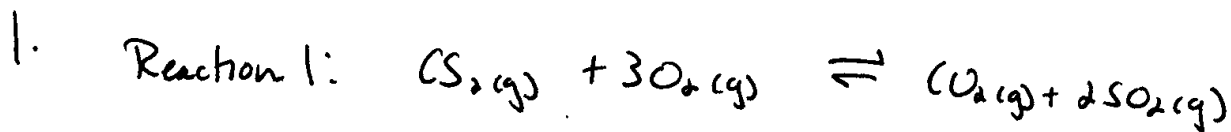
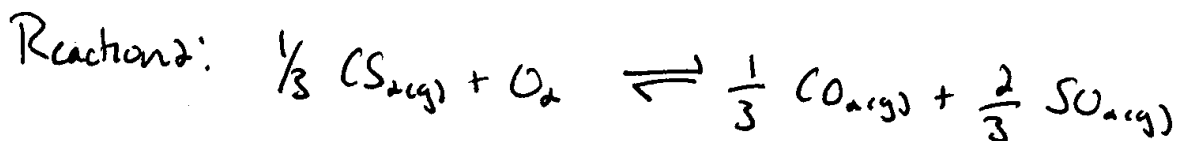


CH302 HW 7 key

(1)



$$K_{p1} = \frac{P_{\text{CO}_2} P_{\text{SO}_2}^2}{P_{\text{CS}_2} P_{\text{O}_2}^3}$$



$$K_{p2} = \frac{P_{\text{CO}_2}^{1/3} P_{\text{SO}_2}^{2/3}}{P_{\text{CS}_2}^{1/3} P_{\text{O}_2}}$$

$$\boxed{K_{p1} = K_{p2}^3}$$

2. need $K_{p3} = \frac{P(\text{XeO}_3\text{F}_2) P(\text{H}_2\text{O})}{P(\text{XeO}_4) P^2(\text{HF})}$

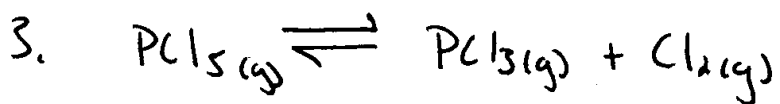
know: $K_{p1} = \frac{P(\text{XeOF}_4) P^2(\text{HF})}{P(\text{XeF}_6) P(\text{H}_2\text{O})}$

$$K_{p2} = \frac{P(\text{XeOF}_4) P(\text{XeO}_3\text{F}_2)}{P(\text{XeO}_4) P(\text{XeF}_6)}$$

By inspection, I can see that I want the numerator of K_{p2} and the denominator of the numerator of K_{p1} :

$$\frac{K_{p2}}{K_{p1}} = \frac{\frac{P(\text{XeOF}_4) P(\text{XeO}_3\text{F}_2)}{P(\text{XeO}_4) P(\text{XeF}_6)}}{\frac{P(\text{XeOF}_4) P^2(\text{HF})}{P(\text{XeF}_6) P(\text{H}_2\text{O})}} = \frac{P(\text{XeO}_3\text{F}_2) P(\text{H}_2\text{O})}{P(\text{XeO}_4) P^2(\text{HF})} = K_{p3}$$

$$\text{So } \boxed{K_{p3} = \frac{K_{p2}}{K_{p1}}}$$



(2)

$\text{FW}(\text{PCl}_5) = 217.5 \text{ g/mol}$

$m = 1.5 \text{ g}$

$n(\text{PCl}_5) = \frac{1.5 \text{ g}}{217.5 \text{ g/mol}} = 0.0069 \text{ mols}$

$V = 0.010 \text{ L} \Rightarrow P(\text{PCl}_5) = \frac{nRT}{V} = (0.0069 \text{ mols})(0.082 \frac{\text{Latm}}{\text{molk}})(523 \text{ K})$
 $T = 250^\circ\text{C} = 523 \text{ K}$

