GE 4

1. $N_2O_{(g)} + \frac{3}{2}O_2 \leftrightarrow N_2O_4 \qquad K_c = ?$

1st Rxn reverse and x by $\frac{1}{2}$

$N_2O \leftrightarrow N_2 + \frac{1}{2}O_2 \qquad K_c = \left(\frac{1}{1.2\times10^{-35}}\right)^{1/2} = 2.89\times10^{17}$

2nd Rxn Reverse only

$2NO_2 \leftrightarrow N_2O_4 \qquad K_c = \left(\frac{1}{4.6\times10^{-3}}\right) = 217.39$

3rd Rxn x by 2

$N_2 + 2O_2 \leftrightarrow 2NO_2 \qquad K_c = (4.1\times10^{-9})^2 = 1.681\times10^{-17}$

+

$N_2O + 2NO_2 + N_2 + \frac{3}{2}O_2 \leftrightarrow N_2 + \frac{1}{2}O_2 + N_2O_4 + 2NO_2$

$N_2O_{(g)} + \frac{3}{2}O_{2(g)} \leftrightarrow N_2O_4$

$K_c = (2.89\times10^{17})(217.39)(1.681\times10^{-17}) = \boxed{1056}$

2. $4HCl_{(g)} + O_{2(g)} \leftrightarrow 2H_2O_{(g)} + 2Cl_{2(g)} \qquad K_c = 1.6$

a. 0.20 M 0.20 M 0.20 M 0

$Q = \frac{(.20\,M)^2(0\,M)^2}{(.20\,M)^4(.20\,M)} \qquad Q = 0 > K_c$

Since no Cl_2, rxn shift Right to reach $\rightleftarrows$

b. $\frac{1.20\,mol}{4.0\,L} = .30\,M \qquad \frac{0.60\,mol}{4.0\,L} = .15\,M \qquad \rightleftarrows \qquad \frac{1.40\,mol}{4.0\,L} = .35\,M \qquad \frac{0.80\,mol}{4.0\,L} = .20\,M \qquad V = 4.0\,L$

$Q = \frac{(.35\,M)^2(.20\,M)^2}{(.30\,M)^4(.15\,M)} = 4.0 > K_c$

Shift Left to reach $\rightleftarrows$

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$T = 900°C = 1173\ K$

3. $C_{(s)} + H_2O_{(g)} \rightleftarrows CO_{(g)} + H_{2(g)}$

(⇄) $\quad 0.010\ M \quad 0.040\ M \quad 0.040\ M$

$$K_c = \frac{(0.040\ M)(0.040\ M)}{(0.010\ M)} = \boxed{0.16}$$

$$K_p = .16\left[(.0821)(1173K)\right]^{2-1} = \boxed{15.4}$$

4. $SO_{3(g)} \leftrightarrow SO_{2(g)} + \frac{1}{2}O_{2(g)} \quad \Delta H = 99\ kJ$ endothermic

a. add O_2 = shift left (reverse)
b. ↓ vol = shift toward less moles gas = shift Left
c. ↑ Ar = no shift
d. ↓ T = remove heat = shift left (endo rxn)
e. ↓ SO_2 = shift Right

5. $CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2(g)} + H_{2(g)} \quad K_c = 1.30$ $\quad T = 650°C$ $\quad V = 2.50\ L$

I	$\frac{0\ mol}{2.50\ L}$	$\frac{0\ mol}{2.50\ L}$	$\frac{4.00\ mol}{2.50\ L}$	$\frac{4.00\ mol}{2.50\ L}$	
	$= 0\ M$	$= 0\ M$	$= 1.60\ M$	$= 1.60\ M$	
C	$+x$	$+x$	$-x$	$-x$	
E	x	x	$1.60 - x$	$1.60 - x$	

$$K_c = \sqrt{1.30} = \sqrt{\frac{(1.60-x)^2}{x^2}} \qquad 1.14 = \frac{1.60 - x}{x}$$

$$1.14x = 1.60 - x$$
$$2.14x = 1.60$$
$$x = .748\ M$$

$$\boxed{[CO] = [H_2O] = .748\ M}$$

$$\boxed{[CO_2] = [H_2] = 1.60\ M - .748\ M = .85\ M}$$

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6. $4NH_{3(g)} + 3O_{2(g)} \rightleftharpoons 2N_{2(g)} + 6H_2O_{(g)}$ $K_p = 0.0049$

