Atomic weight: H=1, C=12, N=14, O=16, F=19, Ne=20.2, Al=27, P=31,S=32, K=39, Cl=35.5, Ar=40,Cr=52, Cu=63.55, Ag=108 amu

Ex. 1: For the reaction of 50.0 g of N_2 with H_2, determine the theoretical yield of ammonia. If 49.6 g of NH_3 was actually produced, calculate the percent yield for the reaction.

Mw N_2 = 2 x14 = 28 amu, Mw NH_3 = 14 + (3 x 1) = 17 amu

Sol. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

28 g 2x17 g

50 g ? g

$$\textbf{Theoretical Yield} = \frac{50 \times 2 \times 17}{28} = \textbf{60.71 g } \textbf{NH}_3$$

$$\textbf{Percent Yield} = \frac{\textbf{Actual yield}}{\textbf{Theoretical Yield}} \times 100 = \frac{49.6\ g}{60.71\ g} \times 100 = \textbf{81.7\%}$$

Ex. 2: Chlorofluorocarbons which has the formula CCl_2F_2 and can be prepared as follows:

$2\ HF\ (g) + CCl_4\ (l) \rightarrow CCl_2F_2\ (g) + 2\ HCl\ (g)$

Calculate the mass of CCl_4 necessary to react completely with 50.0 g of HF.

Mw HF = 1 + 19 = 20 amu, Mw CCl_4= (1 x 12) + (4 x 35.5) = 154 amu

Sol. $2\ HF\ (g) + CCl_4\ (l)$

2 x20 g 1x154 g

50 g ? g

$$? = \frac{50 \times 154}{2 \times 20} = \textbf{192.5 g } \textbf{CCl}_4$$

Ex. 3: Chlorofluorocarbons which has the formula CCl_2F_2 and can be prepared as follows:

$2\ HF\ (g) + CCl_4\ (l) \rightarrow CCl_2F_2\ (g) + 2\ HCl\ (g)$

Calculate the mass of CCl_2F_2 produced when 50.0 g of CCl_4 reacts completely.

Mw CCl_2F_2 = (1 x 12) + (2 x 35.5) + (2 x 19) = 121 amu,

Mw CCl_4 = (1 x 12) + (4 x 35.5)= 154 amu

Sol. $CCl_4\ (l) \rightarrow CCl_2F_2\ (g)$

1x154 g 1x121 g

50 g ? g

$$? = \frac{50 \times 121}{154} = \textbf{39.29 g } \textbf{CCl}_2\textbf{F}_2$$

Ex. 4: Chlorofluorocarbons which has the formula CCl_2F_2 and can be prepared as follows:

$2\ HF\ (g) + CCl_4\ (l) \rightarrow CCl_2F_2\ (g) + 2\ HCl\ (g)$

Calculate the mass of HCl produced when 50.0 g of CCl_2F_2 is produced.

Mw CCl_2F_2 = 121 amu, Mw HCl = 1 + 35.5 = 36.5 amu

Sol. $CCl_2F_2\ (g) + 2\ HCl\ (g)$

121 g 2x36.5 g

50 g ? g

$$? = \frac{50 \times 2 \times 36.5}{121} = \textbf{30.17 g HCl}$$

Ex. 5: Consider the following:

$2\ C_2H_6\ (g) + 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (g)$

How many moles of O_2 will react with 2.50 moles of C_2H_6?

Sol.

$2\ C_2H_6\ (g) + 7\ O_2\ (g)$

2 mol 7 mol

2.50 mol ? mol

$$? = \frac{2.50 \times 7}{2} = \textbf{8.75 mol } \mathbf{O_2}$$

Ex. 6: Consider the following:

$2\ C_2H_6\ (g) + 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (g)$

How many moles of CO_2 form when 3.50 moles of O_2 completely react?

Sol.

$7\ O_2\ (g) \rightarrow 4\ CO_2\ (g)$

7 mol 4 mol

3.5 mol ? mol

$$? = \frac{3.5 \times 4}{7} = \textbf{2.0 mol } \mathbf{CO_2}$$

Ex. 7: Consider the following:

$2\ C_2H_6\ (g) + 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (g)$

How many moles of H_2O form when 4.50 moles of CO_2 form?

