Describing Matter

- Physical Properties
  - Qualitative - state, colour, malleability
  - Quantitative - conductivity, viscosity, density
- Pure Substances
  - Element - a pure substance that cannot be broken down or separated into simpler substances (e.g., gold)
  - Compound - a pure substance composed of at least two elements (e.g., water)

Take the Section 1.2 Quiz

See pages 22 - 23

Inside the Atom

- An atom is the smallest particle of an element that retains the properties of the element.
- All atoms are made up of three kinds of particles called subatomic particles. These particles are:

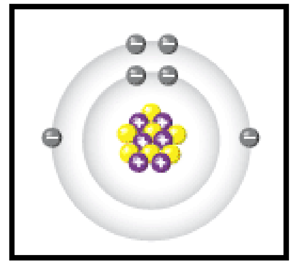


Table 1.2 Subatomic Particles

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

Take the Section 1.3 Quiz

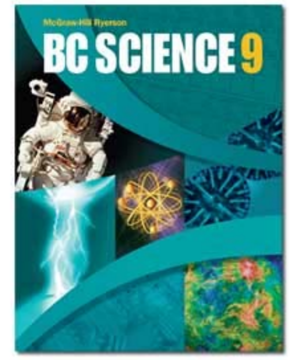
See pages 32 - 33

2.1 Elements

- Why are elements studied in chemistry?
  - Chemistry is the study of matter and its changes.
  - Elements make up an incredible variety of different substances.
  - An element is a pure substance that cannot be broken down or separated into simpler substances. Each element is one kind of atom.
  - By studying elements, we can learn more about the structure of matter.

See page 42

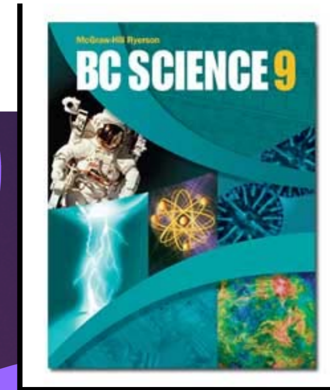
Chemical Symbols



- Element names and symbols
  - Because elements have different names in different languages, chemists use international symbols for them
  - Chemical symbols consist of one or two letters.
  - Ancient names are used as the source of many of the symbols. Example:
  - Mercury - **Hg** - **H**ydra**g**yrum (*Latin for liquid silver*)

See pages 43 - 44

Chemical Symbols



All elements are represented by symbols.

Here are just a few element symbol examples:

Gases at room temperature		
hydrogen	H	*Hydro genes* = water forming
helium	He	*Helios* = sun

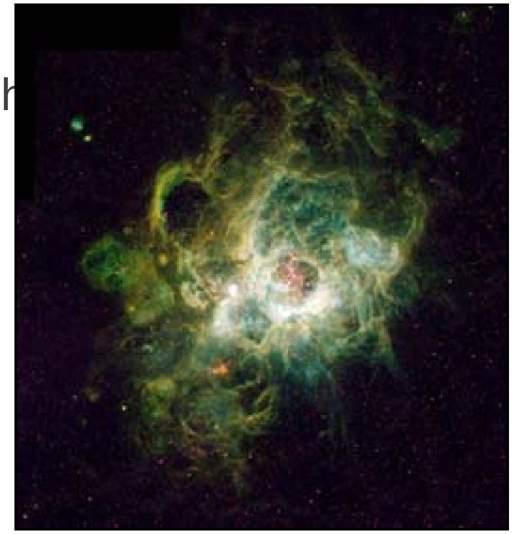
Liquids at room temperature		
bromine	Br	*Bromos* = smelly
mercury	Hg	*Hydrargyrum* = Latin for liquid silver

Solids at room temperature		
lithium	Li	*Lithos* = stone
sodium	Na	*Natrium* = Latin for sodium

