



# **CHEMISTRY 9 REVIEW & INTRO TO CHEMISTRY 10**

**Section 4.1: Atomic Theory and Bonding**

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# ATOMS AND COMPOUNDS

- An **atom** is the **smallest particle** of an element that still has the **properties** of that element
  - An atom = proton(s) + neutron(s) + electron(s)
- Atoms **join together** to form **compounds**.
  - A compound is a **pure substance** that is composed of **two or more atoms** combined in a **specific way**.
  - Oxygen and hydrogen are atoms/elements; H<sub>2</sub>O is a compound.
- A **chemical change** occurs when the **arrangement** of atoms in compounds **changes** to form **new** compounds.

# ATOMIC THEORY

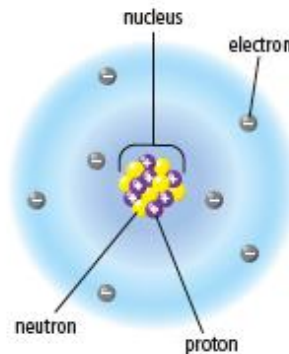
- Atoms are comprised of 3 subatomic particles

**Table 4.1 Subatomic Particles**

Name	Symbol	Electric Charge	Location in the Atom	Relative Mass
Proton	p	1+	Nucleus	1836
Neutron	n	0	Nucleus	1837
Electron	e	1-	Surrounding the nucleus	1

# ATOMIC THEORY

- The **center** of an atom is called the **nucleus**.
  - The nucleus is composed of protons and neutrons.
  - Electrons exist in the space surrounding the nucleus.
  - # of protons = # of electrons in every atom
  - Nuclear charge = charge on the nucleus = # of protons
  - Atomic number = # of protons = # of electrons



# ORGANIZATION OF THE PERIODIC TABLE

- In the periodic table elements are listed in order by their atomic number.
  - Metals are on the left (the transition metals range from group 3 to group 12), non-metals are on the right, and the metalloids form a “staircase” toward the right side.
  - Rows of elements (across) are called periods.
    - All elements in a period have their electrons in the same general area around their nucleus.
  - Columns of elements are called groups, or families.
    - All elements in a family have similar properties and bond with other elements in similar ways.
    - Group 1 = alkali metals
    - Group 2 = alkaline earth metals
    - Group 17 = the halogens
    - Group 18 = noble gases

# THE PERIODIC TABLE

Where are the following?

- Atomic number
- Period
- Group/Family
- Metals
- Non-metals
- Transition metals
- Metalloids
- Alkali metals
- Alkaline earth metals
- Halogens
- Noble gases

Periodic Table of the Elements

1 H Hydrogen 1.0												1 H Hydrogen 1.0		18 He Helium 4.0			
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminum 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulphur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 45.0	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.8	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Cesium 132.9	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium (?)	118 Uuo Ununoctium (294)

Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements that do not occur naturally.

58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

# PERIODIC TABLE AND ION FORMATION

- Atoms gain and lose electrons to form bonds.
  - The atoms become electrically charged particles called ions.
  - Metals lose electrons and become positive ions (cations).
    - Some metals (multivalent) lose electrons in different ways.
    - For example, iron, Fe, loses either two ( $\text{Fe}^{2+}$ ) or three ( $\text{Fe}^{3+}$ ) electrons
  - Non-metals gain electrons and become negative ions (anions).
  - Atoms gain and lose electrons in an attempt to have the same number of valence electrons (electrons farthest from the nucleus) as the nearest noble gas in the periodic table.

19	+	20	2+	21	3+
<b>K</b>		<b>Ca</b>		<b>Sc</b>	
Potassium		Calcium		Scandium	
39.1		40.1		45.0	

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25	2+	26	3+	27	2+
<b>Mn</b>	3+	<b>Fe</b>	2+	<b>Co</b>	3+
Manganese	4+	Iron		Cobalt	
54.9		55.8		58.9	

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8	2-	9	-	10	0
<b>O</b>		<b>F</b>		<b>Ne</b>	
Oxygen		Fluorine		Neon	
16.0		19.0		20.2	