Sol.

$4\ CO_2\ (g) + 6\ H_2O\ (g)$

4 mol 6 mol

4.5 mol ? mol

$$? = \frac{4.5 \times 6}{4} = \textbf{6.75 mol } \mathbf{H_2O}$$

Ex. 8: Consider the following:

$2\ C_2H_6\ (g) + 7\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (g)$

How many moles of C_2H_6 are required to produce 5.50 moles of H_2O?

Sol.

$2\ C_2H_6\ (g) \rightarrow 6\ H_2O\ (g)$

2 mol 6 mol

? mol 5.5 mol

$$? = \frac{5.5 \times 2}{6} = \textbf{1.83 mol } \mathbf{C_2H_6}$$

Ex. 9: Balance the equation:

$P_4\ (s) + Cl_2\ (g) \rightarrow PCl_5\ (s)$

Sol. **P_4 (s) + 10 Cl_2 (g) → 4 PCl_5 (s)**

Ex. 10: Balance the equation:

MgO (s) → O_2 (g) + Mg (s)

Sol. **2 MgO (s) → O_2 (g) + 2 Mg (s)**

Ex. 11: Balance the equation:

Fe_2O_3 (s) + CO (g) → CO_2 (g) + Fe (s)

Sol. **Fe_2O_3 (s) + 3 CO (g) → 3 CO_2 (g) + 2 Fe (s)**

Ex. 12: Balance the equation:

Na_2SO_4 (aq) + $Pb(NO_3)_2$ (aq) → $PbSO_4$ (s) + $NaNO_3$ (aq)

Sol. **Na_2SO_4 (aq) + $Pb(NO_3)_2$ (aq) → $PbSO_4$ (s) + 2 $NaNO_3$ (aq)**

Ex. 13: Balance the equation:

HCl (aq) + $Ca(OH)_2$ (aq) → H_2O (l) + $CaCl_2$ (aq)

Sol. **2 HCl (aq) + $Ca(OH)_2$ (aq) → 2 H_2O (l) + $CaCl_2$ (aq)**

Ex. 14: Balance the equation:

C_4H_6 (g) + O_2 (g) → CO_2 (g) + H_2O (g)

Sol. **2 C_4H_{10} (g) + 13O_2 (g) → 8 CO_2 (g) + 10 H_2O (g)**

Ex. 15: How many moles of Ne are in 50.0 g Ne?

Aw Ne = 20.2 amu

Sol. 1 mol Ne = 6.02×10^{23} Ne atoms = 20.2 g

? mol 50.0 g

$$? = \frac{50.0 \times 1}{20.2} = \textbf{2.48 mol Ne}$$

Ex. 16: How many Ne atoms are in 50.0 g of Ne?

Aw Ne = 20.2 amu

Sol. 1mol Ne = 6.02×10^{23} Ne atoms = 20.2 g Ne mass

? atoms 50.0 g

$$? = \frac{50.0 \times 6.02 \times 10^{23}}{20.2} = \textbf{14.9 x } \mathbf{10^{23}} \textbf{ Ne atoms}$$

Ex. 17: How many moles of CO_2 are in 25.0 g of CO_2?

Mw: CO_2 = 12 + (2 x 16) = 44 amu

Sol. 1 mol CO_2 = 6.02 x 10^{23} CO_2 molecules = 44 g CO_2 mass

? mol 25.0 g

$$? = \frac{25.0 \times 1}{44} = \textbf{0.57 mol of } \mathbf{CO_2}$$

Ex. 18: How many CO_2 molecules are in 25.0 g of CO_2?

Mw: CO_2 = 12 + (2 x 16) = 44 amu

Sol. 1 mol CO_2 = 6.02 x 10^{23} CO_2 molecules = 44 g CO_2 mass

? molecules 25.0 g CO_2

$$? = \frac{25.0 \times 6.02 \times 10^{23}}{44} = \textbf{3.42 } \mathbf{CO_2} \textbf{ molecules}$$

Ex. 19: How many oxygen atoms are in 25.0 g of CO_2?