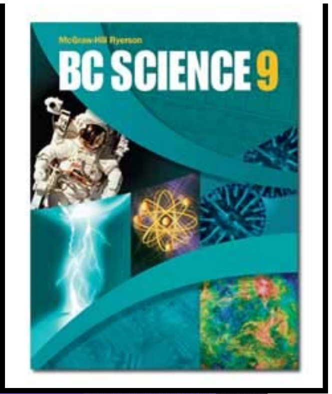
e page 44

Common Elements

- Hydrogen
  - Colourless, odourless, tasteless, and high
    flammable gas.
  - Makes up over 90 percent of the atoms in the universe
  - Used in producing fertilizers
  - Lighter than air
  - Can be separated from water or gasoline and be used as a source of fuel



See page 45



Common Elements

- Iron (**Fe**) - mixed with carbon to make steel
  - Good structural material, but can rust when mixed with water or oxygen

Iron in a river turns water and rocks red

- Oxygen (**O**) - gaseous element we breathe
  - 21 % of the atmosphere
  - Reacts with most other elements

Oxygen and iron react in burning thermite

GNU license photo

See page 45

Other Common Elements

- Sodium (**Na**) - soft metal that reacts with water
- Chlorine (**Cl**) - yellow-green gas that is highly toxic
- Mercury (**Hg**) - liquid at room temperature metal.
- Silver (**Ag**) - precious metal mined in British Columbia
- Silicon (**Si**) - brittle, grey, semiconductor that is second most common element in Earth's crust.

Na

Cl

Hg

Ag

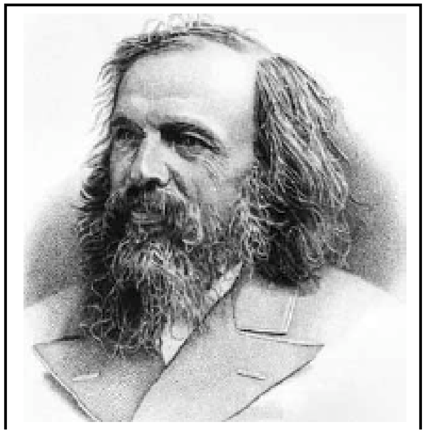
Si

See pages 46 - 47

Take the Section 2.1 Quiz

2.2 Periodic Table

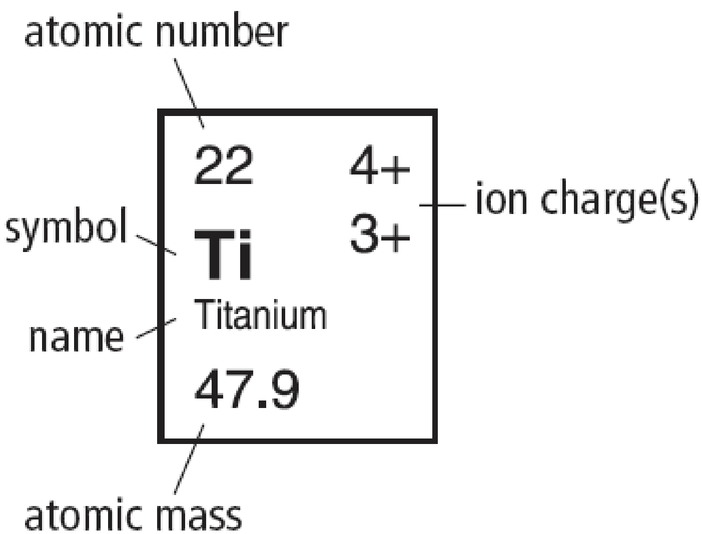
- Origin of the periodic table
  - Chemists in the 10th century wished to organize elements
  - Attempts focused on grouping elements with similar properties
  - In 1867, Dimitri Mendeleev found patterns in the elements and organized them into table
  - The resulting table had holes for elements not yet discovered



See page 52

Periodic Table

- The Periodic Table provides information on the physical and chemical properties of elements



