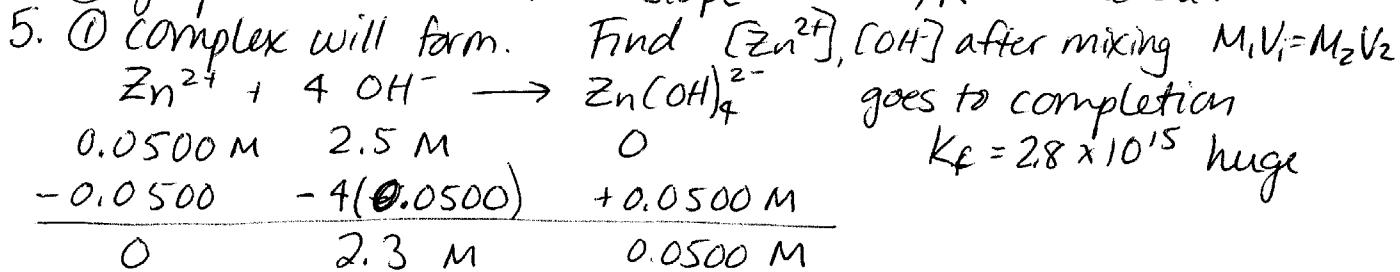
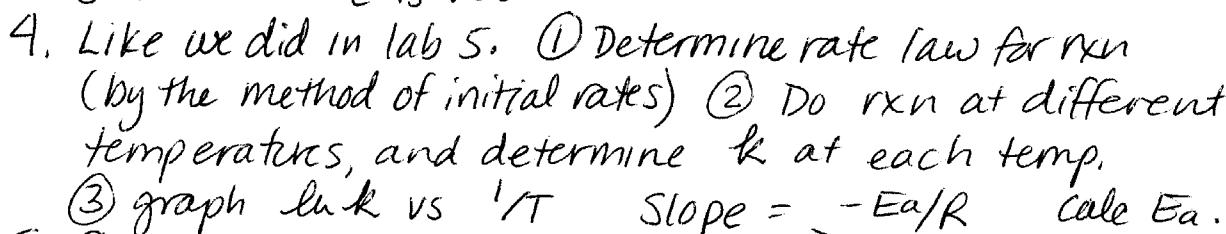
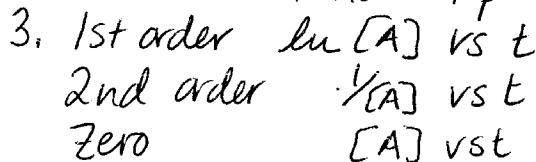
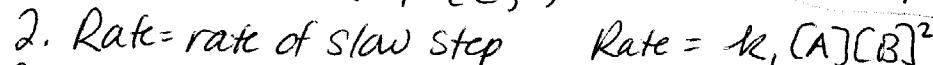
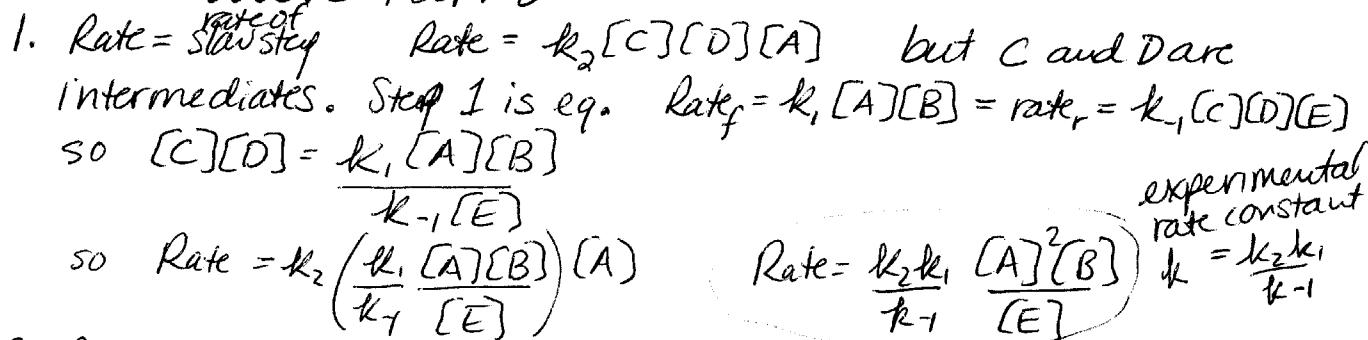


