

# Homework #7

1) At boiling point,  $\Delta \bar{G} = 0$

so At  $80.09^\circ\text{C}$  (or  $353.24\text{ K}$ ),  $\Delta \bar{G}(\text{benzene}) = 0$

$$\Delta \bar{G} = \Delta \bar{H} - T \Delta \bar{S} = 0$$

$$30.72 - 353.24 \Delta \bar{S} = 0$$

$$\Delta \bar{S} = 0.08697 \text{ kJ/k}\cdot\text{mol} = 86.97 \text{ J/k}\cdot\text{mol}$$

At  $75^\circ\text{C}$  ( $348.15\text{ K}$ )

$$\begin{aligned} \Delta \bar{G} &= 30.72 - 348.15(0.08697) = 0.4414 \text{ kJ/mol} \\ &= 441.4 \text{ J/mol} \end{aligned}$$

At  $85^\circ\text{C}$  ( $358.15\text{ K}$ )

$$\begin{aligned} \Delta \bar{G} &= 30.72 - 358.15(0.08697) = -0.4283 \text{ kJ/mol} \\ &= -428.3 \text{ J/mol} \end{aligned}$$

Below the boiling point, benzene won't spontaneously boil ( $\Delta G$  is positive) but above the boiling point, it will spontaneously boil ( $\Delta G$  is negative).

2)  $dS = PdV + \frac{1}{T}dU$

Natural independent variables are  $V$  and  $U$ . Using  $V$  +  $U$  for the formal total derivative will yield simple thermodynamic relationships.

3)  $dU = TdS - PdV$  and  $dU = \left(\frac{\partial U}{\partial S}\right)_V dS + \left(\frac{\partial U}{\partial V}\right)_S dV$

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

$$\left(\frac{\partial^2 U}{\partial V \partial S}\right) = \left(\frac{\partial T}{\partial V}\right)_S$$

$$\left(\frac{\partial^2 U}{\partial S \partial V}\right) = -\left(\frac{\partial P}{\partial S}\right)_V$$

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

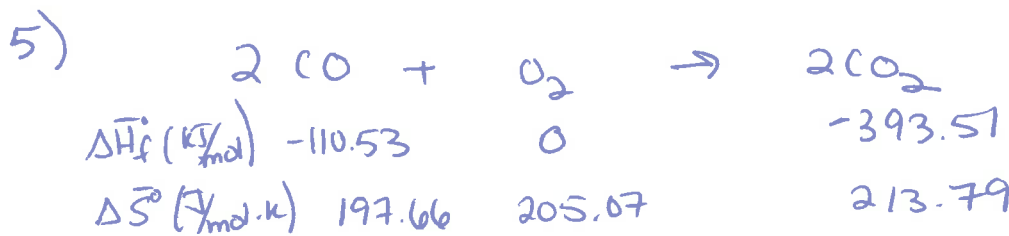
$$4) \Delta H_c (\text{glucose}) = -2808 \text{ kJ/mol}$$

$$T = 37 + 273 = 310 \text{ K}$$

$$\begin{aligned} \Delta \bar{G} &= \Delta \bar{H}_c - T \Delta \bar{S} \\ &= -2808 \text{ kJ/mol} - 310 \text{ K} (0.1824 \text{ kJ/K}\cdot\text{mol}) \\ &= -2865 \text{ kJ/mol} \end{aligned}$$

$$\text{For one mole.. } \Delta G = n \Delta \bar{G} = (1) \Delta \bar{G} = -2865 \text{ kJ}$$

$$\Delta G = W_{\text{nonPV}} \quad \text{so we can do maximum of 2865 kJ of work if we consume 1 mol glucose (but in reality it is much less)}$$



$$298 \text{ K} \left\{ \begin{array}{l} \Delta \bar{H}_r = 2(-393.51) - 0 - 2(-110.53) = -565.96 \text{ kJ/mol} \\ \Delta \bar{S}_r = 2(213.79) - 205.07 - 2(197.66) = -172.81 \text{ J/mol}\cdot\text{K} \\ \Delta \bar{G}_r = -565.96 - 298(-172.81/1000) \\ = -514.46 \text{ kJ/mol} \quad @ \quad 298 \text{ K} \end{array} \right.$$

$$\frac{\Delta_r G(375 \text{ K})}{375} - \frac{\Delta_r G(298 \text{ K})}{298} \approx \Delta_r H(298 \text{ K}) \left( \frac{1}{375} - \frac{1}{298} \right)$$

$$\frac{\Delta_r G(375)}{375} = -1.3355$$

$$\Delta_r G(375) \approx -501 \text{ kJ/mol}$$

b) a) 2 mol gas, 330 K, 3.50 atm  
initial

$$\Delta S = 25 \text{ J/K}$$

$$\begin{aligned}\Delta S &= nR \ln(V_2/V_1) \\ &= nR \ln(P_1/P_2)\end{aligned}$$

$$\begin{aligned}P_2 &= P_1 e^{-\Delta S/nR} \\ &= 15.7 \text{ atm}\end{aligned}$$

$$\begin{aligned}\Delta G &= \Delta H - T\Delta S \\ &= (-330 \text{ K})(25.0 \text{ J/K}) \\ &= 8.25 \text{ kJ}\end{aligned}$$

isothermal

$$P_1 V_1 = P_2 V_2$$

$$V_2/V_1 = P_1/P_2$$

$$\Delta S = nR \ln(P_2/P_1)$$

$$e^{-\frac{\Delta S}{nR}} = P_2/P_1$$

$$P_2 = P_1 e^{-\Delta S/nR}$$

b) SKIP