Stiochiometry
Topic#10
AMSAT Chem 1H

Teacher Edition

Stoichiometry
Topic#10

Reaction Review

Starter #1 - Reactions Review: Predict Products and balance.

1. ___Na + ___$FeBr_3$ → ___ _________ + ___ _________

2. ___NaOH + ___H_2SO_4 →___ _________ + ___ _________

3. ___$C_{10}H_{22}$ + ___O_2 →___ _________ + ___ _________

4. ___$PbSO_4$ + ___$AgNO_3$ →___ _________ + ___ _________

5. ___HBr + ___Fe →___ _________ + ___ _________ (Fe makes Fe^{3+})

6. ___ $KMnO_4$ + ____ $ZnCl_2$ →___ _________ + ___ _________

7. ___H_2O_2 → ___ _________ + ___ _________

8. ___C_5H_{12} + ___O_2 →___ _________ + ___ _________

9. ___F_2 + ___WCl_6 →___ _________ + ___ _________

Moles - A Review

Molar mass (*MM*)

- the mass of 1 mole of a substance
  - Molar Mass (*MM*) of H_2O is 18.02 (2H + O = 2(1.01) + 16 = 18.02g/mol)
  - $CuSO_4 \bullet 5H_2O$ (copper (II) sulfate pentahydrate) = Cu + S + 4O + 10H + 5O = 63.55 + 32.07 + 4(16) + 10(1.01) + 5(16) = 249.72g/mol

Conversions (Go back to Topic#4 and fetch your conversion chart for moles!)

- mol to mass: multiply by *MM*
  - *label: g*
- mass to mol: divide by *MM*
  - *label: mol*
- mol to particles: multiply by 6.022×10^{23}parts/mol
  - *label: part* (ions, molecules, formula units, or atoms)
- particles to mol: divide by 6.022×10^{23}parts/mol
  - *label: mol*
- particles to grams: divide by 6.022×10^{23}parts then multiply by *MM*
  - *label: g*
- grams to particles: divide by *MM* then multiply by 6.022×10^{23}parts
  - *label: part* (ions, molecules, formula units, or atoms)

Stoichiometry
Topic#10

Reaction Review

Re-Introduction to Moles

Groups of two on white board. Show work on whiteboard. Each member submits work on a piece of paper (3pts)

Starter #2 - Mole Practice Problems

1. Detemine the number of moles of each element in 0.354 moles of $Ba(NO_3)_2$.
   (Ans: 0.354 moles Ba, 0.708 moles N, and 2.124 moles of O)

2. What is the molar mass (*MM*) of $Ba(NO_3)_2$? (Ans: 261.35 g/mol)

3. How many grams are in 0.354 moles of $Ba(NO_3)_2$? (Ans: 92.5g)

4. How many moles are in 345.5 mg of $Ba(NO_3)_2$? (Ans:)

Stoichiometry
Topic#10

Compositional Stoichiometry

Stoichiometry
Topic#10

Composition Stoichiometry

- The use of a chemical formula, quantities of an element, and mole ratios to calculate the formula of a chemical species
- Keys to success
  - proper formula of a compounds
  - correct *MM* of compounds
  - using mole ratios between elements in a compound
  - conversion mass of an element to moles of an element

Empirical Formula vs Molecular Formula

Molecular Compounds (all nonmetals)

- Molecular formula: $C_6H_{12}O_6$ (each subscipt can be divide by 6)
- Empirical formulas: CH_2O (empirical ratio (1:2:1))

Ionic Compounds (Starts with a metal or ammonium (NH_{4+})

- Ionic formula : titanium (IV) oxide → Ti_2O_4 (simplify) → TiO_2
  - always written as an empirical formula

Stoichiometry
Topic#10

Percent Composition

Percent composition - the precent by mass of each element in a compound

$$\%X \text{ in } XY = \text{mass } X/(MM_{XY}) \text{ x } 100\%$$

Sample WS#1 - Percent Composition

1. Find the percentage composition of copper (I) sulfide, Cu_2S. Ans: 79.9% Cu, 20.1%S

$$\% Cu : \frac{2Cu}{Cu_2S} \times 100\% = \frac{2(63.55)}{2(63.55)+32.07} \times 100\% = \frac{127.10}{159.17} \times 100\% = \boxed{79.9\%}$$

$$\% S : \frac{S}{Cu_2S} \times 100\% = \frac{32.07}{2(63.55)+32.07} \times 100\% = \frac{32.07}{159.17} \times 100\% = \boxed{20.1\%}$$

$$79.9 + 20.1 = 100\% \checkmark$$

Stoichiometry
Topic#10

Percent Composition

Percent composition - the precent by mass of each element in a compound

$$\%X \text{ in } XY = \text{mass } X/(MM_{XY}) \times 100\%$$

2. As some salts crystallize from a water solution, they bind water molecules in their crystal structure. Sodium carbonate forms such a *hydrate*, in which 10 water molecules are present for every formula unit of sodium carbonate. Find the mass percentage of water in sodium carbonate decahydrate, $Na_2CO_3 \bullet 10H_2O$, which has a *MM* of 286.14g/mol. Ans: 63.0% H_2O

