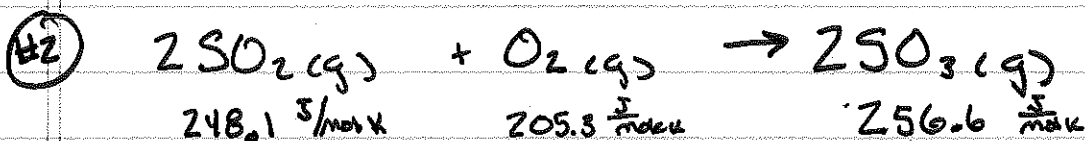
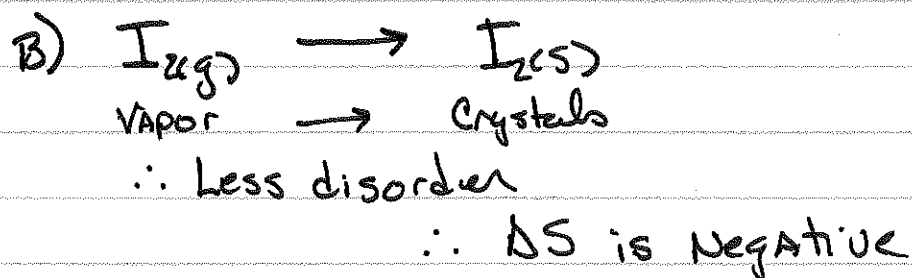
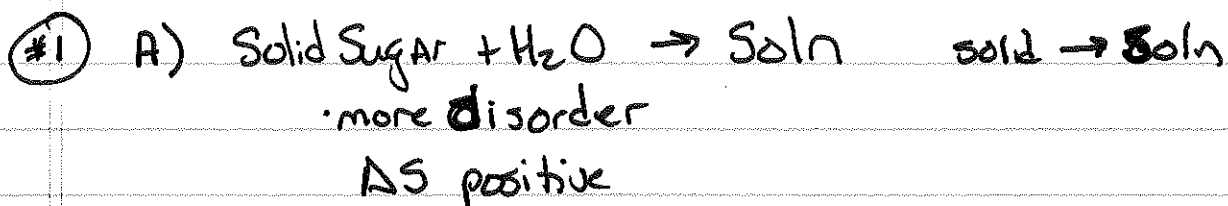


AP Chem Unit 11

NMSI: Entropy & Free Energy

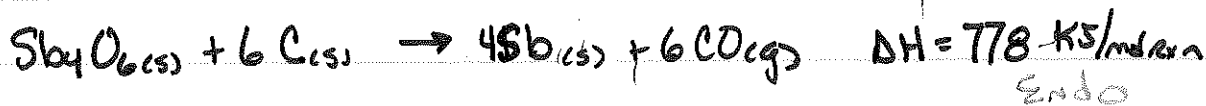
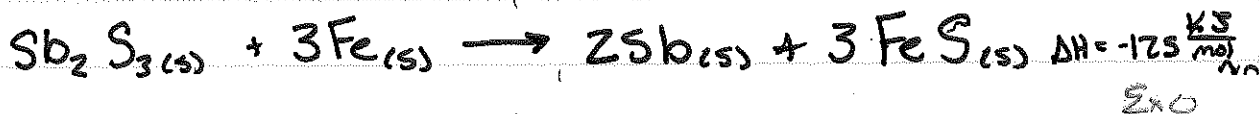


$$\Delta S_{\text{rxn}}^{\circ} = \sum \Delta S_{\text{products}}^{\circ} - \sum \Delta S_{\text{reactants}}^{\circ}$$

$$= \left[\frac{2 \text{ mole}}{\text{mole}\cdot\text{rxn}} \left(\frac{256.6 \text{ J}}{\text{mole}\cdot\text{K}} \right) \right] - \left[\frac{2 \text{ mole}}{\text{mole}\cdot\text{rxn}} \left(\frac{248.1 \text{ J}}{\text{mole}\cdot\text{K}} \right) + \frac{1 \text{ mole}}{\text{mole}\cdot\text{rxn}} \left(\frac{205.3 \text{ J}}{\text{mole}\cdot\text{K}} \right) \right]$$

$$\Delta S_{\text{rxn}}^{\circ} = -188.3 \frac{\text{J}}{\text{mole}\cdot\text{rxn}\cdot\text{K}}$$

