Tuesday 28th September, '10

Moles And Molar Calculations

Moles

- S.I unit of amount or quantity
- Relative atomic mass, relative molecular mass or relative formula mass of a substance expressed in grams is called 1 mole of that substance

Ar = nucleon numbers
It is used for elements in their atomic state

Hydrogen
relative Ar = 1
relative Mr = 2

Mr = molecular mass
It is used for molecules

Relative formula mass :- It is for ionic compounds

→ 1 mole of H_2O
Mr of water = 18 g of water

→ 1 mole of K
Ar of K = 39 g of K

→ 1 mole of Cl_2
Mr of Cl_2 = 71 g of Cl_2

→ 1 mole of NaCl
Formula mass of NaCl = 58.5 g

Mass of Ionic Compounds is called Formula mass
Smallest particle of ionic compounds is formula unit.

Q How many grams of water will be present in 4 moles?

Mole	Mass
1	18 g
4	x g

$x = 18 \times 4$

$x = 72g$

H_2O

$2(1) + (16)$

$2 + 16 = 18$

Formula ⇒

Mass = Moles × Mr (or Ar)

Q How many moles of sulphur will be present in its 60g?

Mole	Mass
1	32g
x	60g

$32x = 60$

$x = \frac{60}{32}$ (15 / 8)

$x = 1.875$ moles

S

32g

Formula ⇒

Moles = mass in g / Mr (or Ar)

Q How many moles of carbondioxide gas are present in it? Ar of carbon = 12, Ar of Oxygen = 16

Moles	Mass
1	44g
x	100g

$44x = 100$

CO_2

$12 + 2(16)$

$12 + 32$

44g

$x = \frac{100}{44}^{25}$ 11

$x = 2.27$ moles

Q How many grams of Sulphuric acid will be present in its 3 moles?

Ans

Moles	Grams
1	98
3	x

$x = 98 \times 3$

$= 294$ g

H_2SO_4

$2(1) + 4(16) + 32$

$2 + 64 + 32$

98 g

Avogadro's Number

The number of particles (atoms, molecules, formula units, ions) present in 1 mole of any substance is called Avogadro's number, which is equal to 6.02×10^{23}.

Q How many atoms are present in 4 moles of phosphorus

Ans $x = 4(6.02 \times 10^{23})$

$x = 2.408 \times 10^{24}$

Mole	Atoms
1	6.02×10^{23}
4	x

$x = 4 \times 6.02 \times 10^{23}$

n = 31
p = 15
not required

5th October

Tuesday

Q

Lab Activity

Objective: To identify the cations (Ca^{+2}, Al^{+3}, Zn^{+2}, NH_4^+, Fe^{+2}, Fe^{+3} & Cu^{2+}) using aqueous Ammonium.

Required:
- 7 testtubes filled with the solutions of the respective ions
- Aqueous ammonium

Method: 1) Add few drops of aq. Ammonium to each test tube

↓

Observation:
- Dirty green ppt of Fe^{+2} formed
- Blue ppt of Cu^{+2} formed
- Reddish brown ppt of Fe^{+3} formed
- White ppt of Zn^{+2} formed
- White ppt of Al^{+3} formed
- No precipitates formed in remaining two test tubes (Ca^{+2}, NH_4^+)

Method: 2) Add an excess of aq. Ammonium to all the test tubes in which ppt were formed

↓

Observation:
- White ppt of Al^{+3} remains same
- White ppt of Zn^{+2} dissolve and colourless
- blue ppt of Cu^{+2} dissolve and the solution turns deep blue.
- Reddish brown ppt of Fe^{+3} remains undissolved

77

Tuesday 7th October, 2010

Moles And Molar Calculations

Q How many molecules are there in 20 grams of carbon dioxide gas?

C + 2(O)
12 + 2(16)
12 + 32
44.

Moles	Grams	Grams
1	44	44.
x	20	20

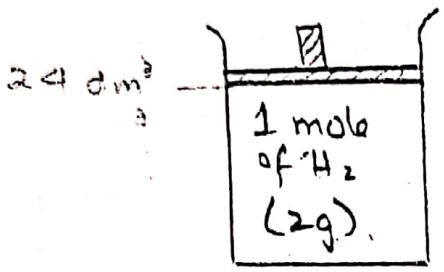
$44x = 20$

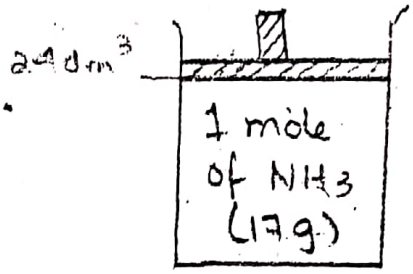
$x = \frac{5}{11} = 0.45$ moles

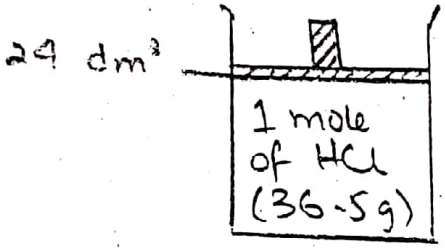
$x = 0.45\left(6.02 \times 10^{23}\right)$