Gvn

$Na_2CO_3 \cdot 10H_2O$

NTK

$*mm_{Na_2CO_3 \cdot 10H_2O} = \underline{286.19}$

$mm_{10H_2O} = 10(18.02) = 180.2g$

Unk

$\%H_2O =$ ______ %

$*MM_{Na_2CO_3 \cdot 10H_2O}$

$= 2Na + C + 3(O) + 10(H_2) + 10(O)$

$= 2Na + C + 13(O) + 20(H)$

$= 286.19g/mol$

Solve:

$$\%H_2O = \frac{10H_2O}{Na_2CO_3 \cdot 10H_2O} \times 100\% = \frac{180.2}{286.19} \times 100\% = \boxed{63.0\%}$$

Percent Composition

Percent composition - the precent by mass of each element in a compound

%X in XY = mass X/(*MM*$_{XY}$) x 100%

3. (OYO) Find the percentage composition of the following. (Ans: (a) 74.5%Pb, 25.5%Cl (b) 52.5%Ba, 10.7%N, 36.7%O)

(a) $PbCl_2$ (b) $Ba(NO_3)_2$

4. (OYO) Find the mass percentage of water in $ZnSO_4•7H_2O$. (Ans: 43.9% H_2O)

Percent Composition

5. Magnesium hydroxide is 54.87% oxygen by mass. How many grams of oxygen are in 175g of the compound? How many moles of oxygen is this? (Ans: 96.0g O, 6 moles)

Gvn	NTK	Unk
% Oxg by mass is 54.87%	$Mg(OH)_2$	mass O: 96.0 g
175 g of compound		moles O: 6 m

Solve:

mass O: $175\,g \times (0.5487) = \boxed{96.0\,g\ O}$

moles O: $\dfrac{96.0\,g\ O \;\Big|\; 1\,mole}{\;\;\Big|\; 16\,g} = \boxed{6\ moles\ O}$

Stoichiometry
Topic#10

Empirical Formula

Empirical formula (EF) from Percent Composition.

1) Convert percents into grams (if given grams go to step 2)
2) Determine moles of each element by dividing the mass of the element by the atomic mass of each element.
3) Divide moles of each element by the smallest of them.
4) Convert to whole numbers by multiplying each by a factor.
    Example: 1.333 is converted to 4 by multiplying by 3.

Stoichiometry Sample WS#2 - Empirical Formula Practice Problems

1. Quantitative analysis shows that a compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. Find the empirical formula of this compound. (Ans: Na_2SO_4)

Gvn

32.38% Na (32.38g)

22.65% S (22.65g)

44.99% O (44.99g)

100 g Sample

NTK

$Na_x S_y O_z$

SOLVE:

	Na_x	S_y	O_z
mass →	32.38g	22.65g	44.99g
÷ *atomic mass* →	22.99	32.07	16
moles →	1.41	0.706	2.81
÷ *smallest value* →	0.706	0.706	0.706
mole ratio →	2	1	4
	x	y	z

$Na_x S_y O_z$

$\boxed{Na_2SO_4}$

Stoichiometry
Topic#10

Empirical Formula

Empirical formula (EF) from Percent Composition.

1) Convert percents into grams (if given grams go to step 2)
2) Determine moles of each element by dividing the mass of the element by the atomic mass of each element.
3) Divide moles of each element by the smallest of them.
4) Convert to whole numbers by multiplying each by a factor.
   Example: 1.333 is converted to 4 by multiplying by 3.

2. Analysis of a 10.150g sample of a compound known to contain only phosphorus and oxygen indicates a phosphorus content of 4.433g. What is the empirical formula of this compound?

(Ans: P_2O_5)

GVN

$m_T = 10.150 = m_P + m_O$

$m_P = 4.433$

NTK

$m_T - m_P = m_O$

$10.150 - 4.433 = m_O$

$m_O = 5.717$

Solve:

	P_x	O_y
mass →	4.433	5.717
÷ *atomic mass* →	30.97	16
moles →	0.143	0.357
÷ *smallest value* →	0.143	0.143
mole ratio →	2(1)	2(2.5)
	X=2	Y=5

$P_xO_y \rightarrow P_2O_5$

Empirical Formula

3. (OYO) A compound is found to contain 63.52% iron and 36.48% sulfur. Find its empirical formula. (Ans: FeS)

mass →		
÷ atomic mass →		
moles →		
÷ smallest value →		
mole ratio →		

Empirical Formula

4. (OYO) Find the empirical formula of a compound found to contain 26.56% potassium, 35.41% chromium, and the remainder oxygen. (Ans: $K_2Cr_2O_7$)

mass →			
÷ atomic mass →			
moles →			
÷ smallest value →			
mole ratio →			

Empirical Formula

5. (OYO) Analysis of 20.0g of a compound containing only calcium and bromine indicates that 4.00g of calcium are present. What is the empirical formula of the compound formed?