#3



$$\Delta S_{\text{surr}} = ? \quad @ 25^\circ\text{C} + 1 \text{ atm}$$

$$\Delta S_{\text{surr}} = -\frac{\Delta H_{\text{system}}}{T}$$

$$\Delta S_{\text{surr}} = -\left(\frac{-125,000 \text{ J}}{298 \text{ K}}\right)$$

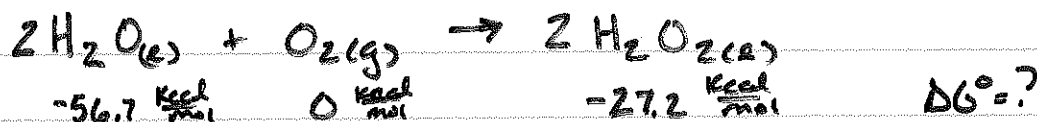
$$\Delta S_{\text{surr}} = 419 \text{ J/mol rxn} \cdot \text{K}$$

$$\Delta S_{\text{surr}} = \frac{-\Delta H_{\text{system}}}{T}$$

$$= -\left(\frac{778,000 \text{ J}}{298 \text{ K}}\right)$$

$$\Delta S_{\text{surr}} = -2.61 \times 10^3 \text{ J/mol rxn} \cdot \text{K}$$

#4



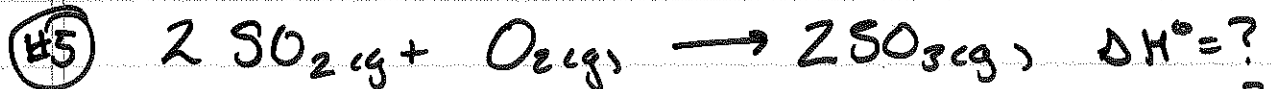
$$\Delta G^\circ_{\text{rxn}} = \sum \Delta G^\circ_f + \sum \Delta G^\circ_r$$

$$= 2(H_2O_2) - [2(H_2O) + O_2]$$

$$= \frac{2 \text{ mol}}{\text{mol rxn}} (-27.2 \frac{\text{kJ}}{\text{mol}}) - \left[\frac{2 \text{ mol}}{\text{mol rxn}} (-56.7 \frac{\text{kJ}}{\text{mol}}) \right]$$

$$= -54.4 \frac{\text{kJ}}{\text{mol rxn}} - (-113.4 \frac{\text{kJ}}{\text{mol rxn}})$$

$$\Delta G^\circ_{\text{rxn}} = 59.0 \text{ kJ/mol rxn}$$



$\Delta S^\circ = ?$

$\Delta G^\circ = ?$

$\Delta H^\circ = 2\Delta H_f^\circ - 2\Delta H_r^\circ$

$= \frac{2 \text{ mol}}{\text{mol rxn}} (-396 \text{ kJ/mol}) - \left[\frac{2 \text{ mol}}{\text{mol rxn}} (-297 \text{ kJ/mol}) + 0 \right]$

$= -792 \frac{\text{kJ}}{\text{mol rxn}} + 594 \frac{\text{kJ}}{\text{mol rxn}}$

$\Delta H^\circ = -198 \text{ kJ/mol rxn}$

$\Delta S^\circ = 2\Delta S_f^\circ - 2\Delta S_r^\circ$

$= \frac{2 \text{ mol}}{\text{mol rxn}} (257 \text{ J/K}\cdot\text{mol}) - \left[\frac{2 \text{ mol}}{\text{mol rxn}} (248 \text{ J/mol}\cdot\text{K}) + \frac{1 \text{ mole}}{1 \text{ mol rxn}} (205 \text{ J/mol}\cdot\text{K}) \right]$

$= 514 \frac{\text{J}}{\text{K}\cdot\text{mol rxn}} - 701 \frac{\text{J}}{\text{K}\cdot\text{mol rxn}}$

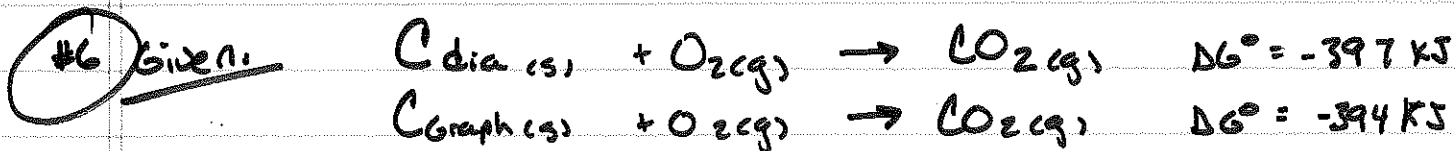
$\Delta S^\circ = -187 \frac{\text{J}}{\text{K}\cdot\text{mol rxn}}$

