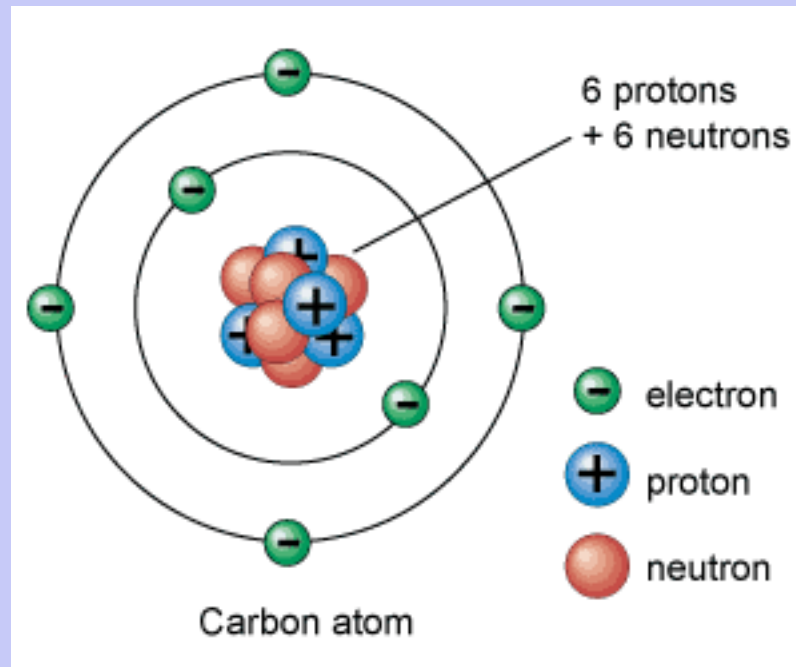


## 4.1 Atomic Theory and Bonding

- An atom is the smallest particle of an element that still has the properties of that element
  - ♦ 50 million atoms, lined up end to end = 1 cm
  - ♦ An atom = proton(s) + neutron(s) + electron(s)
  - ♦ [Crash Course In Chemistry](#)



See pages 168 - 169

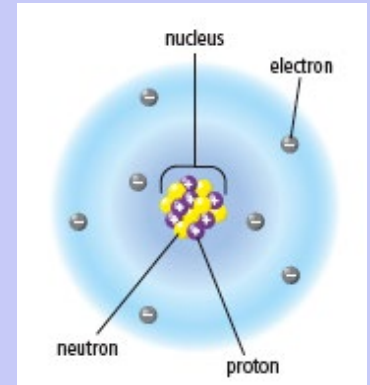
(c) McGraw Hill Ryerson 2007

- **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 made up of smaller particles called 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



- The nucleus is at the centre of an atom.
  - ◆ The nucleus is composed of protons and neutrons.
  - ◆ Electrons exist in the space surrounding the nucleus.
  - ◆ # of protons = # of electrons in every atom, therefore atoms have **NO CHARGE**
  - ◆ Nuclear charge = charge on the nucleus = # of protons
  - ◆ Atomic number = # of protons = # of electrons