(Ans: $CaBr_2$)

mass →		
÷ *atomic mass* →		
moles →		
÷ *smallest value* →		
mole ratio →		

Stoichiometry
Topic#10

Molecular Formulas

Molecular Formula (MF) - the number and types of elements needed to make 1 molecule.

- MF = n(EF) and n = MM/EM
  - MF: molecular formula
  - n: ratio between the molecular and empirical mass
  - EF: empirical formula
  - MM: molecular mass
  - EM: empirical formula mass

glucose
EF:
MF

titanium (IV) sulfide
EF:

Sample WS#3 - Molecular Formula Practice Problems

1. In an previous sample problem, the empirical formula of a compound of phosphorus and oxygen was found to be P_2O_5. Experimentation shows that the *MM* of this compound is 283.89g/mol. What is the compound's molecular formula? (Ans: P_4O_{10})

Gvn

$EF = P_2O_5$

$MM = 283.89 g/mol$

NTK

$MF = n(EF)$

$EM = 2P + 5(O)$

$= 2(30.97) + 5(16) = 141.94 g/mol$

$n = MM/EM$

UNK

MF : P_4O_{10}

SOLVE:

$n = \frac{283.89}{141.94} = 2$

$MF = n(P_2O_5)$

$= 2(P_2O_5) = \boxed{P_4O_{10}}$

Molecular Formulas

2. Determine the molecular formula of the compound with the empirical formula CH and a formula mass of 78.110amu. (Ans: C_6H_6 (benzene))

Gvn

$EF = CH$

$MM = 78.110$ amu*

NTK

$EM = 12.01 + 1.01 = 13.02$

$MF = n(EF) = n(CH)$

$n = \frac{MM}{EM} = \frac{FM\ (amu)}{EM\ (amu)}$

UNK

$MF = C_6H_6$

Solve:

$n = \frac{78.110}{13.02} = 6$

$MF = 6(CH) = \boxed{C_6H_6}$

* really formula mass, but we can use it has molar mass

Stoichiometry
Topic#10

Molecular Formulas

3. A sample of a compound with a formula mass of 34.00amu is found to consist of 0.44g H and 6.92g O. Find its molecular formula. (Ans: H_2O_2)

Gvn

0.44g H

6.92g O

FM: 34.00 amu*

*treat like MM

NTK

EF = HO

$EM = (1.01) + 16 = 17.01$

$n = \frac{MM}{EM} = \frac{FM}{EM}$

$MF = n(EF)$

UNK

$MF = H_2O_2$

Solve:	H	O
mass →	$\frac{0.49}{1.01}$	$\frac{6.92}{16}$
÷ *atomic mass* →		
moles →	$\frac{0.436}{0.433}$	$\frac{0.433}{0.433}$
÷ *smallest value* →		
mole ratio →	≈1	1
	x = 1	y = 1

$n = \frac{FM}{EM} = \frac{34}{17} = 2$

$MF = n(EF) = 2(HO)$

$= \boxed{H_2O_2}$

Molecular Formulas

4. (OYO) Determine the molecular formula when the compound contains 64.27% carbon, 7.19% hydrogen, and 28.54% oxygen with an experimentally determined molar mass of 168.19.

(Ans: $C_9H_{12}O_3$)

mass →			
÷ *atomic mass* →			
moles →			
÷ *smallest value* →			
mole ratio →			

Stoichiometry
Topic#10

Reaction Stoichiometry

Stoichiometry
Topic#10

Reaction Stoichiometry

- The use of a balance equation, quantities of chemical species, and mole ratios to calculate the amount of an unknown substance.
- Keys to success
    - balanced equation
    - correct *MM* of compounds
    - using mole ratios between chemical species
    - conversion of moles to mass and mass to moles
- Must obey the Law of Conservation of Mass

Stoichiometry

Topic#10

Mole to Mole

Process (Mole to Mole)

(1) Balanced chemical equation and mole ratios
(2) Identify given (circle) and unknown (box).
(3) Using the balanced equation, write in given with label under known.
(4) Using the balanced equation, write a (?) with label under unknown.
(5) Above balanced equation, draw arrow from given to unknown.
(6) Use molar ratios to solve for unknown

$$\begin{array}{l|l|} \textbf{moles}_{\textbf{gvn}}\ \textbf{(formula)} & \textbf{coefficient}_{\textbf{unk}}\ \textbf{(formula)} \\ \hline & \textbf{coefficient}_{\textbf{gvn}}\ \textbf{(formula)} \end{array} \quad = \textbf{moles}_{\textbf{unk}}$$