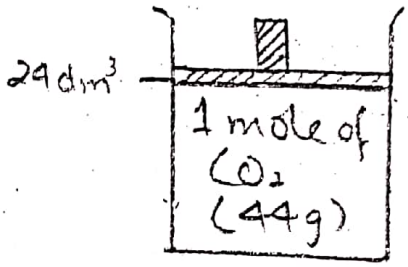
2.709×10^{23}

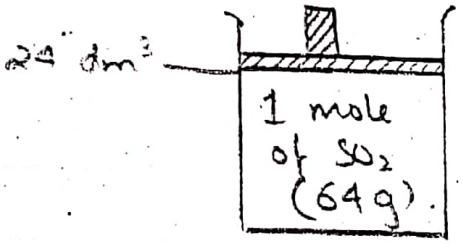
$24\ dm^3 = 24000\ cm^3$ = molar gas volume.











At Room Temp. = 25 °C
& pressure = 1 atm or 760 mm

Gases

$\frac{24\ dm^3}{V} = n_r / Ar / Fr = \frac{1\ mole}{M} = \frac{6.02 \times 10^{23}}{\text{Number}}$

= Inform the relations b/w these to solve various questions.

8th October, 2010

iday

Molar Gas Volume

The volume occupied by one mole of any gas at room temperature and pressure is called molar gas volume, which is equal to 24 dm^3 or 24000 cm^3

Q What volume will be occupied by 10g of SO_2 gas?

Volume		Grams
24	×	64g
x		10g

SO_2
32 + 2(16)
32 + 32
64g.

if answer required in cm^3 → 24000 cm^3

$240 = 64x$

$\frac{240}{64} = x$

$3.75 = x$

$x = 3.75\ dm^3 \times 1000 = 3750\ cm^3$ (if ans in cm^3)

Q What will be the mass of 2000 cm^3 of CO_2 (g)?

Mass		Volume
44g	×	24000
x		2000

$44 \times 2000 = 24000x$

$\frac{44 \times 2000}{24000} = x$

$\frac{88000}{24000}$

$3.667 = x$

$x = 3.667\ gm^3$ of CO_2

Q How many molecules will be present in 5 dm^3 of oxygen gas (O_2)?

Ans

Volume	Mass
24 dm^3	32
5 dm^3	x

$24x = 160$

$x = \frac{160}{24} = 6.667\ g$

Mass	Molecules
32	6.02×10^{23}
6.67	x

$32x = 6.67 \times 6.02 \times 10^{23}$

$32x = 4.01 \times 10^{24}$

$x = \frac{4.01 \times 10^{24}}{32}$

$x = 1.25 \times 10^{23}$ molecules

Q What volume will be occupied by 18.06×10^{23} molecules of $NH_3(g)$?

Volume	Molecules
24	6.02×10^{23}
x	18.06×10^{23}

$6.02 \times 10^{23} x = (18.06 \times 10^{23}) \times 24$

$x = \frac{18.06 \times 10^{23} \times 24}{6.02 \times 10^{23}}$

$x = 72\ dm^3$

Tuesday 14th October, 2020

Stoichiometry

It is a branch of chemistry which deals with the relationship between the amounts of reactants and products involved in a chemical reaction

Relationships of Stoichiometry

1) Mass - Mass relationship
2) Mass - Mole relationship
3) Mole - Mole relationship
4) Mole - Volume relationship
5) Mass - Volume relationship
6) Volume - Volume relationship

Mass - Mass relationship

Q What mass of water will be produced when 5g of hydrogen reacts with oxygen?

$$\underset{\text{mass}}{2H_2} + O_2 \longrightarrow \underset{\text{mass}}{2H_2O}$$

$\underset{\text{mole}}{2} \times \underset{\text{Mr}}{2} = 4g$ — 4g of H_2 will produce 36g of H_2O

$2(2+16)$

$\underset{\text{moles}}{2}\ \underset{\text{Mr}}{(18)} = 36g$

Hydrogen : Water

4 : 36

5 : x

$4x = 180$

$x = \frac{180}{4} = 45g$

$\Rightarrow$ 45 g of water will be produced

(10)

Q What mass of sodium chloride will be produced
of sodium hydroxide reacts with hydrochloric

$$NaOH + HCl \longrightarrow NaCl + \dots$$

mass

$NaOH = 23 + 16 + 1$

$= 40g$

mass

$NaCl$

$23 + 35.5$

$58.5g$

$NaOH : NaCl$

$40 \quad 58.5$

$20 \quad x$

$40x = 1170$

$x = \frac{1170}{40}$

$x = 29.25g$

29.25g of sodium chloride will be produced wh
of sodium hydroxide reacts with hydrochloric acid

iday

15th October, 2010

Stoichiometry

Mole-mole relationship

Q How many moles of Ammonia gas will be produced when 5 moles of nitrogen gas reacts with hydrogen gas?

