Moles

Mole:

The amount of substance that contains exactly the same number of particle(atoms, molecules, ions) as the number of atoms in 12g of carbon-12.

Important:

1. The mass of one mole of a substance is numerically equal to it's atomic mass or molecular mass.
2. For example, mass of one mole of hydrogen is:
   - ➔ Hydrogen consists of 2 hydrogen atoms. (H_2)
   - ➔ The molecular mass of one hydrogen atom is 1.
   - ➔ Therefore, the mass of one mole of hydrogen gas is 2x1=2g
3. Mass of one mole of oxygen is 32g
4. Mass of one mole of magnesium is 24g
5. To find the mass of one mole water:
   - ➔ A molecule of water consists of 2 hydrogen atoms and 1 oxygen atoms.
   - ➔ The composition of water is H_2O
   - ➔ Mass of 1 mole of 2 hydrogen atoms is 2g and mass of 1 mole of and oxygen atom is 16g
   - ➔ Thus, the mass of one mole of water is 18g.
6. Mass of 1 mole of sulphuric acid is(H_2SO_4 98g
7. Mass of 1 mole of sodium chloride(NaCl) is 58.5g

Molar mass:

Mass in grams of 1 mol of a substance is called its molar mass.

Formula:

Moles x Molar mass= Mass (g)

Formula for converting moles to number of particles

No. of particles= No. of moles x $6x10^{23}$ (Avogadro's Constant).

One mole of each gas has a volume of 24 dm^3 at room temperature.

Molar gas volume:

The volume of 1 mole of a gas in dm^3 (Cubic decimeter)

Formula:

Moles x Molar gas volume=Volume of gas in dm^3

Questions:

Q1: State the number of moles.

I. **90g of water**
II. **100g of calcium**
III. **14g of iron(II)oxide**

Q2: State the mass of:

I. **1.5mol of sulphuric acid**
II. **0.5mol of nitrogen dioxide**
III. **0.1mol of calcium carbonate**

Percentage Composition:

Percentage composition refers to the percentage of the mass of 1 particular atom in its compound. For example, the percentage composition of sulphur in sulphur dioxide (SO_2) is 50%.

How to calculate Percentage composition?
Example: sulphur dioxide.
Mass of 1 mole of sulphur is 32g where as mass of 1 mole of oxygen is 16. Total mass of sulphur dioxide is:
32+ (16x2) =64g
Percentage of sulphur= 32/64 x100% =50%
Percentage of Oxygen= (16x2)/64x100%=50%

Questions:

Q3: Calculate the percentage composition of:

I. **Methane**
II. **Sodium hydroxide**
III. **Magnesium nitrate**

Empirical Formula:

Empirical formula gives simplest numerical ratio in which atoms of different elements combine to form a compound.

Molecular Formula:

A molecular formula gives the actual number of atoms of each element that form a molecule.

Examples:

No.	Name of compound	Molecular formula	Empirical formula
1	Benzene	C_6H_6	CH
2	Ethane	C_2H_6	CH_3
3	Ethene	C_2H_4	CH_2
4	Methane	CH_4	CH_4
5	Glucose	$C_6H_{12}O_6$	CH_2O
6	Ammonia	NH_3	NH_3
7	Water	H_2O	H_2O
8	Sulphuric acid	H_2SO_4	H_2SO_4
9	Sucrose	$C_{12}H_{22}O_{11}$	$C_{12}H_{22}O_{11}$
10	Ethanoic acid	CH_3COOH	CH_2O

How to calculate empirical formula if percentage is given?

Q: Magnesium nitrate in which 72% is magnesium combines with nitrogen. Find the simplest formula.

	Magnesium	Nitrogen
Percentage	72	100-72=28
Molar mass	24	14
Moles	$\frac{72}{24}$ =3	$\frac{28}{14}$ =2

*Empirical formula is Mg_3N_2

Steps:

I. Calculate the percentage of an element in the compound.
II. Divide the percentage by that element's molar mass to obtain the number of moles.
III. Number of moles of an element shows its number of atoms in empirical formula.

How to calculate empirical formula if mass is given?