Stoichiometry Sample WS#4 - Mole and Mass Stoichiometry Practice Problem

1. In a spacecraft, the carbon dioxide exhaled by astronauts can be removed by its reaction with lithium hydroxide, LiOH, according to the following chemical equation. $CO_2(g) + 2LiOH(s) \rightarrow Li_2CO_3(s) + H_2O(l)$. How many moles of lithium hydroxide are required to react with 20mol of CO_2, the average amount exhaled by a person each day? (Ans: 40 mol LiOH)

Gvn

20 moles CO_2

NTK

$$\underset{20\text{ mo}}{CO_2} + \underset{?\text{ mol}}{2LiOH} \rightarrow Li_2CO_3 + H_2O$$

mole ratio: 1:2:1:1

UNK

moles LiOH = 40mol

Solve:

$$\begin{array}{l|l} 20\text{moles } \cancel{CO_2} & 2\ LiOH \\ \hline & 1\ \cancel{CO_2} \end{array} = \boxed{40\text{ moles }LiOH}$$

Stoichiometry
Topic#10

Mole to Mole

$$\begin{array}{l|l|} \textbf{moles}_{gvn}\textbf{ (formula)} & \textbf{coefficient}_{unk}\textbf{ (formula)} \\ \hline & \textbf{coefficient}_{gvn}\textbf{ (formula)} \end{array} = \textbf{moles}_{unk}$$

2. Ammonia, NH_3, is widely used as a fertilizer and in many household cleaners. How many moles of ammonia are produced when 6mol of hydrogen gas react with an excess of nitrogen gas. (Ans: 4mol NH_3)

Gvn

6 mol H_2

NTK

$\underset{6\,mol}{3H_2} + N_2 \rightarrow \overset{?}{2NH_3}$

mole ratio: 3 : 1 : 2

UNK

moles NH_3 = 4 mol NH_3

Solve:

$$\begin{array}{l|l} 6\,mol\,\cancel{H_2} & 2\,NH_3 \\ \hline & 3\,\cancel{H_2} \end{array} = \boxed{4\,mol\,NH_3}$$

Stoichiometry
Topic#10

Mole to Mole

$$\begin{array}{l|l|} \textbf{moles}_{gvn}\textbf{ (formula)} & \textbf{coefficient}_{unk}\textbf{ (formula)} \\ \hline & \textbf{coefficient}_{gvn}\textbf{ (formula)} \end{array} \quad = \textbf{moles}_{unk}$$

3. (OYO) The decomposition of potassium chlorate, $KClC_3$, is used as a source of oxygen in the laboratory. How many moles of potassium chlorate are needed to produce 15 mol of oxygen?

$KClO_3 \rightarrow KCl + O_2$ (Ans: 10. mol $KClO_3$)

Stoichiometry
Topic#10

Mass to Mass

Process (Mass to Mass)

(1) Balanced chemical equation and mole ratios
(2) Identify given (circle) and unknown (box).
(3) Using the balanced equation, write in given with label under known.
(4) Using the balanced equation, write a (?) with label under unknown.
(5) Above balanced equation, draw arrow from given to unknown.
(6) Divide given by its *MM*.
(7) Use molar ratios to solve for unknown
(8) Multiply by *MM* of unknown. Write answer in correct s.f.

mass_{gvn} (formula)	**1 mol**	**coefficient_{unk} (formula)**	**MM_{unk}**	**=**	**grams_{unk}**
	MM_{gvn}	**coefficient_{gvn} (formula)**	**1 mol**		

Stoichiometry
Topic#10

Mass to Mass

mass$_{gvn}$ (formula)	**1 mol**	**coefficient$_{unk}$ (formula)**	**MM$_{unk}$**	**=**	**grams$_{unk}$**
	MM$_{gvn}$	**coefficient$_{gvn}$ (formula)**	**1 mol**		

Mass to Mass Practice Problems

4. Tin (II) fluoride, SnF_2, is used in some toothpaste. It is made by the reaction of tin with hydrogen fluoride according to the following equation. $Sn + 2HF \rightarrow SnF_2 + H_2$ How many grams of SnF_2 are produced from the reaction of 30.00g of HF with Sn? (Ans: 117.5g SnF_2)

$Sn + \underset{30.0g}{2HF} \rightarrow \underset{?g}{SnF_2} + H_2$ mole ratio: 1:2:1:1

Gvn
30.00g HF

NTK
$mm_{HF} = 20.01\ g/mol$
$MM_{SnF_2} = 156.71\ g/mol$

UNK
mass SnF_2 = 117.5g

Solve:

