



Chem

With

Com

Ions, Periodic Properties, and Moles

- Chapter 2.3 (Atomic Structure and Symbolism)
- Chapter 3.6 (The Periodic Table)
- Chapter 3.7 (Ionic and Molecular Compounds)
- Chapter 2.4 (Chemical Formulas)
- Appendix B (Essential Mathematics)

Ions

- Chapter 2.3 (Atomic Structure and Symbolism)
- Chapter 3.6 (The Periodic Table)
- Chapter 3.7 (Ionic and Molecular Compounds)

Ions

Properties of Subatomic Particles

Name	Location	Charge (C)	Unit Charge	Mass (amu)	Mass (g)
electron	outside nucleus	-1.602×10^{-19}	1-	0.00055	0.00091×10^{-24}
proton	nucleus	1.602×10^{-19}	1+	1.00727	1.67262×10^{-24}
neutron	nucleus	0	0	1.00866	1.67493×10^{-24}

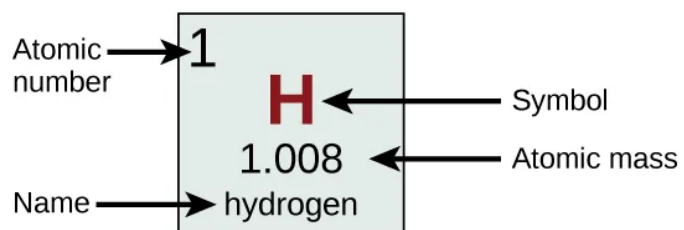
Table 2.2

- Neutral Atoms: protons (+) = electrons (-)

The Periodic Table

Periodic Table of the Elements

Period	Group																	
	1											13	14	15	16	17	18	
1	1 H 1.008 hydrogen																	2 He 4.003 helium
2	3 Li 6.94 lithium	4 Be 9.012 beryllium											5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.18 neon
3	11 Na 22.99 sodium	12 Mg 24.31 magnesium											13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulfur	17 Cl 35.45 chlorine	18 Ar 39.95 argon
4	19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.87 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.69 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.63 germanium	33 As 74.92 arsenic	34 Se 78.97 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton



Color Code	
 Metal	Solid
 Metalloid	Liquid
 Nonmetal	Gas

- Neutral Atoms: protons (+) = electrons (-)

