**4.1 Atomic Theory and Bonding**

**Pure Substances and Chemical Changes**

Pure Substances are made up of only one \_\_\_\_\_\_\_\_\_ of matter. There are two categories:

1) Element –

2) Compound –

Chemical Changes are changes in how the atoms and molecules in a pure substance are \_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_

Clues:

**Atomic Theory**

Atoms are the

Subatomic particles are the particles that make up an atom. There are three types:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Symbol | Electric  Charge | Location in the Atom | Relative Mass |
| 1) Proton |  |  |  |  |
| 2) Neutron |  |  |  |  |
| 3) Electron |  |  |  |  |

The \_\_\_\_\_\_\_\_ is the centre of an atom and always has a positive \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ (equal to the \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_)

For any neutral atom,

of a neutral atom.

**Periodic Table**

Organization:

1) Elements are in order of \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_

2) Each row is called a \_\_\_\_\_\_\_\_\_\_ (1→7); each column is called a \_\_\_\_\_\_\_\_\_ (1→18)

3) \_\_\_\_\_\_\_\_\_ on left side, \_\_\_\_\_\_\_\_\_on right

side, \_\_\_\_\_\_\_\_\_ form a “staircase”

4) Families have similar chemical properties:

(i) Alkali metals:

(ii) Alkaline earth metals:

(iii) Halogens:

(iv) Noble gases:

5) The \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_make up families

3 → 12 (e.g. Fe, Ni, Cu, Ag, Au)

6) Ion charges:

1. Metals lose electrons to form positively charged ions called \_\_\_\_\_\_\_\_\_\_\_ (e.g. Al3+ ion). Some metals are \_\_\_\_\_\_\_\_\_\_\_ (e.g. Fe3+ or Fe2+ ions)
2. Non-metals gain electrons to form negatively charged ions called \_\_\_\_\_\_\_\_\_\_\_ (e.g. Cl-)

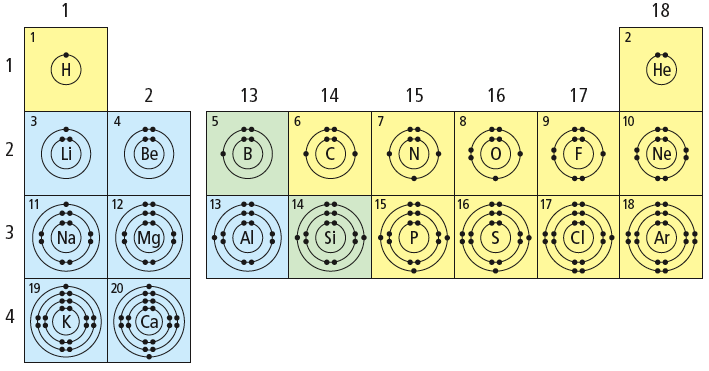
**Bohr Diagrams**

Bohr diagrams:

*Example:*

Potassium atom (K) Potassium ion (K1+)

Patterns



-electrons increase in # from left to right

-the period # = the number of shells

-the first four shells hold a maximum of 2e, 8e, 8e, 18e

-noble gases have filled valence shells

-8e’s in the outermost shell is called a stable octet

Ionic bonding

-ionic bonding occurs when electron(s) transfer from a metal atom (e.g. calcium) to a non-metal atom (e.g. fluorine)

-the ionic compound that forms has a positive ion (e.g. Ca2+) and a negative ion (e.g. F1-)

-square brackets are drawn around each ion with the ion charge at the top right

*Example:* CaF2

**F Ca F**

*Covalent bonding*

* Covalent bonding occurs when
* The covalent compound that forms is called a
* Pairs of valence electrons involved in the covalent bond are called
* Pairs of valence electrons that aren’t involved in the bond are called

*Example:* H2O

**H O**

**H**

**Lewis Diagrams**

-Lewis diagrams illustrate chemical bonding by showing,

(1)

(2)

Rules for Lewis atoms

* Use electron dots to represent valence electrons
* Place electron dots singly until the fifth electron, then pair them

*Examples:*

a) **H** b) **N** c) **Ar**

Rules for Lewis ionic compounds

* Draw valence electrons around the non-metal symbols only
* Draw square brackets around the ions
* Write the ion charges at the top right of the brackets

*Example:* MgCl2

**Cl Mg Cl**

Rules for Lewis covalent compounds

* Draw valence electrons around each symbol:

**H + F**

* Determine bonding pairs by pairing up unpaired electrons:

**H F**

* Draw lines for each bonding pair:

**H F**

***Diatomic molecules***

* A diatomic molecule is a pair of atoms joined by covalent bonds (H2, N2, O2, F2, Cl2, Br2, I2,)