Mw: CO_2 = 12 + (2 x 1) = 44 amu

Sol. 1 mol CO_2 = 6.02 x 10^{23} CO_2 molecules = 44 g CO_2 mass

1 mol CO_2 = 2 mol O = 2 x 6.02x10^{23} O atoms = 44 g CO_2

? O atoms 25.0 g

$$? = \frac{25.0 \times 2 \times 6.02 \times 10^{23}}{44} = \textbf{6.84 x } \mathbf{10^{23}} \textbf{ O atoms}$$

Ex. 20: Glucose has the molecular formula $C_6H_{12}O_6$. How many grams of carbon are in 39.0 g of glucose?

Mw $C_6H_{12}O_6$ = (6 x12) + 12 + (6 x 16) = 180 amu

Sol. 180 g mass $C_6H_{12}O_6$= 1 mol $C_6H_{12}O_6$= 6 mol C= 6 x12 g C mass

39 g ? g C

$$? = \frac{6 \times 12 \times 39}{180} = \textbf{15.6 g C}$$

Ex. 21: How many grams of nitrogen are needed to completely react with 0.525 g of hydrogen in the formation of ammonia?

Mw N_2 = 2 x 14 = 28 amu, Mw H_2 = 2 x 1 = 2 amu

Sol. N_2 (g) + 3 H_2 (g) → 2 NH_3 (g)

28 g 3x2 g

? g 0.525 g

$$? = \frac{28 \times 0.525}{3 \times 2} = \textbf{2.45 g } \mathbf{N_2}$$

Ex. 22: How many moles of H_2 are needed to combine with 5.84 g of N_2 in the formation of ammonia?

Mw N_2 = 2 x 14 = 28 amu

Sol. N_2 (g) + 3 H_2 (g) → 2 NH_3 (g)

28 g 3 mol

5.84 g ? mol

$$? = \frac{5.84 \times 3}{28} = \mathbf{0.62\ mol\ H_2}$$

Ex. 23: How many grams of N_2 will be needed to produce 0.384 moles of NH_3?

Mw N_2 = 2 x 14 = 28 amu

Sol. N_2 (g) + 3 H_2 (g) → 2 NH_3 (g)

28 g 2 mol

? g 0.384 mol

$$? = \frac{28 \times 0.384}{2} = \mathbf{5.376\ g\ N_2}$$

Ex. 24: According to the following reaction:

2 Al(s) + 3 $Cu(NO_3)_2$ (aq) → 2 $Al(NO_3)_3$ (aq) + 3 Cu (s)

Determine the theoretical yield of Cu for 0.5 g of Al reactant. If 1.53 g of Cu was actually produced, calculate the percent yield for the reaction.

Sol. 2 Al (s) → 3 Cu (s)

2x27 g 3x63.55 g

0.5 g ? g

$$? = \frac{0.5 \times 3 \times 63.55}{2 \times 27} = \mathbf{1.77\ g\ Cu\ Theoretical\ Yield}$$

$$\text{Percentage Yield\%} = \frac{1.53}{1.77} \times 100 = \mathbf{86.4\%}$$

Ex. 25: How much glucose is required to prepare 200 mL of 0.150 M of $C_6H_{12}O_6$?

Mw $C_6H_{12}O_6$ = (6 x 12) + 12 + (6 x 16) = 180 amu

Sol.

$$\text{M (molarity)} = \frac{\text{Moles of solute (mol)}}{\text{Volume of solution (L)}} = \frac{m_{(solute)}\ (g)}{MM_{(solute)}\ (g/mol) \times V_{(solution)}(L)}$$

$m = M \times MM \times V = 0.150 \times 180 \times 200 \times 10^{-3} = \mathbf{5.4\ g\ C_6H_{12}O_6}$

Ex. 26: How many Cl atoms are there in 5.01g of elemental Cl?

Mw Cl_2 = 2 x 35.5 = 71 amu

Sol. 71 g Cl_2 = mol Cl_2 = 2 mol Cl = 2 x 6.02 x 10^{23} Cl atoms

5.01 g ? atoms

$$? = \frac{5.01 \times 2 \times 6.02 \times 10^{23}}{71} = \mathbf{8.5 \times 10^{22}\ Cl\ atoms}$$

Ex. 27: How many Aratoms are there in 0.00351 g of Ar?

