KEY

Stoichiometry – Moles, Mass, Molecules and Volume

Name - ________________

1.) __4__ NH_3 (g) + __5__ O_2 (g) → __6__ H_2O (g) + __4__ NO (g)

a.) What mass of NO (g) is produced when $2.00\ mol$ of NH_3 (g) are reacted with excess O_2 (g)?

Answer - $2.00\ mol\ NH_3 \times \frac{4\ mol\ NO}{4\ mol\ NH_3} \times \frac{30.01\ g\ NO}{1\ mol\ NO} = 60.0\ g\ NO$

b.) What mass of H_2O (g) is produced when $4.00\ mol$ of O_2 (g) are reacted with excess NH_3 (g)?

Answer - $4.00\ mol\ O_2 \times \frac{6\ mol\ H_2O}{5\ mol\ O_2} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = 86.5\ g\ H_2O$

c.) What volume of NH_3 (g) at STP is required to react with $3.00\ mol$ of O_2?

Answer - $3.00\ mol\ O_2 \times \frac{4\ mol\ NH_3}{5\ mol\ O_2} \times \frac{22.41\ L\ NH_3}{1\ mol\ NH_3} = 53.8\ L\ NH_3$

d.) What volume of NH_3 (g) at STP is required to react with $0.750\ mol$ of H_2O (g)?

Answer - $0.750\ mol\ H_2O \times \frac{4\ mol\ NH_3}{6\ mol\ H_2O} \times \frac{22.41\ L\ NH_3}{1\ mol\ NH_3} = 11.2\ L\ NH_3$

2.) ____ C_5H_{12} (l) + __8__ O_2 (g) → __5__ CO_2 (g) + __6__ H_2O (g)

a.) What mass of CO_2 (g) is produced when $100.0\ g$ of C_5H_{12} (l) is burned?

Answer - $100.0\ g\ C_5H_{12} \times \frac{1\ mol\ C_5H_{12}}{72.17\ g\ C_5H_{12}} \times \frac{5\ mol\ CO_2}{1\ mol\ C_5H_{12}} \times \frac{44.01\ g\ CO_2}{1\ mol\ CO_2} = 304.9\ g\ CO_2$

b.) What mass of O_2 is required to produce $60.0\ g$ of H_2O (l)?

Answer - $60.0\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\ g\ H_2O} \times \frac{8\ mol\ O_2}{6\ mol\ H_2O} \times \frac{32.00\ g\ O_2}{1\ mol\ O_2} = 142\ g\ O_2$

c.) What mass of C_5H_{12} (l) is required to produce $90.0\ L$ of CO_2 (g) at STP?

Answer - $90.0\ g\ CO_2 \times \frac{1\ mol\ CO_2}{22.41\ L\ CO_2} \times \frac{1\ mol\ C_5H_{12}}{5\ mol\ CO_2} \times \frac{72.17\ g\ CO_2}{1\ mol\ C_5H_{12}} = 58.0\ g\ C_5H_{12}$

d.) What volume of O_2 (g) at STP is required to produce $70.0\ g$ of CO_2 (g)?

Answer - $70.0\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} \times \frac{8\ mol\ O_2}{5\ mol\ CO_2} \times \frac{22.41\ L\ O_2}{1\ mol\ O_2} = 57.0\ L\ O_2$

e.) What volume of O_2 (g) at STP is required to produce $48.0\ L$ of CO_2 (g) at STP?

Answer - $48.0\ L\ CO_2 \times \frac{1\ mol\ CO_2}{22.41\ L\ CO_2} \times \frac{8\ mol\ O_2}{5\ mol\ CO_2} \times \frac{22.41\ L\ O_2}{1\ mol\ O_2} = 76.8\ L\ O_2$

f.) What mass of H_2O (l) is made when the burning of C_5H_{12} gives $106\ L$ of CO_2 (g) at STP?