*Examples:*

a) fluorine b) oxygen c) nitrogen

**F + F O + O N + N**

**↓ ↓ ↓**

**F F O O N N**

**↓ ↓ ↓**

**F F O O N N**

*More practice – Lewis covalent compounds:*

1) CH4

2) PCl3

3\*) HCN

**4.2 Names and Formulas of Compounds**

**Ionic Compounds**

* Ionic compounds are composed of positive ions (e.g. Mg2+) and negative ions (e.g. Cl-)
* Formulas (e.g. MgCl2) show the smallest whole-number ratio of ions (e.g. one Mg2+ for every two Cl-)

*Naming Rules:*

1. The part of the name represents the positive ion
2. The second part of the name represents the negative ion. If the ion is a single element (e.g. S2-), change the ending to “ide” (e.g. sulphur becomes sulphide)
3. To distinguish between ions formed from multivalent metals (e.g. Cu2+, Cu1+), use a Roman numeral after the name of the metal
4. Name a polyatomic ion (e.g. CO32-) by looking up its special name (e.g. carbonate)

*Examples:*

a) Li2O b) CuO

c) (NH4)2S d) Sn3(PO4)4

*Rules for Writing Formulas:*

**(i)** Identify each ion from the name:

lead (IV) sulphide

↓ ↓

**(ii)** Determine the ratio of ions using either method:

Method #1 Method #2

Balancing charges Criss-cross method

Pb4+: +4 = +4 Pb4+ S2-

S2-: -2 -2 = -4

Pb S

Ratio: 1 Pb4+ to 2 S2- 2 Pb4+ to 4 S2-

**(iii)** Write the formula in lowest terms using subscripts:

PbS2

*Examples:*

a) sodium oxide b) platinum (iv) sulphide

c) ammonium sulphite d) lead (II) perchlorate

**Covalent Compounds**

* Covalent compounds are composed of
* Formulas show the \_\_\_\_\_\_\_\_\_\_\_ number of atoms of each element in a molecule (e.g. H2O2)
* Prefixes are used in naming simple covalent compounds:

mono- 1 hexa- 6

di- 2 hepta- 7

tri- 3 octa- 8

tetra- 4 nona- 9

penta- 5 deca- 10

*Naming Rules:*

1. Name the first element.
2. Name the second element and add the suffix “ide”
3. Add a prefix to each element’s name to indicate the number of atoms. Exceptions to rule:

* 1. Do not add a prefix if the first element has only one atom
  2. Shorten mono- to mon- if it is placed before oxide

*Examples:*

a) CO2 b) CO

c) P4S10 d) N2O4

**Rules for Writing Formulas:**

1. Write the first element symbol.
2. Write the second element symbol.
3. Write subscripts to show the number of atoms as indicated by the prefix

*Examples:*

a) carbon tetraiodide b) dichlorine monoxide

c) disulphur decafluoride d) sulphur dioxide

e) phosphorus tribromide f) arsenic pentachloride

**4.3 Chemical Equations**

**Chemical Equations**

* Chemical equations are used to represent chemical reactions
* A chemical equation shows the conversion of reactants into new substances called products

reactant(s) → product(s)

* States of matter are sometimes indicated:
  + Solid (s)
  + Liquid (l)
  + Gas (g)
  + Aqueous (aq)
* Chemical symbols are used for elements not in compounds (e.g. copper is Cu)
* Some compounds containing hydrogen use common names. Examples:
  + Methane (CH4)
  + Hydrochloric acid (HCl)
  + Ammonia (NH3)
  + Glucose (C6H12O6)
  + Hydrogen peroxide (H2O2)
  + Water (H2O)
* There are seven diatomic elements (H2, N2, O2, F2, Cl2, Br2, I2,)

*Chemical equations can be written in three ways:*

1) Word equation – shows the names of the reactants and products:

2) Skeleton equation – shows the formulas of the reactants and products:

3) Balanced chemical equation – shows the formulas of the reactants and products, as well as the correct proportion of atoms:

*Example: A solution of sodium sulphide is mixed with a solution of copper (II) nitrate. A precipitate of copper (II) sulphide is formed in a solution of sodium nitrate.*

*Word equation:*

*Skeleton equation:*

*Balanced chemical equation:*

**Law of Conservation of Mass**

Chemical reactions obey the

total mass of reactants = total mass of products

To satisfy this law, both sides of an equation must have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ numbers of each atom

*Example:*

H2 + O2 → H2O

Reactants Product

*Q: How can we balance the equation above?*

*A: Place the required, lowest whole number coefficient in front of each reactant and product*

H2 + O2 → H2O

reactants product

*Strategies for balancing:*

* 1. Balance compounds first, elements last
  2. Balance one compound at a time
  3. Only add coefficients; NEVER change subscripts!
  4. If H and O appear in more than one place, attempt to balance them LAST
  5. Polyatomic ions (such as SO42–) can often be balanced as a whole group
  6. Always double-check after you think you are finished!

*Examples:*

1) H2 + N2 → NH3

2) P4 + O2 → P2O5

3) Ag2O → Ag + O2

4) BaCl2 + Na2SO4 → NaCl + BaSO4

5) Cd3(PO4)2 + (NH4)2S → CdS + (NH4)3PO4