# BOHR & LEWIS DIAGRAMS



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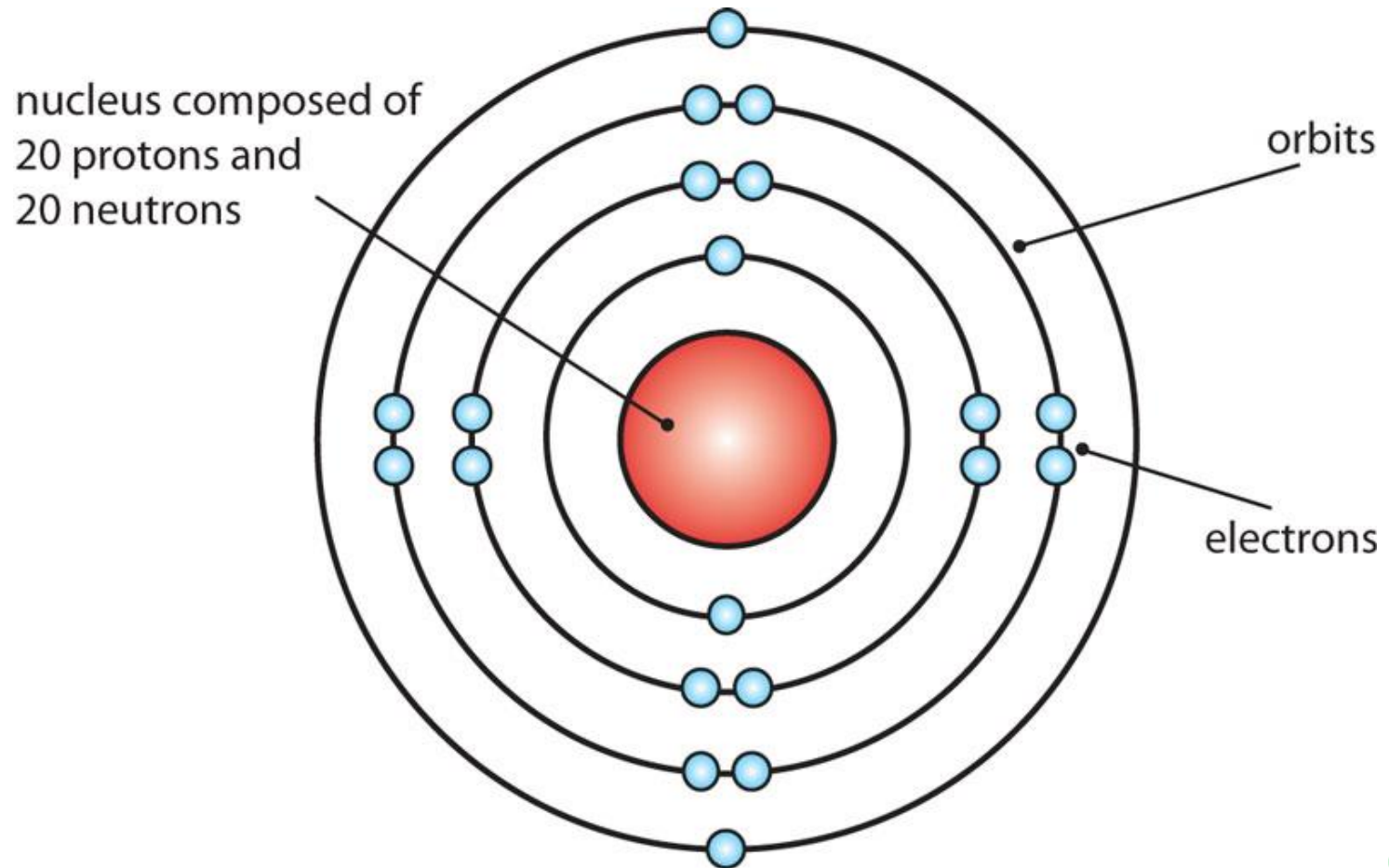


## BOHR DIAGRAMS

- Show the arrangement of electrons in shells around the nucleus of an atom.
  - 1<sup>st</sup> shell = max. 2 electrons
  - 2<sup>nd</sup> shell = max. 8 electrons
  - 3<sup>rd</sup> shell = max. 8 electrons
  - 4<sup>th</sup> shell = max. 18 electrons

- The outermost shell that contains electrons is called the **valence shell**, and the electrons in this shell are called **valence electrons**.

# ELECTRON ORBITALS/SHELLS



## BOHR DIAGRAMS CONTINUED

- **Period (row) number of element = number of occupied shells for that element**
- **Elements in the same family (column) have the same number of valence electrons.**

## BOHR DIAGRAMS OF IONS

- An atom's **ion charge** on the periodic table tells you how many electrons the atom will lose or gain to fill its valence shell.