Ions

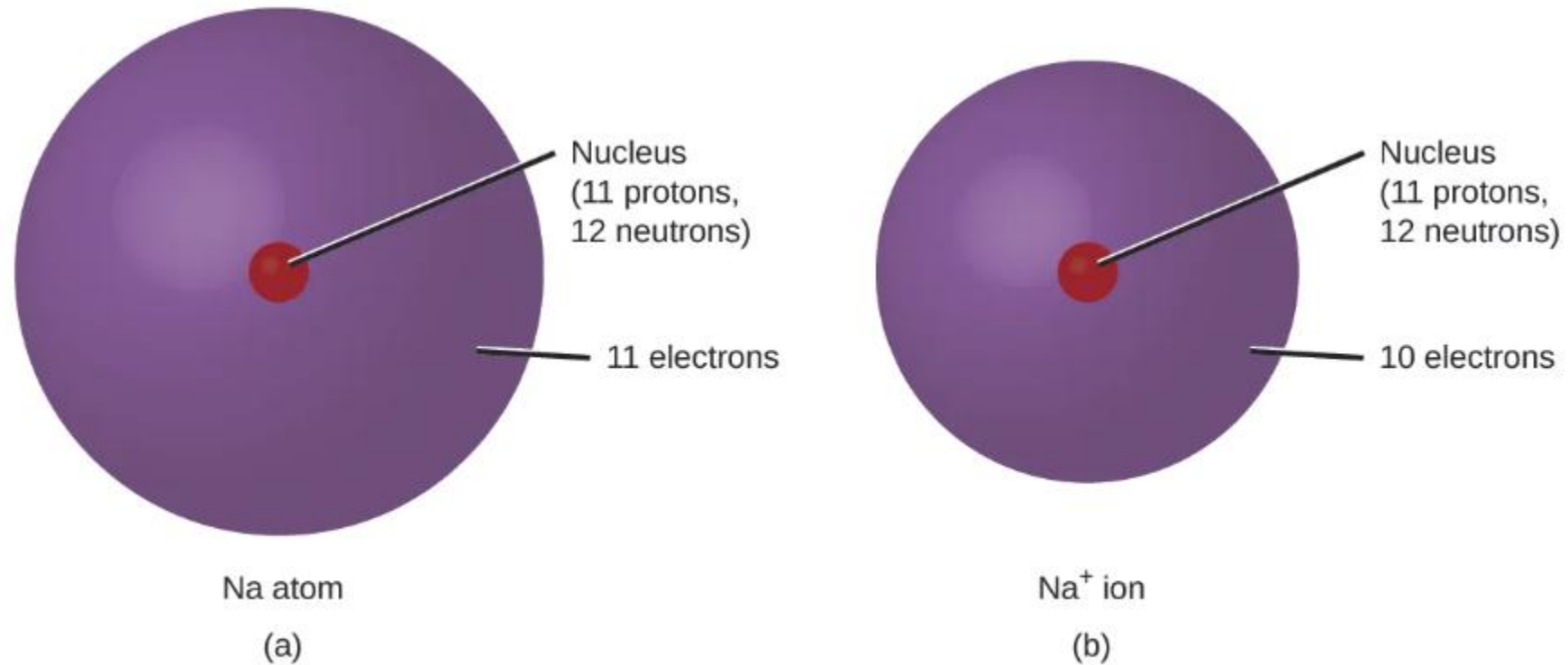


Figure 3.39 (a) A sodium atom (Na) has equal numbers of protons and electrons (11) and is uncharged. (b) A sodium cation (Na⁺) has lost an electron, so it has one more proton (11) than electrons (10), giving it an overall positive charge, signified by a superscripted plus sign.

Ions

Properties of Subatomic Particles

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Table 2.2

- Neutral Atoms: protons (+) = electrons (-)
- Cations (+)
- Anions (-)

Questions

- True/False – A neutral atom has the same amount of electrons and protons
- An atom with more electrons than protons is called a(n) _____?
- An atom with more protons than electrons is called a(n) _____?
- How many electrons in H^{1+} ?
- How many electrons in Cl^{1-} ?
- How many electrons in Al^{3+} ?
- How many electrons in OH^{1-} ?
- How many electrons in NH_4^{1+} ?

Period	Group								18
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Ions

Check Your Learning

Give the symbol and name for the ion with 34 protons and 36 electrons.

Ions

Check Your Learning

An ion of platinum has a mass number of 195 and contains 74 electrons. How many protons and neutrons does it contain, and what is its charge?

Periodic Table

- Chapter 2.3 (Atomic Structure and Symbolism)
- Chapter 3.6 (The Periodic Table)
- Chapter 3.7 (Ionic and Molecular Compounds)

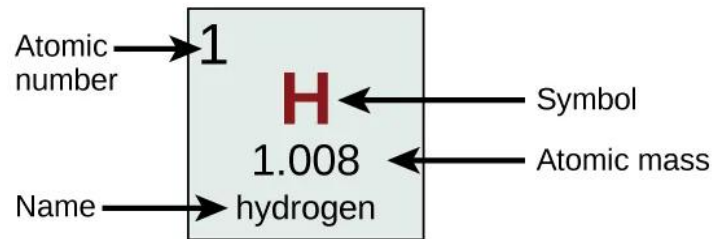
The Periodic Table

- Metals and the “everything that isn’t”