30.00g $\cancel{HF}$	1 $\cancel{mol}$	1 SnF_2	156.71g	=	$\boxed{117.5g\ SnF_2}$
	20.01 $\cancel{g}$	2 $\cancel{HF}$	$\cancel{mol}$		

Stoichiometry
Topic#10

Mass to Mass

Mass to Mass Practice Problems

4. Tin (II) fluoride, SnF_2, is used in some toothpaste. It is made by the reaction of tin with hydrogen fluoride according to the following equation. $Sn + 2HF \rightarrow SnF_2 + H_2$ How many grams of SnF_2 are produced from the reaction of 30.00g of HF with Sn? (Ans: 117.5g SnF_2)

$$\text{mass}_{\text{gvn}} \text{ x } \left[\frac{(\text{coeff}_{\text{unk}})(MM_{\text{unk}})}{(\text{coeff}_{\text{gvn}})(MM_{\text{gvn}})}\right]$$

$$Sn + \underset{\text{gvn}}{2HF} \rightarrow \underset{\text{unk}}{SnF_2} + H_2$$

$$30.00g\ HF \left(\frac{(1)\ 156.71g}{(2)\ 20.01g}\right) = \boxed{117.5g\ SnF_2}$$

Mass to Mass

5. Laughing gas (nitrous oxide, N_2O) is sometimes used as an anesthetic in dentistry. It is produced when ammonium nitrate is decomposed according to the following reaction.

$$NH_4NO_3 \rightarrow N_2O + H_2O$$

(a) How many grams of NH_4NO_3 are required to produce 33.0g of N_2O? (Ans: 60.0g NH_4NO_3)

(b) How many grams of water are produced in this reaction? (Ans: 27.0g H_2O)

Gvn

33.0g N_2O

NTK

(A) (B)

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

? g 33.0g ? g

$MM_{NH_4NO_3}$: 80.06 g/mol

MM_{N_2O} : 44.02 g/mol

MM_{H_2O} = 18.02 g/mol

UNK

(A) $mass_{NH_4NO_3}$ = 60.0 g

(B) $mass_{H_2O}$ = 27.0 g

$$mass_{gvn} \text{ x } \left[\frac{(coeff_{unk})(MM_{unk})}{(coeff_{gvn})(MM_{gvn})}\right]$$

Solve:

(A) $33.0g\left(\frac{(1)(80.06)}{(1)(44.02)}\right) = \boxed{60.0g\ NH_4NO_3}$

(B) $33.0g\left(\frac{(2)(18.02)}{(1)(44.02)}\right) = \boxed{27.0g\ H_2O}$

Mass to Mass

$$\text{mass}_{\text{gvn}} \times \left[\frac{(\text{coeff}_{\text{unk}})(MM_{\text{unk}})}{(\text{coeff}_{\text{gvn}})(MM_{\text{gvn}})}\right]$$

6. (OYO) When copper metal is added to silver (I) nitrate in solution, silver metal and copper (II) nitrate are produced. What mass of silver is produced from 100.g of Cu? (Ans: 339g Ag)

Stoichiometry
Topic#10

Mass to Mass

$$\text{mass}_{\text{gvn}} \text{ x } \left[\frac{(\text{coeff}_{\text{unk}})(MM_{\text{unk}})}{(\text{coeff}_{\text{gvn}})(MM_{\text{gvn}})}\right]$$

7. (OYO) What mass of aluminum is produced by the decomposition of 5.0kg of Al_2O_3?

(Ans: 2.6kg of Al)

Stoichiometry
Topic#10

Mass to Mass

Limiting reactant (LR) - the reactant A_1 or A_2 that limits the amount of B.

Excess reactant (ER) - the reactant A_1 or A_2 that remains after all of the LR is consumed.

Jessica wants to make cookies for her classmates and her recipe makes 24 cookies per batch. She has 120 classmates. How many batches does she need to make? The recipe calls for 2 cups of sugar, 4 cups of flour, 2 eggs, 1 tablespoon of vanilla extract, and 1 cup of semi-sweet chocolate chips. When Jessica gathers all of the ingredients, she has 13 cups of sugar, 29 cups of flour, 11 eggs, 11 tablespoons of vanilla, and 7 cups of chocolate chips. Will Jessica be able to make any extra cookies? How many?