# BOHR DIAGRAMS OF IONS

- **Metal atoms** lose electrons to have a full valence shell (become positive **cations**).
  - Ex. Magnesium loses two electrons from its valence shell and forms a magnesium ion ( $\text{Mg}^{2+}$ ).
  - The Bohr Diagram for a  $\text{Mg}^{2+}$  ion will have two less electrons and square brackets around it with a 2+ charge.

# BOHR DIAGRAMS OF IONS

- **Non-metal atoms gain electrons** to have a full valence shell (become negative **anions**).
  - Ex. Sulfur gains two electrons into its valence shell and forms a sulfur ion ( $S^{2-}$ ).
  - The Bohr Diagram for a  $S^{2-}$  ion will have two more electrons and square brackets around it with a 2- charge.

# FORMATION OF COMPOUNDS

- **Valence electrons** are involved in **chemical bonding** between elements.
- **Noble gases** have a **full valence shell** so they **don't** form compounds!

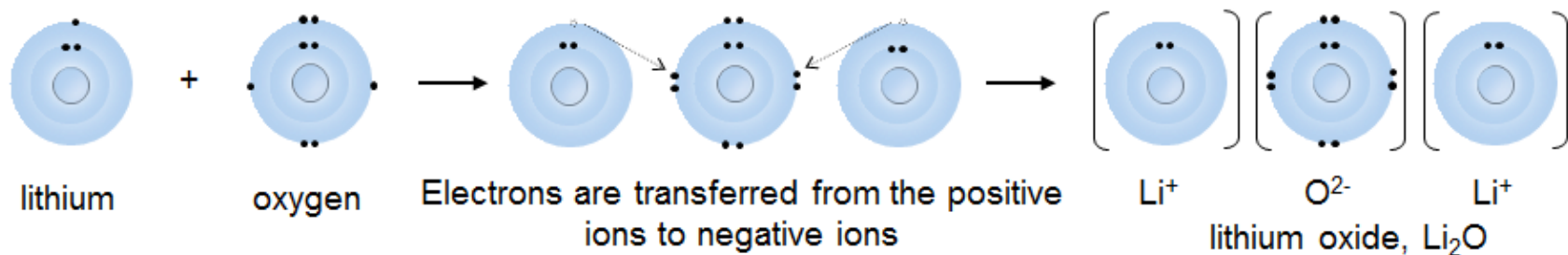


## FORMING COMPOUNDS

- **Ionic bonds** form when **electrons** are **transferred** from positive ions to negative ions.
  
- **Covalent bonds** form when electrons are **shared** between two **non-metals**.
  - Electrons stay with their atom but overlap with other shells.

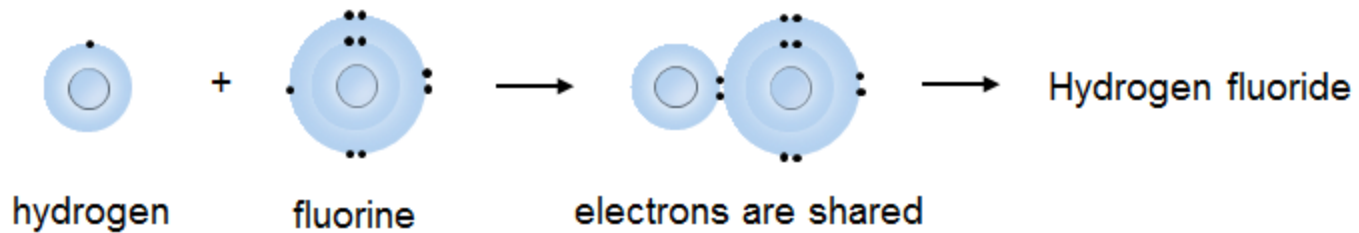
# FORMING COMPOUNDS – IONIC BONDS

- Ionic bonds are formed between positive ions and negative ions.
  - For example, lithium and oxygen form an ionic bond in the compound  $\text{Li}_2\text{O}$ .



# FORMING COMPOUNDS – COVALENT BONDS

- Covalent bonds are formed between two or more non-metals.
  - Electrons are shared between atoms.