Atomic Mass - mass of average atom
Atomic Number - number of protons
Ion Charge - electric charge that forms when an atom gains or loses electrons

See page 53

	metal
(pink, bold border)	metalloid
(yellow)	non-metal

Atomic Number	22
Ion charge(s)	4+ 3+
Symbol	Ti
Name	Titanium
Atomic Mass	47.9

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 + H Hydrogen 1.0																	2 0 He Helium 4.0
2	3 + Li Lithium 6.9	4 2+ Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 3− N Nitrogen 14.0	8 2− O Oxygen 16.0	9 − F Fluorine 19.0	10 0 Ne Neon 20.2
3	11 + Na Sodium 23.0	12 2+ Mg Magnesium 24.3											13 3+ Al Aluminum 27.0	14 Si Silicon 28.1	15 3− P Phosphorus 31.0	16 2− S Sulphur 32.1	17 − Cl Chlorine 35.5	18 0 Ar Argon 39.9
4	19 + K Potassium 39.1	20 2+ Ca Calcium 40.1	21 3+ Sc Scandium 45.0	22 4+ 3+ Ti Titanium 47.9	23 5+ 4+ V Vanadium 50.9	24 3+ 2+ Cr Chromium 52.0	25 2+ 3+ 4+ Mn Manganese 54.9	26 3+ 2+ Fe Iron 55.8	27 2+ 3+ Co Cobalt 58.9	28 2+ 3+ Ni Nickel 58.7	29 2+ 1+ Cu Copper 63.5	30 2+ Zn Zinc 65.4	31 3+ Ga Gallium 69.7	32 4+ Ge Germanium 72.6	33 3− As Arsenic 74.9	34 2− Se Selenium 79.0	35 − Br Bromine 79.9	36 0 Kr Krypton 83.8
5	37 + Rb Rubidium 85.5	38 2+ Sr Strontium 87.6	39 3+ Y Yttrium 88.9	40 4+ Zr Zirconium 91.2	41 3+ 5+ Nb Niobium 92.9	42 2+ 3+ Mo Molybdenum 95.9	43 7+ Tc Technetium (98)	44 3+ 4+ Ru Ruthenium 101.1	45 3+ 4+ Rh Rhodium 102.9	46 2+ 4+ Pd Palladium 106.4	47 1+ Ag Silver 107.9	48 2+ Cd Cadmium 112.4	49 3+ In Indium 114.8	50 4+ 2+ Sn Tin 118.7	51 3+ 5+ Sb Antimony 121.8	52 2− Te Tellurium 127.6	53 − I Iodine 126.9	54 0 Xe Xenon 131.3
6	55 + Cs Cesium 132.9	56 2+ Ba Barium 137.3	57 3+ La Lanthanum 138.9	72 4+ Hf Hafnium 178.5	73 5+ Ta Tantalum 180.9	74 6+ W Tungsten 183.8	75 4+ 7+ Re Rhenium 186.2	76 3+ 4+ Os Osmium 190.2	77 3+ 4+ Ir Iridium 192.2	78 4+ 2+ Pt Platinum 195.1	79 3+ 1+ Au Gold 197.0	80 2+ 1+ Hg Mercury 200.6	81 1+ 3+ Tl Thallium 204.4	82 2+ 4+ Pb Lead 207.2	83 3+ 5+ Bi Bismuth 209.0	84 2+ 4+ Po Polonium (209)	85 − At Astatine (210)	86 0 Rn Radon (222)
7	87 + Fr Francium (223)	88 2+ Ra Radium (226)	89 3+ 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)		