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

(1 mole N_2 : 2 moles NH_3)

N_2	:	NH_3
1		2
5		x

$x = 5 \times 2$

$x = 10$ moles of NH_3

Q How many moles of hydrogen gas will be required to produce 10 moles of Ammonia by reacting it with nitrogen?

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

(3 moles H_2 : 2 moles NH_3)

H_2	:	NH_3
3		2
x		10

$2x = 3 \times 10$

Metals are never diatomic

Diatomic

H_2 ⟶ All gases that end with "-gen" are diatomic

O_2

N_2

F_2

Cl_2

Br_2

I_2

At_2

① ⟶ Hydrogen
② ⟶ Oxygen
③ ⟶ Nitrogen
④ ⟶ Halogens.

$2x = 30$

$x = \frac{30}{2}$ 15

$x = 15$ moles of H_2 gas

Mass - Mole relationship

Q What mass of magnesium will be required to react complete with 5 moles of oxygen gas to produce magnesium oxide?

METHOD 1 (more preferred)

$$\underset{\text{mass}}{2\,Mg} + \underset{\text{mole}}{O_2} \longrightarrow 2\,MgO$$

Mass (Mg) : Mole (O_2)

48 — 1

x — 5

$x = 48 \times 5$

$x = 240$ g of Mg

METHOD 2

$$\underset{\text{mole}}{2\,Mg} + \underset{\text{mole}}{O_2} \longrightarrow 2\,MgO$$

Mole (Mg) : Mole (O_2)

2 : 1

x : 5

$x = 5 \times 2$

$x = 10$ moles

Mole (Mg) : Mass (O_2)

1 — 24

10 — x

$x = 24 \times 10$

$x = 240$ g of Mg

Q What mass of Aluminium oxide will be produced when 10 moles of Aluminium react with oxygen?

$$\underset{\text{moles}}{4\,Al} + 3\,O_2 \rightarrow \underset{\text{mass}}{2\,Al_2O_3}$$

Moles : Mass

4 — 204

10 — x

$4x = 204 \times 10$

Mass
4(Al) H
4(27)+6(
108 + 9
= 204 g
$2Al_2O_3$
= 204 g.

$4x = 2040$

$x = \frac{2040}{4}^{510}$

$x = 510$

510 g of Al_2O_3 will be produced

Mole-Volume relationship

Q What volume of hydrogen gas will be produced when 3 moles of magnesium reacts with hydrochloric acid?

$$\underset{\text{moles}}{Mg} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + \underset{\text{volume}}{H_{2(g)}}$$

Mole	Volume
1	24
3	x

$x = 3 \times 24$

$x = 72\ dm^3$ of hydrogen gas is produced when 3 moles of magnesium react with hydrochloric acid.

Q What volume of oxygen gas will be required to react completely with 5 moles of Aluminium to produce Aluminium oxide?

$3O_2$ ~~Moles~~ $4Al \longrightarrow$ ~~$2Al_2O_3$~~

volume moles

Moles	Volume
4	72
5	x

$4x = 360$

$x = \frac{360}{4}$ 90

$x = 90\ dm^3$

3 moles = 24 x 3 of O_2

Mass Volume relationship

Q What mass of Aluminium oxide will be produced when $10dm^3$ of oxygen gas reacts with Aluminium?

$4Al + 3O_2 \longrightarrow 2Al_2O_3$

volume mass

Mass	Volume
204	72
x	10

$72x = 2040$

$x = \frac{2040}{72}$

$x = 28.333g$

4(27) 108 = 20 (4)Al + = 20

59

Volume - Volume relationship

Q What volume of Ammonia gas will be produced when 5dm³ of Hydrogen gas reacts with nitrogen gas?

$$\underset{\text{volume}}{3H_2} + N_2 \longrightarrow \underset{\text{volume}}{2NH_3}$$

Volume (H_2)	Volume (NH_3)
72	48
5	x

$$72x = 240$$

$$x = \frac{240}{72}$$

$$x = 3.33 \text{ dm}^3 \text{ of } NH_3(g)$$

Calculations based on concentrations

Types of Solution

1) dilute solution ⇒
contains lesser amount of dissolved solute

2) concentrated solution ⇒
contains greater amount of dissolved solute

Excellent
13/10/2020

Tuesday 19th October

Stoichiometry

Calculations based on concentration

Concentration

- Number of moles of solute dissolved per dm^3 of the solution called concentration of the solution.

