12/9/2020

PAGE
DATE

STOICHIOMETRY

Avogadro's Law :-

"Under the same conditions of temperature and pressure, equal volumes of all gases contains the same number of molecules."

Applications of Avogadro's Law

1. To determine the relation between molecular weight and vapour density

Molecular Weight

Mol. wt = $\frac{\text{mass of one molecule of substance}}{\text{mass of one atom of hydrogen}}$

It is the ratio between the mass of one molecule of a substance and the mass of one atom of hydrogen.

~~Velocity ratio~~
Vapour density

~~VD~~

VD = $\frac{\text{mass of a certain volume of gas}}{\text{mass of the same volume of hydrogen}}$

The ratio between the mass of a certain volume of a gas to the mass of the same volume of hydrogen.

NOTE: VD × 2 = Mol. Wt.

Problems on Percentage Composition: Pg 95

1.a) CO_2 [C = 12, O = 16]

Molecular wt. of CO_2 = Atomic wt. of C + 2 × At. wt. of O

= 12 + (2 × 16)

= 12 + 32

Mol. wt of CO_2 = 44g

% Composition of C in CO_2

$= \frac{12}{44} \times 100$

$= \frac{300}{11}$

$= \boxed{27.27\%}$

b) Na_2CO_3 [Na = 23, C = 12, O = 16]

Mol. wt. of Na_2CO_3 = 2(23) + 12 + 3(16)

= 46 + 12 + 48

Mol. wt. of Na_2CO_3 = 106g

% Composition of Na in Na_2CO_3 $= \frac{46}{106} \times 100$

$= \frac{2300}{53} = 43.39\%$

$\approx 43.4\%$

2. AlN = 27 + 14 AlN [Al=27, N=14]

= 41 g

Mol. wt of AlN = 27+14

[Mol. wt of AlN = 41 g]

% Composition of AlN = $\frac{27 \times 100}{41}$

[= 65.85%]

3. $K_3Fe(CN)_6$ [K=39, Fe=56, C=12, N=14]

Mol. wt of $K_3Fe(CN)_6$ = $(3\times39)+56+(12+14)6$

= 117 + 56 + (26)6

= 117 + 56 + 156

[= 329 g]

% of Fe in $K_3Fe(CN)_6$

= $\frac{56}{329} \times 100$

[= 17.02%]

3. $Ca(NO_2)_2$ [Ca = 40, N = 14, O = 16]

RMM = 40 + 2[14 + 3(16)]

= 40 + 2[14 + 48]

= 40 + 2[62]

= 40 + 124

= 164 g

% of N in $Ca(NO_3)_2$ = $\frac{28/164}{164/82} \times 100 = \frac{700}{82}$

= 8.53%

= 17.07%

$(NH_4)_2SO_4$

RMM $= 2[14+4(1)]+32+4\times16$

$= 2[14+4]+32+64$

$= 2\times18+32+64$

$= 36+32+64$

$= 132\ g$

% of N $= \frac{28}{132}\times100 = \frac{700}{33} = 21.21\%$

Ammonium Sulphate has a higher % age of N, ie, 21.21% compared to calcium nitrate, ie, 17.07%.

4. Mol. wt of $Al_2O_3 = 2(27)+3(16)$

$= 54+48$

$= 102\ g$

% of Al $= \frac{54}{102}\times100 = \frac{900}{17}$

pure Al is of 90% purity

∴ % of 90% pure Al in $Al_2O_3 = \frac{900}{17}\times\frac{90}{100}$

$= \frac{810}{17}$

$= 47.64\%$

∴ % of purity of Al in Al_2O_3 maybe 10kg orelse

6. RMM of $CaCO_3$ = 40 + 12 + 3×16
= 40 + 12 + 48
= 100g

Weight of carbon in 100g of $CaCO_3$ is 12g.
But, purity of Ca is 55%.
∴ Percentage of Ca in $CaCO_3$ = $\frac{12 \times 55}{100}$