* Temporary names

58 3+ 4+ Ce Cerium 140.1	59 3+ 4+ Pr Praseodymium 140.9	60 3+ Nd Neodymium 144.2	61 3+ Pm Promethium (145)	62 3+ 4+ Sm Samarium 150.4	63 3+ 2+ Eu Europium 152.0	64 3+ Gd Gadolinium 157.3	65 3+ 4+ Tb Terbium 158.9	66 3+ Dy Dysprosium 162.5	67 3+ Ho Holmium 164.9	68 3+ Er Erbium 167.3	69 3+ 2+ Tm Thulium 168.9	70 3+ 2+ Yb Ytterbium 173.0	71 3+ Lu Lutetium 175.0
90 4+ Th Thorium 232.0	91 5+ 4+ Pa Protactinium 231.0	92 6+ 4+ 5+ U Uranium 238.0	93 5+ 3+ 4+ 6+ Np Neptunium (237)	94 4+ 6+ 3+ 5+ Pu Plutonium (244)	95 3+ 4+ 5+ 6+ Am Americium (243)	96 3+ Cm Curium (247)	97 3+ 4+ Bk Berkelium (247)	98 3+ Cf Californium (251)	99 3+ Es Einsteinium (252)	100 3+ Fm Fermium (257)	101 2+ 3+ Md Mendelevium (258)	102 2+ 3+ No Nobelium (259)	103 3+ Lr Lawrencium (262)

Metals, Non-metals, Metalloids

- Period table has interesting patterns
- Due to Mendeleev's organization, interesting patterns are created, such as the groups: metals, non-metals and metalloids.

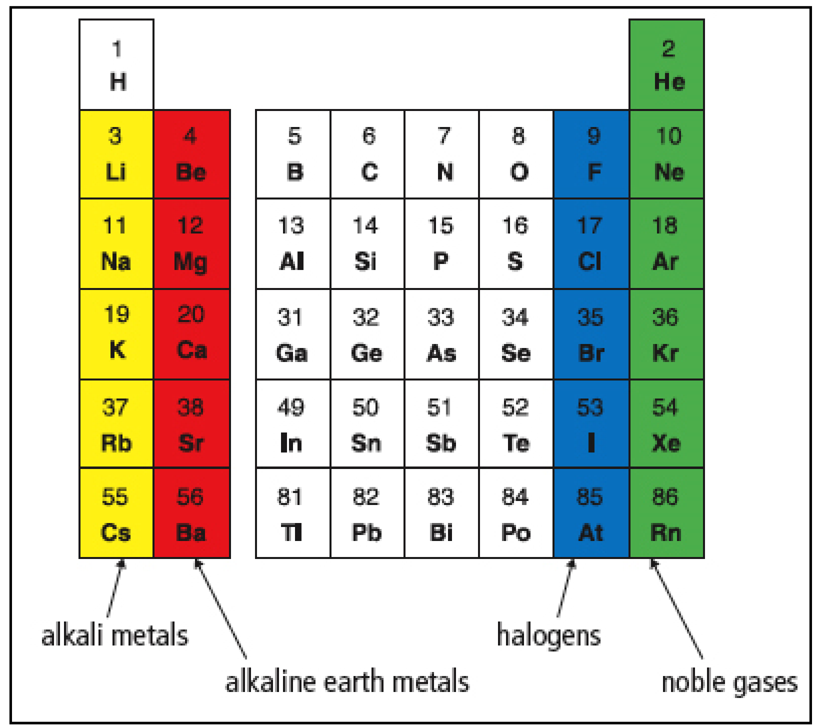
	State at Room Temperature	Appearance	Conductivity	Malleability and Ductility
Metals	• solid except for mercury (a liquid)	• shiny lustre	• good conductors of heat and electricity	• malleable • ductile
Non-metals	• some gases • some solids • only bromine is a liquid	• not very shiny	• poor conductors of heat and electricity	• brittle • not ductile
Metalloids	• solids	• can be shiny or dull	• may conduct electricity • poor conductors of heat	• brittle • not ductile

See page 55

Periods and Families

- Each horizontal row in the periodic table is a **period**
- Vertical columns form groups or **chemical families**

