

CHEM 3410: Physical Chemistry I — Fall 2009

### Homework 3

Due in Class: September 21, 2009

1. A chemical reaction occurs isothermally at 300 K in a gas mixture that behaves ideally, and the total amount of gas increases by 0.27 moles. If  $\Delta U = 9.4$  kJ what is  $\Delta H$ ?
2. The molar heat capacity,  $C_{p,m}$  of  $\text{SO}_2$  gas is described by the following equation over the range 300–1700 K:

$$C_{P,m} = R [3.093 + 6.967 \times 10^{-3}T - 45.81 \times 10^{-7}T^2 + 1.035 \times 10^{-9}T^3]$$

where  $T$  is the absolute temperature in Kelvin. Assuming ideal gas behavior, calculate  $q$ ,  $w$ ,  $\Delta U$ , and  $\Delta H$  if 1 mole of  $\text{SO}_2$  gas is heated from  $75^\circ\text{C}$  to  $1350^\circ\text{C}$  at a constant pressure of 1 atm. Does the sign you calculate for  $w$  make sense?

HINT: It is useful to remember the definition of enthalpy and that you are dealing with an ideal gas, much like Problem 1.

3. The thermite reaction combines aluminum powder (Al) and iron oxide ( $\text{Fe}_2\text{O}_3$ ) and ignites the mixture to make aluminum oxide and iron. As we saw in class, this reaction is quite dramatic and frequently results in a molten iron product.
  - (a) From a balanced chemical reaction and standard thermochemical data determine  $\Delta H$  for the reaction at  $25^\circ\text{C}$ . You will need to look up some thermochemical data to solve this part of the problem.
  - (b) According to your calculations, is enough heat released to melt the iron? Assume that the heat capacities are independent of temperature.

DATA:

Iron undergoes a solid-state phase transformation from the  $\gamma$ -phase to the  $\alpha$ -phase. Above  $912^\circ\text{C}$  Fe is  $\gamma$ -Fe ; below  $912^\circ\text{C}$  it is  $\alpha$ -Fe.

$$\Delta H_{\text{transformation}} = H(\gamma\text{-Fe}) - H(\alpha\text{-Fe}) = 900 \text{ J/mole}$$

Heat capacity of  $\gamma$ -Fe: 34J/mol-K

Heat capacity of  $\alpha$ -Fe: 38J/mol-K

Melting point of iron: 1808 K

Enthalpy of melting (fusion) for iron: 14.9 kJ/mole

Molar mass for Fe: 56g/mole