		Need	Have	Extra
2 cups sugar	**x 5 =**	**10**	**13**	**3**
4 cups flour	**x 5 =**	**20**	**29**	**9**
2 eggs	**x 5 =**	**10**	**11**	**1**
1 Tbsp	**x 5 =**	**5**	**11**	**6**
1 cup chips	**x 5 =**	**5**	**7**	**2**

$$1\text{ egg} \times \frac{1\text{ batch}}{2\text{ eggs}} \times \frac{24\text{ cookies}}{1\text{ batch}} = 12\text{ cookie}$$

Total cookies = 120 + 12 = 132 cookies

$$120\text{ cookies} \times \frac{1\text{ batch}}{24\text{ cookies}} = 5\text{ batches of cookies}$$

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown Moles

A_1(moles)	coefficent$_{unk}$	= moles of unk
	A_1 coefficient$_{gvn}$	

A_2 to Unknown Moles

A_2(moles)	coefficent$_{unk}$	= moles of unk
	A_2 coefficient$_{gvn}$	

The LR *produces* the LESSER of the two calculated unknown masses.

The excess reactant *produces* the GREATER of the two calculated unknown mases

Stoichiometry Sample WS#5 - Limiting/Excess Reactant Practice Problem

1. Silicon dioxide (quartz) is usually quite unreactive but reacts readily with hydrogen fluoride according to the following equation: $SiO_2(s) + 4HF(g) \rightarrow SiF_4(g) + 2H_2O(l)$. If 2.0mol of HF are exposed to 4.5 mol of SiO_2, which is the limiting reactant? Excess reactant? (Ans: HF/SiC_2)

$$\overset{A_1}{\underset{4.5\text{moles}}{SiO_2}} + \overset{A_2}{\underset{2.0\text{moles}}{4HF}} \rightarrow \underset{?}{SiF_4} + 2H_2O$$

SiO_2 is ER

(A_1) $4.5\text{moles } SiO_2 \times \frac{SiF_4}{SiO_2} = 4.5\text{moles } SiF_4$

(A_2) $2.0\text{moles } HF \times \frac{SiF_4}{4HF} = \boxed{0.5\text{moles } SiF_4}$

HF is LR

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown Moles

$$A_1(\text{moles})\left|\frac{\text{coefficent}_{\text{unk}}}{A_1\ \text{coefficient}_{\text{gvn}}}\right| = \text{moles of unk}$$

A_2 to Unknown Moles

$$A_2(\text{moles})\left|\frac{\text{coefficent}_{\text{unk}}}{A_2\ \text{coefficient}_{\text{gvn}}}\right| = \text{moles of un}$$

2. Some rocket engines use a mixture of hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2, as the propellant. The reaction is given by the following equation: $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$.
   (a) Which is the LR in this reaction when 0.750mol of N_2H_4 is mixed with 0.500mol of H_2O_2? (Ans: H_2O_2)
   (b) How much of the ER, in moles, remains unchanged? (Ans: 0.500mol N_2H_4
   (c) How much of each product, in moles, is formed? (Ans: 0.250mol N_2 and 1.00mol H_2O)

<u>Gvn</u>

0.750 mol N_2H_4

0.500 moles H_2O_2

<u>NTR</u>

$$\underset{0.750\ \text{mol}}{N_2H_4} + \underset{0.500\ \text{mol}}{2H_2O_2} \rightarrow N_2 + 4H_2O$$

(A)

$$0.750\ \text{mol}\ N_2H_4\left(\frac{(4)\ H_2O}{(1)\ N_2H_4}\right) = 3.00\ \text{moles}\ H_2O \begin{pmatrix} ER \\ N_2H_4 \end{pmatrix}$$

$$0.500\ \text{mol}\ \underset{\sim\sim}{H_2O_2}\left(\frac{(4)\ H_2O}{(2)\ H_2O_2}\right) = 1.00\ \text{moles}\ H_2O_2 \begin{pmatrix} LR \\ H_2O_2 \end{pmatrix}$$

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown Moles

$$A_1\text{(moles)} \left| \frac{\text{coefficent}_{\text{unk}}}{A_1 \text{ coefficient}_{\text{gvn}}} \right| = \text{moles of unk}$$

A_2 to Unknown Moles

$$A_2\text{(moles)} \left| \frac{\text{coefficent}_{\text{unk}}}{A_2 \text{ coefficient}_{\text{gvn}}} \right| = \text{moles of un}$$

2. Some rocket engines use a mixture of hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2, as the propellant. The reaction is given by the following equation: $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$.
   (a) Which is the LR in this reaction when 0.750mol of N_2H_4 is mixed with 0.500mol of H_2O_2? (Ans: H_2O_2)
   (b) How much of the ER, in moles, remains unchanged? (Ans: 0.500mol N_2H_4
   (c) How much of each product, in moles, is formed? (Ans: 0.250mol N_2 and 1.00mol H_2O)

<u>Gvn</u>

0.750 mol N_2H_4

0.500 moles H_2O_2

<u>NTR</u>

$N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$

0.750 mol   0.500 mol

(B) ER = ?

