Stoichiometry and Mole Concept

Saturday, September 19, 2020 9:44 PM

4.1:
Stoichiometry

The Periodic Table consist of elements known to the world as of today. More elements may be discovered in the future. Element symbols are most commonly named by the letters, usually the 1st or 1st 2, in their element name. Take an example of Helium which is He and Hydrogen which is H.

Exceptions exists. They are usually due to the symbols being named by the old names of the element. Sodium was previously called Natrium which explains why it has a symbol of Na.

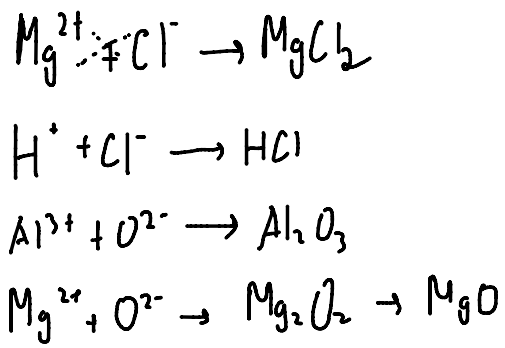
From the number of atoms given, we are able to deduce its formula.

Eg: 2 H and 1 O
$=H_2O$

It is important to also understand how to balance equations. A general tip is to avoid balancing Oxygen and Hydrogen first. Focus on other elements first and, in most cases, oxygen and hydrogen will naturally be balanced as well.

Key Definitions:
1) Relative atomic mass (A_r) --> The average mass of all isotopes of an element compared to 1/12 the mass of a C-12 atom.
2) Relative molecular mass (M_r) --> The sum of the relative atomic mass in a compound/molecule.

Predicting the compound formed when 2 different ions react:



Essentially, the charge of the ion is cross multiplied to the other ion. If, like the last element, the subscript is reoccurring, it can be cancelled out.

We looked at how we can balance chemical reactions but it is also important to understand how to construct ionic equations. This can be especially tricky at times so practice is essential. Key takeaways to understand:
1) Aqueous solutions can split to form ions
2) Insoluble substances, such as precipitates, can not be separated to ions
3) When working with ionic equations, separate the components into ions (if possible) for both sides of the equation
4) Cancel the ions that occur in both of the sides of the equation

$Na_{(s)} + 2HCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + H_{2(g)}$

$Na_{(s)} + 2(H^+_{(aq)} + Cl^-_{(aq)}) \longrightarrow 2(Na^+_{(aq)} + Cl^-_{(aq)}) + H_{2(g)}$

$Na_{(s)} + 2H^+_{(aq)} \longrightarrow 2Na^+_{(aq)} + H_{2(g)}$

$NaCl_{(aq)} + AgNO_{3(aq)} \longrightarrow NaNO_{3(aq)} + AgCl_{(s)}$ (precipitate)

(Double displacement reaction)

$Na^+_{(aq)} + Cl^-_{(aq)} + Ag^+_{(aq)} + NO_3^-{}_{(aq)} \longrightarrow Na^+_{(aq)} + NO_3^-{}_{(aq)} + AgCl_{(s)}$

$Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$

4.2:
Mole Concept

Key Definitions:

1) Mole: Mole often has varying definitions placed for it. However, the most accurate definition is --> The amount of substance that contains the same number of specified participles are there are atoms in 12 grams of Carbon - 12.
2) Avogadro constant : It is the number of particles in 1 mole of a substance.

