INTRODUCTION TO NATURAL SCIENCE 2006/07

CHEMISTRY HOMEWORK - SPRING - WEEK 2

Chapter 12

(5)

$P_1 = 67.5$ torr
$V_1 = 500.$ mL

$\longrightarrow$

$P_2 = ?$
$V_2 = 125$ mL

T and n are constants (Boyle's law can be applied)

$$P_1V_1 = P_2V_2$$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(67.5\text{ torr})(500\text{ mL})}{(125\text{ mL})}$$

$$= 270\text{ torr}$$

(7)

$V_1 = 3.5$ L
$T_1 = 22.0^\circ C = 295$ K

$V_2 = ?$
$T_2 = 37^\circ C = 310$ K

P and n are constants. Charles's law can be applied

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad V_2 = \frac{V_1}{T_1} \cdot T_2$$

$$V_2 = \frac{(3.5\text{ L})(310\text{ K})}{(295\text{ K})} = 3.68\text{ L}$$

(10)

$V_1 = 25.0\ mL$
$T_1 = 20.5°C = 293.5\ K$
$P_1 = 436.5\ torr$

flask A

$P_2 = 94.3\ torr$
$T_2 = 24.5°C = 297.5\ K$
$V_2 = ?$

flask B

$P_1 V_1 = nRT_1$

$$\frac{P_1 V_1}{T_1} = nR \quad \text{—①}$$

$$\frac{P_2 V_2}{T_2} = nR \quad \text{—②}$$

① and ② $\Rightarrow$ $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$$V_2 = \left(\frac{P_1 V_1}{T_1}\right)\left(\frac{T_2}{P_2}\right) = \frac{(436.5\ atm)(25.0\ mL)(297.5\ K)}{(293.5\ K)(94.3\ torr)}$$

$$= \underline{117.29\ mL}$$

(12)

$V_1 = 135\ mL$
$T_1 = 22.5°C = 295.5\ K$
$P_1 = 165\ mm\ Hg$

$P_2 = ?$
$V_2 = 252\ mL$
$T_2 = 0°C = 273\ K$

$$\frac{P_1 V_1}{T_1} = nR \quad \text{—①}$$

$$\frac{P_2 V_2}{T_2} = nR \quad \text{—②}$$

① and ② $\Rightarrow$ $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$$P_2 = \left(\frac{P_1 V_1}{T_1}\right)\left(\frac{T_2}{V_2}\right)$$

$$= \frac{(165\ \text{torr})(135\ \text{mL})(273\ \text{K})}{(295.5\ \text{K})(252\ \text{mL})} = \underline{81.66\ \text{torr}}$$

(16) $$2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(g)$$

$5.2\ L$

moles of $C_2H_6 = \frac{P_1 V_1}{RT} = \frac{P(5.2\ L)}{RT}$

moles of O_2 required = (moles of C_2H_6) $\left(\frac{7\ \text{mol}\ O_2}{2\ \text{mol}\ C_2H_6}\right)$

$$= \frac{P(5.2\ L)}{RT}\left(\frac{7}{2}\right) = \frac{P(18.2\ L)}{RT}$$

~~Volume~~ moles of O_2 required $(n) = \frac{PV}{RT}$ where V = volume of O_2

$\therefore \frac{PV}{RT} = \frac{P(18.2\ L)}{RT} \Rightarrow \underline{V = 18.2\ L}$

moles of $H_2O(g)$ produced = (moles C_2H_6) $\left(\frac{6\ \text{mol}\ H_2O(g)}{2\ \text{mol}\ C_2H_6}\right)$

$$= \frac{P(5.2\ L)}{RT} \cdot \left(\frac{6}{2}\right) = \frac{P(15.6\ L)}{RT}$$

moles of $H_2O(g)$ Produced = $\frac{PV}{RT}$ (V = volume of H_2O)

$$\frac{PV}{RT} = \frac{P(15.6\ L)}{RT} \Rightarrow \underline{V = 15.6\ L}$$

(19) mass of CO_2 = 2.2 g

T = 22°C = 295 K

P = 318 torr

V = ?

moles of CO_2 = $2.2\,g \times \left(\frac{mol}{44.01\,g}\right) = 4.999 \times 10^{-2}\ mol$

