Eq'm

① $I_{2(g)} + H_{2(g)} \rightleftharpoons 2HI_{(g)}$

	$I_{2(g)}$	$H_{2(g)}$	$2HI_{(g)}$
I	1.38×10^{-3}	9.84×10^{-4}	0
C	$-x$	$-x$	$+2x$
E	$1.38\times10^{-3}-x$	$9.84\times10^{-4}-x$	$2x$

$= 4.73\times10^{-4}$

$\therefore x = 0.907\times10^{-3}$

$[H_2]_{eq'm} = 9.84\times10^{-4} - 9.07\times10^{-4}$

$= 7.7\times10^{-5}$ mol/L

$[HI] = 2(9.07\times10^{-4})$

$= 1.81\times10^{-3}$ mol/L

$$K_c = \frac{[HI]^2}{[I_2][H_2]}$$

$$= \frac{(1.81\times10^{-3})^2}{(4.73\times10^{-4})(7.7\times10^{-5})}$$

$= 89.95$

$K_c = 90.0$

2.

	$2\,NO_{(g)}$	+	$O_{2\,(g)}$	$\rightleftharpoons$	$2\,NO_{3\,(g)}$
I	0.02		0.03		0
C	$-2x$		$-x$		$+2x$
E	$0.02-2x$		$0.03-x$		$2x$
					$= 2.2\times10^{-3}$

$x = 1.1\times10^{-3}$

$2x = 2.2\times10^{-3}$

$[NO]_{eqm} = 0.02-2x$

$= 0.02-2(1.1\times10^{-3})$

$= 0.0178\ \frac{mol}{L}$

$[O_2]_{eqm} = 0.03-x$

$= 0.03-1.1\times10^{-3}$

$= 0.0289\ \frac{mol}{L}$

$$K_c = \frac{[NO_3]^2}{[NO]^2[O_2]}$$

$$= \frac{(2.2\times10^{-3})^2}{(0.0178)^2(0.0289)}$$

$$= 0.529$$

3. $SbCl_5(g) \rightleftharpoons SbCl_3(g) + Cl_2(g)$ (6)

(a)

$$[SbCl_5]_{eq'm} = \frac{m}{M \cdot V}$$

$$= 6.91\,g\ SbCl_5 \times \frac{1\,mol\ SbCl_5}{299.00\,g\ SbCl_5} \times \frac{1}{5.00\,L}$$

$$= 4.62 \times 10^{-3}\ mol/L$$

$$[SbCl_3]_{eq'm} = \frac{m}{M \cdot V} = 16.45\,g\ SbCl_3 \times \frac{1\,mol\ SbCl_3}{228.1\,g\ SbCl_3} \times \frac{1}{5.00\,L}$$

$$= 0.0144\ mol/L$$

$$[Cl_2]_{eq'm} = \frac{m}{MV} = 5.11\,g\ Cl_2 \times \frac{1\,mol\ Cl_2}{70.90\,g\ Cl_2} \times \frac{1}{5.00\,L}$$

$$= 0.0144\ mol/L$$

$$K_c = \frac{[SbCl_3][Cl_2]}{[SbCl_5]}$$

$$= \frac{(0.0144)(0.0144)}{(4.62 \times 10^{-3})}$$

$$K_c = 0.0450$$

(b)

	$SbCl_5(g)$	$\rightleftharpoons$	$SbCl_3(g)$	+	$Cl_2(g)$
I	6.69×10^{-3}		0		0
C	$-x$		$+x$		$+x$
E	$6.69 \times 10^{-3} - x$		x		x

$$[SbCl_5] = \frac{10\,g}{(299)(5)} = 6.69 \times 10^{-3}$$

$$K_c = \frac{[SbCl_3][Cl_2]}{[SbCl_5]}$$

$$0.0450 = \frac{(x)(x)}{6.69 \times 10^{-3} - x}$$

$$0 = x^2 + 0.0450x - 3.01 \times 10^{-4}$$

$$x = 5.9 \times 10^{-3}$$

$$[SbCl_3] = [Cl_2] = 5.9 \times 10^{-3}\ mol/L$$

$$[SbCl_5] = 7.9 \times 10^{-4}\ mol/L$$

4. $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ (D)

$$K_{c_1} = \frac{[H_2][I_2]}{[HI]^2}$$

$$= 0.021$$

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

$$K_{c_2} = \frac{[HI]^2}{[H_2][I_2]} = \frac{1}{\frac{[H_2][I_2]}{[HI]^2}}$$

$$K_{c_2} = \frac{1}{K_{c_1}} = \frac{1}{0.021}$$

$$K_{c_2} = 47.6$$

(5)

$$N_2(g) + C_2H_2(g) \rightleftharpoons 2HCN(g)$$

	N_2	C_2H_2	$2HCN$
I	2.2	1.0	0
C	$-x$	$-x$	$+2x$
E	$2.2-x$	$1.0-x$	$2x$
	≈ 2.2	≈ 1.0	

$$K_c = \frac{[HCN]^2}{[N_2][C_2H_2]}$$

$$2.3\times10^{-4} = \frac{(2x)^2}{(2.2)(1.0)}$$

$$4x^2 = 5.06\times10^{-4}$$

$$x = 0.011$$

$$[N_2]_{eq'm} = 2.2 - 0.011$$
$$\approx 2.2\ mol/L$$

$$[C_2H_2]_{eq'm} = 1 - 0.011$$
$$\approx 1.0\ mol/L$$

$$[HCN]_{eq'm} = 2(0.011)$$
$$= 0.022 mol/L$$

check

$$\frac{[\ ]_I}{K_c} = \frac{1.0}{2.3\times10^{-4}}$$

$$= 4348 > 500$$

$\therefore 2.2 - x \approx 2.2$
$1.0 - x \approx 1.0$

proof.