$P(\text{PCl}_5) = 0.30 \text{ atm}$

	PCl_5	PCl_3	Cl_2
I:	0.30	0	0
Δ :	-x	+x	+x
E:	0.30-x	x	x

$\Delta G_f^\circ(\text{PCl}_5) = -305.0 \text{ kJ/mol}$

$\Delta G_f^\circ(\text{PCl}_3) = -267.8 \text{ kJ/mol}$

$\Delta G_f^\circ(\text{Cl}_2) = 0$

$\Delta G_{rxn}^\circ = \Delta G_f^\circ(\text{Cl}_2) + \Delta G_f^\circ(\text{PCl}_3) - \Delta G_f^\circ(\text{PCl}_5)$

$\Delta G_{rxn}^\circ = 0 + -267.8 \text{ kJ/mol} - -305.0 \text{ kJ/mol}$

$\Delta G_{rxn}^\circ = 37.2 \text{ kJ/mol}$

$k_p = \exp\left[\frac{-\Delta G_{rxn}^\circ}{RT}\right] = \exp\left[\frac{-(37.2 \times 10^3 \text{ J/mol})}{(8.314 \text{ J/kmol})(523 \text{ K})}\right]$

$k_p = 1.9 \times 10^{-4} \ll 1$, so assume $0.30 - x \approx 0.30$

$k_p = \frac{P(\text{Cl}_2)P(\text{PCl}_3)}{P(\text{PCl}_5)} = \frac{(x)(x)}{0.30} = \frac{x^2}{0.30} = k_p$

$x = (0.30 k_p)^{1/2} = [(0.30)(1.9 \times 10^{-4})]^{1/2} = 0.0076$

$P(\text{PCl}_5) = 0.30 \text{ atm}$

$P(\text{Cl}_2) = P(\text{PCl}_3) = 0.0076 \text{ atm}$



(3)

P: qualitative: there are two moles of gas on both sides of the equation, so there will be no change in the location of equilibrium as pressure changes

quantitative: $K_p = K_x P_{\text{TOT}}^{\sum \nu_i} = K_x P_{\text{TOT}}^{1+1-2} = K_x P_{\text{TOT}}^0 = K_x (1)$

So no change in K_x to keep K_p constant as P_{TOT} changes

T: We have to do a bit more work:

ΔG_f°	CH_3OH	$(\text{CH}_3)_2\text{O}$	H_2O
ΔG_f°	-166.4 kJ/mol	-112.7 kJ/mol	-228.6 kJ/mol
ΔH_f°	-238.7 kJ/mol	-184.1 kJ/mol	-241.8 kJ/mol

$$\Delta H_{\text{rxn}}^\circ = \Delta H_f^\circ(\text{H}_2\text{O}) + \Delta H_f^\circ((\text{CH}_3)_2\text{O}) - 2\Delta H_f^\circ(\text{CH}_3\text{OH})$$

$$= (-241.8 \text{ kJ/mol}) - 184.1 \text{ kJ/mol} - (2)(-238.7 \text{ kJ/mol})$$

$$\Delta H_{\text{rxn}}^\circ = 50.9 \text{ kJ/mol}$$

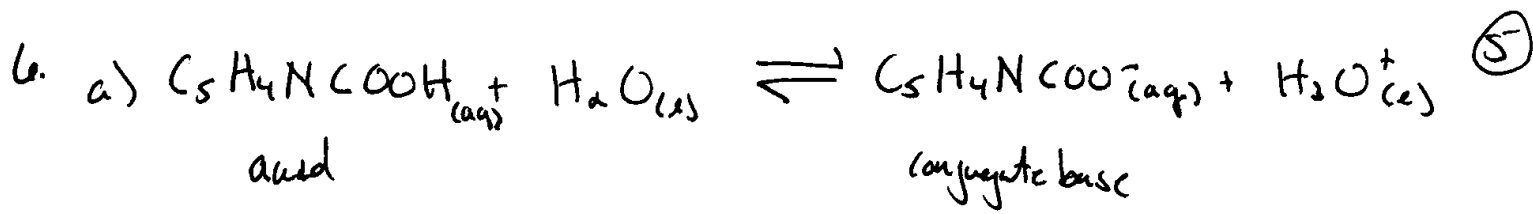
$$\Delta G_{\text{rxn}}^\circ = \Delta G_f^\circ(\text{H}_2\text{O}) + \Delta G_f^\circ((\text{CH}_3)_2\text{O}) - 2\Delta G_f^\circ(\text{CH}_3\text{OH})$$