See page 170

- **How do I figure out how many protons an atom of carbon has?**
  
- **Electrons?**
  
- **Neutrons?**

# Break

- **Pg 60 in workbook**

## 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

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# The Periodic Table

Periodic Table of the Elements

INCREASING REACTIVITY

1 + <b>H</b> Hydrogen 1.0																		18 <b>He</b> Helium 4.0																	
3 + <b>Li</b> Lithium 6.9		4 2+ <b>Be</b> Beryllium 9.0																				5 <b>B</b> Boron 10.8		6 <b>C</b> Carbon 12.0		7 3- <b>N</b> Nitrogen 14.0		8 2- <b>O</b> Oxygen 16.0		9 - <b>F</b> Fluorine 19.0		10 0 <b>Ne</b> Neon 20.2			
11 + <b>Na</b> Sodium 23.0		12 2+ <b>Mg</b> Magnesium 24.3																				13 3+ <b>Al</b> Aluminum 27.0		14 <b>Si</b> Silicon 28.1		15 3- <b>P</b> Phosphorus 31.0		16 2- <b>S</b> Sulphur 32.1		17 - <b>Cl</b> Chlorine 35.5		18 0 <b>Ar</b> Argon 39.9			
19 + <b>K</b> Potassium 39.1		20 2+ <b>Ca</b> Calcium 40.1		21 3+ <b>Sc</b> Scandium 45.0		22 4+ <b>Ti</b> 3+ Titanium 47.9		23 5+ <b>V</b> 4+ Vanadium 50.9		24 3+ <b>Cr</b> 2+ Chromium 52.0		25 2+ <b>Mn</b> 3+ Manganese 54.9		26 3+ <b>Fe</b> 2+ Iron 55.8		27 2+ <b>Co</b> 3+ Cobalt 58.9		28 2+ <b>Ni</b> 3+ Nickel 58.7		29 2+ <b>Cu</b> 1+ Copper 63.5		30 2+ <b>Zn</b> Zinc 65.4		31 3+ <b>Ga</b> Gallium 69.7		32 4+ <b>Ge</b> Germanium 72.6		33 3- <b>As</b> Arsenic 74.9		34 2- <b>Se</b> Selenium 79.0		35 - <b>Br</b> Bromine 79.9		36 0 <b>Kr</b> Krypton 83.8	
37 + <b>Rb</b> Rubidium 85.5		38 2+ <b>Sr</b> Strontium 87.6		39 3+ <b>Y</b> Yttrium 88.9		40 4+ <b>Zr</b> Zirconium 91.2		41 3+ <b>Nb</b> 5+ Niobium 92.9		42 2+ <b>Mo</b> 3+ Molybdenum 95.9		43 7+ <b>Tc</b> Technetium (98)		44 3+ <b>Ru</b> 4+ Ruthenium 101.1		45 3+ <b>Rh</b> 4+ Rhodium 102.9		46 2+ <b>Pd</b> 4+ Palladium 106.4		47 1+ <b>Ag</b> Silver 107.9		48 2+ <b>Cd</b> Cadmium 112.4		49 3+ <b>In</b> Indium 114.8		50 4+ <b>Sn</b> 2+ Tin 118.7		51 3+ <b>Sb</b> 5+ Antimony 121.8		52 2- <b>Te</b> Tellurium 127.6		53 - <b>I</b> Iodine 126.9		54 0 <b>Xe</b> Xenon 131.3	
55 + <b>Cs</b> Cesium 132.9		56 2+ <b>Ba</b> Barium 137.3		57 3+ <b>La</b> Lanthanum 138.9		72 4+ <b>Hf</b> Hafnium 178.5		73 5+ <b>Ta</b> Tantalum 180.9		74 6+ <b>W</b> Tungsten 183.8		75 4+ <b>Re</b> 7+ Rhenium 186.2		76 3+ <b>Os</b> 4+ Osmium 190.2		77 3+ <b>Ir</b> 4+ Iridium 192.2		78 4+ <b>Pt</b> 2+ Platinum 195.1		79 3+ <b>Au</b> 1+ Gold 197.0		80 2+ <b>Hg</b> Mercury 200.6		81 1+ <b>Tl</b> 3+ Thallium 204.4		82 2+ <b>Pb</b> 4+ Lead 207.2		83 3+ <b>Bi</b> 5+ Bismuth 209.0		84 2+ <b>Po</b> 4+ Polonium (209)		85 - <b>At</b> Astatine (210)		86 0 <b>Rn</b> Radon (222)	
87 + <b>Fr</b> Francium (223)		88 2+ <b>Ra</b> Radium (226)		89 3+ <b>Ac</b> Actinium (227)		104 <b>Rf</b> Rutherfordium (261)		105 <b>Db</b> Dubnium (262)		106 <b>Sg</b> Seaborgium (263)		107 <b>Bh</b> Bohrium (262)		108 <b>Hs</b> Hassium (265)		109 <b>Mt</b> Meitnerium (266)		110 <b>Ds</b> Darmstadtium (281)		111 <b>Rg</b> Roentgenium (272)		112 <b>Uub</b> Ununbium (285)		113 <b>Uut</b> Ununtrium (284)		114 <b>Uuq</b> Ununquadium (289)		115 <b>Uup</b> Ununpentium (288)		116 <b>Uuh</b> Ununhexium (292)		117 <b>Uus</b> Ununseptium (?)		118 <b>Uuo</b> Ununoctium (294)	
58 3+ <b>Ce</b> 4+ Cerium 140.1		59 3+ <b>Pr</b> 4+ Praseodymium 140.9		60 3+ <b>Nd</b> Neodymium 144.2		61 3+ <b>Pm</b> Promethium (145)		62 3+ <b>Sm</b> 4+ Samarium 150.4		63 3+ <b>Eu</b> 2+ Europium 152.0		64 3+ <b>Gd</b> Gadolinium 157.3		65 3+ <b>Tb</b> 4+ Terbium 158.9		66 3+ <b>Dy</b> Dysprosium 162.5		67 3+ <b>Ho</b> Holmium 164.9		68 3+ <b>Er</b> Erbium 167.3		69 3+ <b>Tm</b> 2+ Thulium 168.9		70 3+ <b>Yb</b> 2+ Ytterbium 173.0		71 3+ <b>Lu</b> Lutetium 175.0									
90 4+ <b>Th</b> Thorium 232.0		91 5+ <b>Pa</b> 4+ Protactinium 231.0		92 6+ <b>U</b> 4+ Uranium 238.0		93 5+ <b>Np</b> 3+ Neptunium (237)		94 4+ <b>Pu</b> 6+ Plutonium (244)		95 3+ <b>Am</b> 5+ Americium (243)		96 3+ <b>Cm</b> 4+ Curium (247)		97 3+ <b>Bk</b> 4+ Berkelium (247)		98 3+ <b>Cf</b> Californium (251)		99 3+ <b>Es</b> Einsteinium (252)		100 3+ <b>Fm</b> Fermium (257)		101 2+ <b>Md</b> 3+ Mendelevium (258)		102 2+ <b>No</b> 3+ Nobelium (259)		103 3+ <b>Lr</b> Lawrencium (262)									

