Problems

31. $2NH_3 \rightleftharpoons N_2 + 3H_2$

	$2NH_3$	N_2	$3H_2$
I	3 mol/L	0	0
C	$-2x$	$+x$	$+3x$
E	2.34 mol/L	0.33 mol/L	1 mol/L

$3x = 1$

$x = 0.33$

$$K_c = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.33)(1)^3}{(2.34)^2}$$

$$= 0.0603$$

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32. $N_2 + O_2 \rightleftharpoons 2NO \quad K_c = 4.8 \times 10^{-8}$

	N_2	O_2	$2NO$
	1.25	0.5	0
	$-x$	$-x$	$+2x$

$$K_c = 4.8 \times 10^{-8} = \frac{(2x)^2}{(1.25-x)(0.5-x)}$$

$$4.8 \times 10^{-8} = \frac{4x^2}{0.625}$$

$$4x^2 = 3 \times 10^{-8}$$

$$x = 8.66 \times 10^{-5}$$

$\therefore [N_2] = 1.2499$ mol/L

$[O_2] = 0.4999$ mol/L

$[NO] = 1.73 \times 10^{-4}$

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33. $PCl_3 + Cl_2 \rightleftharpoons PCl_5 \quad K_c = 0.18$

	PCl_3	Cl_2	PCl_5
	0.225	0.15	0
	$-x$	$-x$	$+x$

$$K_c = 0.18 = \frac{x}{(0.225-x)(0.15-x)}$$

$$x = (0.03375 - 0.375x + x^2)(0.18)$$

$$x = 0.006075 - 0.0675x + 0.18x^2$$

$$0 = 0.006075 - 1.0675x + 0.18x^2$$

$$x = \frac{1.0675 \pm \sqrt{(1.0675)^2 - 4(0.18)(0.006075)}}{2(0.18)}$$

$$= \frac{1.0675 \pm 1.0634}{0.36}$$

$= 5.925$ or 0.00583

unreasonable

$\therefore [PCl_3] = 0.219$ mol/L

$[Cl_2] = 0.144$ mol/L

$[PCl_5] = 0.00583$ mol/L

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34. $Al(OH)_{3(s)} \rightleftharpoons Al^{3+} + 3OH^-$ $K_{sp} = 4.0 \times 10^{-12}$

I	/	0
C	/	$+x$

0

$+3x$

3/3 $K_{sp} = 4 \times 10^{-12} = (x)(3x)^3$

$4 \times 10^{-12} = 27x^4$

$x = 6.2 \times 10^{-4}$

∴ the molar solubility of $Al(OH)_3$ is 6.2×10^{-4} mol/L

35. $CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$

$n = \frac{m}{M}$

$= \frac{5.6 \times 10^{-3}}{100.09}$

$= 1.26 \times 10^{-4}$

$\frac{1.26 \times 10^{-4}}{0.025}$

$= 5.04 \times 10^{-3}$ mol/L

2.5/3 $K_{sp} = [Ca^{2+}][CO_3^{2-}] = (5.04 \times 10^{-3})^2$

$= 2.54 \times 10^{-5}$

3.8×10^{-9}

36. $Mg(OH)_2 + KOH$

$Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$ $K_{sp} = 9 \times 10^{-12}$

I	/	0	0.55
C	/	$+x$	$+2x$

insignificant

3/3 $K_{sp} = 9 \times 10^{-12} = (x)(0.55 + 2x)^2$

$9 \times 10^{-12} = (x)(0.55)^2$

$x = 2.975 \times 10^{-11}$

∴ the solubility of $Mg(OH)_2$ is 2.975×10^{-11} mol/L

37. $Ni(NO_3)_2 + KOH$

2.5×10^{-5} mol/L $\quad 4.86 \times 10^{-2}$ mol/L

6/6 $Ni(OH)_{2(s)} \rightleftharpoons Ni^{2+} + 2OH^-$ $K_{sp} = 6 \times 10^{-10}$

$[Ni(NO_3)_2] : [Ni^{2+}] = 2.5 \times 10^{-5} \times \frac{845}{1000} = 2.03 \times 10^{-5}$ mol/L

$[KOH] : [OH^-] = 4.86 \times 10^{-2} \times \frac{185}{1000} = 9.11 \times 10^{-3}$ mol/L

$Q = (2.03 \times 10^{-5})(9.11 \times 10^{-3})^2$

$= 1.69 \times 10^{-9}$

∵ $Q > K$, a precipitate will form

38. $\Delta H^\circ_f = [(-393.5) + 2(-45.9)] - [(-333.5) + (-285.8)]$
$= 134\ kJ$

$\Delta S^\circ = [213.78 + 2(192.78)] - [104.6 + 69.95]$
$= 424.79\ J/k$
$= 0.42479\ kJ/k$

$\Delta G = \Delta H^\circ_f - T\Delta S^\circ$
$= 134 - (298)(0.42479)$
$= 7.41$

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No, the reaction will not be spontaneous at SATP. It would need a higher temp. to be spontaneous in the forward direction.