Q: 0.8g of methane contains 0.6g of Carbon. Calculate the empirical formula.

	Carbon	Hydrogen
Mass	0.6	0.8-0.6=0.2
Molar mass	12	1
Moles	$\frac{0.6}{12}$ =0.05	$\frac{0.2}{1}$ =0.2
Mole Ratio	1	0.2/0.05=4

*Empirical formula is CH_4

Tip:

IV. In case of given mass divide it by the molar mass to get moles

V. When moles are attained in decimals then obtain the ratio of the moles of

Questions

Q4: Find the empirical formula of:

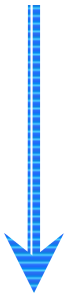
I. Silicon oxide given that 6g of the oxide contains 2.8g of silicon

II. Iron bromide if 0.378g of iron reacts with bromine to form 2g of compound.

III. Hydrated Calcium sulphate ($CaSO_4$) contains 21% water. Work out the empirical formula.

Calculations from equations

Now this is a difficult method to understand. From this method we calculate moles, mass or volume of one of the products/reactants. This method uses different types of relationship. Well! Just focus on what I am about to tell you.



Q: Hydrogen is burned to form water. When 1.5g of hydrogen is burned calculate:

1. **Mass of water**
2. **Mass of oxygen**

Sol: First form an equation for this reaction

$2H_2 + O_2 = 2H_2O$

Mass of hydrogen is given! Find the mass of water

Now form a ratio:

Compound	H_2	H_2O
Molar mass	2g	36g
Mass	1.5g	X

Form a ratio:

$2/1.5 = 36/x$

Solve the ratio!

$2X=36x1.5$

$X=27g$ (Correct answer as given in by book)

Now we have to find the mass of oxygen in a similar manner

Compound	H_2 (Take any of the compound whose mass in known)	O_2
Molar mass	2g	32g
Mass	1.5g	X

Solve!

$2/1.5g=32/X$

$2X=1.5x32$

$X=24g$

Q: What moles of iron are obtained form the reduction of 3mol of the oxide?

Sol: Equation of reaction.

$Fe_2O_3 + 3CO = 2Fe + 3CO_2$

Form a ratio. Note that now it asks for 'MOLES' therefore, we will form a ratio according to the moles of equation.

Notice that the co-efficient of Iron oxide is 1 there fore it has 1 mole as stated by the equation. Similarly, the co-efficient of Iron is 2 there for it has 2 moles in the equation.

Form a ratio:

Compound	Fe	Fe_2O_3
Moles in equation	2	1
Moles in actual	X	3

Solve!

$2/X = 1/3$

$X=2/3$ moles

I made this question. It is not authentic but was just to make you understand that how to solve a problem asking for moles of a substance.

Q: What mass of aluminum is required to react with dry chlorine gas to make 20 moles of anhydrous aluminum chloride?

Sol: Note that it has now asked mass but has given the number of moles in the question. First form an equation.

$2Al + 3Cl_2 = 2AlCl_3$

Now notice we have to find the mass so then convert the number of moles into mass of aluminum chloride.

Use the formula: Moles x Molar mass = Mass

20 = X/267

X= 5340 grams

Form a ratio

Compound	$AlCl_3$	Al
Molar mass	267	54
Mass	5340	X

Solve!

267/5340=54/X

X= 1080g

There fore mass of Aluminum is 1080 grams.

Q: A mixture of 60 cm^3 methane and 100 cm^3 oxygen is ignited in a close container. If all the products are gases what is the volume composition of there resulting mixture.

Now first form an equation: CH_4 (g) + $2O_2$ (g) = CO_2 (g) + $2H_2O$ (g)

Notice that all the products and reactants are gases. Focus on the method to solve this problem.

Methane in the equation has 1 mole, oxygen has 2 moles, Carbon dioxide has 1 mole and water has 2 moles. Now we have to recognize that which reactant is in excess.

Methane has 1 mole and 60 cm^3 of volume where as oxygen has 2 moles and its volume is 100 cm^3

So, 1 moles of oxygen has 50 cm^3 of volume and this makes equal number of moles for both Methane and oxygen which makes it clear that 50 cm^3 of Methane is required; therefore, Methane is 10 cm^3 excess!