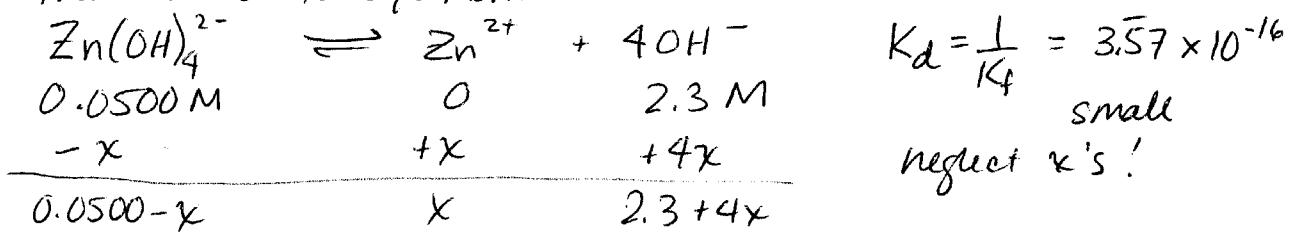
IB Review for Final

Part 2

Answers Part 2

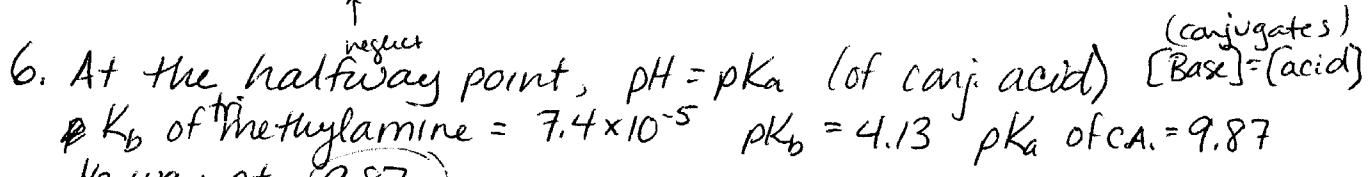


Then comes to equilibrium

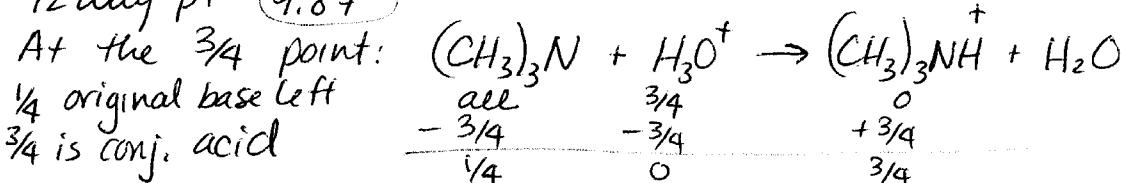


$$K_d = \frac{(x)(2.3+4x)^4}{(0.0500-x)} = \frac{x(2.3)^4}{0.0500}$$

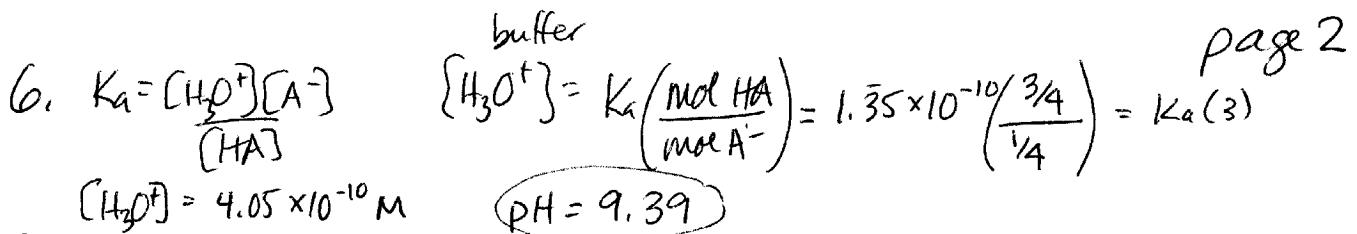
$$x = \frac{K_d(0.0500)}{(2.3)^4} = 6.4 \times 10^{-19} M$$



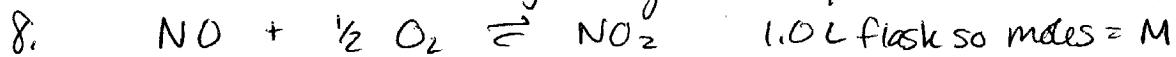
1/2 way pt 9.87



part 2



7. $\text{N}_2 + 3 \text{ H}_2 \rightleftharpoons 2 \text{ NH}_3$
- N_2 added: shift \rightarrow R↑ [Reactants] ↓, [Prod] ↑
 - NH_3 added: shift \leftarrow R↓ [R] ↑, [P] ↓
 - $T \uparrow$ favors ^{endo}othermic direction. Forward is endo. will shift \rightarrow R↑ [R] ↑, [P] ↑
 - $V \uparrow$ so shifts toward less moles gas: forward [R] ↑ [P] ↑
 - no shift. Will just get to equilibrium faster.