$PV = nRT \Rightarrow V = \frac{nRT}{P}$

$V = \frac{(4.999 \times 10^{-2}\ mol)(0.08206\ atm\,L\,K^{-1}\,mol^{-1})(295\,K)}{(318\ torr)} \times \left(\frac{760\ torr}{1\ atm}\right)$

$= \underline{\underline{2.89\ L}}$

(22) P = 1.1 atm V = 5.0 L T = 25°C = 298 K

$PV = nRT \Rightarrow n = \frac{PV}{RT}$

$n = \frac{(1.1\ atm)(5.0\,L)}{(0.08206\ atm\,L\,K^{-1}\,mol^{-1})(298\,K)} = 0.2249\ mol$

$0.2249\ mol \times \left(\frac{4.0026\,g}{1\,mol}\right) = \underline{\underline{0.900\,g\ of\ He}}$

(24) P = 233 torr T = 298 K d = ?

$d = \frac{PM}{RT}$ M = molar mass

$M\ (g/mol) = [4(12.011) + 10(1.008) + 15.99]\ g/mol$

$$d = \frac{(233\ \text{torr})(74.114\ \text{g mol}^{-1})}{(0.08206\ \text{atm L K}^{-1}\ \text{mol}^{-1})(298\ \text{K})} \cdot \left(\frac{\text{atm}}{760\ \text{torr}}\right)$$

$$d = \cancel{706} \quad \underline{\underline{0.929\ \text{g/L}}}$$

(27) $PV = nRT \qquad n = \frac{PV}{RT} \qquad T = 23^\circ C = 296\ K$

$$n = \frac{(715\ \text{torr})(452\ \text{mL})}{(0.08206\ \text{atm L K}^{-1}\ \text{mol}^{-1})(296\ \text{K})} \times \left(\frac{1\ \text{atm}}{760\ \text{torr}}\right)\left(\frac{\text{L}}{10^3\ \text{mL}}\right)$$

$$n = 1.75 \times 10^{-2}\ \text{mol}$$

mass of sample = 1.007 g

$$\text{molar mass} = \frac{\text{mass}}{\#\ \text{moles}} = \frac{1.007\ \text{g}}{1.75 \times 10^{-2}\ \text{mol}} = \underline{\underline{57.5\ \text{g/mol}}}$$

(28) $$n = \frac{PV}{RT} = \frac{(13.7\ \text{torr})(165\ \text{mL})}{(0.08206\ \text{atm L K}^{-1}\ \text{mol}^{-1})(295.5\ \text{K})} \times \left(\frac{1\ \text{atm}}{760\ \text{torr}}\right)\left(\frac{\text{L}}{10^3\ \text{mL}}\right)$$

$$= 1.227 \times 10^{-4}\ \text{mol}$$

mass = 0.0125 g

$$\text{molar mass} = \frac{0.0125\ \text{g}}{1.227 \times 10^{-4}\ \text{mol}} = 101.91\ \text{g/mol}$$

empirical formula $[CHF_2]$ mass $= [12.011 + 1.008 + 2(18.998)]\ \text{g}$

$= 51.015\ \text{g}$

$$\left.\begin{array}{l}\#\ \text{of empirical formula units} \\ \text{in molecular formula}\end{array}\right\} = \frac{101.91}{51.015} = 2$$

∴ Molecular formula = $2(CHF_2) = \underline{\underline{C_2H_2F_4}}$

(32) $SiH_4(g) + 2O_2(g) \longrightarrow SiO_2(s) + 2H_2O(\ell)$

5.20 L	425 torr
356 torr	298 K
298 K	V = ?

$$\#\text{ of moles } (n) \text{ of } SiH_4 = \frac{PV}{RT} = \frac{(356\text{ torr})(5.20\text{ L})}{(0.08206\text{ atm L K}^{-1}\text{mol}^{-1})(298\text{ K})}\left(\frac{1\text{ atm}}{760\text{ torr}}\right)$$

$$= 9.96 \times 10^{-2}\text{ mol}$$

$$\left.\begin{array}{l}\#\text{ of moles of } O_2 \text{ required}\\ \text{to react w/ silane}\end{array}\right\} = 9.96\times10^{-2}\text{ mol } SiH_4 \times \left(\frac{2\text{ mol } O_2}{1\text{ mol } SiH_4}\right)$$