Here are the key formulas that will be applied for this chapter.

$$mol = \frac{mass}{Mr/Ar} \qquad C = \frac{mol}{V(dm^3)} \qquad \%\ yield = \frac{Actual}{Calculated} \times 100$$

$$mol = \frac{V}{24} \qquad mol = \frac{V}{22.7} \qquad \%\ purity = \frac{Mass\ of\ Pure}{Mass\ of\ Impure} \times 100$$

$$mol = \frac{no.\ of\ particles}{L}$$

↳ avogadro constant

Extra formulas

↳ mass of an element in a molecule/compound = $\frac{\text{Ar of the element}}{\text{Total Mr}} \times \text{Total Mass}$

% of an element in a compound/molecule = $\frac{\text{Ar of the element}}{\text{Total Mr}} \times 100$

Key Concepts:

1) Limiting reactant : The reactant which is used up in a chemical reaction
2) Empirical formula : Simplest ratio of atoms in a compound
3) Molecular formula : Actual number of atoms in a molecule or compound
4) Percentage yield : The actual amount of product produced is often less then the calculated amount. It is never more. Hence, this value displays the percentage of a product that is produced, actually.
5) Concentration , c : It is the amount of moles per unit volume in a solution. The lower the concentration, the more dilute the solution is.

Example:

Dilute hydrochloric acid reacts with sodium carbonate solution.
2HCl (aq) + Na2CO3(aq) → 2NaCl (aq) + H2O(l) + CO2(g)

10.0 cm3 of 0.100 mol / dm3 hydrochloric acid were placed in a conical flask.
A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
The mixture was titrated with sodium carbonate solution.
16.2 cm3 of sodium carbonate solution were required to react completely with the acid.

1) How many moles of HCl are used
2) Number of moles sodium carbonate that has reacted
3) Calculate concentration of sodium carbonate. Give appropriate units
4) In another experiment, if 0.05 moles of sodium carbonate reacts with excess HCl, calculate volume of carbon dioxide that is produced, in room temperature
5) In the experiment for number 4, if the volume of carbon dioxide calculated is 0.5dm^3, calculate percentage yield

$C = \frac{mol}{dm^3}$ $0.1 = \frac{mol}{10/1000}$ $mol = 0.001(2)$

2 : 1

$\frac{0.001}{2} = 0.0005(2)$ $C = \frac{mol}{dm^3}$

$C = \frac{0.005}{162/1000} = 0.031 \text{ mol/dm}^3$ (3)

$\text{mol} = \frac{V}{24}$ $\quad 0.03 \times 24 = 1.2 \text{ dm}^3$

$\% \text{ yield} = \frac{0.5}{1.2} \times 100$

$= 41.67\%$

A compound X contains carbon, hydrogen and oxygen only.
X contains 54.54% of carbon by mass, 9.09% of hydrogen by mass and 36.37% of oxygen by mass.
(i) Calculate the empirical formula of compound X·

	C	H	O
%	54.54	9.09	36.37
mol	$\frac{54.54}{12} = 4.545$	$\frac{9.09}{1} = 9.09$	$\frac{36.37}{16} = 2.27$
Simplest ratio	2	4	1

C_2H_4O

Ii) If its molecular mass is 88, deduce its molecular formula

$(C_2H_4O)_x = (12 \times 2 + 4 + 16)x = 88$

$x = 2$

$C_4H_8O_2$

In a reaction, 3.5 grams of magnesium reacts with 20cm^3 of Nitric acid at a concentration of 0.08 mol dm^{-3}.

1) Write down the chemical equation of the above reaction and list down **2** events that can be observed
2) If 80 cm^3 of hydrogen gas is produced in room temperature and pressure, determine percentage yield

$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2$

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$

→ Bubbles of gas

→ solid dissolves into the solution

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$ → Compare which n is higher

(n)

	Mg	$2HNO_3$
I	mol = $\frac{3.5}{24}$	mol = $(0.08 \times \frac{20}{1000})$
R	0.0008	0.0016

Higher means in excess.

Remember to divide by coefficient

F 0.145 — 0.0008 0.0008

↳

$mol = \frac{V}{24}$

$V = 0.0008 \times 24$

$= 0.192\ dm^3 \times 1000$

$= 192\ cm^3$

% yield $= \frac{80}{192} \times 100$

$= 41.67\%$