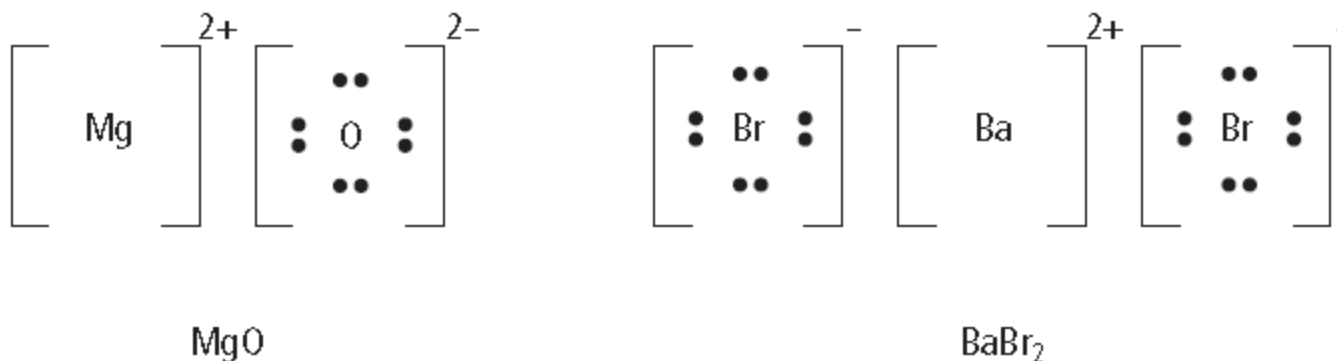
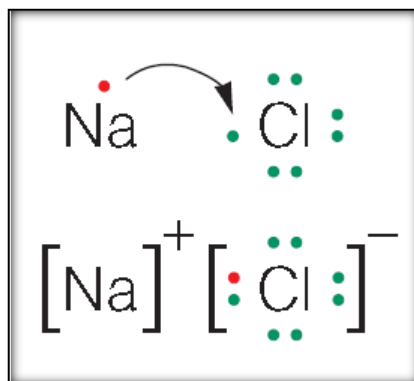
# LEWIS DIAGRAMS

- They illustrate chemical bonding by showing only an atom's valence electrons and the chemical symbol.
  - Dots** representing **electrons** are placed around the element symbols
  - Electron dots are placed **singly until the fifth electron** is reached then they are paired.

	1								18
1	1 H •								2 He ••
2	3 Li •	4 • Be •	5 • B •	6 • C • •	7 • N ••	8 •• O •• •	9 •• F •• •	10 •• Ne •• ••	
3	11 Na •	12 • Mg •	13 • Al •	14 • Si • •	15 • P •• •	16 •• S •• •	17 •• Cl •• •	18 •• Ar •• ••	

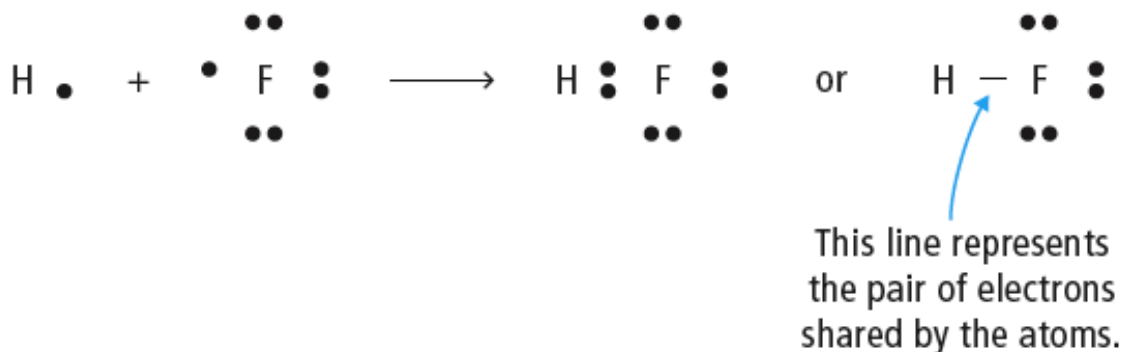
# LEWIS DIAGRAMS OF IONS AND IONIC BONDS

- For **positive ions**, electron dots are **removed**.
- For **negative ions**, electron dots are **added**.
- Square brackets are placed around each ion to indicate transfer of electrons.



# LEWIS DIAGRAMS OF COVALENT BONDS

- Like Bohr diagrams, valence electrons are drawn to show sharing of electrons.
- The **shared pairs** of electrons are usually **drawn as a straight line**.



# LEWIS DIAGRAMS OF DIATOMIC MOLECULES

- Diatomic Molecules form between two atoms of the same type.