- Concentration (c) = Moles of solute (n) / Volume of solution in dm^3 (V)

$$c = \frac{n}{V}$$

- Unit of concentration = $mole/dm^3$

Q What will be the concentration of 200 cm^3 of a solution which contains 80g of sodium hydroxide present in it?

Ans Concentration = ? Moles / Volume (dm^3)

NaOH
23+16+1
= 40g
1 mole = 40g

Volume in dm^3 = $\frac{200}{1000}$ = 0.2 dm^3

Mole	Mass
1	40g
x	80g

$40x = 80$

$x = \frac{80}{40}$

$x = 2$ moles

$C = \frac{2}{0.2} = 10$ mol

Q How many moles of HCl will be present in 500 cm^3 of 0.2 mole/dm^3 solution?

Ans Moles = ? Conc = $\frac{Mol}{Volume}$

Volume = $\frac{500}{1000}$ = 0.5 dm^3 Conc. × Volume = Mol.

= 0.5 dm^3 0.2 × 0.5

0.1 moles

Q What mass of sulphuric acid will be required in order to produce 600 cm^3 of 0.4 mole/dm^3 solution?

Ans Mass = ?

Volume in dm^3 = $\frac{600}{1000}$ = 0.6 dm^3

Concentration = 0.4 mole/dm^3

Moles = Conc. × Volume

= 0.4 × 0.6

= 0.24 moles

H_2SO_4

2+32+64

98 g

Mr = 98g

Mole	Mass
1	98
0.24	x

x = 23.52 g

Q What ~~0.1 mole/dm^3~~ be the volume of solution [illegible]

Q What will be the volume of 0.1 mol/dm³ which contains 20 g of nitric acid ?

Ans Volume = ?

Conc. = 0.1 mole/dm³

Mass = 20 g.

H NO₃
1 + 14 +
63 g
Fr = 63

Mass	Mole
63	1
20	x

$63x = 20$

$x = \frac{20}{63}$

$x = 0.3$ moles

$Conc = \frac{M}{V}$

$V = \frac{M}{C}$

$V = \frac{0.3}{0.1}$

$V = 3.$ dm³

Q What volume of carbondioxide gas will be produced when 100 cm³ of 0.2 mol/dm³ hydrochloric acid solution reacts with calcium carbonate ?

Ans (HCl) Conc. = 0.2 mole/dm³

Volume (HCl) = ? dm³
(Calculate)

Volume of HCl $(dm^3) = \frac{100}{1000} = 0.1\ dm^3$

CO_2
$V = ?$
$n = ?$
$c = ?$

$$\underbrace{2HCl}_{\text{Volume/Conc.}} + CaCO_3 \longrightarrow \underbrace{CO_2}_{\text{Volume (g)}} + CaCl_2 + H_2O$$

$$C = \frac{n}{V}$$

$$C \times V = n$$

$$0.2 \times 0.1 = n$$

$$0.02 = n$$

0.02 moles of HCl solution

Mole	Volume
2	24
0.02	x

$$2x = 24 \times 0.02$$

$$2x = 0.48$$

$$x = \frac{0.48}{2}$$

$x = 0.24\ dm^3$ of carbondioxide gas

Q What mass of sodium chloride will be produced when 200 cm^3 of 0.4 mol/dm^3 sodium hydroxide solution reacts with hydrochloric acid?

NaCl
Mass = ?

NaOH Volume = $200 cm^3 = {}^{200}/_{1000} = 0.2\ dm^3$

NaOH Conc. = $0.4\ mol/dm^3$

$$HCl + \underbrace{NaOH}_{\text{mole / volume}} \longrightarrow \underbrace{NaCl}_{\text{mass}} + H_2O$$

$$C = \frac{n}{V}$$

$$C \times V = n$$

$$0.4 \times 0.2 = n$$

$$0.08 = n$$

$$n = 0.08$$

0.08 moles of NaOH

Mole	Mass
1	58.5
0.08	x

$$x = 0.08 \times 58.5$$

$$x = 4.68$$

4.68 g of NaCl

Na
Na-
Cl-3
23+3
=58.
fr=58.

Q What will be the concentration of 25 cm^3 sodium hydroxide solution which is neutralized by 100 cm^3 of 0.5 mol/dm^3 sulphuric acid solution?

NaOH

C = ?

n = ?

$V = \frac{25}{1000} = 0.025\ dm^3$

H_2SO_4

$V = \frac{100}{1000} = 0.1\ dm^3$

$C = 0.5\ mol/dm^3$

n = ?

