Ch 2 solutions

18) $\frac{nR}{V} = \frac{P_{gauge} + P_{atm}}{T} = \frac{2.5 \cdot 10^5 \, N/m^2 + 1.013 \cdot 10^5 \, N/m^2}{308.15\,k}$

$= 1140.03 \, \frac{N}{m^2 \cdot k}$

$P' = \frac{nR}{V} T' = 1140.03 \frac{N}{m^2 \cdot k} \cdot 233.15 = 2.658 \cdot 10^5 \, N/m^2$

$P'_{jauge} = P' - P_{atm} = \boxed{1.645 \, N/m^2}$

31) a) $\frac{nR}{V} = \frac{P}{T} = \frac{1.40 \cdot 10^7 \, N/m^2}{298.15\,k} = 4.696 \cdot 10^4 \, N/m^2 \cdot k$

$P' = \frac{nR}{V} T' = 4.696 \cdot 10^4 \, N/m^2 \cdot k \cdot 194.65\,k = \boxed{9.140 \cdot 10^6 \, \frac{N}{m^2}}$

b) $P'' = 0.9 P' = \boxed{8.226 \cdot 10^5 \, N/m^2}$

c) $T''' = \frac{P'''}{nR/V} = \frac{1.013 \cdot 10^5 \, N/m^2}{4.696 \cdot 10^4 \, N/m^2 k} = \boxed{2.157\,k}$

d) No Liquid Helium at 4.15k is achieveable only in high-tech labs, and this 2.157k is even colder!

39) $V_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3 \cdot 1.38 \cdot 10^{-23} \, 5.00}{6.646 \cdot 10^{-27}}} = \boxed{176.5 \, m/s}$

48) $E = \frac{3}{2} kT \Rightarrow T = \frac{E}{\frac{3}{2}k} = \boxed{3.09 \cdot 10^9 \, k}$

64) a) $n_{total} = \frac{PV}{RT} = 91.39$ moles

$n_{He} = 0.79 \, n_{total} = \boxed{72.20 \, mol}$

$n_{O_2} = 0.21 \, n_{total} = \boxed{19.19 \, mol}$

b) $\Delta U_{He} = n_{He} C_{v_{H}} \Delta T = 72.20 \; 1.50R \; 4 = 3601.8\,J$

$\Delta U_{O_2} = n_{O_2} C_{v_{O_2}} \Delta T = 19.19 \; 2.53R \; 4 = 1614.7\,J$

$\Delta U_{total} = \Delta U_{He} + \Delta U_{O_2} = \boxed{5217\,J}$

65) $\Delta U_{N_2O} + \Delta U_{air} = 0$

$\Rightarrow n_{N_2O} C_{v_{N_2O}} (T_f - T_{i_{N_2O}}) = n_{air} C_{v_{air}} (T_f - T_{i,air})$

$\Rightarrow T_f - T_{i_{N_2O}} = - \underbrace{\frac{n_{air} C_{v_{air}}}{n_{N_2O} C_{v_{N_2O}}}}_{\equiv \alpha} (T_f - T_{i,air})$

$\Rightarrow T_f = -\alpha T_f + \alpha T_{i,air} + T_{i,N_2O}$

$\Rightarrow T_f = \frac{\alpha T_{i,air} + T_{i,N_2O}}{1+\alpha}$ where $\alpha = \frac{4 \cdot 2.50 \cdot 8.3145}{1 \cdot 30.43} = 2.732$

$= \boxed{271.5\,k}$

66) see example 2.10 in text

$M = 34.1\,g/mol \Rightarrow m = 5.663 \cdot 10^{-26}\,kg$

$v_1 = \sqrt{\frac{3RT}{M}} = 468.45\,m/s$

$v_2 = 2v_1 = 936.90\,m/s$

$\frac{f(v_1)}{f(v_2)} = \left(\frac{v_1}{v_2}\right)^2 e^{-\frac{m}{2kT}(v_1^2 - v_2^2)}$

$= \boxed{22.56}$

67) Equation 2.15 in text $f(v)\,\Delta v = \frac{4}{\sqrt{\pi}} \left(\frac{m}{2kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}} \Delta v$

where $m = 4.652 \cdot 10^{-26}\,kg$ from $28.0134\,g/mol \div 6.022 \cdot 10^{23}$ molecules/mol

and $\Delta v = 1\,m/s$ and $T = 300\,k$ and $v = 290\,m/s$

$\Rightarrow \boxed{0.001576}$

76) a) $P = \frac{N}{V} kT = (10^6)(k_B)(2.7\,k) = \boxed{3.73 \cdot 10^{-17}\ N/m^2}$

b) $\#density = \frac{N}{V} \Rightarrow V = \frac{N}{\#density} = \frac{6.022 \cdot 10^{23}}{10^6} = \boxed{6.022 \cdot 10^{17}\ m^3}$

c) $L = \sqrt[3]{V} = \boxed{844\ km}$

78) $\frac{N}{V} = \frac{P}{kT} = 1.984 \cdot 10^{25}\ m^{-3}$

$\rho = \left(0.78\, m_{N_2} + 0.21\, m_{O_2} + 0.01\, m_{Ar}\right) \frac{N}{V} = \boxed{0.954\ kg/m^3}$

where $m_{N_2} = 28.0134\ g/mol \rightarrow 4.652 \cdot 10^{-26}\ kg$

$m_{O_2} = 31.998\ g/mol \rightarrow 5.314 \cdot 10^{-26}\ kg$

$m_{Ar} = 39.948\ g/mol \rightarrow 6.634 \cdot 10^{-26}\ kg$