Periodic Table of the Elements

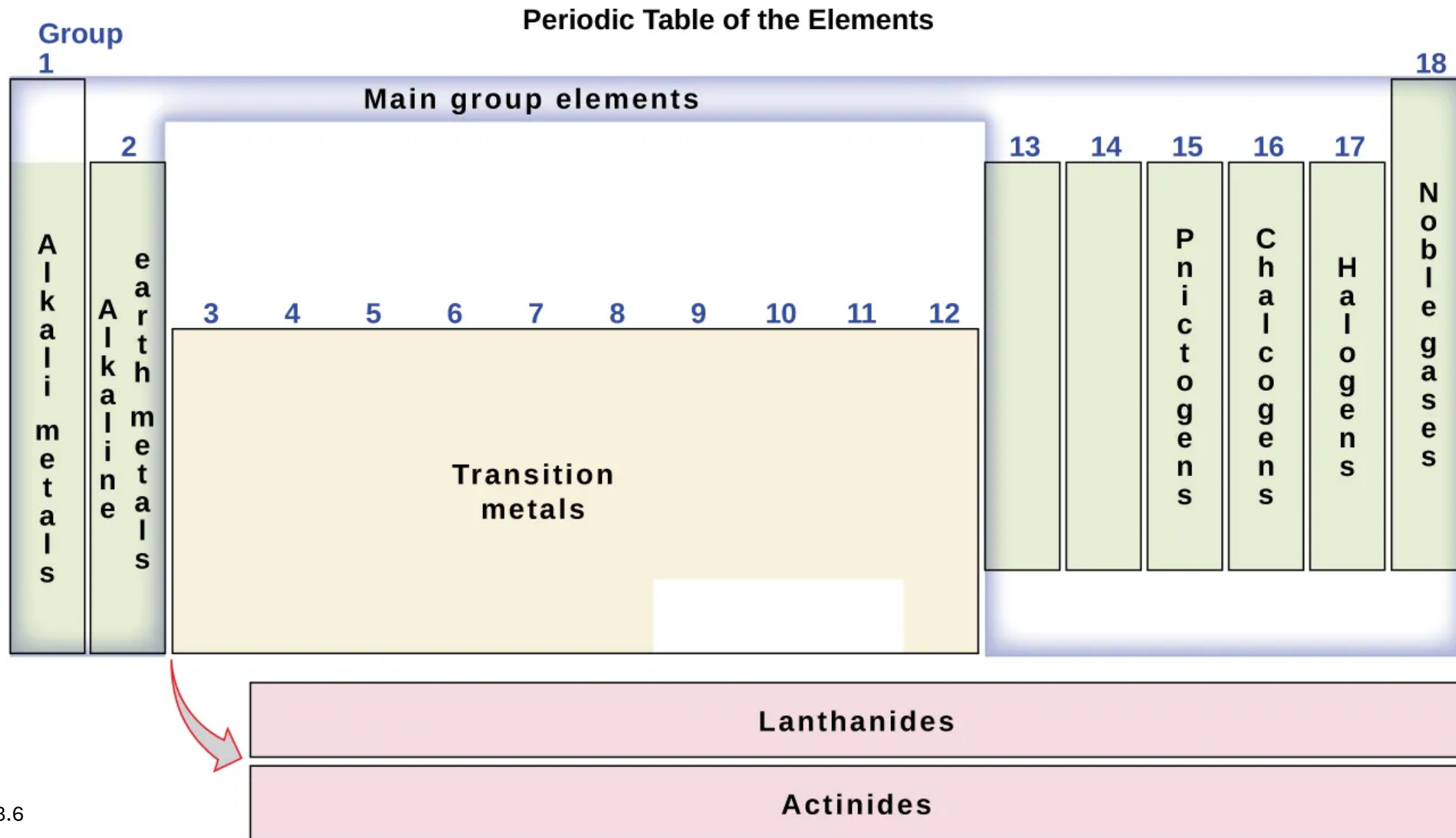
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Period	Group																	
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5	37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.95 molybdenum	43 Tc [97] technetium	44 Ru 101.1 ruthenium	45 Rh 102.9 rhodium	46 Pd 106.4 palladium	47 Ag 107.9 silver	48 Cd 112.4 cadmium	49 In 114.8 indium	50 Sn 118.7 tin	51 Sb 121.8 antimony	52 Te 127.6 tellurium	53 I 126.9 iodine	54 Xe 131.3 xenon
6	55 Cs 132.9 cesium	56 Ba 137.3 barium	57-71 La-Lu *	72 Hf 178.5 hafnium	73 Ta 180.9 tantalum	74 W 183.8 tungsten	75 Re 186.2 rhenium	76 Os 190.2 osmium	77 Ir 192.2 iridium	78 Pt 195.1 platinum	79 Au 197.0 gold	80 Hg 200.6 mercury	81 Tl 204.4 thallium	82 Pb 207.2 lead	83 Bi 209.0 bismuth	84 Po [209] polonium	85 At [210] astatine	86 Rn [222] radon
7	87 Fr [223] francium	88 Ra [226] radium	89-103 Ac-Lr **	104 Rf [267] rutherfordium	105 Db [270] dubnium	106 Sg [271] seaborgium	107 Bh [270] bohrium	108 Hs [277] hassium	109 Mt [276] meitnerium	110 Ds [281] darmstadtium	111 Rg [282] roentgenium	112 Cn [285] copernicium	113 Nh [285] nihonium	114 Fl [289] flerovium	115 Mc [288] moscovium	116 Lv [293] livermorium	117 Ts [294] tennessine	118 Og [294] oganeson