Aw Ar = 40 amu

Sol. 1 mol Ar = 6.02×10^{23} Ar atoms = 40 g Ar mass

? atoms 0.00351 g Ar

$$? = \frac{0.00351 \times 6.02 \times 10^{23}}{40} = \mathbf{5.28 \times 10^{19}\ Ar\ atoms}$$

Ex. 28: How many moles and atoms in 3.05 g Cu?

Aw Cu = 63.5 amu

Sol. 1 mol Cu = 6.02×10^{23} Cu atoms = 63.5 g Cu mass

? atoms 3.05 g Cu

$$? = \frac{3.05 \times 6.02 \times 10^{23}}{63.5} = \mathbf{2.89 \times 10^{22}\ Cu\ atoms}$$

Ex. 29: Balance the reaction: $NH_3 + F_2 \rightarrow N_2F_4 + HF$

Sol. $\mathbf{2\ NH_3 + 5\ F_2 \rightarrow N_2F_4 + 6\ HF}$

Ex. 30: How many grams of Ag in 300g of Ag_2S?

Aw Ag= 108 amu, Mw Ag_2S=2x108 + 1x32= 248 amu

Sol. 248 g Ag_2S mass = 1 mol Ag_2S =2 mol Ag = 2 x 108 g Ag mass

300 g Ag_2S ? g

$$? = \frac{300 \times 2 \times 108}{248} = \mathbf{261.3\ g\ Ag\ mass}$$

Ex. 31: Convert 0.250 mol of NaOH to number of Na ions.

Sol. 1 mol NaOH= 1 mol Na^+ = 6.02×10^{23} Na^+ ions

0.250 mol ? ions

$$? = \frac{0.250 \times 6.02 \times 10^{23}}{1} = \mathbf{1.505 \times 10^{23}\ Na^+\ ions}$$

Ex. 32: Convert 2.0 mol of NaOH to g.

Mw NaOH = 23 +16 + 1 = 40 amu

Sol. m = n x MM

m = 2.0 X 40 = **80 g NaOH**

Ex. 33: Find concentration in molar of 20.1g of NaOH in 300 mL volume of solution.

Mw NaOH = 23 + 16 + 1 = 40 amu

Sol.

$$M\ (\text{molarity}) = \frac{\text{Moles of solute (mol)}}{\text{Volume of solution (L)}} = \frac{m_{(solute)}\ (g)}{MM_{(solute)}\ (g/mol) \times V_{(solution)}(L)}$$

$$M = \frac{20.1}{40 \times 300 \times 10^{-3}} = \mathbf{1.675\ M\ or\ (mol/L)}$$

Ex. 34: How many grams of Cl atoms are needed to combine with 24.4 g of Si atoms to make $SiCl_4$?

Aw Si = 28 amu, Aw Cl = 35.5 amu

Sol. 1 mol Si = 28 g Si mass = 4 mol Cl = 4 x 35.5 g Cl atom mass

24.4 g ? g

$$? = \frac{24.4 \times 4 \times 35.5}{28} = \mathbf{123.7\ g\ Cl\ atom\ mass}$$

Ex. 35: What is the percent yield of the reaction if 32.8 g of $C_5H_{12}O$ is obtained from reaction of 26.3 g of C_4H_8 with sufficient methanol?

$C_4H_8\ (g) + CH_3OH\ (l) \rightarrow C_5H_{12}O\ (l)$

Mw C_4H_8 = (4 x 12) + (8 x1) = 56 amu

Mw $C_5H_{12}O$ = (5 x 12) + (12 x 1) + 16 = 88 amu

Sol. $C_4H_8\ (g) + CH_3OH\ (l) \rightarrow C_5H_{12}O\ (l)$

56 g 88 g

26.3 g ? g

$$? = \frac{26.3 \times 88}{56} = \mathbf{41.33\ g\ C_5H_{12}O}\ \text{mass (}\mathbf{\text{Theoretical yield)}}$$

$$\text{Percent yield\%} = \frac{\text{Actual Yield}}{\text{Theoretical yield}} \times 100 = \frac{32.8}{41.33} \times 100 = 79.36\%$$

$$V = \frac{0.20 \times 1}{0.250 \times 1} = 0.03\ L = \mathbf{30\ mL\ CaCl_2\ is\ needed}$$

Ex.36: How many grams of CO_2 (theoretical yield)will be formed when a mixture containing 1.93 g C_2H_4 and 5.92 g O_2 is burned? How many grams of which reactant will remain unreacted?

