Ch 14 examples

(14.1) $PV = nRT$

$V_{total} = \frac{nRT}{P} = \frac{(1)(8.314\ J/mol\cdot K)(300K)}{101325\ Pa} = 0.025\ m^3$

$1\ mm^3 = 1.0\times10^{-9}\ m^3$

$n = \frac{PV}{RT}$ $\quad N_{small} = N_{large}\frac{V_{small}}{V_{large}}$

$= \frac{(6.022\times10^{23}\ mol)\cdot(1.0\times10^{-9}\ m^3)}{(0.025)\ m^3}$

$= 2.41\times10^{16}$ molecules

(14.2) $P = \frac{nM}{3V}\langle v^2\rangle$

$\langle v^2\rangle = \frac{3VP}{nM} = \frac{3(2.46\times10^{-2}\ m^3)(101325\ Pa)}{(1.00\ mol)(4.0026)}$

$= 1968\ m/s$

$\langle v^2\rangle = \frac{3VP}{nM} = \frac{3(2.46\times10^{-2}\ m^3)(101325\ Pa)}{(1.000\ mol)(4.0026\times10^{-3}\ kg/mol)}$

$= 1.87\times10^6\ m^2/s^2$

$v_{rms} = \sqrt{\langle v^2\rangle} = 1367\ m/s$

(14.3) 1000 protons @ 100 m/s

2000 @ 200 m/s

4000 @ 300 m/s

3000 @ 400 m/s

1000 @ 500 m/s

$\langle v\rangle = \frac{v_1 + v_2 + v_3 + v_N}{N}$

$= \frac{(1000\cdot100\ m/s + 2000\cdot200 + 4000\cdot300 + 3000\cdot400 + 1000\cdot500)}{(1000+2000+4000+3000+1000)}$

$= 309\ m/s$ ✓

$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_n^2}{N}}$

$= \sqrt{\frac{(1000\cdot100^2) + (2000\cdot200^2) + (4000\cdot300^2) + (3000\cdot400^2) + (1000\cdot500^2)}{1000+2000+4000+3000+1000}}$

$= 327.5\ m/s$

(14.4) He 300K 0.500 atm

$KE_{avg} = \frac{3}{2}kT = \frac{3}{2}(1.38\times10^{-23}\ J/K)(300K)$

$= 6.21\times10^{-21}\ J$

(14.5) a) $v_{rms} = \sqrt{\frac{3PV}{nM}}$

$PV = nRT$

$= \sqrt{\frac{nRT}{nM}}$

$= \sqrt{\frac{RT}{M}} = \sqrt{\frac{(8.314\ J/mol\cdot K)(300K)}{(0.004\ kg/mol)}}$

$= 790.\ m/s$

$v_{rms} = \sqrt{\frac{3RT}{M}}$

$= \sqrt{\frac{3(8.314\ J/mol\cdot K)(300K)}{0.004\ kg/mol}}$

$= 1370\ m/s$

$v_{avg\ molecular} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(8.314)(300K)}{(0.0202\ kg/mol)}}$

$= 609\ m/s$

b) $KE = \frac{3}{2}kT = \frac{3}{2}(1.38\times10^{-23}\ J/K)(300K) = 6.21\times10^{-21}\ J$

(14.6) $v_{rms} = \sqrt{\frac{3RT}{M}}$ $\quad v_{rms}^2 = \frac{3RT}{M}$

$T = \frac{m v_{rms}^2}{3R} = \frac{(0.004\ kg/mol)(1000\ m/s)^2}{3(8.314\ J/mol\cdot K)}$

$= 160K$

adiabatic (compression)

(11.7) diatomic, $T_0 = 300K$, $P_0 = 1000\ atm$

$V_0 = 0.009\ m^3$

$V_f = 0.0009\ m^3$

a) $P_0 V_0^{\gamma} = P_f V_f^{\gamma}$ $\quad \gamma = 1.4$

$P_f = P_0 \frac{V_0^{\gamma}}{V_f^{\gamma}} = (101325\ Pa)\frac{(0.009\ m^3)}{(0.0009\ m^3)}$

$= 10\ atm$

b) $\rightarrow$ $(10)(1\ atm)\left(\frac{0.009^{(1.4)}}{(0.0009^{1.4})}\right)$

$= 25.1\ atm$

b) $T_0 V_0^{(\gamma-1)} = T_f V_f^{(\gamma-1)}$

$T_f = T_0 \frac{V_0^{\gamma-1}}{V_f^{\gamma-1}} = 300K\left(\frac{0.009^{0.4}}{0.0009^{0.4}}\right)$

$= 754\ K$

c) $W = -n C_V \Delta T$

$= -\frac{P_0 V_0 C_V \Delta T}{R T_0}$

$PV = nRT$

$= -\frac{(101325\ Pa)(0.009\ m^3)\left(\frac{5(8.314)}{2}\right)(454K)}{(8.314)(300K)}$

$= -3450\ J$

$n = \frac{PV}{RT} = \frac{(101325\ Pa)(0.009\ m^3)}{8.314\ \frac{J}{mol \cdot K} \cdot 300K}$

$= 0.0366\ mol$

$W = -n C_V \Delta T$

$= -(0.0366)\frac{5R(454K)}{2} = -345\ J$

$-330\ J$ (rounding?)