Answer - $106\ L\ CO_2 \times \frac{1\ mol\ CO_2}{22.41\ L\ CO_2} \times \frac{6\ mol\ H_2O}{5\ mol\ CO_2} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = 102\ g\ H_2O$

3.) Tetraethyl lead, $Pb(C_2H_5)_4$, is an "antiknock" ingredient which was added to some gasoline. Tetraethyl lead burns according to this equation

$$2\ Pb(C_2H_5)_4\ (l) + 27\ O_2\ (g) \rightarrow 2\ PbO\ (s) + 16\ CO_2\ (g) + 20\ H_2O\ (g)$$

a.) What volume of O_2 (g) at STP is consumed when $100.0\ g$ of PbO (s) are formed?

Answer - $100.0\ g\ PbO \times \frac{1\ mol\ PbO}{223.2\ g\ PbO} \times \frac{27\ mol\ O_2}{2\ mol\ PbO} \times \frac{22.41\ L\ O_2}{1\ mol\ O_2} = 135.5\ L\ O_2$

b.) How many molecules of CO_2 are formed when $1.00 \times 10^{-6}\ g$ of tetraethyl lead are burned?

Answer - $1.00 \times 10^{-6} g\ Pb(C_2H_5)_4 \times \frac{1\ mol\ Pb(C_2H_5)_4}{323.48\ g\ Pb(C_2H_5)_4} \times \frac{16\ mol\ CO_2}{2\ mol\ Pb(C_2H_5)_4} \times \frac{6.022\times10^{23} molec\ CO_2}{1\ mol\ CO_2} =$

$$1.49 \times 10^{16}\ molec\ CO_2$$

c.) How many molecules of H_2O are formed when $135\ molecules$ of O_2 react?

Answer - $135\ molec\ O_2 \times \frac{1\ mol\ O_2}{6.022\times10^{23} molec\ O_2} \times \frac{20\ mol\ H_2O}{27\ mol\ O_2} \times \frac{6.022\times10^{23} molec\ H_2O}{1\ mol\ H_2O} = 100.\ molec\ H_2O$

d.) What volume of O_2 (g) at STP, in mL, is required to react with $1.00 \times 10^{15}\ molecules$ of tetraethyl lead?

Answer - $1.00 \times 10^{15} g\ Pb(C_2H_5)_4 \times \frac{1\ mol\ Pb(C_2H_5)_4}{6.022\times10^{23} molec\ Pb(C_2H_5)_4} \times \frac{27\ mol\ O_2}{2\ mol\ Pb(C_2H_5)_4} \times \frac{22.41\ L\ CO_2}{1\ mol\ O_2} =$

$$5.02 \times 10^{-7} L\ O_2 \quad or \quad 5.02 \times 10^{-4}\ mL\ O_2$$

4.) Nitromethane, a dragster fuel, burns according to the following reaction

_4_ CH_3NO_2 (l) + _3_ O_2 (g) → _4_ CO_2 (g) + _6_ H_2O (g) + _2_ N_2 (g)

a.) What mass of H_2O (g) is produced when $0.150\ g$ of CH_3NO_2 (l) is burned?

Answer - $0.150\ g\ CH_3NO_2 \times \frac{1\ mol\ CH_3NO_2}{61.05 g\ CH_3NO_2} \times \frac{6\ mol\ H_2O}{4\ mol\ CH_3NO_2} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = 0.0664\ g\ H_2O$

b.) What combined volume of gas at STP is produced if $0.316\ g$ of CH_3NO_2 (l) is burned?

Answer - $0.316\ g\ CH_3NO_2 \times \frac{1\ mol\ CH_3NO_2}{61.05g\ CH_3NO_2} \times \frac{12\ mol\ gas}{4\ mol\ CH_3NO_2} \times \frac{22.41\ L\ gas}{1\ mol\ gas} = 0.348\ L\ gas$

c.) What volume of O_2 (g) at STP is required to produce $0.250\ g$ of CO_2 (g)?

Answer - $0.250\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} \times \frac{3\ mol\ O_2}{4\ mol\ CO_2} \times \frac{22.41\ L\ O_2}{1\ mol\ O_2} = 0.0955\ L\ O_2$

d.) What mass of H_2O (l) is produced when $0.410\ g$ of CO_2 is produced?

