Chapters 1 - Homework Solutions

1.1 (a) $$4.5x10^{23}\ atoms\,O \cdot \frac{1\,molecule}{6\,atoms\,O} \cdot \frac{1\,mol}{6.02x10^{23}\ molecule} \cdot \frac{148.3\,g}{1\,mol} = 18.5\,g$$

(b) $$50\,g \cdot \frac{1\,mol}{114\,g} \cdot \frac{6.02x10^{23}\ molecule}{1\,mol} \cdot \frac{26\,atoms}{1\,mol} = 6.86x10^{24}\ atoms$$

1.2 M(CO_2) = 44 g/mol V = 7.5 L T = 258 K P = 142 torr x (1 kPa/7.50 torr) = 18.9 kPa

(a) $$n = \frac{PV}{RT} = \frac{(18.9\,kPa)(7.5\,L)}{(8.314\,J/mol \cdot K)(258\,K)} = 0.066\,mol$$

$$m = n \cdot M = 0.066\,mol \cdot 44\,g/mol = 2.9\,g$$

(b) $$N = nN_A = 0.066\,mol \cdot \frac{6.02x10^{23}\ molecules}{1\,mol} = 4.0x10^{22}\ molecules$$

1.3 M(Ne) = 20.2 g/mol V = 250 mL = 0.25 L T = 122 K

n = 0.255 g / 20.2 g/mol = 0.0126 mol

$$P = \frac{nRT}{V} = \frac{(0.0126\,mol)(8.314\,kPa \cdot L/mol \cdot K)(122\,K)}{3.0\,L} = 4.26\,kPa \cdot \frac{7.50\,torr}{1\,kPa} = 32.0\,torr$$

1.4 P = 24.5 kPa V = 250 mL = 0.250 L T = 19.5 ^oC = 292.5 K

$$n = \frac{PV}{RT} = \frac{(24.5\,kPa)(0.250\,L)}{(8.314\,kPa \cdot L/mol \cdot K)(292.5\,K)} = 2.52x10^{-3}\ mol$$

1.5 P_1 = 125 kPa T_1 = 18 ^oC = 291 K P_2 = ?? T_2 = 700 ^oC = 973 K

$$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \ \rightarrow\ \frac{P_2}{T_2} = \frac{P_1}{T_1}$$ because V doesn't change

$$P_2 = P_1 \cdot \frac{T_2}{T_1} = 125\,kPa \cdot \frac{973\,K}{291\,K} = 418\,kPa$$

1.6 V_1 = 1.0 L T_1 = 22.2 ^oC = 295.2 K V_2 = 100 mL = 0.10 L T_2 = ??

$$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \ \rightarrow\ \frac{V_2}{T_2} = \frac{V_1}{T_1}$$ because P doesn't change

$$T_2 = T_1 \cdot \frac{V_2}{V_1} = 295.2\,K \cdot \frac{0.10\,L}{1.0\,L} = 29.5\,K = -243.5\,^oC$$

1.7 P_1 = 104 kPa V_1 = 2.0 m^3 T_1 = 21.1 ºC = 294.1 K

(a) P_2 = 52 kPa T_2 = -5 ºC = 268 K V_2 = ??

$$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \rightarrow V_2 = V_1 \cdot \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} = 2.0\,m^3 \cdot \frac{104\,kPa}{52\,kPa} \cdot \frac{268\,K}{294.1\,K} = 3.65\,m^3$$

(b) P_2 = 880 Pa = 0.88 kPa T_2 = -52 ºC = 221 K V_2 = ??

$$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \rightarrow V_2 = V_1 \cdot \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} = 2.0\,m^3 \cdot \frac{104\,kPa}{0.88\,kPa} \cdot \frac{221\,K}{294.1\,K} = 178\,m^3$$

1.8 P_1 = 1 bar = 100 kPa T_1 = 20 ºC = 293 K r_1 = 1 m $V_1 = \frac{4}{3}(3.1416)(1.0\,m)^3 = 4.19\,m^3$

P_2 = ?? T_2 = -20 ºC = 253 K r_2 = 3 m $V_2 = \frac{4}{3}(3.1416)(3.0\,m)^3 = 113\,m^3$

$$\frac{P_2V_2}{T_2} = \frac{P_1V_1}{T_1} \rightarrow P_2 = P_1 \cdot \frac{V_1}{V_2} \cdot \frac{T_2}{T_1} = 100\,kPa \cdot \frac{4.19\,m^3}{113\,m^3} \cdot \frac{253\,K}{293\,K} = 3.2\,kPa$$