$\Delta G = \Delta H - T\Delta S$

$= -198 \frac{\text{kJ}}{\text{mol rxn}} - (298 \text{ K}) \left(-187 \frac{\text{J}}{\text{K}\cdot\text{mol rxn}} \right) \left(\frac{1 \text{ KJ}}{1000 \text{ J}} \right) \quad T = 25^\circ + 273 = 298 \text{ K}$

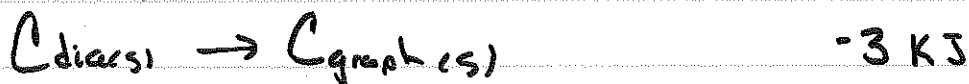
$= -198 \frac{\text{kJ}}{\text{mol rxn}} + 55.7 \frac{\text{kJ}}{\text{mol rxn}}$

$\Delta G^\circ = -142 \text{ kJ/mol rxn}$



Find: $\Delta G^\circ \quad \text{C}_{\text{dia}}(s) \rightarrow \text{C}_{\text{graph}}$

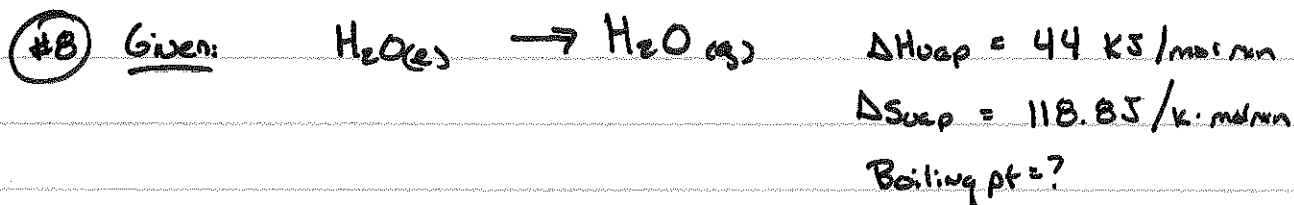
Soln:



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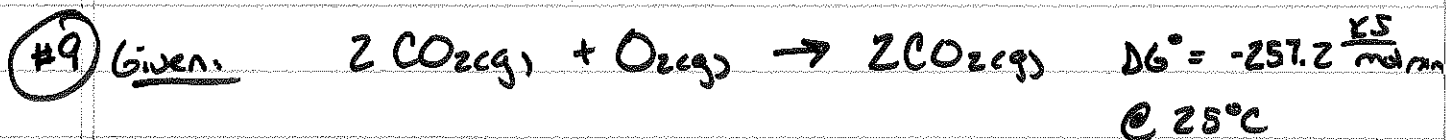


Soln: $\Delta G^\circ = 0$ @ phase change, because system is @ Equilibrium
 (Key Point!)

$$\cancel{\Delta G^\circ} = \Delta H^\circ - T\Delta S^\circ \quad \Delta G^\circ = 0 \text{ @ Equilibrium}$$

$$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{44 \text{ kJ/mol rxn}}{\left(\frac{118.8 \text{ J}}{\text{K}\cdot\text{mol rxn}}\right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}}\right)}$$

$T = 370 \text{ K}$



Find: $k = ?$

Soln:

$$\Delta G^\circ = -RT \ln K$$

$$T = 25^\circ\text{C} + 273$$

$$T = 298 \text{ K}$$

$$-257.2 \frac{\text{kJ}}{\text{mol rxn}} = -\left(8.3145 \frac{\text{J}}{\text{mol K}}\right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}}\right) (298 \text{ K}) \ln K$$

$$-257.2 \frac{\text{kJ}}{\text{mol rxn}} = -2.48 \frac{\text{kJ}}{\text{mol rxn}} \ln K$$

$$\ln K = 104$$

$$K_e = 1.47 \times 10^{45}$$

$$K_p = K_e (RT)^{\Delta n}$$

$$\Delta n = \# \text{ mol}_{\text{sp}} - \# \text{ mol}_{\text{r}}$$

$$\Delta n = 2 - 3$$

$$\Delta n = -1$$