$C = \frac{n}{V}$

$C \times V = n$

$0.5 \times 0.1 = n$

$0.05 = n$

0.05 moles of H_2SO_4

$2\ NaOH + H_2SO_4 \rightarrow 2\ H_2O + Na_2SO_4$

2 mole, 1 mole

Mole — Mole

2 — 1

x — 0.05

$x = 2 \times 0.05$

$x = 0.1$ mol

0.1 moles of NaOH

$$c = \frac{n}{V}$$

$$= \frac{0.1}{0.025}$$

$= 4 \text{ mol/dm}^3$

Concentration of NaOH is 4 mol/dm³.

Q What will be the concentration of 25 cm³ of $Ca(OH)_2$ solution which is neutralized by 30 cm³ of 0.1 mol/dm³ nitric acid solution?

Ans $Ca(OH)_2$

$c = ?$

$V = 25/1000 = 0.025 \text{ dm}^3$

$n = ?$

HNO_3

$c = 0.1$

$V = 30/1000 = 0.03$

$n = ?$

$$c = \frac{n}{V}$$

$c \times V = n$

(25)

$0.1 \times 0.03 = n$

$0.003 = n$

$n = 0.003$ moles of HNO_3

$$\underset{\text{mole}}{Ca(OH)_2} + \underset{\text{mole}}{2HNO_3} \longrightarrow 2H_2O + Ca(NO_3)_2$$

Mole	Mole
1	2
x	0.003

$2x = 0.003$

$x = \frac{0.003}{2}$

$x = 0.0015$ moles of $Ca(OH)_2$

$C = \frac{m}{V}$

$C = \frac{0.0015}{0.025}$

$C = 0.06$ mol/dm^3 of $Ca(OH)_2$

Percentage yield

⇒ Amount of product given in the question is ACTUAL

⇒ Percentage yield is actually measure of efficiency of a process

Q Why actual yield is always less than theoretical yield?

This is due to following factors

= Presence of impurities in the raw material

⇒ Loss of mass during handling and transportation

⇒ Inaccuracy in weighing and measure

Friday 22nd October, 2010

Percentage Yeild

Q When 20 g of Aluminium reacts with oxygen, it produces 35 g of Aluminium Oxide. Calculate the percentage yield of the procen.

$$\underset{\text{man}}{4\ Al} + 3O_2 \longrightarrow \underset{\text{man}}{2\ Al_2O_3}$$

At
4 x 27
= 108g.

Man	Man
108	204
20	x

$$108x = 4080$$

$$x = \frac{4080}{108}$$

$$x = 37.778\ g$$

$$\text{Percentage yield} = \frac{\text{Actual yield or given yield}}{\text{theoratical yield}} \times 100$$

Actual yield = 35 g
Theoratical yield = 37.778 g

$$\% \text{ yield} = \frac{35}{37.78} \times 100$$

$$= 92.65\%$$

Q Why actual yield is always less than theoratical yield?
Ans ① presence of impurities in the reactants

100

How many tonnes

what mass of iron will be produced if 20 tonnes of Fe_2O_3 is reduced by carbon monoxide?

(1 tonne = 10^6 grams)

mass mass

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

159 g — 111 g

20 tonnes — x tonnes

But if mass in grams is told to calculate in question

mass mass

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

159 g — 111 g

20×10^6 g — x grams

OR

tonnes in the answer can also be converted into grams.

$$x = \frac{20 \times 10^6 \times 111}{159}$$

② loss of mass during handling and transportation
③ inaccuracy in weighing and measurement

Q When 40g of Sodium chloride is electrolysed it decomposes to give 12g of sodium. Other product of this reaction is chlorine gas. Calculate the percentage yield of sodium

$$\underset{\text{mass}}{2Na} + Cl_2 \longrightarrow \underset{\text{mass}}{2NaCl}$$

$2(23) + 35.5$
$46 + 35.5$
81.5

Mass	Mass
46	81.5
x	40

$2(23)$
46

$81.5x = 1840$

$x = \frac{1840}{81.5}$

$x = 15.738\text{g of Na}$

$\%Y = \frac{12.3}{15.73} \times 100\ \%$

$= 76.29\ \%$

Q When 10g of impure calcium carbonate is decomposed by heating, it gives $2dm^3$ of carbon dioxide gas Calculate the percentage purity of calcium carbonate.

$$\underset{\text{mass}}{CaCO_3} \longrightarrow CaO + \underset{\text{volume}}{CO_2}$$

$$\% \text{ purity} = \frac{\text{mass of } CaCO_3}{\text{mass of } CaCO_3 + \text{impurities}} \times 100$$

Mass		Volume
100 g		24 dm^3
x		2 dm^3

$$24x = 200$$

$$x = \frac{200}{24}$$

$$x = 8.33 \text{ g of } CaCO_3$$

$$\% \text{ purity} = \frac{8.333}{10} \times 100$$

$$= 83.33\ \%$$

Q When 50 g of ↑Impure Iron (III) oxide decomposes it gives 10 g of oxygen gas. Calculate the percentage purity of Iron (III) oxide.

