MUĞLA SITKI KOÇMAN UNIVERSITY

MME 2009 Metallurgical Thermodynamics I

Midterm Examination

04.11.2016 9.30-11.30

Questions

1- (20 points) 1 mole of liquid water at 25 C and 1 bar fills a rigid vessel. If heat is added to the water until its temperature reaches 50 C, what pressure is developed on the vessel? The average value of β between 25 and 50 C is $36.2*10^{-5}$/K. The value of κ at 1 bar and 50 C is $4.42*10^{-5}$/bar and is independent of P. The volume of liquid water at 25 C is 18.075 cm^3/mol.

2- (20 points) Two moles of an ideal gas are contained adiabatically at 30 atm and 298K. The pressure is released to 10 atm and the gas undergoes a reversible adiabatic expansion as a result of which its volume increases four times. Calculate the internal energy change for this process. Cv=1.5R, Cp=2.5R

3- (20 points) Calculate the heat required to increase the temperature of 360 grams of ice from -10 C to 140 C.

4- (25 points) Sodium carbonate, Na_2CO_3, can be prepared by heating sodium hydrogen carbonate, $NaHCO_3$:

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(\text{l or } g) + CO_2(g)$

Calculate the enthalpy change for the formation of 1 mole of sodium carbonate a) at 298 K and b) at 400 K and 1 atm. Is the reaction endothermic or exothermic at each temperature?

5- (15 points) The normal freezing point for pure copper is 1083 C but small droplets of liquid copper have been supercooled to 847 C before spontaneous solidification occurs. Calculate the enthalpy change for the solidification of copper at 847 C.

Universal gas constant

R = 8.3144621 J/mole.K = 8.3144621 L.kPa/mole.K = 8.3144621 m^3.Pa/mole.K = 83.144621 L.mbar/mole.K = 0.082057 L.atm/mole.K = $8.2057*10^{-5}$ m^3.atm/mole.K = 62.36368 L.mmHg/mole.K

Thermochemical Data

Substance	ΔH^o (kJ/mol)	C_P (J/mol.K)	Latent heat (J/mol)
Cu(s)	0	22.65+0.00628T	13000 at 1356 K
Cu(l)	0	31.4	300400 at 2835 K
H_2O(s)		37.116	6010 at 273 K
H_2O(l)	-285.83	75.312	40660 at 373 K
H_2O(g)	-241.83	41.8+0.00564T	
CO_2(g)	-393.5	22.24+0.0598T - 349900/T^2	
$NaHCO_3$(s)	–947.7	87.61	
Na_2CO_3(s)	–1130.8	112.3	

Table of unit conversion

Quantity	Conversion	Quantity	Conversion
Length	1 m = 100 cm = 3.28084(ft) = 39.3701(in)	Volume	1 m^3 = 10^6 cm^3 = 10^3 liters = 35.3147$(ft)^3$ = 264.172(gal)
Mass	1 kg = 10^3 g = 2.20462(lb_m)	Density	1 g cm^{-3} = 10^3 kg m^{-3} = 62.4278(lb_m)$(ft)^{-3}$
Force	1 N = 1 kg m s^{-2} = 10^5(dyne) = 0.224809(lb_f)	Energy	1 J = 1 kg m^2 s^{-2} = 1 N m = 1 m^3 Pa = 10^{-5} m^3 bar = 10 cm^3 bar = 9.86923 cm^3(atm) = 10^7(dyne) cm = 10^7(erg) = 0.239006(cal) = 5.12197 × $10^{-3}$$(ft)^3$(psia) = 0.737562(ft)($lb_f$) = 9.47831 ×$10^{-4}$(Btu) = 2.77778 ×$10^{-7}$ kWhr
Pressure	1 bar = 10^5 kg m^{-1} s^{-2} = 10^5 N m^{-2} = 10^5 Pa = 10^2 kPa = 10^6(dyne) cm^{-2} = 0.986923(atm) = 14.5038(psia) = 750.061(torr)	Power	1 kW = 10^3 W = 10^3 kg m^2 s^{-3} = 10^3 J s^{-1} = 239.006(cal) s^{-1} = 737.562(ft)(lb_f) s^{-1} = 0.947831(Btu) s^{-1} = 1.34102(hp)