

MUĞLA SITKI KOÇMAN UNIVERSITY
MME 2009 Metallurgical Thermodynamics I

Midterm Examination

04.11.2016 9.30-11.30

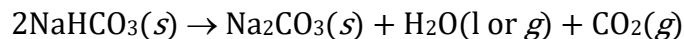
Questions

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 $36.2 \cdot 10^{-5}/K$. The value of κ at 1 bar and 50 C is $4.42 \cdot 10^{-5}/bar$ and is independent of P. The volume of liquid water at 25 C is $18.075 \text{ cm}^3/\text{mol}$.

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. $C_v=1.5R$, $C_p=2.5R$

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 :



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

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

Thermochemical Data

Substance	ΔH° (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 ₂ O(s)		37.116	6010 at 273 K
H ₂ O(l)	-285.83	75.312	40660 at 373 K
H ₂ O(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 ₂ CO 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)