= 6.6%

7. RMM of $CuSO_4 \cdot 5H_2O$
= 63.5 + 32 + (4×16) + 5(2+16)
= 63.5 + 32 + 64 + 90
= 249.50 g

% of water of crystallization
= $\frac{90 \times 100}{249.50}$ × 100 = $\frac{90 \times 100}{249.5}$
= $\frac{9000}{2495}$ = 36.07%

8. Mol. wt. of $CaSO_4$ = 40 + 32 + 4×16 + x(2+16)
= 40 + 32 + 64 + 18x
= 136 + 18x

136g of 18x $CaSO_4$ · (100 - 21%)
· 79% of total mass of
$CaSO_4 \cdot xH_2O$ = A
∴ 79% of A = 136g of $CaSO_4$
⇒ $\frac{79}{100}$ of A = 136

Weight of metallic chloride = 4 g
Weight of metal = 1.89 g
Weight of chloride = 4 − 1.89
= 2.11 g

Element	% Comp	At weight	Rel no of atom	Simplest ratio
X	1.89	64	$\frac{1.89}{64} = 0.033$	$\frac{0.033}{0.033} = 1$
Cl	2.11	35.5	$\frac{2.11}{35.5} = 0.06$	$\frac{0.06}{0.033} = 2$

simplest ratio = 1:2
empirical formula = XCl_2
EF = CH_2O
EF wt = 12 + 2 + 16
= 30
VD = 30
Mol wt = 2 × 30 = 60
$n = \frac{\text{mol wt}}{\text{Ef wt}} = \frac{60}{30} = 2$
MF = $(EF)_n$
= $(CH_2O)_2$
= $C_2H_4O_2$ [CH_3COOH]

Pg 95

Q2.

Element	% Comp	At. wt	Rel. no. of atoms	simple ratio
C	57.82	12	$\frac{57.82}{12} = 4.8$	$\frac{4.8}{2.41} = 2$ $\frac{9.64}{2.41} = 4$
H	3.60	1	$\frac{3.60}{1} = 3.6$	$\frac{3.6}{2.41} = 1.5$ $\frac{3.6}{2.41} = 3$
O	38.58	16	$\frac{38.58}{16} = 2.41$	$\frac{2.41}{2.41} = 1$ $\frac{2.41}{2.41} = 2$

Total Simplest ratio = 4 : 3 : 2

empirical formula = $C_4H_3O_2$

E.F. wt = $4\times12 + 3\times1 + 2\times16$

$= 48 + 3 + 32$

$= 83$

VD = 83

Mol. wt of = 83×2

$= 166$

$n = \frac{166}{83} = 2$

Mol. formula = $C_4(EF)_n$

$= (C_4H_3O_2)_2$

$= C_8H_6O_4$

Element	% Comp	At wt	Rel no. of atoms	Simplest ratio
Al	0.2675	27	$\frac{0.2675}{27}$	
P	0.3505	31	$= 0.0099 \cdot 99$	$\frac{99}{99} = 1$
O	0.6620	16		
P	0.3505	31	$\frac{0.3505}{31}$	
				$\frac{113}{99} = 1$
O	0.6820	16	$= 0.113 = 43$	
O	0.6820	16	$\frac{0.6820}{16}$	
				$\frac{426}{99} = 4$
			$= 0.426 = 426$	

Simplest ratio - 1:1:4

empirical formula = $AlPO_4$

VD of $x = 13$ $\therefore MW = 2 \times VD = 2 \times 13 = 26$

VD of $y = 39$ $\therefore MV = 2 \times VD = 2 \times 39 = 78$

Let the formula of x be C_mH_n

Mol. mass of $x = 12m + 1n$

$= 12m + n$

$26 = 12m + n$

The only simple whole number values of m & n which satisfies this equation are $m = 2$ & $n = 2$

MF of $x = C_2H_2$

Let formula of $y = C_xH_y$ where x & y are simple whole nos.

Mol mass $= 12x + y = 78$.