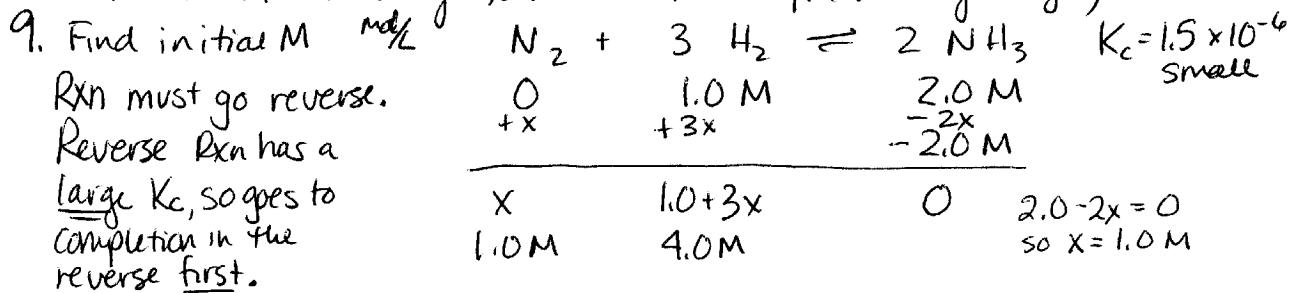


a) $K_c = \frac{[\text{NO}_2]}{[\text{NO}][\text{O}_2]^{\frac{1}{2}}} = \frac{(1.4 \times 10^{-3})}{(6.5 \times 10^{-4})(0.25)^{\frac{1}{2}}} = 4.3$

b) Totals: 10.5×10^{-4} mol NO
 0.35 mol O_2
 2.4×10^{-3} mol NO_2

 $Q = \frac{(2.4 \times 10^{-3})}{(10.5 \times 10^{-4})(0.35)^{\frac{1}{2}}} = 3.9$

$Q < K$. Rxn must go forward to reach eq. (Q must get larger)



O	1.0 M	2.0 M
$+x$	$+3x$	$-2x$

$$\begin{array}{ccc} x & 1.0 + 3x & 0 \\ 1.0 \text{ M} & 4.0 \text{ M} & 2.0 - 2x = 0 \\ & & \text{so } x = 1.0 \text{ M} \end{array}$$

N_2	3 H_2	$\rightleftharpoons 2 \text{ NH}_3$
1.0	4.0	0
$-x$	$-3x$	$+2x$

$$\begin{array}{ccc} 1.0 - x & 4.0 - 3x & 2x \text{ M} \end{array}$$

$$K_c = \frac{[\text{NH}_3]^2}{(\text{N}_2)(\text{H}_2)^3} = \frac{(2x)^2}{(1.0)(4.0)^3} = 1.5 \times 10^{-6} \quad 4x^2 = \sqrt{\frac{1.5 \times 10^{-6}(1.0)(4.0)^3}{4}}$$

K_c is small. Neglect x !

