

Exam #1 Solutions

$$\textcircled{\#1} \quad \sum Q_i = 0 = m_w c (T_F - T_i) + m_i L + c m_i (T_F - T_0)$$

$m_w \equiv$ mass of water, $m_i \equiv$ mass of ice
 Since all temperatures are different we
 can work in centigrade where $T_0 = 0$.

Solve for T_F !

$$T_F = \frac{m_w}{m_i + m_w} T_i - \frac{m_i}{m_i + m_w} \frac{L}{c}$$

$$L/c = \frac{334}{4.190} \Delta C = 79.7 \Delta C$$

$$T_F = \frac{100}{110} 30^\circ C - \frac{10}{110} 79.7^\circ C = 20.0^\circ C$$

$$\textcircled{\#2} \quad V_{rms} \text{ for } N_2 @ 30^\circ C$$

$$\frac{1}{2} m V_{rms}^2 = \frac{3}{2} RT$$

$$V_{rms} = \left[\frac{3 (8.31 \text{ J/mol}\cdot\text{K}) 303 \text{ K}}{28 \times 10^{-3} \text{ kg/mol}} \right]^{1/2}$$

$$= \sqrt{\frac{3 (8.3) (3.03)}{28.0}} \text{ km/s} = 0.52 \text{ km/s}$$

$$\textcircled{\#3} \text{ (a) } Q = C_p \Delta T$$

$$C_p = C_v + R, \quad \gamma = \frac{C_p}{C_v} \Rightarrow C_p = \left(\frac{\gamma}{\gamma-1}\right) R$$

$$Q = \frac{\gamma}{\gamma-1} R \Delta T = \frac{1.4}{0.4} (8.31 \text{ J/mole}\cdot\text{K})(1 \text{ mole}) 10 \text{ K} \\ = 291 \text{ J}$$

$$\text{(b) } W = Q - \Delta U, \quad \Delta U = C_v \Delta T = \frac{R}{\gamma-1} \Delta T = 208 \text{ J} \\ W = 83 \text{ J} \quad \underline{\text{or}} \quad W = p \Delta V = R \Delta T = 83 \text{ J}$$

$$\text{(c) } C_v = \frac{f}{2} R, \quad \gamma = 2 \quad \frac{C_v}{R} = \left(\frac{2}{\gamma-1}\right) = 5$$

$$\textcircled{\#4} \text{ (a) } Q_H = \int p dV = \int_V^{+V} R T_H \frac{dV}{V} = R T_H \ln r$$

$$Q_C = -C_v (T_H - T_C) = -\frac{R}{\gamma-1} (T_H - T_C)$$

$$\text{(b) } W = Q_H - |Q_C|$$

$$\text{(c) } \Delta S_{ab} = 0 \\ \Delta S_{bc} = \int \frac{dq}{T_H} = \frac{Q_H}{T_H} = R \ln r$$

$$\Delta S_{ca} = \int \frac{C_v dT}{T} = -C_v \ln\left(\frac{T_H}{T_C}\right) = -\left(\frac{R}{\gamma-1}\right) \ln \frac{T_H}{T_C}$$

$$\text{(d) } T_C (rV)^{\gamma-1} = T_H V^{\gamma-1} \Rightarrow \ln \frac{T_H}{T_C} = (\gamma-1) \ln r$$

$$\text{So } \Delta S_{ab} + \Delta S_{bc} + \Delta S_{ca} = 0 + R \ln r - R \ln r = 0$$