes
- \- Only use mono on second element -

P_2O_5 = diphosphorus pentoxide

CO_2 = carbon dioxide

CO = carbon monoxide

N_2O = dinitrogen monoxide

Calculating Formula Mass

Calculate the formula mass of magnesium carbonate, $MgCO_3$.

$$24.31\ g + 12.01\ g + 3(16.00\ g) = 84.32\ g$$

Calculating Percentage Composition

Calculate the percentage composition of magnesium carbonate, $MgCO_3$.

From previous slide:

24.31 g + 12.01 g + 3(16.00 g) = 84.32 g

$$Mg = \left(\frac{24.31}{84.32}\right) \bullet 100 = 28.83\%$$

$$C = \left(\frac{12.01}{84.32}\right) \bullet 100 = 14.24\%$$

$$O = \left(\frac{48.00}{84.32}\right) \bullet 100 = 56.93\%$$

100.00

Formulas

Empirical formula: the lowest whole number ratio of atoms in a compound.

Molecular formula: the true number of atoms of each element in the formula of a compound.

- molecular formula = (empirical formula)$_n$ [n = integer]
- molecular formula = C_6H_6 = $(CH)_6$
- empirical formula = CH

Formulas (continued)

Formulas for ionic compounds are ALWAYS empirical (lowest whole number ratio).

Examples:

$NaCl$ $MgCl_2$ $Al_2(SO_4)_3$ K_2CO_3

Formulas (continued)

Formulas for molecular compounds MIGHT be empirical (lowest whole number ratio).

Molecular:	H_2O	$C_6H_{12}O_6$	$C_{12}H_{22}O_{11}$
	↓	↓	↓
Empirical:	H_2O	CH_2O	$C_{12}H_{22}O_{11}$

Empirical Formula Determination

1. Base calculation on 100 grams of compound.
2. Determine moles of each element in 100 grams of compound.
3. Divide each value of moles by the smallest of the values.
4. Multiply each number by an integer to obtain all whole numbers.

Empirical Formula Determination

Adipic acid contains 49.32% C, 43.84% O, and 6.85% H by mass. What is the empirical formula of adipic acid?

$$\frac{(49.32g\ C)(1\ mol\ C)}{(12.01\ g\ C)} = 4.107\ mol\ C$$

$$\frac{(6.85g\ H)(1\ mol\ H)}{(1.01\ g\ H)} = 6.78\ mol\ H$$

$$\frac{(43.84g\ O)(1\ mol\ O)}{(16.00\ g\ O)} = 2.74\ mol\ O$$

Empirical Formula Determination (part 2)

Divide each value of moles by the smallest of the values.

Carbon: $$\frac{4.107\ mol\ C}{2.74\ mol\ O} = 1.50$$

Hydrogen: $$\frac{6.78\ mol\ H}{2.74\ mol\ O} = 2.47$$

Oxygen: $$\frac{2.74\ mol\ O}{2.74\ mol\ O} = 1.00$$

Empirical Formula Determination (part 3)

Multiply each number by an integer to obtain all whole numbers.

Carbon: 1.50	Hydrogen: 2.50	Oxygen: 1.00
× 2	× 2	× 2
3	5	2

Empirical formula: $C_3H_5O_2$

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

1. Find the formula mass of $C_3H_5O_2$

3(12.01 *g*) + 5(1.01) + 2(16.00) = 73.08 *g*

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

2. Divide the molecular mass by the mass given by the emipirical formula.

$$3(12.01\ g) + 5(1.01) + 2(16.00) = 73.08\ g$$

$$\frac{146}{73} = 2$$

Finding the Molecular Formula

The empirical formula for adipic acid is $C_3H_5O_2$. The molecular mass of adipic acid is 146 g/mol. What is the molecular formula of adipic acid?

3. Multiply the empirical formula by this number to get the molecular formula.

3(12.01 g) + 5(1.01) + 2(16.00) = 73.08 g

$$\frac{146}{73} = 2$$

$(C_3H_5O_2) \times 2 =$ $C_6H_{10}O_4$