$$= 0.1992\text{ mol } O_2$$

<u>For O_2</u> $\quad V = \dfrac{nRT}{P}$

$$V = \frac{(0.1992\text{ mol})(0.08206\text{ atm L K}^{-1}\text{mol}^{-1})(298\text{ K})}{(425\text{ torr})} \times \left(\frac{760\text{ torr}}{1\text{ atm}}\right)$$

$$= \underline{\underline{8.71\text{ L}}}$$

(34) $2\ C_8H_{18}(g) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$

$0.095\ g$ $\qquad V = 4.75\ L$

$P = ?$

molar mass of $C_8H_{18} = [8(12.011) + 18(1.008)]\ g/mol$

$= 114.232\ g/mol$

# of moles of $C_8H_{18} = \dfrac{0.095\ g}{114.232\ g/mol} = 8.32 \times 10^{-4}\ mol$

mol of H_2O produced $= 8.32 \times 10^{-4}\ mol\ C_8H_{18} \times \left(\dfrac{18\ mol\ H_2O}{2\ mol\ C_8H_{18}}\right)$

$= 7.48 \times 10^{-3}\ mol\ H_2O$

For $H_2O(g)$ $\qquad P = \dfrac{nRT}{V}$

$$P = \frac{(7.48 \times 10^{-3}\ mol)(0.08206\ atm\,L\,K^{-1}\,mol^{-1})(303\ K)}{(4.75\ L)}$$

$$P = 3.92 \times 10^{-2}\ atm$$

moles of O_2 required $= 8.32 \times 10^{-4}\ mol\ C_8H_{18} \times \left(\dfrac{25\ mol\ O_2}{2\ mol\ C_8H_{18}}\right)$

$= 0.0104\ mol\ O_2$ ~~0.0116~~

For $O_2(g)$ $\qquad P = \dfrac{nRT}{V}$

$$P = \frac{(0.0104\ mol)(0.08206\ atm\,L\,K^{-1}\,mol^{-1})(295\ K)}{(4.75\ L)}$$

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$P = \underline{0.053 \text{ atm}}$

(36) $4\ KO_2(s) + 2\ CO_2(g) \longrightarrow 2\ K_2CO_3(s) + 3\ O_2(g)$

8.90 L
767 torr
295 K

$$\#\text{ of moles } (n) \text{ of } CO_2 = \frac{PV}{RT}$$

$$= \frac{(767 \text{ torr})(8.90 \text{ L})}{(0.08206 \text{ atm L K}^{-1}\text{mol}^{-1})(295 \text{ K})} \left(\frac{1 \text{ atm}}{760 \text{ torr}}\right)$$

$$= 0.371 \text{ mol}$$

$$\left.\begin{array}{l}\text{moles of } KO_2 \text{ required} \\ \text{for the reaction}\end{array}\right\} = 0.371 \text{ mol } CO_2 \times \left(\frac{4 \text{ mol } KO_2}{2 \text{ mol } CO_2}\right)$$

$$= 0.742 \text{ mol } KO_2$$

$$\text{molar mass of } KO_2 = [39.0983 + 2(15.99)] \text{ g/mol}$$

$$= 71.0783 \text{ g/mol}$$

$$\therefore \text{ Mass of } KO_2 = 0.742 \text{ mol } KO_2 \times \left(\frac{71.0783 \text{ g}}{\text{mol}}\right)$$

$$= \underline{52.74 \text{ g } KO_2}$$

(39) Total pressure = sum of partial pressures

$$P_{tot} = (170 + 570)\ \text{torr} = 740\ \text{torr}$$

$$P_i = \chi_i P_{total}$$

$$\chi_i = \frac{P_i}{P_{tot}}$$

$$\chi_{halothane} = \frac{170\ \text{torr}}{740\ \text{torr}} = 0.229 = \frac{n_{halothane}}{n_{tot}}$$

$$\chi_{O_2} = \frac{570\ \text{torr}}{740\ \text{torr}} = 0.771 = \frac{n_{O_2}}{n_{tot}}$$