Answer - $0.410\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} \times \frac{6\ mol\ H_2O}{4\ mol\ CO_2} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = 0.252\ g\ H_2O$

5.) A sample of high purity silicon is prepared by strongly heating of hydrogen and silicon tetrachloride in a sealed tube: ___ $SiCl_4$ (g) + _2_ H_2 (g) → ___ Si (s) + _4_ HCl (g)

If exactly $1.00\ g$ of silicon is required, what mass of each of $SiCl_4$ (g) and H_2 (g) must react?

Answer - $1.00\ g\ Si \times \frac{1\ mol\ Si}{28.09\ g\ Si} \times \frac{1\ mol\ SiCl_4}{1\ mol\ Si} \times \frac{169.89\ g\ SiCl_4}{1\ mol\ SiCl_4} = 6.05\ g\ SiCl_4$

Answer - $1.00\ g\ Si \times \frac{1\ mol\ Si}{28.09\ g\ Si} \times \frac{2\ mol\ H_2}{1\ mol\ Si} \times \frac{2.02\ g\ H_2}{1\ mol\ H_2} = 0.144\ g\ H_2$

6.) Hydrazine, N_2H_4, is a rocket fuel which is prepared according to the reaction

_2_ NH_3 (aq) + ___ NaOCl (aq) → ___ N_2H_4 (aq) + ___ NaCl (aq) + ___ H_2O (l)

NaOCl is common "bleach" and NH_3 (aq) is prepared by passing NH_3 (g) into water. If $1.25 \times 10^4\ kg$ of hydrazine is required, how many litres of ammonia gas, at STP, is required in the reaction?

Answer - $1.25 \times 10^7 g\ N_2H_4 \times \frac{1\ mol\ N_2H_4}{32.06\ g\ N_2H_4} \times \frac{2\ mol\ NH_3}{1\ mol\ N_2H_4} \times \frac{22.41\ L\ NH_3}{1\ mol\ NH_3} = 1.75 \times 10^7 L\ NH_3$

7.) One of the most efficient drying agents known as P_4O_{10} will even remove water from pure H_2SO_4 to produce SO_3 in the manner shown. P_4O_{10} (s) + 6 H_2SO_4 (l) → 4 H_3PO_4 (aq) + 6 SO_3 (g)

Pure H_2SO_4 (l) has a density of $1.84 \frac{g}{mL}$. If $25.0\ mL$ of H_2SO_4 (l) react, what mass of P_4O_{10} also reacts and what volume of SO_3 (g) at STP is produced?

Answer - $25.0\ mL\ H_2SO_4 \times \frac{1.84\ g\ H_2SO_4}{1\ mL\ H_2SO_4} \times \frac{1\ mol\ H_2SO_4}{98.08\ g\ H_2SO_4} \times \frac{1\ mol\ P_4O_{10}}{6\ mol\ H_2SO_4} \times \frac{283.88\ g\ P_4O_{10}}{1\ mol\ P_4O_{10}} = 22.18566\ g\ P_4O_{10}$

$25.0\ mL\ H_2SO_4 \times \frac{1.84\ g\ H_2SO_4}{1\ mL\ H_2SO_4} \times \frac{1\ mol\ H_2SO_4}{98.08\ g\ H_2SO_4} \times \frac{6\ mol\ SO_3}{6\ mol\ H_2SO_4} \times \frac{22.41\ L\ SO_3}{1\ mol\ SO_3} = 10.5\ L\ SO_3$

8.) Ozone, O_3, in the upper atmosphere protects the earth from the sun's harmful ultraviolet radiation. One step in the destruction of the ozone layer by chlorine-containing compounds is

$$\_\_\_ \; Cl_{(g)} + \_\_\_ \; O_{3\,(g)} \rightarrow \_\_\_ \; ClO_{(g)} + \_\_\_ \; O_{2\,(g)}$$

The volume of the ozone is estimated to be $1.5 \times 10^{15}\ L$ at STP. Each Chlorine atom is continually "recycled" so as to be capable of destroying an average of about $1.0 \times 10^{5}\ molecules$ of ozone. What mass of chlorine atoms would be required to destroy the available ozone if no repair occurred?