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.

Where are the following?

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

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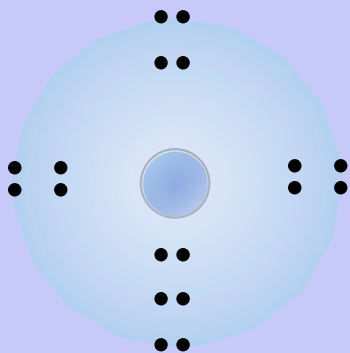
# Colour Periodic Table

- **Use different colours to highlight the main groups of the periodic table.**



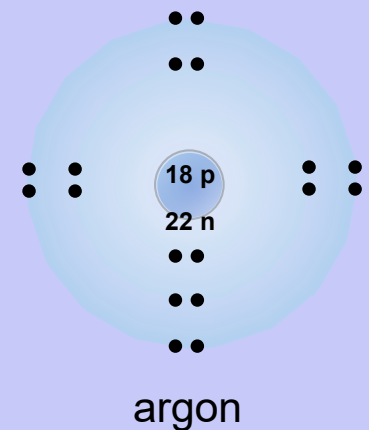
# Bohr Diagrams

- Bohr diagrams show how many electrons appear in each electron shell around an atom.
  - ♦ Electrons in the outermost shell are called valence electrons.
  - ♦ Think of the shells as being 3-D like spheres, not 2-D like circles.



What element is this?