$$0.500 \text{ moles } H_2\cancel{O_2} \left(\frac{(1)\,N_2H_4}{(2)\,H_2\cancel{O_2}} \right) = 0.250 \text{ moles } N_2H_4 \text{ (used)}$$

total - used = excess

0.750 - 0.250 = <u>0.500 moles N_2H_4 in excess</u>

Limiting/Excess Reactant

A_1 to Unknown Moles

$$A_1(\text{moles}) \left|\, \frac{\text{coefficent}_{\text{unk}}}{A_1 \text{ coefficient}_{\text{gvn}}} \right| = \text{moles of unk}$$

A_2 to Unknown Moles

$$A_2(\text{moles}) \left|\, \frac{\text{coefficent}_{\text{unk}}}{A_2 \text{ coefficient}_{\text{gvn}}} \right| = \text{moles of un}$$

2. Some rocket engines use a mixture of hydrazine, N_2H_4, and hydrogen peroxide, H_2O_2, as the propellant. The reaction is given by the following equation: $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$.
   (a) Which is the LR in this reaction when 0.750mol of N_2H_4 is mixed with 0.500mol of H_2O_2? (Ans: H_2O_2)
   (b) How much of the ER, in moles, remains unchanged? (Ans: 0.500mol N_2H_4
   (c) How much of each product, in moles, is formed? (Ans: 0.250mol N_2 and 1.00mol H_2O)

<u>Gvn</u>

0.750 mol N_2H_4

0.500 moles H_2O_2

<u>NTR</u>

$N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$

0.750 mol   0.500 mol

(C) use LR (0.500 mol H_2O_2)

N_2 : 0.500 mol $H_2\cancel{O_2}$ $\left(\frac{(1)(N_2)}{(2)(\cancel{H_2O_2})}\right) = \boxed{0.250 \text{ mol } N_2}$

H_2O : 0.500 mol $H_2\cancel{O_2}$ $\left(\frac{(4)(H_2O)}{(2)(\cancel{H_2O_2})}\right) = \boxed{1.00 \text{ mol } H_2O}$

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown (grams)

A_1(grams)	coefficent$_{unk}$ x MM$_{unk}$	= ? grams of unk
	coefficient$_{A1}$ x MM$_{A1}$	

A_2 to Unknown (grams)

A_2(grams)	coefficent$_{unk}$ x MM$_{unk}$	= ? grams of
	coefficient$_{A2}$ x MM$_{A2}$	

3. If 5.6g of H_2 is reacted with 10.2g O_2, what mass of H_2O will be produced? (Ans: 11g H_2O)

Gvn

A_1: 5.6g H_2

A_2: 10.2g O_2

3 MM's

MM_{H_2} = 2.02

MM_{O_2} = 32.00

MM_{H_2O} = 18.02

NTK

$$\underset{5.6g}{2H_2} + \underset{10.2g}{O_2} \longrightarrow \underset{?g}{2H_2O}$$

Unk

mass$_{H_2O}$ = 11.5 g

Solve:

$$A_1: \quad 5.6g\left(\frac{(2)(18.02)}{(2)(2.02)}\right) = \underline{50.0g\ H_2O}$$

$$A_2: \quad 10.2g\left(\frac{(2)(18.02)}{(1)(32.00)}\right) = \boxed{11.5g\ H_2O}$$

* smallest amount produced is the correct answer.

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown (grams)

$$A_1\text{(grams)}\left|\frac{\text{coefficent}_{unk} \times MM_{unk}}{\text{coefficient}_{A1} \times MM_{A1}}\right| = \text{? grams of unk}$$

A_2 to Unknown (grams)

$$A_2\text{(grams)}\left|\frac{\text{coefficent}_{unk} \times MM_{unk}}{\text{coefficient}_{A2} \times MM_{A2}}\right| = \text{? grams o}$$

4. What mass of CO_2 will be produced form the combustion of 23.4g CH_4 with 49.8g O_2? The other product is H_2O. How many grams of the excess reactant is left after the reaction?

(Ans: 34.3g CO_2/10.9g CH_4)

Gvn

A_1: 23.4g CH_4 MM = 16.05

MM = 32

A_2: 49.8g O_2 MM_{CO_2} = 44.01

NTK

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Unk

mass_{CO_2} = ______ g

Solve:

$$A_1: \quad 23.4g\ CH_4 \left(\frac{(1)(44.01)}{(1)(16.05)}\right) = 64.2g$$

$$A_2: \quad 49.8g\ O_2 \left(\frac{(1)(44.01)}{(2)(32.00)}\right) = \boxed{34.2g}\ *$$

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown (grams)

$$\frac{A_1(\text{grams})}{} \left| \frac{\text{coefficent}_{unk} \times MM_{unk}}{\text{coefficient}_{A1} \times MM_{A1}} \right| = \text{? grams of unk}$$

A_2 to Unknown (grams)

$$\frac{A_2(\text{grams})}{} \left| \frac{\text{coefficent}_{unk} \times MM_{unk}}{\text{coefficient}_{A2} \times MM_{A2}} \right| = \text{? grams o}$$

4. What mass of CO_2 will be produced form the combustion of 23.4g CH_4 with 49.8g O_2? The other product is H_2O. How many grams of the excess reactant is left after the reaction?