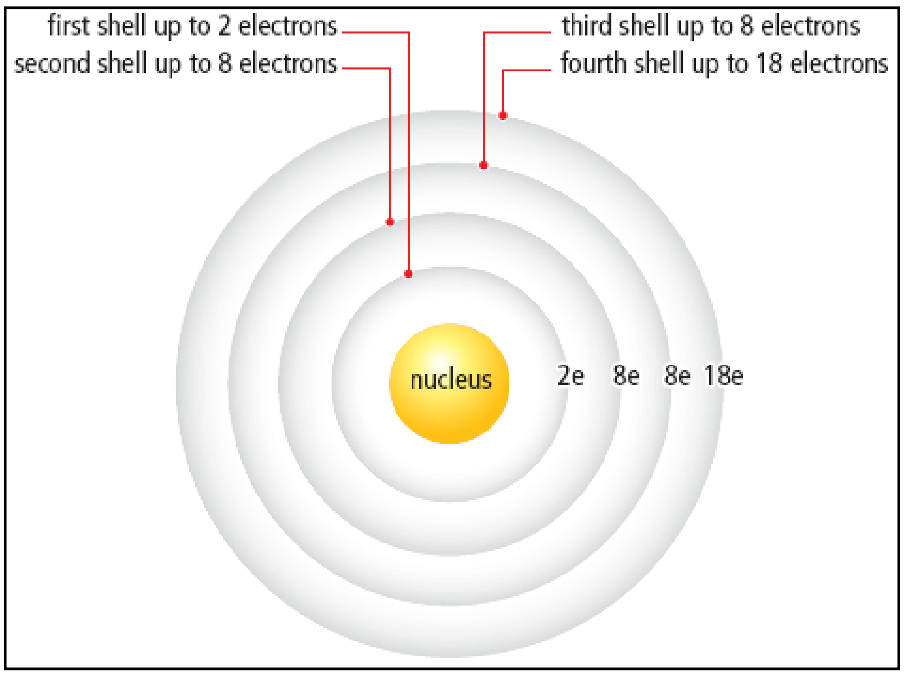
  - **Alkali metals** - highly reactive group 1
  - **Alkaline earth metals** - group 2, burn in air if heated
  - **Halogens** - group 17, highly reactive non-metals
  - **Noble gases** - group 18, stable and unreactive non-metals

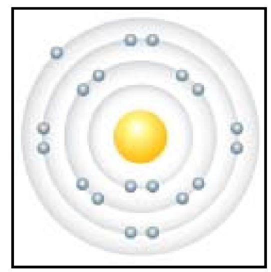


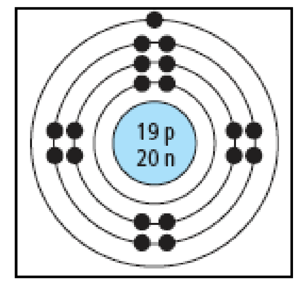
Take the Section 2.2 Quiz

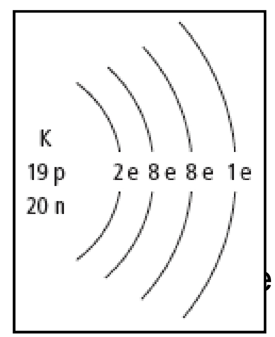
2.3 Periodic Table and Atomic Theory

- Elements with similar properties have similar electron arrangements
- Bohr models show electron arrangement in shells