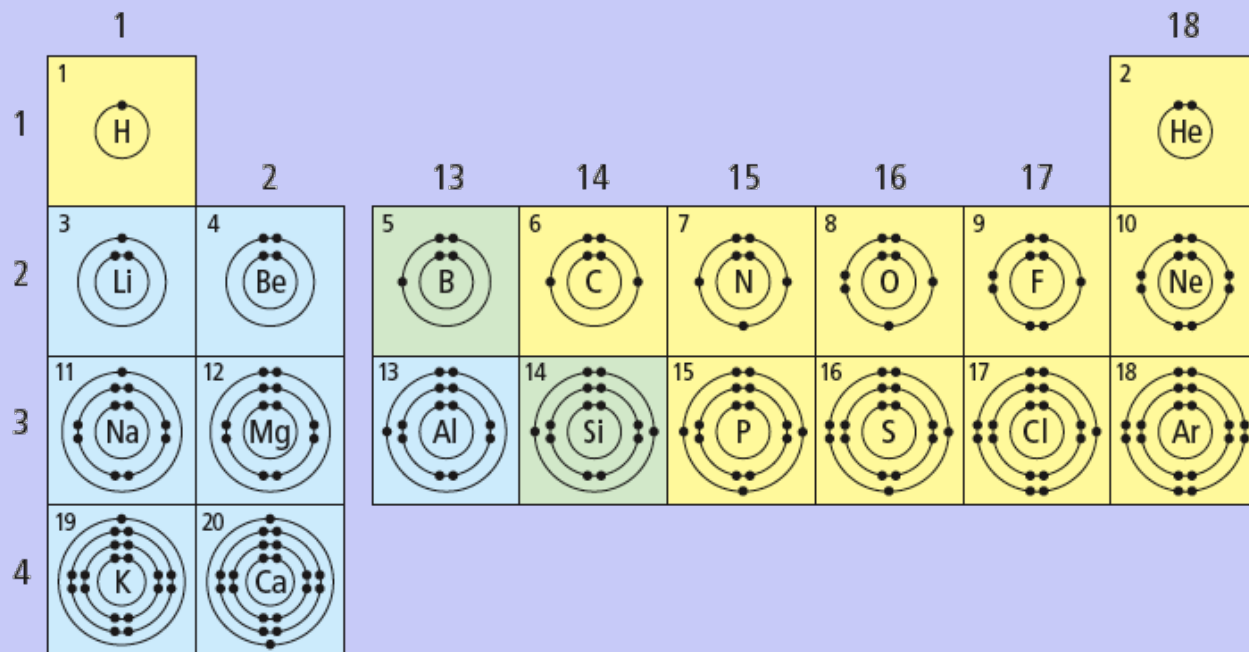
- It has  $2 + 8 + 8 = 18$  electrons, and therefore, 18 protons.
- It has three electron shells, so it is in period 3.
- It has eight electrons in the outer (valence) shell.



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# Patterns of Electron Arrangement in Periods and Groups

- Electrons appear in shells in a very predictable manner.
- There is a maximum of two electrons in the first shell, eight in the 2nd shell, and eight in the 3rd shell.
  - ◆ The period number = the number of shells in the atom.
  - ◆ Except for the transition elements, the last digit of the group number = the number of electrons in the valence shell.



- ◆ The noble gas elements have full electron shells and are very stable.

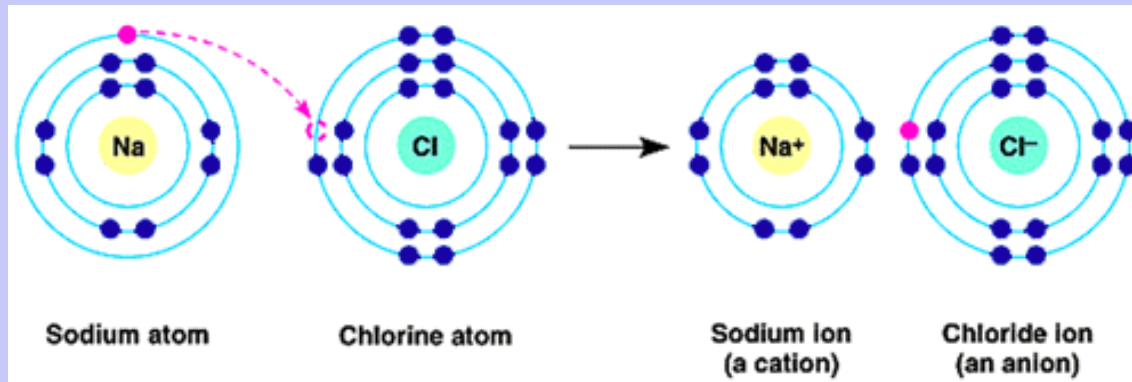
See page 175

# Practice Drawing Bohr Diagrams

- **Bohr diagram worksheet**
  - ◆ **Atoms vs Ions**
    - **Remember, atoms are neutral and ions are charged!**