$$\frac{x}{[\ ]_I} \times 100\% < 5\%$$

$$\frac{0.011}{1} \times 100\%$$

$$= 1.1\% < 5\%$$

$\therefore$ assumpt. valid

(6)

$$Br_{2(g)} + F_{2(g)} \rightleftharpoons 2\,BrF_{(g)}$$

	Br_2	F_2	BrF
I	0.25	0.25	0
C	$-x$	$-x$	$+2x$
E	$0.25-x$	$0.25-x$	$2x$

$$K_c = \frac{[BrF]^2}{[Br_2][F_2]}$$

$$55.3 = \frac{(2x)^2}{(0.25-x)(0.25-x)}$$

perfect square
take square root of both sides

$$7.44 = \frac{2x}{0.25-x}$$

$$1.86 - 7.44x = 2x$$

$$1.86 = 9.44x$$

$$x = 0.197$$

$$[Br_2]_{eqm} = [F_2]_{eqm} = 0.25 - 0.197$$

$$= 0.05 \text{ mol/L}$$

$$[BrF]_{eqm} = 0.20 \text{ mol/L}$$

7. ⑥

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$$

	PCl_3	Cl_2	PCl_5
I	0	0	0.020
C	$+x$	$+x$	$-x$
E	x	x	$0.020 - x$
			$\therefore \approx 0.02$

$$K_c = \frac{[PCl_5]}{[PCl_3][Cl_2]}$$

$$962 = \frac{(0.02 - x)}{(x)(x)}$$

$$962 = \frac{0.02}{x^2}$$

$$x^2 = \frac{0.02}{962}$$

$$x = 4.6 \times 10^{-3}$$

check $\frac{[\,]_I}{K_c}$

$\frac{0.02}{962}$ << small

∴ change from product is small

proof $\frac{x}{[\,]_I} \times 100\%$

$\frac{4.6 \times 10^{-3}}{2 \times 10^{-2}} \times 100\%$

$23\% >> 5\%$

∴ Quadratic

$0 = 962x^2 + x - 0.02$

$x = 4.1 \times 10^{-3}$ mol

$[PCl_3]_{eqlm} = [Cl_2]_{eqlm} = 4.1 \times 10^{-3}$ mol/L

8.

	N_2O_4 (g)	$\rightleftharpoons$	$2NO_2$ (g)
I	0.0326		0
C	$-x$		$+2x$
E	$0.0326 - x$		$2x$

$$[N_2O_4]_{initial} = \frac{m}{MV} = 15.0\,g\,N_2O_4 \times \frac{1\,mol\,N_2O_4}{92.02\,g\,N_2O_4} \times \frac{1}{5.00\,L}$$

$$= 0.0326\ mol/L$$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}$$

$$5.85\times10^{-5} = \frac{(2x)^2}{(0.0326 - x)}$$

$$1.91\times10^{-6} - 5.85\times10^{-5}x = 4x^2$$

$$0 = 4x^2 + 5.85\times10^{-5}x - 1.91\times10^{-6}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-5.85\times10^{-5} \pm \sqrt{(5.85\times10^{-5})^2 - 4(4)(-1.91\times10^{-6})}}{2(4)}$$

$$= \frac{-5.85\times10^{-5} \pm \sqrt{3.06\times10^{-5}}}{8}$$

$$x = 6.8\times10^{-4}$$

$$[NO_2]_{eq'm} = 2x$$

$$= 1.4\times10^{-3}\ \frac{mol}{L}$$

$$n_{NO_2} = [\,]V$$

$$= 1.4\times10^{-3}\ \frac{mol}{L} \times 5\,L$$

$$= 6.8\times10^{-3}\ mol\ NO_2$$

(b)

$$\%\ rxn = \frac{change}{[\,]_I} \times 100\%$$

$$= \frac{6.8\times10^{-4}}{0.0326} \times 100\%$$

$$\%\ rxn = 2.1\%$$

(B)

(H)

9.

$$3\,Fe_{(s)} + 4\,H_2O_{(g)} \rightleftharpoons Fe_3O_{4(s)} + 4\,H_{2(g)}$$

I		0.125		0
C		$-4x$		$+4x$
E		$0.125-4x$		$4x$

$$[H_2O]_I = \frac{m}{M.V}$$

$$= 36\,g \times \frac{1\,mol}{18.02\,g} \times \frac{1}{1\,L}$$

$$= 0.125\ mol/L$$

* do not include solids in K_c expression as they have a constant [ ]

$$K_c = \frac{[H_2]^4}{[H_2O]^4}$$

$$4.6 = \frac{(4x)^4}{(0.125-4x)^4}$$

take 4th root

$$\sqrt[4]{4.6} = \frac{4x}{0.125-4x}$$

$$1.46 = \frac{4x}{0.125-4x}$$

$$0.1825 - 5.84x = 4x$$

$$0.1825 = 9.84x$$

$$x = 0.0185$$

$$[H_2]_{eqlm} = 4(0.0185)$$

$$= 0.074\ \frac{mol}{L}$$

$$[H_2O]_{eqlm} = 0.125 - 4(0.0185)$$

$$= 0.051\ \frac{mol}{L}$$