1.9 V_1 = 0.78 L P_1 = 1.0 bar T_1 = 21 ºC = 294 K
V_2 = ?? P_2 = 0.87 bar T_2 = 37 ºC = 310 K

$$V_2 = V_1 \cdot \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} = 0.78\,L \cdot \frac{1.0}{0.87} \cdot \frac{310}{294} = 0.95\,L$$

1.10 V = 250 mL = 0.25 L T = 298 K P = 152 torr x 1 kPa/7.50 torr = 20.3 kPa
mass = 33.5 mg = 3.35×10^{-2} g

We'll first use the PG Law to calculate the number of moles:

$$n = \frac{PV}{RT} = \frac{(20.3\,kPa)(0.25\,L)}{(8.314\,kPa \cdot L/mol \cdot K)(298\,K)} = 2.05x10^{-3}\,mol$$

Then, we calculate the Molar Mass: $M = \frac{mass}{n} = \frac{3.35x10^{-2}\,g}{2.05x10^{-3}\,mol} = 16.3\,g/mol$

1.11 Assume 100 g: M(He) = 15.0 g m(Ar) = 85.0 g
T = 50 ºC = 323 K P = 4.0 bar x 100 kPa/bar = 400 kPa

$$n(He) = \frac{m(He)}{M(He)} = \frac{15.0\,g}{4.0\,g/mol} = 3.75\,mol$$

$$n(Ar) = \frac{m(Ar)}{M(Ar)} = \frac{85.0\,g}{40\,g/mol} = 2.13\,mol$$

n(tot) = 3,75+2,13 = 5.88 mol

$$X(He) = \frac{n(He)}{n(tot)} = \frac{3.75\,mol}{5.88\,mol} = 0.64$$

$$P(He) = X(He) \cdot P = 0.64 \cdot 4.0\,bar = 2.56\,bar \cdot \frac{100\,kPa}{1\,bar} = 256\,kPa$$

$$X(Ar) = \frac{n(Ar)}{n(tot)} = \frac{2.13\,mol}{5.88\,mol} = 0.36$$

$$P(Ar) = X(Ar) \cdot P = 0.36 \cdot 4.0\,bar = 1.44\,bar \cdot \frac{100\,kPa}{1\,bar} = 144\,kPa$$

$$Note: P(x)V = n(x)RT \rightarrow \frac{n(x)}{V} = c(x) = \frac{P(x)}{RT}$$

$$c(He) = [He] = \frac{P(He)}{RT} = \frac{256\,kPa}{(8.31\,kPa \cdot L/mol \cdot K)(323\,K)} = 0.095\,mol/L$$

$$c(Ar) = [Ar] = \frac{P(Ar)}{RT} = \frac{144\,kPa}{(8.31\,kPa \cdot L/mol \cdot K)(323\,K)} = 0.054\,mol/L$$

1.12 $t(O_2)$ = 17.8 min $M(O_2)$ = 32 g/mol t(X) = 12.6 min M(X) = ??

$$\frac{t(X)}{t(O_2)} = \sqrt{\frac{M(X)}{M(O_2)}} \rightarrow \sqrt{\frac{M(X)}{32\,g/mol}} = \frac{12.6}{17.8} = 0.71 \rightarrow \frac{M(X)}{32\,g/mol} = (0.71)^2 = 0.50$$

Therefore M(X) = 0.50 x 32 g/mol = 16 g/mol

1.13 (a) $c(N_2)$ = 515 m/s $M(N_2)$ = 28 g/mol $c(H_2)$ = ?? $M(H_2)$ = 2 g/mol

$$\frac{c(H_2)}{c(N_2)} = \sqrt{\frac{M(N_2)}{M(H_2)}} \rightarrow \frac{c(H_2)}{515} = \sqrt{\frac{28}{2}} = 3.74$$

Therefore, $c(H_2)$ = 3.74 x 515 m/s = 1930 m/s

(b) T_1 = 298 K c_1 = 515 T_2 = 1473 K c_2 = ??

$$\frac{c_2}{c_1} = \sqrt{\frac{T_2}{T_1}} \rightarrow \frac{c_2}{515} = \sqrt{\frac{1473}{298}} = 2.22$$

Therefore, c_2 = 2.22 x 515 m/s = 1150 m/s