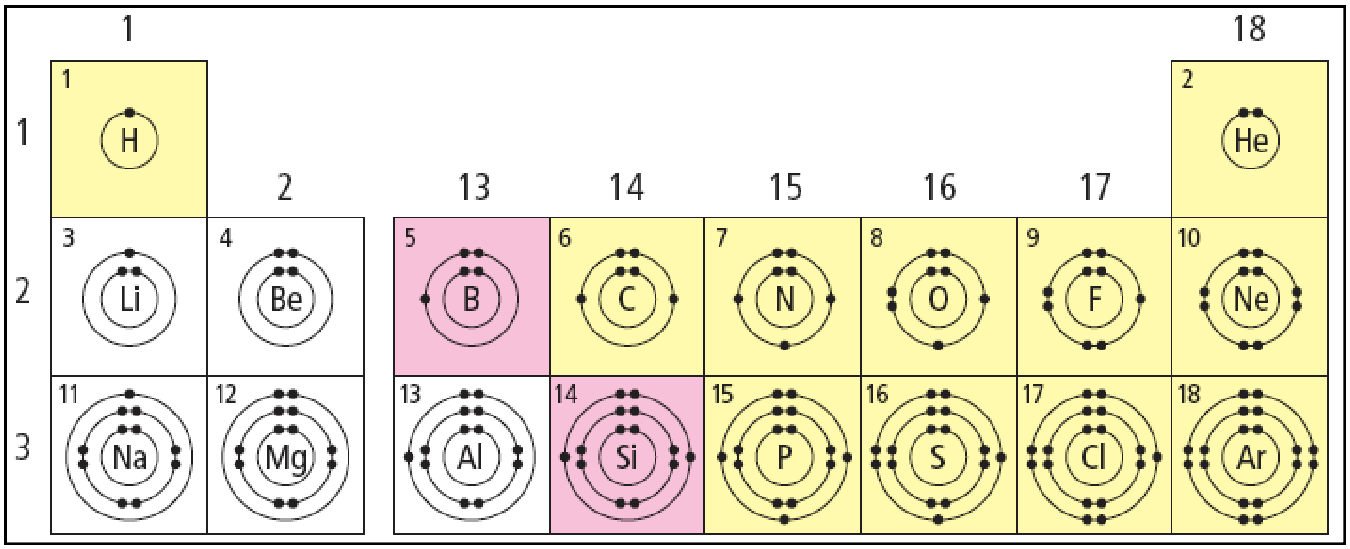




64 - 65

Bohr model patterns

- Chemical families on the periodic table have the same number of valence electrons
- Elements in the same period have the same number of shells
- Period number indicates the number of electron shells



See page 66

Atom Stability

- Noble gases are very unreactive because their atoms have filled valence shells. Filled shells make atoms stable. Atoms with filled shells do not easily trade or share electrons.
- Other atoms gain or lose electrons in order to achieve the stability of noble gases. Gaining or losing electrons makes atoms into ions.
  - Metals lose electrons to form positive ions
  - Non-metals gain electrons to form negative ions
  - Ions have a similar electron arrangement to the nearest noble gas
  - Example: Sodium ion (**Na^+**) has 11 protons (**11^+**) and 10 electrons (**10^-**) for a total charge of **1^+**

Take the Section 2.3 Quiz

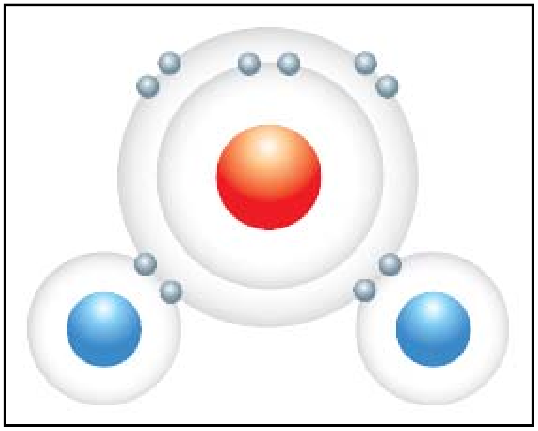
	Lithium	Magnesium	Chlorine
Atom	Li 3 p 2, 1	Mg 12 p 2, 8, 2	Cl 17 p 2, 8, 7
Ion	Li+ 3 p 2	Mg^{2+} 12 p 2, 8	Cl– 17 p 2, 8, 8