$$\frac{n_{halothane}}{n_{tot}} : \frac{n_{O_2}}{n_{tot}} = 0.229 : 0.771$$

$$n_{halothane} : n_{O_2} = 0.229 : 0.771$$

$$= \underline{0.297}$$

mass of O_2 = 160 g

moles of O_2 = $160\ g \times \left(\frac{\text{mol}}{32\ g}\right)$ = 5 mol O_2

$$\chi_{O_2} = \frac{\text{mol of } O_2}{n_{tot}} = 0.771$$

$$\Rightarrow \frac{5\ \text{mol } O_2}{n_{tot}} = 0.771 \Rightarrow n_{tot} = 6.49\ \text{mol}$$

$$n_{tot} = n_{halothane} + n_{O_2}$$

$\therefore\ n_{halothane} = (6.49 - 5)\ mol = 1.49 mol$

molar mass of halothane $= [2(12.011) + 1.008 + 79.904 + 35.45 + 3(18.99)]\ g/mol$

$= 197.354\ g/mol$

mass of halothane $= 1.49 mol \times \left(\frac{197.354\ g}{mol}\right)$

$= 294.0\ g$

$= \underline{294\ g}$

(40) $T = 21.5^{\circ}C = 294.5\ K$

$V_1 = 12.5\ L$	$V_2 = 26\ L$
$P_1 = 1.00\ atm$	$P_2 = 1.00\ atm$
$T_1 = 294.5\ K$	$T_2 = 294.5 K$
He only	$He + O_2$

(a) <u>He only</u> $n_1 = \frac{P_1 V_1}{RT_1} = \frac{(1.00\ atm)(12.5\ L)}{(0.08206\ atm\ L\ K^{-1} mol^{-1})(294.5 K)}$

$n_1 = 0.517\ mol$ of He

mass of He $= 0.517 mol \times \left(\frac{4.00269\ g}{mol}\right) = \underline{2.070\ g}$

(b) <u>$He + O_2$ mixture</u> $n_2 = \frac{P_2 V_2}{RT_2}$

$$n_2 = \frac{(1.00\ \text{atm})(26\ \text{L})}{(0.08206\ \text{atm L K}^{-1}\text{mol}^{-1})(294.5\ \text{K})} = 1.076\ \text{mol}$$

= mol of He + mol of O_2

$\therefore$ mol of O_2 = n_2 − mol of He = $(1.076 - 0.517)$ mol

= 0.559 mol of O_2

$$\text{mole fraction of He} = \frac{\text{moles of He}}{\text{total moles}} = \frac{0.517\ \text{mol}}{1.076\ \text{mol}}$$

= 0.480

$$P_i = \chi_i P_{tot}$$

$$P_{He} = \chi_{He} P_{tot}$$

$= (0.480)\ 1.00\ \text{atm} =$ <u>0.480 atm</u>

(c) $P_{O_2} = \chi_{O_2} \cdot P_{tot} = \underbrace{\left(\frac{0.559}{1.076}\right)}_{\chi_{O_2}} 1\ \text{atm}$

= <u>0.519 atm</u>

(d) $\chi_{He} =$ <u>0.480</u> $\chi_{O_2} =$ <u>0.519</u>

(43) $\sqrt{\overline{u^2}} = \sqrt{\frac{3RT}{M}}$ let $O_2 = 1$

$CO_2 = 2$

$\sqrt{\overline{u_1^2}} = \sqrt{\frac{3RT}{M_1}}$ —① $\sqrt{\overline{u_2^2}} = \sqrt{\frac{3RT}{M_2}}$ —②

$\frac{②}{①} \sqrt{\frac{\overline{u_2^2}}{\overline{u_1^2}}} = \sqrt{\frac{M_1}{M_2}}$

$\frac{\overline{u_2^2}}{\overline{u_1^2}} = \frac{M_1}{M_2} = \frac{32\ g\ mol^{-1}}{44\ g\ mol} = 0.727$

$\overline{u_2^2} = (0.727)\overline{u_1^2} = 0.727(4.28 \times 10^4\ cm\ s^{-1})$

$= 3.11 \times 10^4\ cm\ s^{-1} =$ ~~311 m s^{-1}~~

$=$ ~~310~~ $311\ m\ s^{-1}$