* 57 La 138.9 lanthanum	58 Ce 140.1 cerium	59 Pr 140.9 praseodymium	60 Nd 144.2 neodymium	61 Pm [145] promethium	62 Sm 150.4 samarium	63 Eu 152.0 europium	64 Gd 157.3 gadolinium	65 Tb 158.9 terbium	66 Dy 162.5 dysprosium	67 Ho 164.9 holmium	68 Er 167.3 erbium	69 Tm 168.9 thulium	70 Yb 173.1 ytterbium	71 Lu 175.0 lutetium
** 89 Ac [227] actinium	90 Th 232.0 thorium	91 Pa 231.0 protactinium	92 U 238.0 uranium	93 Np [237] neptunium	94 Pu [244] plutonium	95 Am [243] americium	96 Cm [247] curium	97 Bk [247] berkelium	98 Cf [251] californium	99 Es [252] einsteinium	100 Fm [257] fermium	101 Md [258] mendelevium	102 No [259] nobelium	103 Lr [262] lawrencium

The Periodic Table



The Periodic Table

- Metals and the everything that isn't

Periodic Table of the Elements

Color Code

 Metal	Solid
 Metalloid	Liquid
 Nonmetal	Gas

Period	Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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Atomic number → 1

Symbol → **H**

Atomic mass → 1.008

Name → hydrogen

1. Is lithium a metal or nonmetal?

3. Is hydrogen a metal or nonmetal?

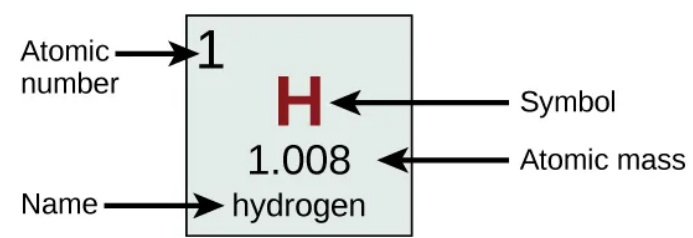
2. Is chlorine a metal or nonmetal?

4. Is silicon a metal or nonmetal?

The Periodic Table

Periodic Table of the Elements

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Color Code	
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 Metalloid	Liquid
 Nonmetal	Gas

Ions

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3 11 Na 22.99 sodium	12 Mg 24.31 magnesium					17 Cl 35.45 chlorine		18 Ar 39.95 argon

- Rows (periods) = energy levels
- Columns (groups) = valence electrons
- Columns (groups) = predicted charge (usually)

Octet Rule (Chapter 4.4)

Guideline that states that main group atoms will “want” 8 electrons

The Periodic Table

Periodic Table of the Elements

Period	Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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Annotations for Ions

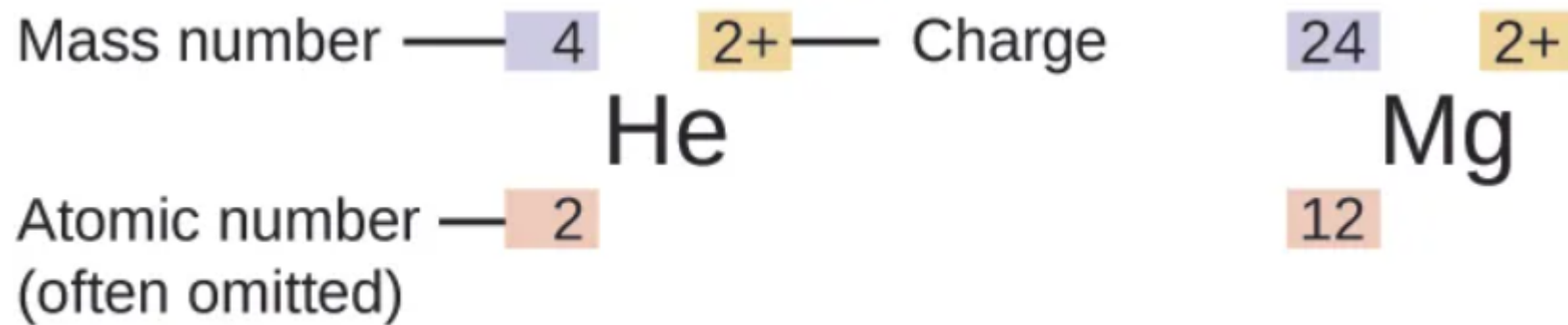


Figure 2.14 The symbol for an atom indicates the element via its usual two-letter symbol, the mass number as a left superscript, the atomic number as a left subscript (sometimes omitted), and the charge as a right superscript.