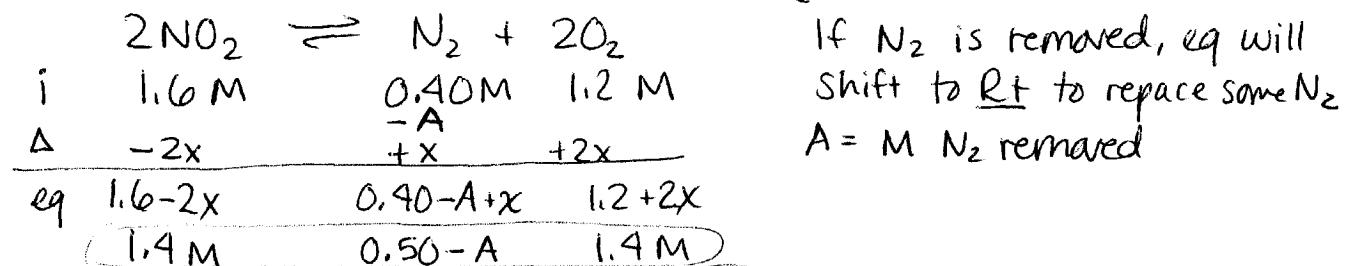
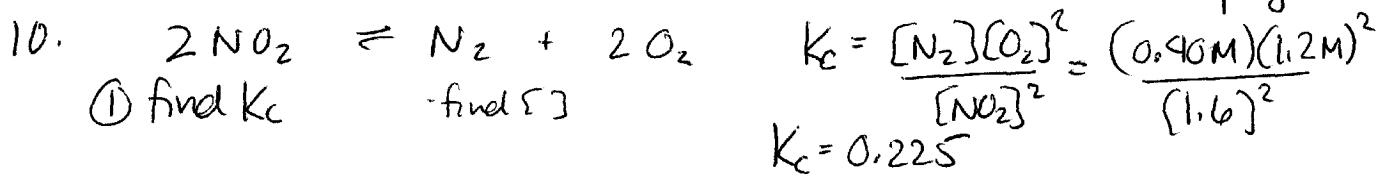
$$x = 0.0049$$

$$[\text{NH}_3] = 2x = 0.0098$$

$$\begin{array}{l} [\text{N}_2] = 1.0 \text{ M} \\ [\text{H}_2] = 4.0 \text{ M} \end{array}$$

part 2

page 3



$\text{NO}_2 \text{ at eq} = 0.70 \text{ moles} \div 0.50 \text{ L} = 1.4 \text{ M}$

$1.6 - 2x = 1.4$

$-2x = -0.2$

$x = 0.10 \text{ M}$

$K_c = \frac{(0.50-A)(1.4)^2}{(1.4)^2}$
 $K_c = 0.50 - A$
 $A = 0.50 - K_c = 0.50 - 0.225 = 0.275 = \text{M N}_2 \text{ removed}$

$(0.275 \text{ mol}) (0.50 \text{ L}) = 0.1375 \text{ moles N}_2 \text{ to be removed} : 0.14 \text{ mol N}_2$



$\text{Temp at which } P_{\text{CCl}_4} = 1.00 \text{ atm}$

$K = P_{\text{CCl}_4}$

$\text{Temp at which } K = 1$

$\Delta G^\circ = -RT \ln K \quad \text{if } K=1, \ln K=0, \text{ and } \Delta G^\circ = 0$

so it's also the temp at which $\Delta G^\circ = 0$.

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \quad \text{calc } \Delta H^\circ, \Delta S^\circ$

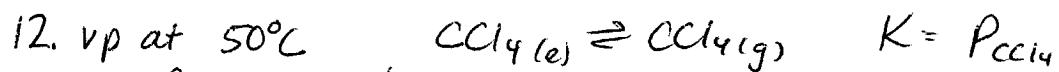
$\Delta H^\circ = \text{prod - react} = \text{gas - liquid} = (-106.7) - (-139.3) = 32.6 \text{ kJ/mol}$

$\Delta S^\circ = (309.4 - 214.4) = +95.0 \text{ J/K.mol} = 0.0950 \text{ kJ/K.mol}$

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

$0 = \Delta H^\circ - T\Delta S^\circ \quad \Delta H^\circ = T\Delta S^\circ$

$T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{32.6 \text{ kJ/mol}}{0.0950 \text{ kJ/K.mol}} = 343 \text{ K} \Rightarrow 70^\circ\text{C}$



$vp = P_{\text{CCl}_4} = K! \quad \text{① find } \Delta G^\circ @ 50^\circ\text{C} \quad \text{② find } K \text{ at } 50^\circ\text{C}$

use $\Delta H^\circ, \Delta S^\circ$ from above problem.

$$\begin{aligned} \Delta G^\circ &= \Delta H^\circ - T\Delta S^\circ = \frac{32600 \text{ J/mol}}{32600} - (323\text{K})(95.0 \text{ J/K.mol}) \\ &\quad - 30685 \\ &= 1915 \text{ J/mol} \end{aligned}$$