See pages 66 - 67

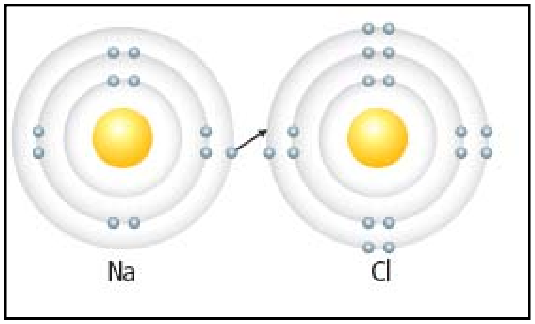
3.1 Compounds

- Compounds are pure substances made of more than one kind of atom joined together. The atoms are held together with chemical bonds.
- Compounds come in two basic types: **covalent** and **ionic**.

Covalent compounds share electrons to form molecules. Example: water



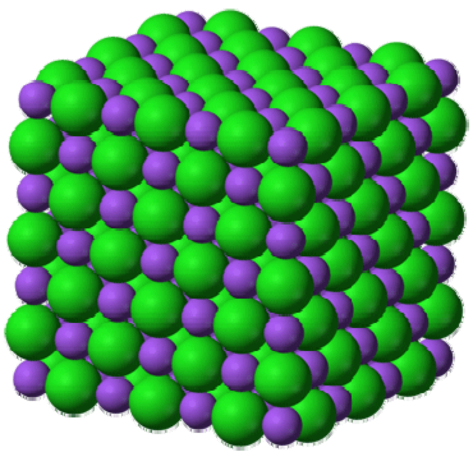
In ionic compounds, atoms gain or lose electrons to form ions. Example: NaCl



See pages 76 - 78

Ionic Compounds

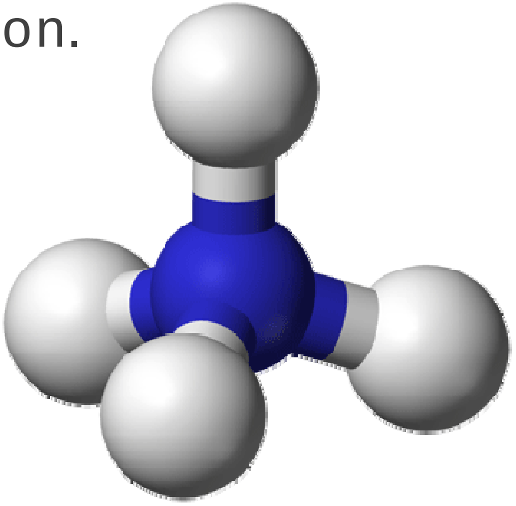
- Ionic solids exist as a solid in the form of an ionic lattice.
- The positive ions attract all of the negative ions, and vice versa. In the example of table salt (NaCl) the one-to-one ratio of ions results in a simple square-shaped ionic cyrstal:



See page 78

Polyatomic Ions

- Covalent and ionic bonds can occur together
- A molecule can gain or lose electrons to become charged, forming a polyatomic ion.
- Polyatomic ions form compounds like other ions.
  - Example: Ammonium ion (NH_4^+)
- There are many types of polyatomic ions, but they occur in a few basic shapes.



Take the Section 3.1 Quiz

See pages 79 - 80

3.2 Names and Formulas of Ionic Compounds

- The chemical name indicates the elements present in the compound. Chemical names for ionic compounds are given according to rules.
  - The positive ion is always the first part of the name
  - The negative ion is always the second part of the name
  - The non-metal ion’s name ends with the suffix “-ide”

Examples of Names of Ionic Compounds

Elements Forming the Ionic Compound	Name of the Ionic Compound
calcium and nitrogen	calcium nitride
potassium and oxygen	potassium oxide
lithium and chlorine	lithium chloride
magnesium and sulphur	magnesium sulphide
silver and fluorine	silver fluoride

See page 85

Ionic Chemical Formulas

- In an ionic compound, the positive charges balance the negative charges. This balance of charge is used to determine the smallest whole number ratio of positive to negative ions.