# 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.

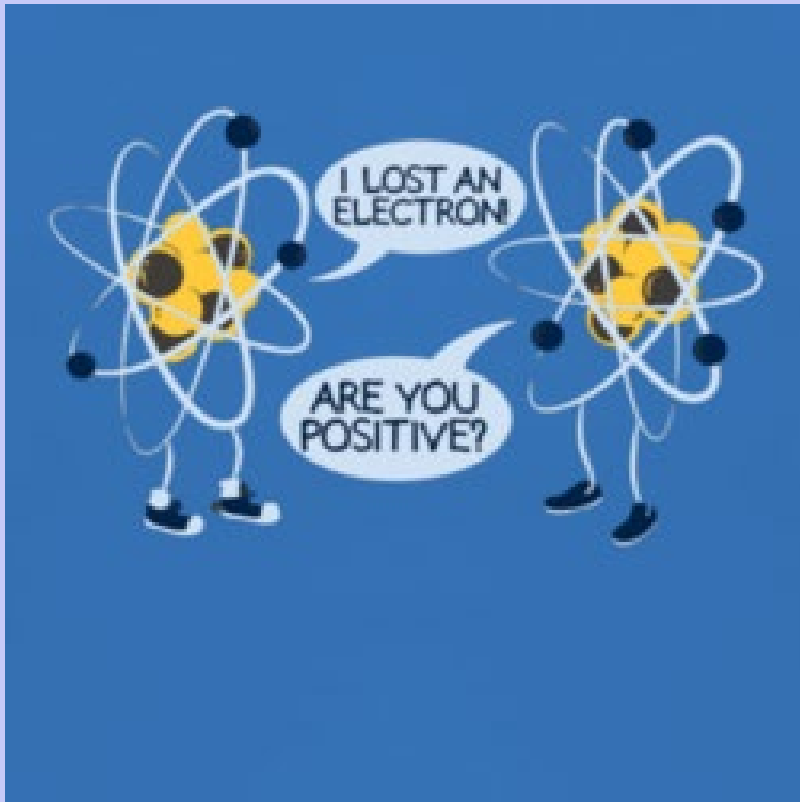


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# Forming Compounds

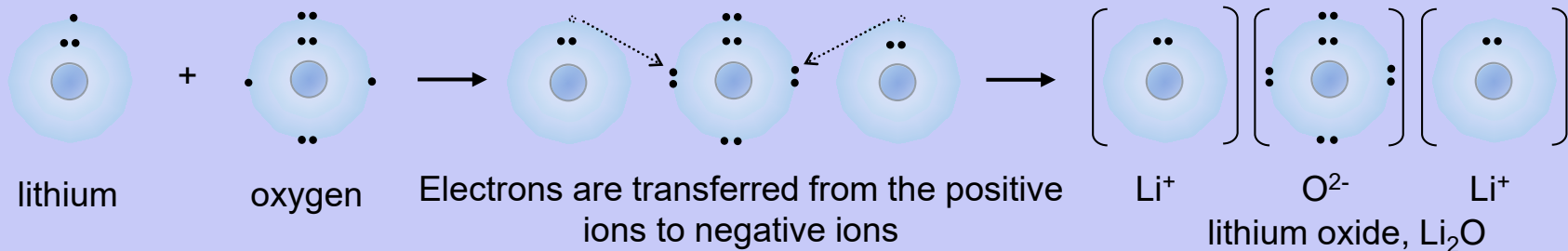
- **When two atoms get close together, their valence electrons interact.**
  - ♦ **If the valence electrons can combine to form a low-energy bond, a compound is formed.**
  - ♦ **Each atom in the compound attempts to have the stable number of valence electrons as the nearest noble gas.**
  - ♦ **Metals may lose electrons and non-metals may gain electrons (ionic bond), or atoms may share electrons (covalent bond).**
- **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.**