$0.255\ atm \quad 0.213\ atm \quad 0.833\ atm$

$$K_p = \frac{(P_{N_2})^2 (P_{H_2O})^6}{(P_{NH_3})^4 (P_{O_2})^3} \qquad 0.0049 = \frac{(0.213\ atm)^2 (0.833\ atm)^6}{(P_{NH_3})^4 (0.255\ atm)^3}$$

$$\boxed{P_{NH_3} = 3.70\ atm}$$

$$P_T = P_{NH_3} + P_{O_2} + P_{N_2} + P_{H_2O}$$

$$P_T = 3.70\ atm + 0.255\ atm + 0.213\ atm + 0.833\ atm$$

$$\boxed{P_T = 5.00\ atm}$$

7. $SO_{2(g)} + NO_{(g)} \Leftrightarrow NO_{(g)} + SO_{3(g)}$ $K_c = 84.7$

I $\frac{0.02077\ mol}{1.0\ L}$ $\frac{0.02077\ mol}{1.0\ L}$ $\frac{0.02077\ mol}{1.0\ L}$ $\frac{0.02077\ mol}{1.0\ L}$ $V = 1.0\ L$

$= 0.02077\ M \quad = 0.02077\ M \quad = 0.02077\ M \quad = 0.02077\ M$

C $-x \quad -x \quad +x \quad +x$

E $0.02077 - x \quad 0.02077 - x \quad 0.02077 + x \quad 0.02077 + x$

$$K_c = 84.7 = \sqrt{\frac{(0.02077 + x)^2}{(0.02077 - x)^2}}$$

$$9.20 = \frac{.02077 + x}{.02077 - x}$$

$$.191 - 9.20x = .02077 + x$$

$$.17023 = 10.20x$$

$$x = .0167\ M$$

$Q = \frac{(.02077)^2}{(.02077)^2} = 1$

$Q < K_c$

∴ MUST shift Rt (+x on P side)

At ⇄ $[SO_2] = [NO] = .02077\ M - .0167\ M = .00407\ M$

$[NO] = [SO_3] = .02077\ M + .0167\ M = .03747\ M$

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8. $N_{2(g)} + O_{2(g)} \leftrightarrow 2NO_{(g)}$ $K_p = 0.0255$

I	0.300 atm	0.300 atm	0.300 atm	which way shift?
C	$+x$	$+x$	$-2x$	$Q = \frac{(.3)^2}{(.3)^2} = 1 > K_p$
E	$0.300 + x$	$0.300 + x$	$0.300 - 2x$	shift left

$$K_p = \sqrt{0.0255} = \sqrt{\frac{(.300 - 2x)^2}{(.300 + x)(.300 + x)}}$$

$$.160 = \frac{.300 - 2x}{.300 + x}$$

$$.048 + .160x = .300 - 2x$$

$$2.160x = .252$$

$$x = .1167 \text{ atm}$$

$P_{NO} = .300 - 2(.1167)$
$= .0666$ atm

$P_{N_2} = P_{O_2} = .300 + .1167$
$= .4167$ atm

9. $2HI_{(g)} \leftrightarrow I_{2(g)} + H_{2(g)}$ $K_p = 0.0169$ $T = 800$ K $V = 1.00$ L

I	0.200 atm	0 atm	0 atm
C	$-2x$	$+x$	$+x$
E	$0.200 - 2x$	x	x

a. $n_{HI} = \frac{PV}{RT} = \frac{(0.200 \text{ atm})(1.00 \text{ L})}{(.0821 \frac{\text{L atm}}{\text{mol K}})(800 \text{ K})} = .00305$ mol HI

b. $K_p = \sqrt{0.0169} = \sqrt{\frac{x^2}{(0.200 - 2x)^2}}$ $\quad .13 = \frac{x}{.200 - 2x}$

$$.026 - .26x = x$$

$$x = .0206$$

$P_{I_2} = P_{H_2} = .0206$ atm

c. $P_T = P_{HI} + P_{I_2} + P_{H_2} = 0.200 - 2(.0206) + .0206 + .0206$

$P_T = .200$ atm

d. $n_T = \frac{P_T V}{RT} = \frac{(.200 \text{ atm})(1.0 \text{ L})}{(.0821 \frac{\text{L atm}}{\text{mol K}})(800 \text{ K})} = .00305$ mol