Steps for Writing the Formula	Examples	
	zinc nitride	aluminum chloride
1. Identify each ion and its charge.	zinc: Zn^{2+} nitride: N^{3-}	aluminum: Al^{3+} chloride: Cl^{-}
2. Determine the total charges needed to balance positive with negative.	Zn^{2+}: +2 +2 +2 = +6 N^{3-}: −3 −3 = −6	Al^{3+} : = +3 Cl^{-}: −1 −1 −1 = −3
3. Note the ratio of positive ions to negative ions.	3 Zn^{2+} ions for every 2 N^{3-} ions	1 Al^{3+} ion for every 3 Cl^{-} ions
4. Use subscripts to write the formula. A "1" is not shown in the subscripts.	Zn_3N_2	$AlCl_3$

Multivalent Metal Compounds

- Many metals are multivalent, meaning the metals
  form two or more different positive ions with different charges
- For example, the atom iron forms two ions Fe^{2+} and Fe^{3+}
- Too distinguish different ions for the same metal, roman numerals are added to their name. For example, Fe^{3+} would be named "iron(III)"

Compounds with Multivalent Metal Ions

Name	Formula
chromium(II) fluoride	CrF_2
chromium(III) fluoride	CrF_3
lead(IV) sulphide	PbS_2
copper(I) phosphide	Cu_3P

Metal Ion Charge	Roman Numeral
1+	I
2+	II
3+	III
4+	IV
5+	V
6+	VI
7+	VII

Writing Multivalent Formulas

- Writing ionic compound formulas with multivalent ions follows the same rules as regular ionic compounds

Steps for Writing the Formula	Examples	
	Iron(III) sulphide	Lead(IV) oxide
1. Identify each ion and its charge.	iron(III): Fe^{3+} sulphide: S^{2-}	lead(IV): Pb^{4+} oxide: O^{2-}
2. Determine the total charges needed to balance positive with negative.	Fe^{3+}: +3 +3 = +6 S^{2-} : −2 −2 −2 = −6	Pb^{4+}: = +4 O^{2-}: −2 −2 = −4
3. Note the ratio of positive ions to negative ions.	2 Fe^{3+} ions for every 3 S^{2-} ions	1 Pb^{4+} ion for every 2 O^{2-} ions
4. Use subscripts to write the formula. A "1" is not shown in the subscripts.	Fe_2S_3	PbO_2

See page 89

Multivalent Compound Names

- Steps to writing multivalent compound names are as follows:
  - Identify the metal and verify it forms more than one ion
  - Determine the ratio of ions - for example, Fe_2O_3 means 2 iron ions for every 3 oxygen ions
  - Note the charge on the negative ion: Oxygen is O^{2-}
  - The positive and negative charges must balance, so 2 iron ions of 3+ charge (Fe3+) are needed to balance the 3 oxygen ions
  - Write the name of the compound: Iron(III) oxide

See page 90

Polyatomic Ion Compounds

- Steps to writing names for formulas involving polyatomic ions are similar to other ionic compounds

Steps for Writing the Formula	Examples	
	iron(III) hydroxide	ammonium carbonate
1. Identify each ion and its charge.	iron(III): Fe^{3+} hydroxide: OH^-	ammonium: NH_4^+ carbonate: CO_3^{2-}
2. Determine the total charges needed to balance positive with negative.	Fe^{3+}: = 3+ OH^{-1}: −1 −1 −1 = 3−	NH_4^+: +1 +1 = 2+ CO_3^{2-}: = 2−
3. Note the ratio of positive ions to negative ions.	1 Fe^{3+} ion for every 3 OH^- ions	2 NH_4^+ ions for every 1 CO_3^{2-} ion
4. Use subscripts and brackets to write the formula. Omit brackets if only one ion is needed.	$Fe(OH)_3$	$(NH_4)_2CO_3$