Ans $2Fe_2O_3 \rightarrow 3O_2 + 4Fe$

mass mass

Fe_2O_3	O_2
m = 50 g	m = 10 g

Mass		Mass
320		96
x		10

$$96x = 3200$$

4(Fe) + 6(O)
2(56) + 3(16)
224 + 96
320 g
6(O)
96

$$X = \frac{3200}{96}$$

$$X = 33.33\ g$$

$$\%\ purity = \frac{33.33}{50} \times 100\ \%$$

$$\%\ purity = 66.661\ \%$$

Limiting reactant (CONCEPT)

$2H_2 + O_2 \longrightarrow 2H_2O$ (none of the reactant is in excess)

H : O : H_2O

2 : 1 : 2

doubled

$4H_2 + O_2 \longrightarrow 2H_2O + 2H_2$

4 : 2 } only 1 given

4 ↓ excess

2 moles left unreacted (in excess)

$2H_2 + 2O_2 \longrightarrow 2H_2O + O_2$

2 : 1 } 2 given but 1 needed

1 ↓ excess

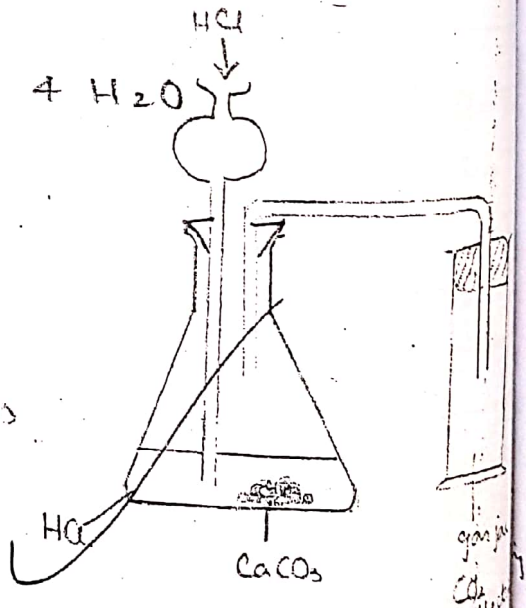
1 mole left unreacted (in excess)

$4H_2 + 2O_2 \longrightarrow 4H_2O$

$\not{4}^2 : \not{2}^1$ ✓

Limiting reactants

- finishes during reaction
- used fully.
- reactant due to which reaction stops
- controls reactions



Add HCl slowly from the thistle funnel to prevent it from being the reactant in excess

CO_2 gas can be tested by glowing splint which extinguishes & lime water which turns milky. CO_2 reads to be tested. Industrialist can test some other way but we have to experimentally prove our theories!

Tuesday 28th October, 2010

Calculations based on Limiting Reactants

Limiting Reactant

- The reactant which gives lesser amount of product is called the limiting reactant

- Limiting reactant controls the speed of a reaction and is used up during chemical reaction.

Reactant in excess

- The reactant which can produce greater amount of product is called the reactant in excess.

- It is always left unreacted during the chemical reaction.

Calculations based on limiting reactant

Q1 What mass of sodium chloride will be produced when 500 cm^3 of 0.3 mol/dm^3 hydrochloric acid solution reacts with 300 cm^3 of 0.2 mol/dm^3 sodium hydroxide solution?

HCl

$V = 50/1000 = 0.5\ dm^3$

$C = 0.3\ mol/dm^3$

$n = C \times V = 0.15$

NaOH

$V = 300/1000 = 0.3\ dm^3$

$C = 0.2\ mol/dm^3$

$n = C \times V = 0.06$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

1 mole : 1 mole : 1 mol

0.15 : 0.15

limiting reactant → 0.06 moles of NaOH

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

mole → mass

1 : 58.5 g

0.06 : x

$x = 3.51\ g$

Limiting reactant = NaOH

Reactant in excess = HCl

0.15 − 0.06

0.09 moles of HCl are in excess

Friday 29th October, 2010

Calculations based on limiting reactants

Q.1 What mass of sodium chloride will be produced when 100cm³ of 0.2 mol/dm³ hydrochloric acid solution reacts with 100cm³ of 0.3 mol/dm³ sodium hydroxide solution?

Identify the limiting reactant and reactant in excess and also explain your answer.

