South Dakota School of Mines and Technology
Department of Materials and Metallurgical Engineering

Met 320 HQ 2 Oct 27, 2005

CLOSED BOOK and NOTES - NO CALCULATORS - SHOW ALL WORK ON THIS SHEET - DISCARD ALL OTHER WORK SHEETS. If there seems to be an error in the problem statement, suggest a correction and proceed with your assumed correction.

ALWAYS BROWSE THE ENTIRE EXAM FIRST. THEN WORK THE SHORTEST, EASIEST PROBLEMS FIRST. Each problem is worth 16 points.

1. One mole of ideal gas at 2 atm and 300 K is expanded isothermally to 1 atm while in contact with a heat sink at 400 K. Find ΔS for the 1) gas and 2) the heat sink if the
   a) Expansion is reversible

$$\Delta S_g = \int_i^f dS = \int_i^f \frac{dq}{T_g}\Bigg)_{\text{Rev}} = \int_i^f \frac{dw_{Max}}{T_g} = \int_i^f \frac{PdV}{T_g} = \int_i^f \frac{nRdV}{V} = nR\ln\left[\frac{V_f}{V_i}\right] = nR\ln\left[\frac{P_i}{P_f}\right] = R\ln(2)$$

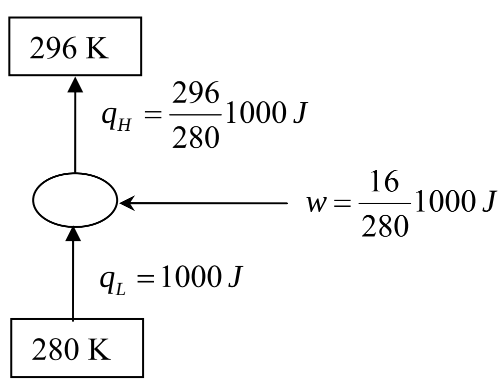
$$\Delta S_S = \int_i^f dS = \int_i^f \frac{dq}{T_s}\Bigg)_{\text{Rev}} = \int_i^f \frac{-dq_g}{T_s} = -\int_i^f \frac{PdV}{T_s} = -\int_i^f \frac{nRT_g dV}{T_s V} = -nR\frac{T_g}{T_s}\ln\left[\frac{P_i}{P_f}\right] = -0.75R\ln(2)$$

   b) Expansion results in no work being performed.

$\Delta S_g =$ same as part a) - State Function

$$\Delta S_S = \int_i^f dS = \int_i^f \frac{dq}{T_s}\Bigg)_{\text{Rev}} = \int_i^f \frac{-dq_g}{T_s} = -\int_i^f \frac{0}{T_s} = 0$$

2. On a theoretical basis, how much work must be supplied to a heat pump to move 1000 Joules of heat from a lake at 280 K to a home at 23°C?



3. Find the configurational entropy change when 30 gram moles of Ag are alloyed with 70 gram moles of Au.

$$\Delta S^{Mix} = -Rn_{Total}\left(x_A \ln x_A + x_B \ln x_B\right)$$
$$= -100R\left(0.3\ln 0.3 + 0.7\ln 0.7\right)$$

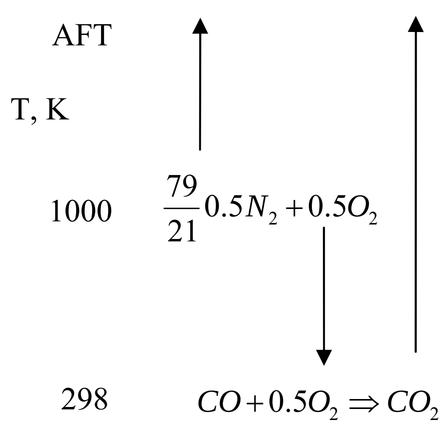
4. Tool Kit Problems:
   a) Write the Fundamental equations emanating from the definitions of H, A, and G.
   dU = TdS – PdV