In the equation 1 mole of gas has a volume of 50 cm^3. As stated by equation there is 1 mole of carbon dioxide which makes it Volume to be 50 cm^3 and 2 moles of water which makes its volume to be 100 cm^3

The Composition of the resulting mixture:

10 cm^3 of Methane

100 cm^3 of Water

50 cm3 of carbon dioxide

Q: Calculate the volume of carbon dioxide given off at room temperature, when 0.9g of glucose ferments. $C_6H_{12}O_{16}$ (s) = $2C_2H_5OH$ (aq) + $2CO_2$ (g)

Sol: Note that all the reactants and products are not gases so we cannot apply the formula in previous questions. So we will first find the mass of carbon dioxide and then convert it into volume.

Compound	$C_6H_{12}O_6$	CO_2
Molar mass	180	44
Mass	0.9g	X

Solve!

180/0.9 = 44/X

X = 0.22g

Convert mass into volume.

Moles of carbon dioxide = 0.22/ 44

= 0.005 x 2 mol (In equation carbon dioxide has 2 co-efficient and has 2 moles).

0.01 = Volume/24000

Volume = 240 cm^3

Q: When 6.4g of copper were heated in air 7.6g of copper (II) oxide, CuO, were obtained

2Cu (s) + O_2 (g) = 2CuO:

(a) Calculate the mass of copper (II) oxide that would be formed.

(b) Calculate the PERCENTAGE YIELD that was actually obtained.

Sol: In part a find the mass of CuO

Compound	Cu	CuO
Molar mass	128 (Copper has 2 as co-efficient)	160
Mass	6.4	X

Solve: 128/6.4 = 160/X

X = 8g, there fore 8 g of CuO is formed but in question it is given 7.6 g of CuO was formed. What is the confusion? It is revealed in part (b).

Now the formula of finding percentage yield is:

Percentage Yield = (Actual yield/Theoretical yield) x 100%

Actual yield refers to that of given in the question and theoretical yield refers to that of we calculated in question by using theory formula.

Now observe,

Percentage yield = (7.6/8.0) x 100%

= 95%

Q: A 0.68g of impure zinc was reacted with excess hydrochloric acid and hydrogen formed collected in a gas syringe. Hydrogen collected measured 240 cm3 at room temperature. Calculate:

(i) The mass of pure zinc that reacted with acid

(ii) Percentage purity of the sample of zinc.

Form and equation: $Zn + 2HCl = ZnCl_2 + H_2$

Now first convert the volume of HCl into mass

Mole = 240/24000

Moles of HCl = 0.01 moles

0.01= mass/36.5

Mass= 0.365g

Form ratio

Compound	HCl	Zn
Molar mass	36.5	65
Mass	0.365	X

Solve!

36.5/0.365 = 65/X

X= 0.65g

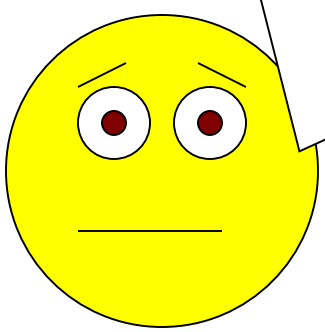
Now how to calculate Percentage purity:

Formula for percentage purity is:

Percentage purity = (Theoretical yield/total mass) x 100%

= (0.65/0.68) x 100%

=95.6%



Molar Concentration:
The moles of solute per unit volume of solution.
Formula:
Concentration = Moles of solute/Volume of solution (dm^3)

OR
Concentration = Mass of solute (g)/ [Molar mass x volume of solution (dm3)]

Q: Calculate the concentration of 30g of Ethanoic acid, $C_2H_4O_2$ in 500 cm^3 of solution.
Convert 500 cm^3 into dm^3
500/1000 = 0.5 dm^3
Apply to formula:
Concentration= 30/ (0.5 x 60)
Concentration = 1 mol/dm^3

Hope u understand!