Moles, Stoichiometry and chemical equations

Moles, Relative Atomic Mass Ar, Relative molecular mass Mr

- A mole is defined as the amount of substances which contains the same number of particles in exactly 12.0 g of Carbon 12. This number is known as the Avogadro constant = 6.02×10^{23}.
- Relative atomic mass Ar, is defined the mass of an atom relative to 1/12th the mass of a carbon 12 atom. Given by the nucleon number of the atom.
- Relative Molecular mass Mr, is defined as the mass of a molecule relative to 1/12th the mass of a carbon 12 atom. It is the sum of the relative atomic mass of the Stoichiometric number of atoms in a Compound, given by its molecular formula.
- No of moles of a compound = mass of substance / molar mass of a substance.
- Molar mass of a substance = relative atomic mass for a pure element substance or relative molecular mass for a compound.

Molar volume

- Molar volume is defined as the volume occupied by one mole of ideal gas.
- At RTP (Room temperature and pressure), Molar volume = 24 dm^3.
- No of moles of x dm^3 of a gas = x/molar volume.

Stoichiometry of compounds

- Covalent compounds are formed between non metals usually. (Element from group 4 to group 7).
- The valency or number of bonds formed by a non metal element depends on its group number (n), where valency, V = -(8-n) which is a negative number.
- The valency or number of electrons in the outer shell of a metal elements (fron group one to group three) are given by its group number n.
- For transition metals, They may have more than one valency states Eg Fe^{2+}, Fe^{3+}.
- Some of the common valencies of the transition elements are Fe^{2+} , Fe^{3+}, Cu^{+}, Cu^{2+}, Zn^{2+}, Au^{+}, Ag^{+}, Mn^{2+}, Mn^{4+}, Mn^{7+}, Cr^{3+}, Cr^{6+}.

Stoichiometry of compounds

- The stoichiometry of compounds are such that the valencies of the elements in the compounds add up to zero.
- For example Copper (II)Chloride. Cu has a valency of +2, while Chlorine in group 7 has a valency = -(8- group number =7) = -1
- Hence to have zero compound valency, there need to have 2 chlorine ions so that the +2 valency of Cu is balanced by -2 valency of the 2 chlorine ions.

Chemical equations

- Chemical equations represent the stoichiometric amounts of reactants and their products forms. The number of the same atoms must balance on both LHS and RHS of the equations, LHS contains the reactants and RHS the products.
- The reactants and products can be present in three states, solid (s), liquid (lq), aqueous solution (aq) and gas (g)
- For example the reaction between solid Na_2CO_3 and aqueous solution HCl producing aqueous solution NaCl, liquid water and gaseous carbon dioxide.
- Na_2CO_3 (s) + 2HCl (aq) = 2NaCl (aq) + H_2O (lq) + CO_2 (g)

Chemical equations

- Limiting reactant is the reagent being used up in the reaction. It limits the amount of products that can be formed.
- To determine the limiting reagent look at the mole ratio between the reactants. Compare it to the stoichiometric mole ratio in the chemical equation.
- Eg the stoichiometric mole ratio of Na2CO3 and HCl is 1:2. If the reacting mole ratio of Na2CO3 to HCl is lower than the stoichiometric ratio then Na2CO3 is the limiting agent , if it is higher then HCl is the limiting agent.

Chemical equations

- Ionic equations
- To form the ionic equations, the steps are as below, first write the stoichiometric equations.
- 2nd step, write down the ions in the reactants on LHS and products on RHS.
- 3rd step, remove the ion that appears on both sides of the equations in step 2 above.
- E.g. Na2CO3 + 2HCl = 2NaCl + H2O + CO2 – step 1
- 2Na+ + CO32- + 2H+ + 2Cl- = 2Na+ + 2Cl- + H2O + CO2 – step 2
- Step 3 , remove common ions on the both sides of the equation.
- 2H+ + CO32- = H2O + CO2

Percentage mass of elements in compound

- To calculate percentage of element in a compound given the amount of individual element.
- Take x g of element divided by the total mass of the given compound sample.

Empirical formula and molecular formula

- Empirical formula is the lowest ratio of individual elements in a compound.
- Molecular formula is the actual number of individual atoms in a molecule of a compound.

Calculating empirical formula and molecular formula

- Given the percentage mass or mass of individual elements, x , y and z in a compound and divided by their relative atomic masses Ar.

X = Mx/Ar (x), Y = My/Ar(y), Z = Mz/Ar (z)

Take the lowest ratio of X:Y:Z, called it Xmin, Ymin, Zmin. This is the empirical formula.

To find the Molecular formula, you need to know the empirical formula masses and the molar mass.

Take the molar mass/empirical formula mass = n

Molecular formula = Xmin*n, Ymin*n, Zmin*n.