Homework #2

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1.23) gas density at STP $\approx 10^{25}\ m^{-3} = \rho$

$1L = 1000\ cm^3 = \frac{1}{1000}\ m^3$

$N = V \cdot \rho = \frac{1}{1000}\ m^3 \cdot 10^{25}\ m^{-3}$

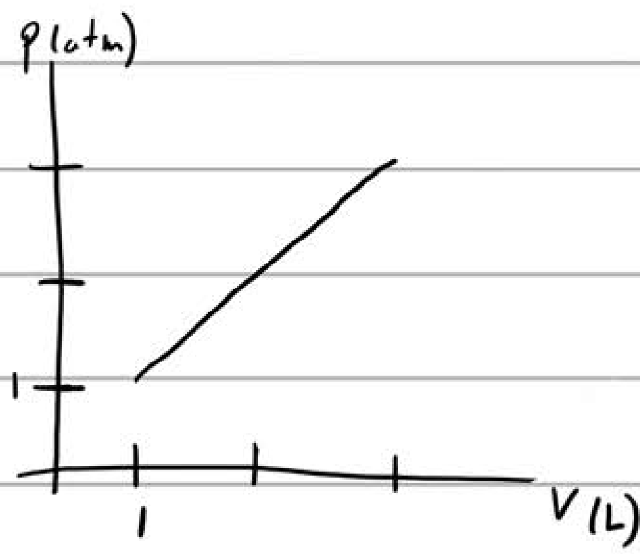
$= 10^{22}$ molecules

$U = \frac{3}{2} NkT$

$= \frac{3}{2} \cdot 10^{22} \cdot 1.38 \times 10^{-23}\ J/K \cdot 300\ K$

$= 62.1\ J$

1.31) (a)



(b) $W = 1atm \cdot 2L + \frac{1}{2} \cdot 2atm \cdot 2L$

$= 4\ atm \cdot L$

(c) $P_1 V_1 = NkT_1$; $N = 10^{22}$

$T_1 = \frac{P_1 V_1}{Nk}$

$= \frac{101325\ Pa \cdot 0.001\ m^3}{10^{22} \cdot 1.38 \times 10^{-23}\ J/K}$

$= 734.239\ K$

$T_2 = \frac{101325\ Pa \cdot 0.001\ m^3}{10^{22} \cdot 1.38 \times 10^{-23}\ J/K} \cdot 9$

$= 6608.15\ K$

$\Delta U = \frac{3}{2} Nk\Delta T$

$\Delta T = 5873.91\,K$

$\Delta U = \frac{3}{2} \cdot 10^{22} \cdot 1.38 \times 10^{-23}\,J/K \cdot 5873.91\,K$

$= 1215.9\,J$

(d) $Q = \Delta U - W$

$= 1215.9\,J - (-405.3\,J)$

$= 1621\,J$

(e) You might put the container in an oven as it is mechanically expanded.

1.34) (a) $W_A = \cancel{P\Delta}V = 0$

$W_B = P_2(V_2 - V_1)$

$W_C = \cancel{P(V_2 - V_2)} = 0$

$W_D = P_3(V_2 - V_1)$

$\Delta U_A = \frac{5}{2}(P_2 - P_1)V_1$

$\Delta U_B = \frac{5}{2} P_2(V_2 - V_1)$

$\Delta U_C = \frac{5}{2}(P_1 - P_2)V_2$

$\Delta U_D = \frac{5}{2} P_1(V_1 - V_2)$

$Q_A = \Delta U_A - W_A$

$= \frac{5}{2}(P_1 - P_2)V_1$

$Q_B = \frac{5}{2} P_2(V_2 - V_1) - P_2(V_2 - V_1)$

$= \frac{3}{2} P_2(V_2 - V_1)$

$Q_C = \frac{5}{2}(P_2 - P_1)V_2$

$Q_D = \frac{3}{2} P_1(V_1 - V_2)$

(b) In step A heat is added while the piston is held fixed. In step B, heat is added while the piston is moved so that the gas expands. In step C, heat is removed such as by placing the canister in a freezer, while the piston is held still. In step D heat is removed while the piston is compressed.

C) $\sum W = W_A + W_B + W_C + W_D$

$$= P_2(V_2 - V_1) + P_1(V_1 - V_2)$$

$$= (P_2 - P_1)(V_2 - V_1)$$

$$\sum Q = \frac{5}{2}(P_2 - P_1)V_1 + \frac{3}{2}P_2(V_2 - V_1) + \frac{5}{2}(P_1 - P_2)V_2 + \frac{3}{2}P_1(V_1 - V_2)$$

$$= \frac{5}{2}((P_2 - P_1)(V_1 - V_2)) + \frac{3}{2}((P_2 - P_1)(V_2 - V_1))$$

$$= -(P_2 - P_1)(V_2 - V_1)$$

$$\Delta U = (P_2 - P_1)(V_2 - V_1) - (P_2 - P_1)(V_2 - V_1)$$

$$= 0$$

1.36) (a) $\gamma = \frac{f+2}{f} = \frac{7}{5}$

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$\frac{1\,atm}{7\,atm}(1L)^{7/5} = V_2^{7/5}$$

$$V_2 = \left(\frac{1}{7}\right)^{5/7}$$

$$= 0.249\ L$$

(b) $W = \int_{V_1}^{V_2} P(V)\, dV$

$P(V) = P_1 \left(\frac{V_1}{V}\right)^{\gamma}$

$W = \int_{V_i}^{V_f} P_1 \left(\frac{V_1}{V}\right)^{\gamma} dV$

$= P_1 V_1^{\gamma} \frac{V_2^{1-\gamma} - V_1^{1-\gamma}}{1-\gamma}$

$= \frac{P_2 V_2 - P_1 V_1}{1-\gamma}$

$= \frac{7\,atm \cdot \left(\frac{1}{7}\right)^{5/7} - 1\,atm\,1L}{1 - 5/7}$

$= \frac{7}{2}\left(7^{2/7} - 1\right) L \cdot atm$

$= 2.60\ L \cdot atm$

$= 263\ J$