Mw C_2H_4 = 28, Mw O_2 = 32, Mw CO_2 = 44 amu

Sol. $C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$

Finding Limiting Reactant: L.R.

	Mass	1.93 g C_2H_4 react with	5.92 g O_2
Convert to mol.	n	1.93/28 mol	5.92/32 mol
	Mol	0.069 mol	0.185 mol
Divide by coefficient		0.069/1	0.185/3
Smallest # is L.R.		0.0689	**0.0617**

O_2 is the limiting reactant. Use the amount of L.R. to calculate the product (theoretical yield of CO_2)

$$C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$$

3x32 g 2x44 g

5.92 g ?

$$? = \frac{5.92 \times 2 \times 44}{3 \times 32} = \textbf{5.43 g } \mathbf{CO_2} \textbf{ (Theoretical yield)}$$

Mass of remain unreacted C_2H_4 (in Excess):

a) Calculate the mass reacted from L.R.

Sol.

$$C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$$

28 g 3x32 g

? 5.92 g

$$? = \frac{5.92 \times 28}{3 \times 32} = \textbf{1.73 g } \mathbf{O_2} \textbf{ (reacted)}$$

b) Mass of remain unreacted = mass in reaction - mass reacted

Mass of remain unreacted = 1.93 – 1.73= **0.20 g C_2H_4 unreacted**

Ex.37: What is the empirical formula of a compound composed of 43.7% P and 56.3% O? n = m/MM

Sol.

		P		O
	Mass	43.7 g		56.3 g
a) Convert mass to moles		43.7/31		56.3/16
	mol	**1.41mol**		3.52 mol
b) Divide by smallest #		1.41/1.41		3.52/1.41
		1		2.5
c) Convert to whole #				
Multiply by 2 to obtain:		2x1=2		2x2.5=5
d) Empirical Formula		$(PO_{2.5})_2$	→	$\mathbf{P_2O_5}$

Ex.38: What is the molecular formula of the compound which has a molecular mass 92.0 and empirical formula is NO_2?

Mw NO_2 = 46 amu

Sol.

a) Find the Repeated Factor (R.F.) = $\frac{\text{Molecular Mass}}{\text{Mass of the Empirical Formula}}$

Repeated Factor is the number of times the empirical formula repeated in the compound.

$$\text{R.F.} = \frac{92.0}{46.0} = 2 \quad \text{(whole \#)}$$

b) Multiply Empirical Formula (subscript of element in the formula) by R.F. to get Molecular Formula

2 x (NO_2) → $\mathbf{N_2O_4}$ Molecular Formula

Ex 39: Calculate the percentage of Cr in $K_2\mathbf{Cr_2}O_7$.

Sol. $$\%Cr = \frac{\text{\# Mol. of Cr in formula x MM Cr}}{\text{MM of the substance } K_2Cr_2O_7} \times 100$$

$$\%Cr = \frac{2 \times 52}{2x39 + 2x52 + 7x16} \times 100 = \frac{104 \times 100}{294} = \mathbf{35.4\%\ Cr\ (w/w)}$$

Ex.40: What is the molecular formula of the substance which has a molar mass of 62.1 g/mol and is composed of 38.7%C, 9.7% H, and the rest of O?

Sol. Find %O;

%O= 100- (38.7 + 9.7) = 51.6% O

	C	H	O
Convert mass to mol	38.7/12	9.7/1	51.6/16
Mole	3.225	9.7	3.225
Divide by smallest #	1	3	1

Empirical Formula: CH_3O

Molecular Formula: Find **R.F.** = $\frac{62.1}{12+3+16} = 2$ (multiply by E.F.)

The Molecular Formula: $(CH_3O)_2 \rightarrow \mathbf{C_2H_6O_2}$