- Write the symbol, atomic number, mass number, and charge for calcium with 18 electrons.
- Write the symbol, atomic number, mass number, and charge for nitrogen with 10 electrons.

Ions and the Periodic Table

Periodic Table of the Elements

Period	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 18
1	H ⁺																	He
2	Li ⁺	Be ²⁺											B ³⁺		N ³⁻	O ²⁻	F ⁻	Ne
3	Na ⁺	Mg ²⁺											Al ³⁺		P ³⁻	S ²⁻	Cl ⁻	Ar
4	K ⁺	Ca ²⁺										Zn ²⁺			As ³⁻	Se ²⁻	Br ⁻	Kr
5	Rb ⁺	Sr ²⁺									Ag ⁺					Te ²⁻	I ⁻	Xe
6	Cs ⁺	Ba ²⁺															At ⁻	Rn
7	Fr ⁺	Ra ²⁺																

Practice/Review

- Predict the charge of Mg
- Predict the charge of F
- Predict the charge of Kr
- Combine atoms of Mg and F to make a neutral compound (the charges added together equal 0)

Polyatomic Ions

Name	Formula
ammonium	NH_4^+
hydronium	H_3O^+
peroxide	O_2^{2-}
hydroxide	OH^-
acetate	CH_3COO^-
cyanide	CN^-
azide	N_3^-
carbonate	CO_3^{2-}
bicarbonate	HCO_3^-
nitrate	NO_3^-
nitrite	NO_2^-
sulfate	SO_4^{2-}

Name	Formula
hydrogen sulfate	HSO_4^-
sulfite	SO_3^{2-}
hydrogen sulfite	HSO_3^-
phosphate	PO_4^{3-}
hydrogen phosphate	HPO_4^{2-}
dihydrogen phosphate	H_2PO_4^-
perchlorate	ClO_4^-
chlorate	ClO_3^-
chlorite	ClO_2^-
hypochlorite	ClO^-
chromate	CrO_4^{2-}
dichromate	$\text{Cr}_2\text{O}_7^{2-}$
permanganate	MnO_4^-

Moles and Exponential Notation

- Chapter 2.4 (Chemical Formulas)
- Appendix B (Essential Mathematics)

Grams Per Mole?

- The atomic masses on the periodic table are in the units of grams per mole (g/mol) and sometimes atomic mass units (amu)
- Grams (g) = unit of mass
 - mass is how much matter something has
 - weight is the effect of gravity on mass, on earth mass is the same as weight
- Moles = a specific number of things (6.022×10^{23})
 - dozen = 12, tetra = 4, pair = 2, cent = 100

Element	Average Atomic Mass (amu)	Molar Mass (g/mol)	Atoms/Mole
C	12.01	12.01	6.022×10^{23}
H	1.008	1.008	6.022×10^{23}
O	16.00	16.00	6.022×10^{23}
Na	22.99	22.99	6.022×10^{23}
Cl	35.45	35.45	6.022×10^{23}

What is a mole? (The Chemist's Dozen)

Exponential Notation

$$\#.\#\#\#\# \times 10^\#$$

- A number followed by a decimal and then however many significant figures there are
- The things in red are in every exponential notation number
- The things in black are optional (but there most of the time)

