PH202 Recitation 5 Thermo Part 2 Solutions

Discussion Question 1:

water placed in freezer and turns into ice at thermal equilibrium

which of the following are true?

A) water gains entropy in accord of 2nd law of thermo — False ✗

B) water loses entropy violating the 2nd law — False ✗

C) water gains entropy but the air loses entropy in accord with 2nd law — False ✗

D) both water and air lose entropy, universe gains in accord with 2nd law — False ✗

E) water loses entropy air gains entropy in accord with the 2nd law — True ✓

ice has crystalline structure which is more ordered than water $\Rightarrow S\downarrow$, but the air around the ice got warmer $\Rightarrow S\uparrow$ and $S\uparrow > S\downarrow$ for this case ✓

Question 1: 0.500kg Al pan 0.250L H_2O

heat system from 20°C to 120°C, how much heat required?

$C_w = 4186\ J/kg°C$ $C_{Al} = 900 J/kg°C$ $L_{w,v} = 2260 kJ/kg$

.250L H_2O = .250kg H_2O since density of water is 1.

Well, we know there is a phase transition from water to steam (water vapor) at 100°C so include latent heat

$$Q_{TOTAL} = Q_{Al}(20°C \rightarrow 120°C) + Q_{H_2O\ liquid}(20°C \rightarrow 100°C) + Q_{L,v} + Q_{H_2O\ steam}(100° \rightarrow 120°C)$$

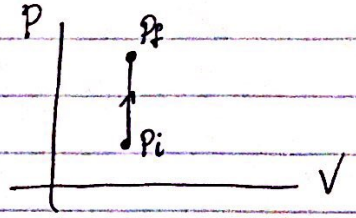
$$Q_{total} = m_{Al} C_{Al} \Delta T_{Al} + m_{H_2O} C_{H_2O} \Delta T_{H_2O} + m_{H_2O} L_v + m_{steam} C_{steam} \Delta T_{steam}$$

$$= (0.500kg)(900 J/kg°C)(120-20) + (.250kg)(4186 J/kg°C)(100-20) + (250kg)(2260kJ/kg) +$$
$$+ (250kg)(1996 J/kg°C)(120-100)$$

$$Q_{total} = 45000J + 83720J + 565000J + 19960J + 9980J$$
$$= 723660J = 723.7kJ \text{ or } 724kJ$$
$$= 703708J = 703.7kJ = 704kJ$$

Question 2: Sketch the PV processes and discuss E_{th}, Q, W for each

a) Isochoric => volume is constant and Pressure changes

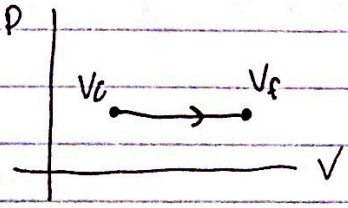


$\Delta E_{th} = \frac{3}{2} N k_B \Delta T$

$Q = \frac{3}{2} N k_B \Delta T$

$W = 0$

b) Isobaric => constant pressure and volume changes

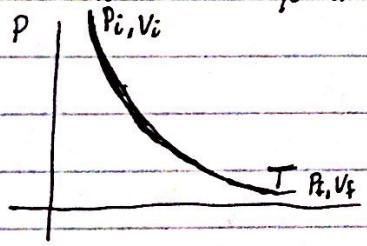


$\Delta E_{th} = \frac{3}{2} N k_B \Delta T$

$Q = \frac{3}{2} N k_B \Delta T + P \Delta V$

$W = -P \Delta V$

c) Isothermal => temperature is constant as P and V change

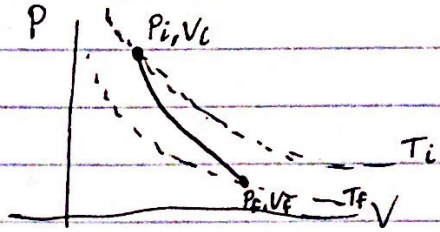


$\Delta E_{th} = 0$

$Q = N k_B T \ln\left(\frac{V_f}{V_i}\right)$

$W = -N k_B T \ln\left(\frac{V_f}{V_i}\right)$

d) Adiabatic => no heat in or out or Q=0, goes from one isotherm to another, steeper



$\Delta E_{th} = -\frac{3}{2} N k_B \Delta T$

$Q = 0$

$W = \frac{3}{2} N k_B \Delta T$

CHO: .15kg Al can contains 0.2kg H_2O

$T_i = 18°C$

unknown material $m = 0.04kg$ has temperature of 97°C then added to H_2O

final temp of system = 22°C, find specific heat of material

assume no phase changes, just add up heats to solve for specific heat

since isolated system we know that

$$|Q_{heat}| = |Q_{cold}|$$

$$\Rightarrow |Q_{gained}| = |Q_{lost}|$$

$$\Rightarrow Q_{Al} + Q_{H_2O} = Q_{material}$$

$$\Rightarrow m_{Al} C_{Al} \Delta T_{Al} + m_{H_2O} C_{H_2O} \Delta T_{H_2O} = m_{material} C_{material} \Delta T_{material}$$

Solve