Ans METHOD 1

$HCl \longrightarrow NaCl$

mole — mass

1 mole — 58.5g

0.02 mole — x g

$x = 0.02 \times 58.5$

$= 1.17$ g of NaCl ✓

HCl

$c = 0.2$ mol/dm³

$V = \frac{100}{1000} = 0.1$ dm³

$n = c \times v$

$= 0.2 \times 0.1$

$= 0.02$ moles of HCl

$NaOH \longrightarrow NaCl$

mole — mass

1 mole — 58.5g

0.03 mole — x g

$x = 0.03 \times 58.5$

$= 1.755$ g of NaCl.

NaOH

$c = 0.33$ mol/dm³

$V = \frac{100}{1000} = 0.1$ dm³

$n = c \times v$

$= 0.3 \times 0.1$

$= 0.03$ moles of NaOH

HCl is the limiting reactant while NaOH is reactant in excess because 1 mole of HCl reacts with 1 mole of NaOH and 0.02 moles of HCl will react with 0.02 of NaOH but given moles of NaOH are 0.03 (more than required)

Method 1 for question 2 ← Question

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

1 mole	1 mole
0.02	x

x = 0.02 mole of NaOH

given 0.03 mole of NaOH

Excess = 0.03 − 0.02 = 0.01 mole

Mass = 0.01 × 40 = 0.4g

(40 ↑ As of NaOH)

Q3: What volume of hydrogen gas will be produced when 10g of magnesium reacts with 500 cm^3 of 0.3 mol/dm^3 hydrochloric acid?

$$Mg + 2HCl \longrightarrow H_2 + MgCl_2$$

mole of Mg = 10/24	1 mol	2 mol
0.4167	0.075 mol	0.15 mol

moles of HCl

500 cm^3/1000 = 0.5 dm^3

C = 0.3

n = 0.3 × 0.5 = 0.15 mol

required moles of Mg are 0.075

But given moles are 0.4167 which are more than requirement, so Mg is excess

Moles	Volume of H_2
2	24 dm^3
0.15 mol	x

2x = 3.6

x = 3.6/2

1.8 dm^3 of H_2 gas will be produced.

METHOD 2 for question #2

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

mole mole

1 mole 1 mole

0.02 mole 0.03 mole — 0.03 mole given

NaOH is excess

HCl will form the correct reaction.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

mole mole

1 — 58.5

0.02 — x

$$x = 0.02 \times 58.5$$

$$= 1.17\ g$$

HCl is the limiting reactant while NaOH is the reactant in excess because 1 mole of HCl reacts with 1 mole of NaOH and 0.02 moles of HCl will require 0.02 moles of NaOH but given moles of NaOH are 0.03 which are more than required.

Q4 (a) What volume of hydrogen gas will be produced when 5g of Magnesium reacts with 200 cm^3 of 0.5 mol/dm^3 hydrochloric acid.

(b) Identify the limiting reactant and reactant in excess Explain your answer.

Method 1 for question #4

Solution

$$2\,HCl + Mg \longrightarrow H_2 + MgCl_2$$

2 mole : 1 mole

0.1 : 0.05

HCl
V = 200 cm³ / 1000 = 0.2 dm³
C = 0.5 mol dm⁻³
n = 0.1

HCl = 0.1 mole

Mg = 0.208 Greater

Mg = 5g

1 mole — 24g
x — 5g

x = 0.208 moles

Mg is excess

HCl is the limiting reactant

2 HCl → H₂

2 mole — 24 dm³
0.1 mole — x

x = 1.2 dm³ of H₂

HCl is the limiting reactant while Mg is in excess because 2 moles of HCl react with 1 moles of Mg, so 0.1 will react with 0.05 moles of Mg. But given moles of Mg are 0.208 which are more than requirement.

Method 2 for question #4

(a) Hydrogen $2HCl + 2Mg \longrightarrow H_2 + MgCl_2$

(mole → volume; mole → mass; volume)

Mg: Mole : Mass

1 : 24

x : 5

$24x = 5$

$x = \frac{5}{24}$

$x = 0.208$ moles.

Mg = 0.208 moles.

HCl = 0.1 moles

HCl : H_2

2 : 2

0.1 : x

$2x = 0.1 \times 24$

$x = \frac{0.1 \times 24}{2}$

$x = 1.2\ dm^3$ of H_2

~~$x = 1.25 dm^3$ of H_2~~

Mg : H_2

1 : 24 dm^3

0.208 : x

~~$x = 4.992 dm^3$ of H_2 (excess)~~

Mg = 5g

HCl

V = 200

c = 0.5

n = c x V

~~0.5~~ x 0.5

= ~~0.5~~ mol

H_2

V = ?

1.2 dm^3 of hydrogen gas will be produced.