$$\bullet 3.14 \times 10^6$$

$$\bullet 2 \times 10^{-6}$$

$$\bullet 6.022 \times 10^{23}$$

Exponential Notation

$$1000 = 1 \times 10^3$$

$$100 = 1 \times 10^2$$

$$10 = 1 \times 10^1$$

$$1 = 1 \times 10^0$$

$$0.1 = 1 \times 10^{-1}$$

$$0.001 = 1 \times 10^{-3}$$

$$2386 = 2.386 \times 1000 = 2.386 \times 10^3$$

$$0.123 = 1.23 \times 0.1 = 1.23 \times 10^{-1}$$

Exponential Notation and Standard Notation

**Exponential
Notation**

**Standard
Notation**

• 3.14×10^6

= 3,140,000



• 2×10^{-6}

= 0.000002

• 6.022×10^{23}

= 602,200,000,000,000,000,000,000

Exponential Notation


- The decimal moves amount of times as the **number in the exponent**.
 - For something like 3.05×10^4 , you would move the decimal **4** places, since the exponent is positive, you know the final number will be greater than 1.
 - For something like 2.1×10^{-3} , you would move the decimal **3** place, since the exponent is negative, you know the final number will be less than 1.
 - For 0.0078077 , you would move the decimal **3** places to get to the first non-zero digit. If the number started as a number less than 1, it is a negative exponent.
 - For $97,105,000$ you would move the decimal **7** places to get to the first non-zero digit. If the number started as a number greater than 1, it is a positive exponent.


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Exponential Notation to Standard Notation

Exponential
Notation

Standard
Notation

- = 70,602,020,000

- 2×10^6 =

- = 0.000197345

- 9.27542×10^{-7} =

Grams Per Mole?

Element	Average Atomic Mass (amu)	Molar Mass (g/mol)	Atoms/Mole
C	12.01	12.01	6.022×10^{23}
H	1.008	1.008	6.022×10^{23}
O	16.00	16.00	6.022×10^{23}
Na	22.99	22.99	6.022×10^{23}
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Grams Per Mole!

