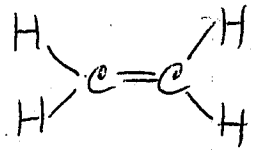
Quiz #2 Thermo 3760.

#1



a) translational dof = 3

rotational dof = 3 (molecule is not axial)

vibrational dof = $3N-6 = 12$ (N - number of atoms in the molecule)

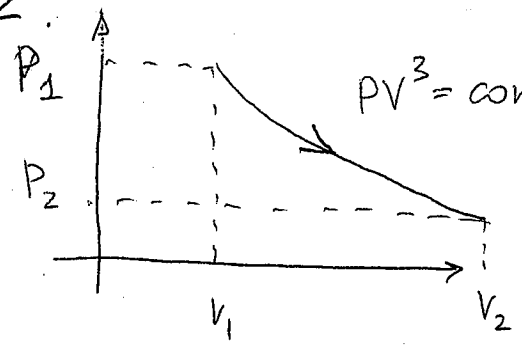
comm: (In Shroeder definition $N_{vib} = 2(3N-6) = 24$ – will be correct answer too)

b) every translational and rotational dof carries $\frac{1}{2}kT$ amount of energy, vibrational dof carries kT amount of energy. So total energy of 1 mole of ethylene is

$$U = \frac{1}{2}kT \cdot N_a \cdot 6 + kT N_a \cdot 12 = 15 k_1 N_A \cdot T = 15RT$$

$$C_v = \left(\frac{\partial U}{\partial T}\right)_v = 15R = 15 \cdot 8.3 \ J/mole \cdot k$$

#2.



$PV^3 = \text{const.}$, 1 mole, monoatomic gas

b) $T_1 = \frac{P_1 V_1}{R}$ (for 1 mole)

$P_1 V_1^3 = P_2 V_2^3 \qquad P_2 = P_1 \cdot \frac{V_1^3}{V_2^3}$

$$T_2 = \frac{P_2 V_2}{R} = P_1 \cdot \frac{V_1^3}{V_2^3} \cdot \frac{V_2}{R} = P_1 V_1^3 / V_2^2 \cdot R$$

$U = \frac{3}{2} RT$ for monoatomic gas $\quad i = 3$

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

$$\Delta U = \frac{3}{2} R \cdot (T_2 - T_1) = \frac{3}{2} \left(\frac{P_1 V_1^3}{V_2^2} - P_1 V_1 \right) < 0$$

a) Work done by the system

$$W = \int_{T_1}^{V_2} \cdot P(V)\, dV = \int_{V_1}^{V_2} \frac{P_1 V_1^3}{V^3} \cdot dV = P_1 V_1^3 \cdot \left(-\frac{1}{2} V^{-2} \right) \Big|_{V_1}^{V_2} =$$

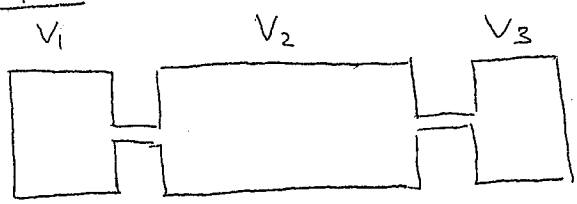
$$= P_1 V_1^3 \left(\frac{V_1^{-2}}{2} - \frac{V_2^{-2}}{2} \right) = \frac{P_1 V_1^3}{2} \cdot \left(\frac{1}{V_1^2} - \frac{1}{V_2^2} \right) > 0$$

c) $Q = W + U =$

$$\frac{3}{2} \frac{P_1 V_1^3}{V_2^2} - \frac{3}{2} P_1 V_1 + \frac{1}{2} P_1 V_1 - \frac{1}{2} \frac{P_1 V_1^3}{V_2^2} = \frac{P_1 V_1^3}{V_2^2} - P_1 V_1 < 0$$

heat is released by the system.

#3



a) Probability to find A molecule in V_1 is

$$\frac{V_1}{V_1+V_2+V_3} = P_A$$

Probability to find B molecule in V_2 is $\frac{V_2}{V_1+V_2+V_3} = P_B$

Motion of A and B molecule is independent so the probability to find A in V_1 and B in V_2 is

$$P_{AB} = P_A \cdot P_B = \frac{V_1 \cdot V_2}{(V_1+V_2+V_3)^2}$$

b) If molecules are the same we have two combination. (A' in V_1, A'' in V_2 and A' in V_2, A'' in V_1) that are not distinguishable so.

$$P_{AA} = 2 \cdot \frac{V_1 V_2}{(V_1+V_2+V_3)^2}$$