Answer - $1.5 \times 10^{15} L\ O_3 \times \frac{1\ mol\ O_3}{22.41\ L\ O_3} \times \frac{6.022\times10^{23} molec\ O_3}{1\ mol\ O_3} \times \frac{1\ atom\ Cl}{1.0\times10^{5} molec\ O_3} \times \frac{1\ mol\ Cl}{6.022\times10^{23} atom\ Cl} \times \frac{35.45\ g\ Cl}{1\ mol\ Cl} =$

$$2.37 \times 10^{10} g\ Cl$$

9.) What is the molar mass of Q if $0.150\ mol$ of R_4 and $143.8\ g$ of Q_2 react completely to yield RQ_3 as the only product? $6\ Q_2 + R_4 \rightarrow 4\ RQ_3$

Answer - $0.150\ mol\ R_4 \times \frac{6\ mol\ Q_2}{1\ mol\ R_4} = 0.900\ mol\ Q_2$ $\quad \frac{143.8\ g\ Q_2}{0.0900\ mol\ Q_2} = 159.7777 \frac{g}{mol}\ Q_2$ $\quad \frac{159.7777 \frac{g}{mol}}{2}\ Q_2$

$79.9 \frac{g}{mol}\ Q$ which corresponds to Bromine.

10.) Mercury (II) oxide decomposes when heated. $\_2\_\ HgO_{(s)} \rightarrow \_2\_\ Hg_{(l)} + \_\_\ O_{2\,(g)}$

What mass of HgO decomposes to yield one-third as many atoms as there are in $100.0\ g$ of neon gas?

Answer - $100.0\ g\ Ne \times \frac{1\ mol\ Ne}{20.18\ g\ Ne} \times \frac{6.022\times10^{23} atom\ Ne}{1\ mol\ Ne} = 2.98 \times 10^{24} \div 3 = 9.94714 \times 10^{23}\ atoms\ Ne$

$9.94714 \times 10^{23}\ atoms\ Ne \times \frac{1\ mol\ product}{6.022\times10^{23} atom\ Ne} \times \frac{2\ mol\ HgO}{3\ mol\ products} \times \frac{216.59\ g\ HgO}{1\ mol\ HgO} = 238.5\ g\ HgO$

11.) When $7.682\ g$ of $XZO_{3\,(s)}$ is heated, $2.208\ g$ of $O_{2\,(g)}$ and $5.474\ g$ of $XZ_{(s)}$ are formed. When XZ is mixed with $AgNO_{3\,(aq)}$, all the XZ reacts to form $8.639\ g$ of $AgZ_{(s)}$. Find the molar masses of X and Z.

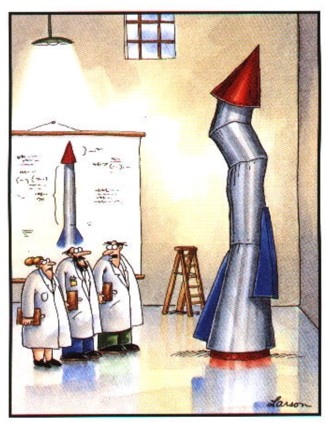
Answer – 1.) balance both equations 2.) find mol XZ

3.) find mol. mass of XZ 4.) find mol. mass of AgZ

$\_2\_\ XZO_{3\,(s)} \rightarrow \_3\_\ O_{2\,(g)} + \_2\_\ XZ_{(s)}$

$XZ_{(s)} + AgNO_{3\,(aq)} \rightarrow \_\_\ AgZ_{(s)} + XNO_{3\,(s)}$

$2.208\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g\ O_2} \times \frac{2\ mol\ XZ}{3\ mol\ O_2} = 0.04600\ mol\ XZ$



"It's time we face reality, my friends. ... We're not exactly rocket scientists."

$\frac{5.474\ g}{0.04600\ mol} = 119.0 \frac{g}{mol}\ XZ$ $\quad 5.474\ g\ XZ \times \frac{1\ mol\ XZ}{119.0\ g\ XZ} \times \frac{1\ mol\ AgZ}{1\ mol\ XZ} = 0.04600\ mol\ AgZ$

$\frac{8.639\ g}{0.04600\ mol} = 187.804\frac{g}{mol}\ AgZ$ $\quad 187.8 - 107.9 = 79.9\frac{g}{mol}\ Z$ $\quad 119 - 79.9 = 39.1\frac{g}{mol}\ X$