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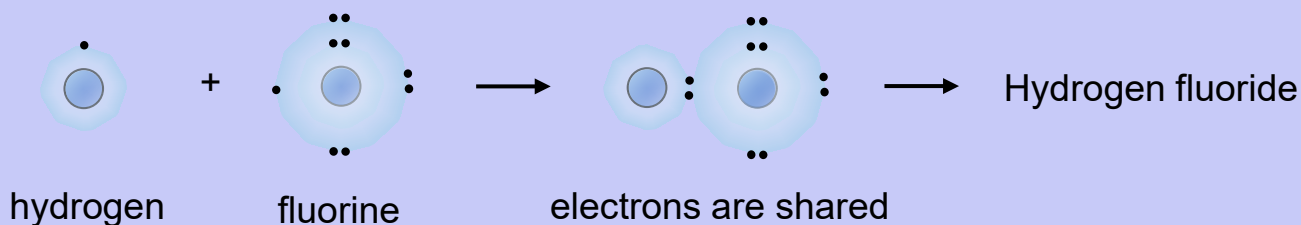


## Forming Compounds (continued)

- **Ionic bonds are formed between positive ions and negative ions.**
  - ◆ Generally, this is a metal (+) and a non-metal (-) ion.
  - ◆ For example, lithium and oxygen form an ionic bond in the compound  $\text{Li}_2\text{O}$ .



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



See pages 176 - 177

# Bohr Diagram

- **Pg 61 in workbook**



# Lewis Diagrams

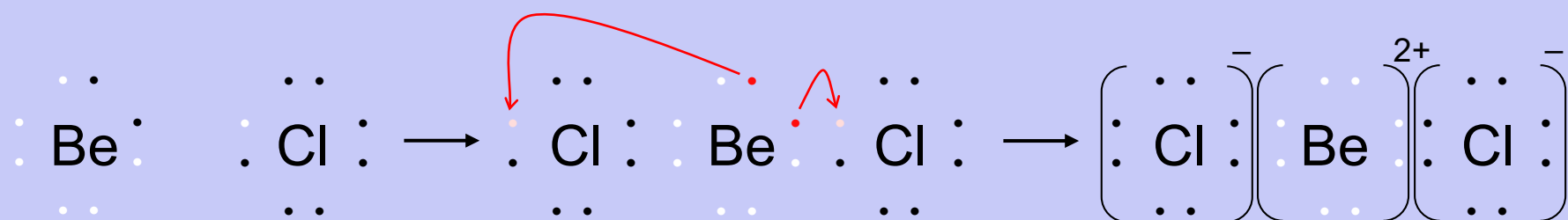
- Lewis diagrams illustrate chemical bonding by showing only an atom's valence electrons and the chemical symbol.
  - ◆ Dots representing electrons are placed around the element symbols at the points of the compass (north, east, south, and west).
  - ◆ Electron dots are placed singly until the fifth 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 •• ••	

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# Lewis Diagrams of Ions

- Lewis diagrams can be used to represent ions and ionic bonds.
  - ◆ For positive ions, one electron dot is removed from the valence shell for each positive charge.
  - ◆ For negative ions, one electron dot is added to each valence shell for each negative charge.
  - ◆ Square brackets are placed around each ion to indicate transfer of electrons.



Each beryllium has two electrons to transfer away, and each chlorine can receive one more electron.

Since  $\text{Be}^{2+}$  can donate two electrons and each  $\text{Cl}^-$  can accept only one, two  $\text{Cl}^-$  ions are necessary.

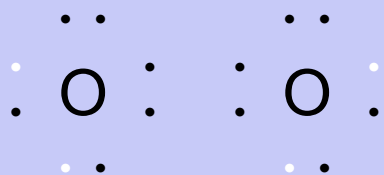
beryllium chloride

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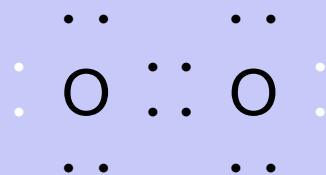


# Lewis Diagrams of Diatomic Molecules

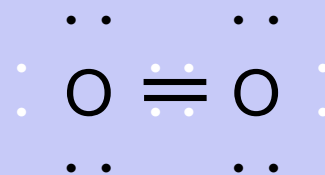
- **Diatomic molecules, like  $O_2$ , are also easy to draw as Lewis diagrams.**



Several non-metals join to form diatomic molecules.



Valence electrons are shared, here in two pairs.



This is drawn as a double bond.

[Take the Section 4.1 Quiz](#)

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