   H=U+PV, A= U-TS, G=H-TS
   dH = TdS – PdV + PdV + VdP = TdS + VdP
   dA = TdS – PdV - TdS – SdT = – PdV - SdT
   dG = TdS + VdP - TdS - SdT = VdP - SdT

   b) What is the Maxwell Relation from dU = TdS – PdV?

$$\left.\frac{\partial T}{\partial V}\right)_S = -\left.\frac{\partial P}{\partial S}\right)_V$$

5. Draw a calculation schematic for determining the adiabatic flame temperature for the combustion of CO gas with dry air (21% O_2, 79% N_2) to form CO_2 gas. The air is preheated to 1000 K. The CO is at 298 K and the only heat of formation data available are at 298 K. Heat capacities are known.



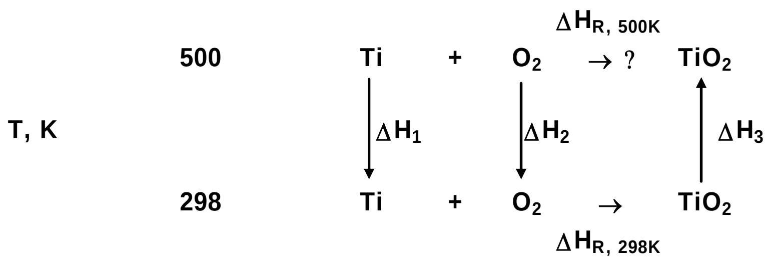
6. Using the JANAF data provided, how much heat would be required to raise one mole of solid Cu at 298 K to pure gaseous Cu at 3000 K? (*It is a good idea to describe briefly how you obtained this number and to mark the data sheet(s) at the appropriate place(s) so partial credit may be assigned in the event your write the answer incorrectly.*)

   See JANAF Tables: 94.991 Kcal

7. Using the textbook data provided, find the heat of reaction at 500 K for the reaction

$$Ti + O_2 = TiO_{2\ (rutile)}.$$

Complete all steps except the arithmetic.



Cp Data	a	$bX10^3$	$cX10^{-5}$
$+TiO_2$	73.35	3.05	-17.03
-Ti	24.94	6.57	-1.63
$-O_2$	29.96	4.18	-1.67
ΔCp	18.45	-7.7	-13.73

$\Delta H_{R,\ 298K} = \Delta H_{f,\ TiO2,298K} = -944{,}000$ Joules

Δa 18.5

Δb -7.7 $X10^3$

Δc -13.7 $X10^{-5}$

$$\Delta H^o_{R,500K} = \Delta H^o_{R,298K} + \int_{298}^{500} \Delta Cp dT = \Delta a\left(500-298\right) + \frac{\Delta b}{2}\left(500^2 - 298^2\right) - \Delta c\left(\frac{1}{500} - \frac{1}{298}\right)$$

Note Δb should be $-7.7x10^{-3}$ and Δc should be $-13.7x10^5$

Data given: Selected JANAF Tables

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MET 320 HQ 2 Oct 28, 2004

CLOSED BOOK & NOTES - NO CALCULATORS. SHOW ALL WORK ON THIS SHEET.
Turn in only these sheets with the problems on them. Keep or discard all other paper.

1. Write the
   a. Fundamental Equations
   b. Maxwell Relations

2. What is the entropy change for the ideal mixing of 3 moles of Neon with 7 moles of Argon?

3. How much heat is required to raise one mole of pure, solid Ag from 300K to pure, liquid Ag at 1400K?

4. Draw a calculation schematic by which you could determine the adiabatic flame temperature for the combustion of one gmole of C (graphite) starting at 400 kalvin with air (21% O_2 & 79% N_2) at 298K to form CO_2. Show how to calculate each enthalpy change and give the appropriate values for the required parameters from the data sheet. No computations or integrations are required.

