

Chemistry 456  
First Exam  
February 4, 2002

Constants and conversion factors that you *may* need

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$R = 8.21 \times 10^{-2} \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$R = 62.364 \text{ L Torr K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101.325 \times 10^3 \text{ Pa}$$

$$k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

$$1 \text{ L} = 10^{-3} \text{ m}^3$$

**NOTE: You must show your work to receive credit!**

Chemistry 456A  
First Exam  
February 4, 2002

-1-

Name \_\_\_\_\_

1) 1.00 mol of an ideal gas with  $C_{v,m}=3/2R$  is compressed adiabatically with a constant external pressure of  $1.00 \times 10^6$  Pa. Initially, the gas is at  $27^\circ\text{C}$  and  $0.10 \times 10^6$  Pa. The final pressure is  $1.00 \times 10^6$  Pa.

a) Calculate the final temperature of the gas

b) Calculate Q.

c) Calculate W.

Chemistry 456A  
First Exam  
February 4, 2002

-2-

Name \_\_\_\_\_

d) Calculate  $\Delta U$ .

e) Calculate  $\Delta H$ .

Chemistry 456A  
First Exam  
February 4, 2002

-3-

Name \_\_\_\_\_

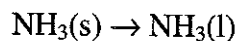
2) You are given the following data at 25°C:

Substance	Fe(s)	FeS <sub>2</sub> (s)	Fe <sub>2</sub> O <sub>3</sub> (s)	S(s)	SO <sub>2</sub> (g)
$\Delta H_f^\circ /(\text{kJ/mol})$	0	?	-824.2	0	-296.81
$C_{p,m}/R$	3.02	7.48		2.72	

You are also given that  $\Delta H^\circ$  is -1655 kJ/mol at 25°C for the reaction

$2\text{FeS}_2(\text{s}) + 11/2 \text{O}_2(\text{g}) \rightarrow \text{Fe}_2\text{O}_3(\text{s}) + 4\text{SO}_2(\text{g})$ . From this information, calculate  $\Delta H_f^\circ$  of FeS<sub>2</sub>(s) at 300°C.

3) The standard enthalpy of fusion of  $\text{NH}_3$  at a standard pressure of 1.00 bar is  $\Delta_{\text{fus}}H^0$  and the temperature of this transition at a standard pressure of 1.00 bar is  $T_{\text{fus}}$ . The molar heat capacities of the solid and liquid are  $C_{p,s}$  and  $C_{p,l}$ . You wish to determine  $\Delta S$ ,  $\Delta S_{\text{surr}}$ , and  $\Delta S_{\text{total}}$ , for the process



At a temperature  $T_2 < T_{\text{fus}}$ .

a) Because this process is not reversible, you need to come up with a reversible pathway involving the transition at  $T_{\text{fus}}$  in order to calculate  $\Delta S$ . This pathway must originate at  $\text{NH}_3(\text{s}, T_2)$  and end at  $\text{NH}_3(\text{l}, T_2)$ . Indicate such a pathway below.

b) Set up an expression for  $\Delta S$  for each segment of the pathway of part a) in terms of  $\Delta_{\text{fus}}H^0$ ,  $C_{p,s}$ ,  $C_{p,l}$ ,  $T_2$ , and  $T_{\text{fus}}$ . Obtain an expression for  $\Delta S$  using your results.

Chemistry 456A  
First Exam  
February 4, 2002

-5-

Name \_\_\_\_\_

c) Set up an expression for  $\Delta S_{\text{surr}}$  for the transformation being considered in terms of  $\Delta_{\text{fus}} H^{\circ}$ ,  $C_{\text{p,s}}$ ,  $C_{\text{p,l}}$ ,  $T_2$ , and  $T_{\text{fus}}$ .

d) Do you expect that  $\Delta S_{\text{total}}$  will be positive or negative? Why?

4) Give brief responses to the four statements below, indicating whether the statement is correct or not and why, or answer the question asked.

a) Because both  $\Delta U$  and  $\Delta S$  are state functions,  $\Delta U_{\text{total}} = \Delta U_{\text{system}} + \Delta U_{\text{surroundings}}$  and  $\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$  are zero in any change occurring in the system.

b) What quantities  $\left(\frac{\partial U}{\partial x}\right)_y$  and  $\left(\frac{\partial H}{\partial x}\right)_y$  are zero for an ideal gas, resulting in the fact that  $dH = C_p dT$  and  $dU = C_v dT$  are functions of temperature only? You are asked to identify  $x$  and  $y$  in each expression.

Chemistry 456A  
First Exam  
February 4, 2002

-7-

Name \_\_\_\_\_

c) For an adiabatic change,  $\Delta S_{\text{system}}$  and  $\Delta S_{\text{surroundings}}$  are both zero.

d)  $\Delta U$  and  $\Delta H$  are never identical for a chemical reaction involving only gaseous species.