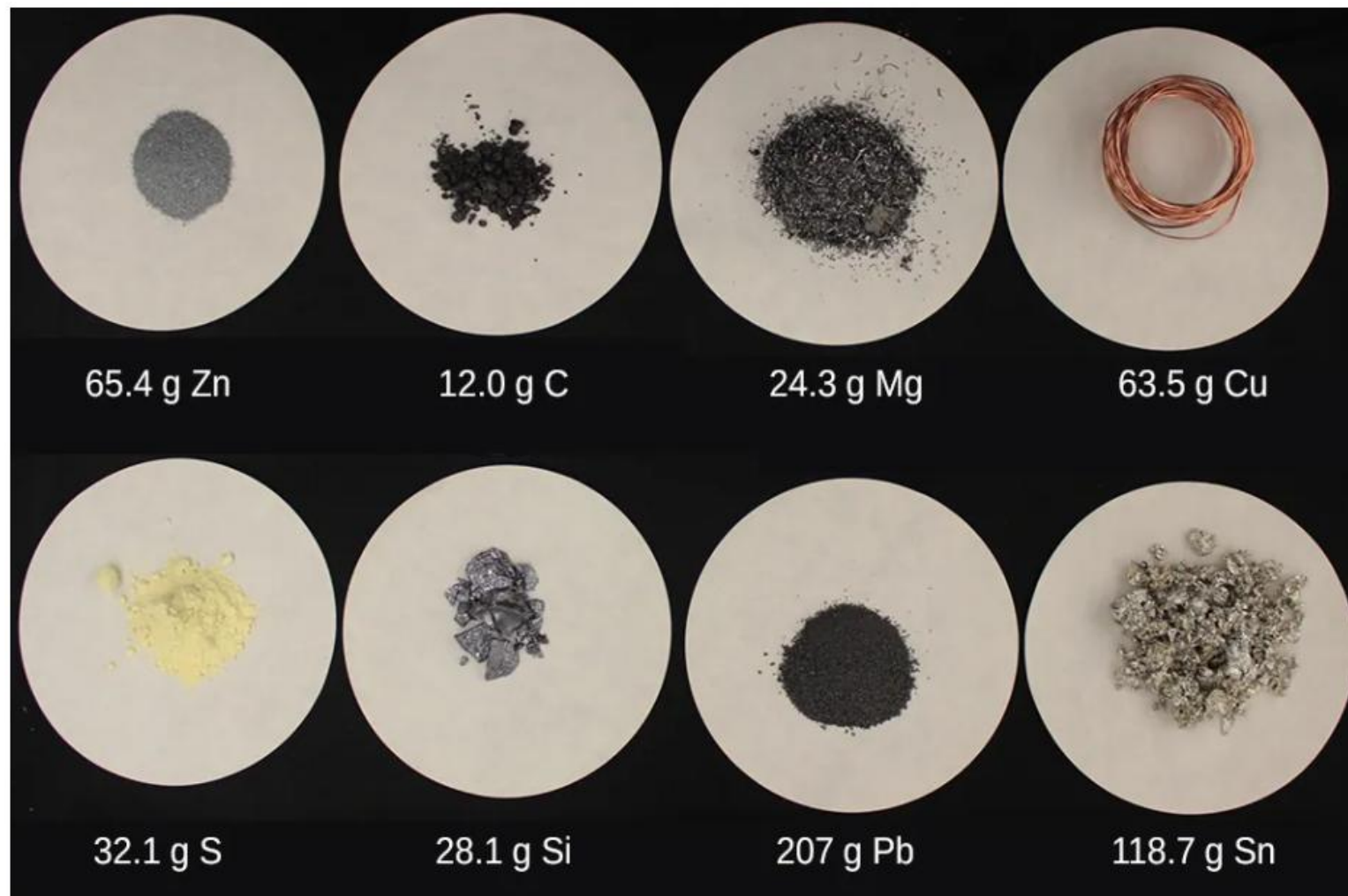


Figure 2.25 Each sample contains 6.022×10^{23} atoms — 1.00 mol of atoms. From left to right (top row): 65.4 g zinc, 12.0 g carbon, 24.3 g magnesium, and 63.5 g copper. From left to right (bottom row): 32.1 g sulfur, 28.1 g silicon, 207 g lead, and 118.7 g tin. (credit: modification of work by Mark Ott)

Grams Per Mole!

What is a mole?

12 g C. How many moles?

6 g C. How many moles?

1 mol Si. How many grams?

2 mols C. How many grams?

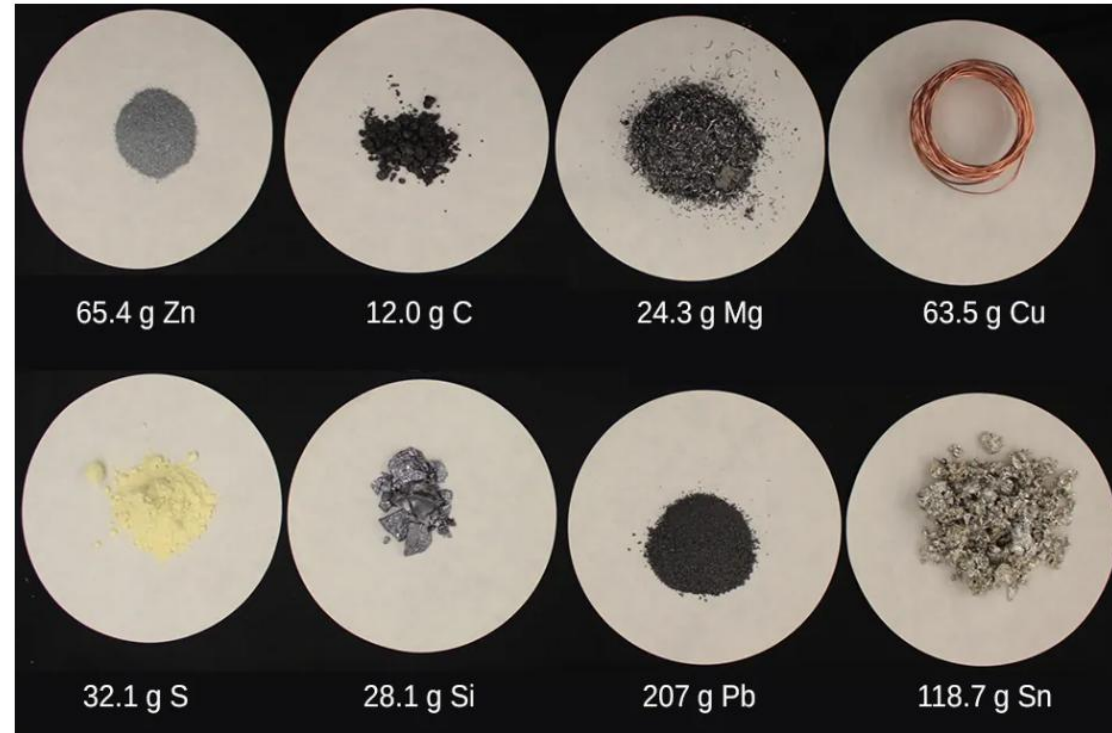


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