5. Estimate the heat of vaporization of Mg from the following data, the vapor pressure at the melting point (922K) is 4.08×10^{-3} atm and its boiling point is 1363K.

6. Complete
   a. reduced temperature = ______________________________
   b. reduced pressure =______________________________
   c. definition of chemical potential______________________________
   d. definition of fugacity______________________________
   e. criterion of equilibrium at constant T & P__________________

South Dakota School of Mines and Technology
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MET 320	HQ 2	Nov 10, 2003
MI 220	Data Sheet Provided	9:00 –9:50 AM

Algebraic solutions are OK. No Calculators

1. How much heat is required to raise the temperature of 2 moles of **solid** Pb at 300 K to **liquid** Pb at 600 K? Be sure to draw the calculation schematic.

2. Find the heat of reaction for the following reaction at 298 K. All reactants and products are pure solids.

$$3\ Mn + Cr_2O_3 = 3\ MnO + 2\ Cr$$

3. What is the vapor pressure of ice at its melting point (273 K) is 4.579 Torr (1 mm Hg) and drops to 1.012 Torr at –17.2 C. Determine the heat of sublimation from these data.

4. Draw the calculation schematic for determining the Adiabatic Flame Temperature for the combustion of Methane with air. In that combustion one mole of CH_4 burns with two moles of O_2 to form CO_2 and H_2O (balance the reaction!). Since the O_2 is supplied by air, there are also 7.52 moles of N_2 accompanying the process that do not react but go along for the ride. Assume everything starts at 400 K and that you have data for the heats of formation at 298 K only.

5. Use the Attached JANAF tables to answer the following questions:

   a) How much heat is required to raise one gram mole of solid Cu from 298 K to liquid Cu at 1500 K?
   b) How much heat is required to raise solid Cu from 298 K to hypothetical, solid Cu at 1500 K?
   c) How much heat is required to vaporize solid Cu at 1000 K to gaseous Cu at 1000 K?

6. Real Gas Problem:
   a) What volume would one gram mole of ideal gas occupy at 304 K and 73 atm?
   b) What volume would one gram mole of CO_2 gas occupy at 304 K and 73 atm?

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
DEPARTMENT OF METALLURGICAL ENGINEERING

MET 320 | Hour Exam | Oct 29, 2001

1. Complete the Fundamental Equations for a closed system
   dU = TdS - PdV
   dH =
   dA =
   dG = VdP – SdT

2. Write the "Other" Thermodynamic Relations that derive from dU and dG.

3. Write the Maxwell Relationships that derive from dU and dG.

4. Two moles of neon mix with 8 moles of helium at 298 K. Find the configurational entropy change.

5. Write
   a) The Gibb's Helmholtz Equation
   b) The Definition of Chemical potential $\mu \equiv$
   c) The criterion of equilibrium at dT = dP = 0

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
DEPARTMENT OF METALLURGICAL ENGINEERING

Met 320 | HQ 2 | Oct 23, 2000

CLOSED BOOK & NOTES - NO CALCULATORS. SHOW ALL WORK ON THIS SHEET. DISCARD ALL OTHER WORK SHEETS. (WORK MAY BE SHOWN ON THE BACK)

1. Two moles of ideal gas at 10 atm and 500°K expand isothermally to 2 atm. Find ΔS for the gas if
   a) the expansion is reversible
   b) the expansion results in no work being performed. (However, the same state is, reached).

2. How much work can be obtained from 1000 Joules of heat coming from a source at 527°C if the lowest temperature heat sink available is at 77°C?

8. One mole of ideal gas at 1000 K is isothermally compressed from 3 atm to 8 atm while exchanging heat with a heat sink at 800 K. Find the final ΔS for the
   a) gas and
   b) heat sink.

9. Find the configurational entropy change when 30 gmoles of liquid mercury mix with 70 gmoles of liquid gallium.