The only simple whole number ratios which satisfies this $x = 6$, $y = 6$

$\therefore$ Mol formula = C_6H_6

To determine the molecular formula of a compound having

C = 26.59% H = 2.22% O = 71.19% VD = 45

[Ca = 12 H = 1 O = 16]

Calculation of empirical formula

Element	% Composition	At. wt.	Rel. no. of atoms	simple ratio
Carbon	26.59%	12	$\frac{26.59}{12} = 2.215$	$\frac{2.21}{2.21} = 1$
Hydrogen	2.22%	1	$\frac{2.22}{1} = 2.22$	$\frac{2.22}{2.21} = 1$
Oxygen	71.19%	16	$\frac{71.19}{16} = 4.44$	$\frac{4.44}{2.21} = 2$

Simplest ratio of whole nos = 1:1:2

$\therefore$ E.F. = CHO_2

E.F. wt = 12+1+2×16

= 12+1+32

= 45

VD = 45

Mol. wt = 45×2 = 90

$n = \frac{90}{45} = 2$

Mol. formula = $(EF)_n$

= $2(CHO_2)_2$

= $C_2H_2O_4$

Step 1 Calculate the empirical formula wt. from empirical formula

Step 2 Calculate mol. wt from the VD of a compound If VD is given, calculate molecular weight from it.

Formula: Mol. wt = 2 × VD

Step 3 Determine the value of integer of n by applying formula.

Formula: Mol. wt = n × empirical formula wt.

$$n = \frac{\text{Mol. wt}}{\text{E.F. wt}}$$

Step 4 Calculate mol. formula by applying formula

Molecular formula = E.F × n.

Problems based on empirical formula & molecular formula

Na = 29.11% S = 40.31% O = 13.38%

= 23 = 32 = 16

Element	% Comp	At wt	Rel. no. of atoms	Simplest ratio
Zn	22.65%	65	$\frac{22.65}{65} = 0.35$	1
S	11.15%	32	$\frac{11.15}{32} = 0.35$	1
O	61.32%	16	$\frac{61.321}{16} = 3.83$	11
H	4.88%	1	$\frac{4.881}{1} = 4.88$	14

But all the Hydrogen in the compound is present in combination with O_2 as water of crystallisation.

$\therefore H_2 : O = 14 : 11$

7 mols of H_2 need 7 atoms of O_2 to form

$\therefore 11 - 7 = 4$ atoms of O_2 are left

1 : 1 : 4 : 7

$\therefore$ Formula = $ZnSO_4 \cdot 7H_2O$

PAGE
DATE

Steps to determine empirical formula of a compound.

step1: Write down the % age composition & at wt of each element in the compound in tabular form.

step2: Divide the % age composition of each element by its at. wt. to get the relative no. of atoms

step3: Select smallest ratio of the
and divide the remaining ratio by it to get the simplest ratio

Note: If the simplest ratio is not a whole number, multiply each ratio by the small-est integer to get a whole number for simplest ratio.

Molecular Formula

It is a chemical formula which represent the actual no. of atoms of each element present in the molecule of the compound.
Ex 1: $C_6H_{12}O_6$ 6 atoms of C
12
6

Steps to determine the molecular formula of a compound from its empirical formula

$$A = \frac{136 \times 100}{79}$$

2 mols of water = 21% of A

$$= \frac{21}{100} \times \frac{136 \times 100}{79}$$

$$= \frac{21 \times 136}{79}$$

∴ no. of molecules of water

$$n(18) = \frac{21 \times 136}{79}$$

$$n = \frac{21 \times 136}{79 \times 18_6} 68 = \frac{21 \times 136}{79 \times 18_6} 68$$

$$= \frac{476}{237} = \frac{474}{237}$$

$$= \frac{2}{2}$$

Empirical Formula

Definition: Empirical Formula is the formula of a compound which shows the simplest whole number ratio between the atoms of the elements of a compound.

Ex 1: glucose = $C_6H_{12}O_6$

= 1:2:1

= CH_2O

Ex 2: benzene = C_6H_6

= 1:1

= CH