(b) HCl is the limiting reactant while Mg is the reactant in excess because 2 moles of HCl reacts with 1 mole of Mg and

0.1 moles of HCl will require 0.05 moles of Mg but the given moles of Mg are 0.208 which are more required

$$Mg \quad ---- \quad 2HCl$$

$$1 \quad \times \quad 2$$

$$x \quad \times \quad 0.1$$

$$2x = 0.1$$

$$x = \frac{0.1}{2}$$

$x = 0.05$ moles of Mg required

$\Rightarrow$ 0.208 moles are given which are more than required

Tuesday 4th November

Limiting Reactants

Q: When 5g of Magnesium Carbonate reacts with 500cm³ of 0.2 mol/dm³ hydrochloric acid it produces Magnesium chloride, water and carbon dioxide gas.

Equation: $MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$

Identify the limiting reactant and reactant in excess. Explain.

Ans

Mole	Mass
1	24 + 12 + (16×3)
	24 + 12 + 48 = 84
x	5

$84x = 5$

$x = \frac{5}{84}$

$x = 0.0595$ moles

$MgCO_3$
$m = 5g$
$n = 0.0595$

HCl
$V = 500\ cm^3$
$c = 0.2\ mol/dm^3$
$n = c \times v$
$= 0.5 \times 0.2$
$= 0.1$ moles

$MgCO_3 : HCl$

1 : 2

0.05 : 0.1

greater → given moles 0.0595 which are greater.

$MgCO_3$ (excess)

HCl (limiting reactant)

$0.0595 - 0.05 = 0.0095$ moles of unreacted/excess of $MgCO_3$.

Empirical Formula & Molecular Formula

- Molecular formula tells us about the actual number of atoms of each type of element present in a compound.

- The formula which tells us about the simplest whole number ratio between the atoms of the elements present in a compound is the empirical formula.

Example

Q A compound contains 0.547 g of Potassium, 0.195 g of Iron, 0.252 g of carbon and 0.294 g of nitrogen. Find the empirical formula.

	K	Fe	C	N.
Moles	0.547	0.195	0.252	0.294
Ar	39	56	12	14
↓				
Ans	0.014	0.00348	0.021	0.021
Ans	0.014	0.00348	0.021	0.021
smallest Ans.	0.00348	0.00348	0.00348	0.00348
Ratio for empirical formula.	4.0229	1	6.0345	6.0345

DATA
Potassium 0.547
Iron 0.195
Carbon 0.252
Nitrogen 0.294

$K_4 Fe C_6 N_6$: Empirical formula

Excellent
06/11/2020

Monday 8th November, 2010

Empirical & Molecular Formula

Q A compound contains 40g of carbon, 6.66 g of hydrogen, and 53.33g of oxygen It's relative molecular mass is 180g Calculate its molecular formula

Ans

C	H	O
$\frac{40}{12}$	$\frac{6.66}{1}$	$\frac{53.33}{16}$
3.333	6.66	3.333
3.333	6.666	3.333
3.333	3.333	3.333
1	2	1

$C_1H_2O_1$

CH_2O = Empirical Formula

Molecular formula = n (Empirical formula)

$n = \frac{180}{12+16+1(2)} = \frac{180}{30} = 6$

$n = \frac{\text{relative } M_r}{\text{Empirical Fn}}$

$6(CH_2O)$

$C_6H_{12}O_6$ = Molecular Formula

Q A compound contains 82.7 % carbon, and 17.3 % hydrogen. Calculate its empirical formula. Its relative molecular mass is 58

C	H
$\frac{82.7}{12}$	$\frac{17.3}{1}$
6.89	17.3
$\frac{6.89}{6.89}$	$\frac{17.3}{6.89}$
1	2.51

$\frac{2(1)}{2}$ $\frac{2(2.51)}{5}$

C_2H_5 = Empirical formula.

$\frac{58}{12(2)+5(1)}$

$\frac{58}{24+5} = \frac{58}{29} = 2$

$2(C_2H_5)$

C_4H_{10} = Molecular formula.

9th November, 2010

Monday

Empirical & Molecular Formula

Q CFCs are compounds that contain only carbon, chlorine, and flourine. They are atmospheric pollutants and destroy ozone in the upper atmosphere.

'CFC 11' has the following composition, by mass:

C, 8.7%; F, 13.8%; Cl, 77.5%

Calculate the empirical formula of CFC 11.

Ans

C	F	Cl
$\frac{8.7}{12}$	$\frac{13.8}{19}$	$\frac{77.5}{35.5}$
0.725	0.726	2.18
$\frac{0.725}{0.725}$ 1	$\frac{0.726}{0.725}$ 1	$\frac{2.18}{0.725}$ 3
1	1	3

$CFCl_3$