J

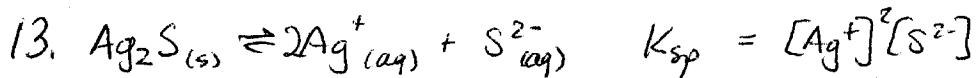
12 continued

page 4

$$\Delta G^\circ = -RT \ln K \quad \ln K = \frac{-\Delta G^\circ}{RT} = \frac{-1915 \text{ J/mol}}{(8.314 \text{ J/kmol})(323 \text{ K})} = -0.7131$$

$$K = e^{-0.7131} = 0.49$$

$P = 0.49 \text{ atm at } 50^\circ\text{C}$



① calc $\Delta H^\circ, \Delta S^\circ$ ② calc $\Delta G^\circ @ 45^\circ\text{C}$ ③ calc $K_{sp} @ 45^\circ\text{C}$ ④ calc solubility

$$\Delta H^\circ = [2(105.9) + (41.8)] - [-31.8] = 285.4 \text{ kJ/mol}$$

$$\Delta S^\circ = [2(73.93) + (22)] - [146] = 23.86 \text{ J/K.mol}$$

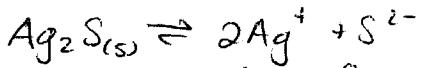
$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\begin{aligned} \Delta G^\circ &= (285400 \text{ J/mol}) - (318 \text{ K})(23.86 \text{ J/K.mol}) \\ &= 285400 \quad - 7587.48 \quad = 277812.52 \text{ J/mol} \end{aligned}$$

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

$$\ln K = \frac{-\Delta G^\circ}{RT} = \frac{-277812.52 \text{ J/mol}}{(8.314 \text{ J/kmol})(318 \text{ K})} = -105.08$$

$$K = e^{-105.08} = 2.3 \times 10^{-46} \quad (\text{no sf})$$



Some	0	0
-x	+2x	+x
some-x	2x	x

$$\begin{aligned} K_{sp} &= (2x)^2(x = 4x^3) \\ x &= \sqrt[3]{\frac{K_{sp}}{4}} = \sqrt[3]{\frac{2.3 \times 10^{-46}}{4}} = 3.9 \times 10^{-16} \text{ M} \end{aligned}$$

$$(3.9 \times 10^{-16} \text{ mol L}) \left(\frac{247.87 \text{ g}}{1 \text{ mol}} \right) = 9.7 \times 10^{-14} \text{ g/L} \quad \text{so close to } 1 \times 10^{-13} \text{ g/L}$$

Solubility @ 45°C

At room temp (25°C), will it be more or less soluble?

Look @ signs of ΔS° and ΔH°

If $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ at first sight, it looks like we can just answer this on the basis of the sign of ΔS°

if ΔS° is \oplus , The $T\Delta S$ term is larger at higher temps, so it gives us a larger \ominus term... more favorable @ higher temps. But, if we look more closely...

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -RT \ln K$$

ΔG° and K both depend on T .

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$$\frac{\Delta H^\circ - T\Delta S^\circ}{-RT} = \frac{-RT \ln K}{-RT}$$

$$\ln K = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$$

The value of K_{sp} at a particular temperature is directly related to solubility.

according to this, it's really the sign of ΔH° that matters.
if ΔH° is \oplus and ΔS° is \oplus , as is the case here,

$$\ln K = \frac{-(+)}{RT} + \oplus$$

\curvearrowleft negative \curvearrowleft positive
term term

if T is lower, the $\frac{\Delta H^\circ}{RT}$ term will have a higher magnitude.

Since this term is \ominus , it will lower $\ln K$ and lower K .

* If ΔH° is \oplus , higher $T \Rightarrow$ higher K (more favorable)

If ΔH° is \ominus

$$\ln K = \frac{-(-)}{RT} + \text{constant}$$

lower T , larger magnitude of $\frac{\Delta H^\circ}{RT}$ term. Term is \oplus overall.

This means $\ln K$ is larger, so K is larger.

* If ΔH° is \ominus , higher $T \Rightarrow$ lower K (less favorable)

14. $2\text{Na}_{(s)} + \text{Cl}_2_{(g)} \rightarrow 2\text{NaCl}_{(s)}$ gases are much more disordered than solids. ~~Even though we have 3 sub~~
Since a gas is being consumed, products have more order. $\Delta S \ominus$

15. a. larger molecules have more entropy - more bending + vibration motions are possible. ($\text{CH}_3\text{CH}_2\text{CH}_3$)
b. 2 mol NO_2 has more degrees of freedom than 1 mol N_2O_4 .
the molecules are separate and can move around independently.
- c. $\text{H}_2\text{O}_{(l)}$ liquids are more disordered than solids.

16. See sheet for answers. Think of exo/endo and increase/decrease in disorder.