(Ans: 34.3g CO_2/10.9g CH_4)

$mm_{CH_4} = 16.05$

$mm_{O_2} = 32.00$

$mm_{CO_2} = 44.01$

$$\underset{23.4g}{\overset{A}{CH_4}} + \underset{49.8}{\overset{B}{\boxed{2O_2}}} \rightarrow \underset{?}{CO_2} + 2H_2O$$

CH_4 O_2

$64.2 - 34.2 = 30g\ CO_2$

excess product related to the ER

excess: $30.\textcircled{0}\ CO_2 \left(\frac{(1)(16.05)}{(1)(44.01)} \right) = \boxed{10.9g\ CH_4 \text{ in excess}}$

Stoichiometry
Topic#10

Limiting/Excess Reactant

A_1 to Unknown (grams)

A_1(grams)	coefficent$_{unk}$ x MM$_{unk}$	=	? grams of unk
	coefficient$_{A1}$ x MM$_{A1}$		

A_2 to Unknown (grams)

A_2(grams)	coefficent$_{unk}$ x MM$_{unk}$	=	? grams of
	coefficient$_{A2}$ x MM$_{A2}$		

5. (OYO) If 0.345g Sb are reacted with 0.928g of C_2 to produce Sb_2O_5, how much Sb_2O_5 can be produced? (The reactionis a synthesis reaction) (Ans: 0.458g Sb_2O_5)
(Ans: 0.814g O_2 extra)

Stoichiometry
Topic#10

Percent Yield

Theoretical yield - calculated using masses (calculated)

Actual yield - from an experiment (experimental)

$$\%\,\text{yield} = \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

Stoichiometry Sample WS#6 - Percent Yield Practice Problem

1. Determine the percent yield for the reaction between 12.1g of C with excess O_2 if 32.2g of CO_2 is recovered? (Ans: 72.7%)

Gvn

12.1g C (MM=12.01)

Excess O_2

32.2g CO_2 (MM=44.01)

(experimental)

NTK

$C + O_2 \longrightarrow CO_2$

$\%\,\text{yield} = \frac{\text{exp}}{\text{theo}} \times 100\%$

UNK

%yield = 72.7 %

Solve:

$$12.1\text{g C}\left(\frac{(1)(44.01)}{(1)(12.01)}\right) = 44.3\text{g } CO_2$$

(theo)

$$\%\,\text{yield} = \frac{\text{exp}}{\text{theo}} \times 100\% = \frac{32.2}{44.3} \times 100\% = \boxed{72.7\%}$$

Stoichiometry
Topic#10

Percent Yield

Theoretical yield - calculated using masses (calculated)
Actual yield - from an experiment (experimental)

$$\%\ \text{yield} = \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

2. If a reaction has a percent yield of 85.2% and the theoretical yield is 23.2g. What is the actual yield for the reaction? (Ans: 19.8g)

GUN

%yield = 85.2%

theo = 23.2g

NTK

$$\%\text{yield} = \frac{\text{exp}}{\text{theo}} \times 100\%$$

$$\text{dec} = \frac{\text{exp}}{\text{theo}}$$

UNK

actual(exp) = 19.8 g

Solve:

$$0.852 = \frac{\text{exp}}{23.2}$$

$$\text{exp} = (23.2)(0.852) = \boxed{19.8g}$$

Stoichiometry
Topic#10

Percent Yield

Theoretical yield - calculated using masses (calculated)

Actual yield - from an experiment (experimental)

$$\%\,\text{yield} = \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

3. If the reaction has a percent yield 74.5% and the actual yield is 58.7g. What is the theoretical yield for this reaction? (Ans: 78.8g)

GVN

%yield = 74.5 %

actual(exp) = 58.7g

NTK

$\%\text{yield} = \frac{\text{exp}}{\text{theo}} \times 100\%$

UNK

theo = 78.8 g

Solve:

$\text{dec} = \frac{\text{exp}}{\text{theo}}$

$(0.745) = \frac{58.7}{\text{theo}}$

$\text{theo} = \frac{58.7}{0.745} = \boxed{78.8\text{g}}$

Percent Yield

Theoretical yield - calculated using masses (calculated)

Actual yield - from an experiment (experimental)

$$\%\text{yield} = \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

4. (OYO)Determine the percent yield for the reaction between 3.74g of Na and 4.89g C_2 if 4.34g of Na_2O_2 is recovered. (Ans: 68.5%)