CHEM 1105 ANSWERS TO PROBLEM SET 3

1. $P_1V_1 = P_2V_2 \quad V_2 = \frac{P_1V_1}{P_2} = \frac{150 \text{ atm x } 10.0 \text{ L}}{1.00 \text{ atm}} = 1500 \text{ L}$

volume of helium at 1.00 atm = 1500 L; 10 L in the tank and 1490 L for the balloons. No. of balloons = 1490 L x = $\frac{1 \text{ balloon}}{1.50 \text{ L}}$ = 993

2. $\frac{V_2}{T_2} = \frac{V_1}{T_1} \quad V_2 = \frac{V_1T_2}{T_1} \quad V_1 = 250.00 \text{ mL} \quad T_1 = 273 \text{ K} \quad T_2 = 274 \text{ K}$

$V_2 = \frac{250.00 \text{ mL x } 274 \text{ K}}{273 \text{ K}} = 251 \text{ mL}$. Increase = 251-250 = 1 mL

3. (i) $\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad T_1 = 273 + 25 = 298 \text{ K} \quad T_2 = 273 + 75 = 348 \text{ K} \quad P_1 = 2.00 \text{ atm}$

$P_2 = \frac{P_1T_2}{T_1} = \frac{2.00 \text{ atm x } 348 \text{ K}}{298 \text{ K}} = 2.34 \text{ atm}$

(ii) $P_1 = 2.00 \text{ atm} \quad P_2 = 10.0 \text{ atm} \quad T_1 = 298 \text{ K}$

$T_2 = \frac{P_2T_1}{P_1} = \frac{10.0 \text{ atm x } 298 \text{ K}}{2.00 \text{ atm}} = 1490 \text{ K} = (1490\text{-}273)˚\text{C} = 1217˚\text{C}$

4. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad T_1 = 273 + 25 = 298 \text{ K} \quad T_2 = 273 + 200 = 473 \text{ K}$

$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{1.25 \text{ atm x } 1.00 \text{ L x } 473 \text{ K}}{298 \text{ K x } 4.00 \text{ L}} = 0.496 \text{ atm}$

$= 0.496 \text{ atm x } \frac{760 \text{ mm Hg}}{1 \text{ atm}} = 377 \text{ mm Hg}$

5. $PV = nRT = \frac{g}{MW} RT \quad V = \frac{gRT}{MW \text{ x } P}$

$V = \frac{3.00 \text{ x } 10^3 \text{ g x } 0.0821 \text{ L.atm/K.mole x } 373 \text{ K}}{44.0 \text{ g/mole x } 266 \text{ torr}} \text{ x } \frac{760 \text{ torr}}{1 \text{ atm}}$

$= 5.97 \text{ x } 10^3 \text{ L}$

6. $PV = \frac{g}{MW} RT \quad \text{density} = \frac{g}{V} = \frac{P \text{ x } MW}{RT} = \frac{0.750 \text{ atm x } 44.0 \text{ g/mole}}{0.0821 \text{ L.atm/K.mole x } 298 \text{ K}}$

$= 1.35 \text{ g/L}$

7. $P = \frac{g \text{ x } RT}{V \text{ x } MW} = \frac{dRT}{MW} = \frac{0.500 \text{ g/L x } 0.0821 \text{ L.atm/K.mole x } 323 \text{ K}}{28.0 \text{ g/mole}}$

$= 0.474 \text{ atm}$

8. $MW = \underline{g \text{ x } RT} = \underline{dRT} = \underline{0.572 \text{ g/L x } 0.0821 \text{ L.atm/K.mole x } 363 \text{ K}}$

V P P 380/760 atm

$= 34.1$ g/mole

9. $MW = \frac{gRT}{PV} = \frac{0.300 \text{ g} \times 0.0821 \text{ L.atm/K.mole} \times 423 \text{ K}}{0.998 \text{ atm} \times 0.1800 \text{ L}} = 58.0$ g/mole

10. (a) moles $CH_4 = 1.50 \text{ g } Al_4C_3 \times \frac{1 \text{ mole } Al_4C_3}{144 \text{ g } Al_4C_3} \times \frac{3 \text{ moles } CH_4}{1 \text{ mole } Al_4C_3}$

$= 0.03125$ mole CH_4

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

$V = \frac{0.03125 \text{ mole} \times 0.0821 \text{ L.atm/mole.K} \times 293 \text{ K}}{0.750 \text{ atm}} = 1.00$ L

(b) $n = \frac{PV}{RT} = \frac{743}{760} \text{ atm} \times \frac{0.487 \text{ L}}{0.0821 \text{ L.atm/K.mole} \times 318 \text{ K}}$

$= 0.018236$ mole CH_4

moles $Al_4C_3 = 0.018236 \text{ mole } CH_4 \times \frac{1 \text{ mole } Al_4C_3}{3 \text{ mole } CH_4} = 0.0060787$

No. of g $Al_4C_3 = 0.0060787 \text{ mole } Al_4C_3 \times \frac{144 \text{ g } Al_4C_3}{1 \text{ mole } Al_4C_3} = 0.875$ g

11. (a) Total pressure = (0.200 + 0.600) atm = 0.800 atm

(b) X_A (mole fraction of A) = $\frac{p_A}{P_{TOTAL}}$

$X_{CO} = \frac{0.200}{0.800 \text{ atm}} \text{ atm} = 0.250 \quad X_{CO_2} = 1 - 0.250 = 0.750$ atm

(c) $n_{TOTAL} = \frac{PV}{RT} = \frac{0.800 \text{ atm} \times 11.6 \text{ L}}{0.0821 \text{ L.atm/K.mole} \times 323 \text{ K}} = 0.350$ mole

(d) $n_A = X_A \times n_{TOTAL} \quad n_{CO} = 0.250 \times 0.350$ mole $= 0.0875$ mole

No. of g CO = 0.0875 mole CO x $\frac{28.0 \text{ g CO}}{1 \text{ mole CO}}$ = 2.45 g CO

$n_{CO_2} = 0.350 - 0.0875 = 0.2625$

No. of g $CO_2 = 0.2625 \text{ mole } CO_2 \times \frac{44.0 \text{ g } CO_2}{1 \text{ mole } CO_2} = 11.6 \text{ g } CO_2$

12. moles NaOH = 0.475 L x $\frac{1.085 \text{ moles NaOH}}{1 \text{ L}}$ = 0.5154 mole

moles $CO_2 = \frac{PV}{RT} = \frac{815}{760} \text{ atm} \times \frac{5.50 \text{ L}}{0.0821 \text{ L.atm/K.mole} \times 298 \text{ K}}$

$= 0.2411$ mole

moles NaOH needed by 0.2411 mole CO_2 =

0.2411 mole CO_2 x $\frac{2 \text{ moles NaOH}}{1 \text{ mole } CO_2}$ = 0.4822 mole NaOH

BUT, 0.5154 mole NaOH present; therefore, NaOH is in excess and CO_2 is the limiting reagent.

$$\text{moles } Na_2CO_3 = 0.2411 \text{ mole } CO_2 \times \frac{1 \text{ mole } Na_2CO_3}{1 \text{ mole } CO_2} = 0.2411 \text{ mole}$$

$$\text{No. of g } Na_2CO_3 = 0.2411 \text{ mole } Na_2CO_3 \times \frac{106.0 \text{ g } Na_2CO_3}{1 \text{ mole } Na_2CO_3}$$

$$= 25.6 \text{ g } Na_2CO_3$$