$$= -228.6 \text{ kJ/mol} + -112.7 \text{ kJ/mol} - (2)(-166.4 \text{ kJ/mol})$$

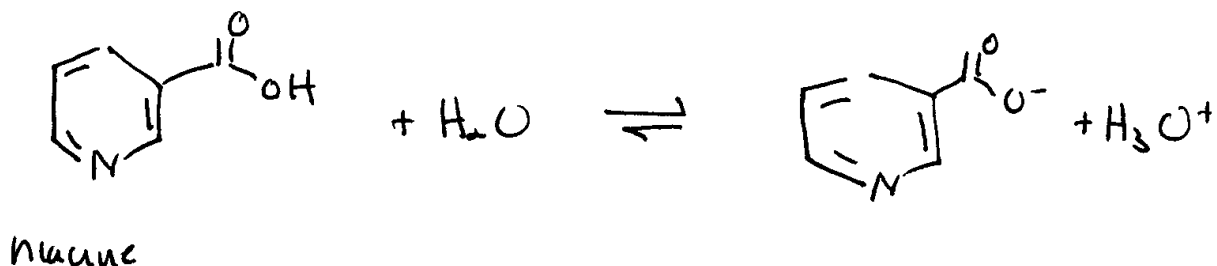
$$\Delta G_{\text{rxn}}^\circ = -8.5 \text{ kJ/mol}$$

$$K_p = \exp \left[\frac{-(-8.5 \times 10^3 \text{ J/mol})}{(8.314 \text{ J/kmol})(298 \text{ K})} \right] = \underline{30} = K_p$$



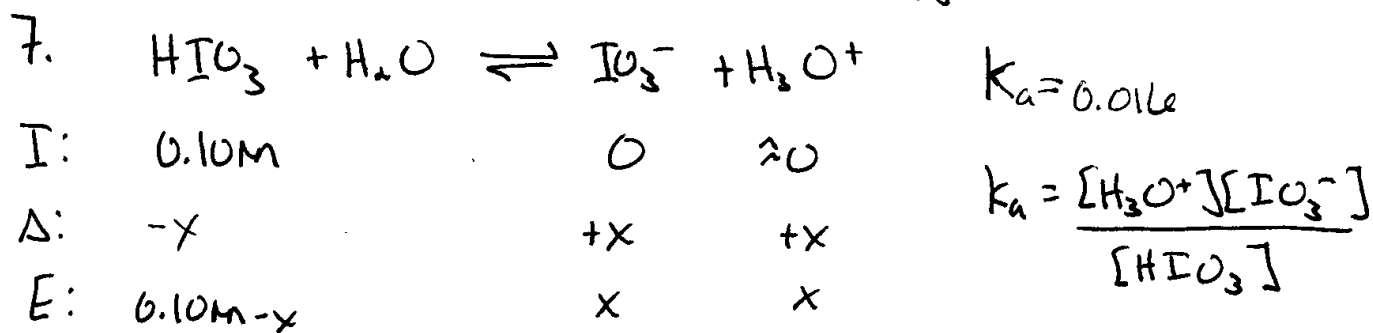


b) Now we have to look at structures:



The only H atoms that pyridine has to give up are the H atoms on the benzyl ring. It will be significantly more difficult to remove these H than the acidic H of nicotinic acid, so we predict

$$K_a(\text{nicotinic acid}) > K_a(\text{pyridine})$$



assume ≈ 0.10

$$K_a = \frac{x^2}{0.10}$$

$$x = (0.10 K_a)^{1/2} = (0.10)(0.016)^{1/2} = 0.04$$

$$[IO_3^-] = [H_3O^+] = 0.04$$

$$\boxed{pH = -\log[H_3O^+] = 1.4}$$