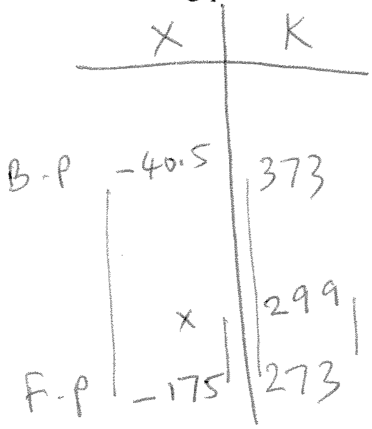
PHYS 212-11AM   Spring 2012   Test #1   Name: Key   99 Ave: 78.5

Show your work explicitly. Time: 50 min.

A. Suppose that on a linear temperature scale X, water boils at -40.5°X and freezes at -175°X. What is a temperature of 299 K on the X scale? (Approximate water's boiling point = 373 K, and freezing point = 273 K)



$$\frac{X-(-175)}{-40.5-(-175)} = \frac{299-273}{373-273}$$

$$\frac{X+175}{175-40.5} = \frac{26}{100}$$

$$\frac{X+175}{134.5} = \frac{26}{100}$$

$$X+175 = 134.5 \times \frac{26}{100} = 34.97$$

$$X = -175 + 34.97 = -140.03$$

$$299\,K = -140^\circ X$$

The volume expansion is given by: $\Delta V = \beta V_0 \Delta T$

B. Suppose that the steel gas tank in your car is completely filled when the temperature is 17 °C. How many gallons will spill out of the twenty-gallon tank when the temperature rises to 35 °C? Include the expansion of the steel tank.

(Volumetric coefficient of thermal expansion (β) of gasoline = 950 $\times 10^{-6}(C^\circ)^{-1}$ and Steel = 36 $\times 10^{-6}(C^\circ)^{-1}$)

$$\Delta V_{gas} = 950\times10^{-6} \times 20\,gal \times (35-17) = 0.342\,gal$$

$$\Delta V_{tank} = 36\times10^{-6} \times 20\,gal \times (35-17) = 0.01296\,gal$$

$$Spill = 0.342 - 0.01296 = 0.33\,gal$$

$Q = mc\Delta T$ $Q = mL$ $dQ = mcdT$ $\Delta S = S_f - S_i = \frac{\Delta Q}{T} = \int_i^f \frac{dQ}{T}$

C. An insulated container contains 200 g of water at 20°C. A lump of aluminum of mass 100 g is heated in boiling water (100°C) and transferred to the water.
(Specific heat: c_W = 4180 J/kg ·K, c_{Al} = 900 J/kg ·K)

1. What is the equilibrium temperature of the aluminum–water system?
2. What is the entropy change for water?
3. What is the entropy change for aluminum?
4. What is the entropy change for aluminum-water system?

100°C = 373.15 K
20°C = 293.15 K

$Q_{gain} = Q_{lost}$

$mc_w\Delta T = mc_{Al}\Delta T$

$(.2)(4180)(T - 293.15) = (.1)(900)(373.15 - T)$

$836T - 245073.4 = 33583.5 - 90T$

$T(836 + 90) = 278656.9$

$T = 300.9\ K$

$\Delta S_w = \int_{T_i}^{T_f} \frac{dQ}{T}$

$= \int_{T_i}^{T_f} \frac{mc_w dT}{T}$

$= mc_w \int_{T_i}^{T_f} \frac{1}{T} dt = mc_w \ln T \Big]_{T_i}^{T_f}$

$= (836) \ln \frac{300.9}{293.15} = 21.8\ J/K$

$\Delta S_{Al} = \int_{T_i}^{T_f} \frac{mc_{Al} dT}{T} = mc_{Al} \ln T \Big]_{T_i}^{T_f}$

$= (90) \ln \frac{300.9}{373.15} = -19.37\ J/K$

$\Delta S_{Al\&W} = (21.37) + (-19.37)$

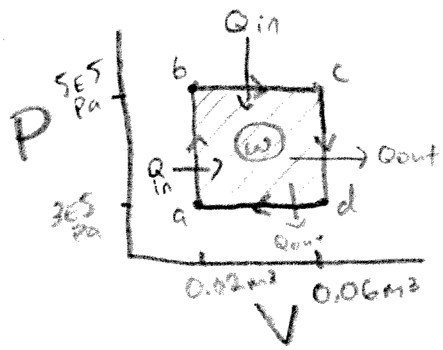
$\Delta S_{Al\&W} = 2.00\ J/K$

Ideal gas law: PV = nRT; R = 8.315 J/mol.K. First Law of T.D: $\Delta E_{int} = Q - W$

Heat = Q = nCΔT; $C_V=(3/2)R$, $C_p= C_V+R$ for monatomic gas Efficiency = $\frac{|W|}{|Q_H|}$

D. Three mol of a monatomic ideal gas initially at a pressure of 3.0×10^5 Pa and volume of 0.02 m^3 undergoes the following cycle: (1) heated at constant volume to a pressure of 5.0×10^5 Pa, (2) then allowed to expand at constant pressure to a volume of 0.06 m^3, (3) then cooled down at constant volume to the initial pressure, and (4) finally compressed at constant pressure to its initial volume.

(a) Draw a P-V diagram of the cycle.
(b) Identify the paths where heat goes in or out.
(c) The net work done by the gas.
(d) Energy transferred as heat to the gas.
(e) The efficiency of the cycle.



W_{net} = Area in Box

$W_{net} = (0.06 - 0.02) \times (5E5 - 3E5)$

$W_{net} = (.04) \times (2E5) = 8000\ J$

PV = nRT

$\frac{P_aV_a}{nR} = T_a = \frac{6000}{24.942} = 240.5K$

$\frac{P_bV_b}{nR} = T_b = \frac{10000}{24.942} = 400.9K$

$\frac{P_cV_c}{nR} = T_c = \frac{30000}{24.942} = 1202.8K$

$Q_{in(ab)} = nC_v\Delta T$

$Q_{in(ab)} = (3)(12.5)(400.9 - 240.5)$

$Q_{in(ab)} = 6015\ J$

$Q_{in(bc)} = nC_p\Delta T$

$Q_{in(bc)} = (3)(20.8)(1202.8 - 400.9)$

$Q_{in(bc)} = 50038.56\ J$

$Q_{in(abc)} = 56053.56\ J = 56.054\ kJ$

$\varepsilon = \frac{W}{Q_{in}} = \frac{8000\ J}{56054\ J}$

$\varepsilon = 0.143$ or 14.3%