1) a) $K_{eq} = \dfrac{[PCl_5]}{[PCl_3][Cl_2]}$

b) $K_{eq} = \dfrac{[CO][H_2]^3}{[CH_4][H_2O]}$

c) $K_{eq} = \dfrac{[NO_2]^2}{[NO]^2[O_2]}$

d) $K_{eq} = [Ca^{2+}][SO_4^{2-}]$

e) $K_{eq} = \dfrac{1}{[O_2]}$

f) $K_{eq} = [CO_2][H_2O]$

g) $K_{eq} = \dfrac{[CaCl_2][CO_2]}{[HCl]^2}$

h) $K_{eq} = \dfrac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$

i) $K_{eq} = [CO_2]$

j) $K_{eq} = \dfrac{[NO_2]^4[H_2O]^6}{[NH_3]^4[O_2]^7}$

② $K_{eq} = \dfrac{1}{[SO_3][H_2O]}$

$\qquad = \dfrac{1}{(0.4)(0.48)}$

$K_{eq} = 5.21$

③ $[PCl_5]_{eq} = \dfrac{0.075 \text{ mol}}{2 \text{ L}} = 0.0375 \text{ M}$

$[H_2O]_{eq} = \dfrac{0.050 \text{ mol}}{2 \text{ L}} = 0.025 \text{ M}$

$[HCl]_{eq} = \dfrac{0.750 \text{ mol}}{2 \text{ L}} = 0.375 \text{ M}$

$[POCl_3]_{eq} = \dfrac{0.500 \text{ mol}}{2 \text{ L}} = 0.250 \text{ M}$

$K_{eq} = \dfrac{[HCl]^2[POCl_3]}{[H_2O]}$

$\qquad = \dfrac{(0.375)^2(0.25)}{(0.025)}$

$K_{eq} = 1.41$

④ $[NO_2]_{eq} = \dfrac{2\ mol}{4\ L} = 0.5\ M$

$[N_2O_4]_{eq} = \dfrac{1.6\ mol}{4\ L} = 0.4\ M$

$K_{eq} = \dfrac{[N_2O_4]}{[NO_2]^2}$

$= \dfrac{(0.4)}{(0.5)^2}$

$K_{eq} = 1.6$

⑤ $K_{eq} = \dfrac{[HI]^2}{[H_2][I_2]}$

$55.6 = \dfrac{[HI]^2}{(0.2)(0.2)}$

$2.224 = [HI]^2$

$[HI] = 1.49\ M$

⑥ $[CO]_{eq} = \dfrac{1.6\ mol}{8\ L} = 0.2\ M$

$[H_2O]_{eq} = \dfrac{1.6\ mol}{8\ L} = 0.2\ M$

$[CO_2]_{eq} = \dfrac{4\ mol}{8\ L} = 0.5\ M$

$[H_2]_{eq} = \dfrac{4\ mol}{8\ L} = 0.5\ M$

$K_{eq} = \dfrac{[CO_2][H_2]}{[CO][H_2O]}$

$= \dfrac{(0.5)(0.5)}{(0.2)(0.2)}$

$K_{eq} = 6.25$

⑦ $K_{eq} = \dfrac{[SO_3]^2}{[SO_2]^2[O_2]}$

$798 = \dfrac{11^2}{(4.2)^2[O_2]}$

$[O_2] = \dfrac{11^2}{(4.2)^2(798)}$

$[O_2] = 0.0086 \text{ M}$

⑧ $CO_2 \quad + \quad H_2 \quad \Longleftrightarrow \quad CO \quad + \quad H_2O$

	CO_2	H_2	CO	H_2O
I	0	0	1.95	1.25
C	$+x$	$+x$	$-x$	$-x$
E	x	x	$1.95-x$	$1.25-x$

$[CO_2]_{eq} = 0.85 \text{ M}$

$\therefore \quad x = 0.85$

$K_{eq} = \dfrac{[CO][H_2O]}{[CO_2][H_2]}$
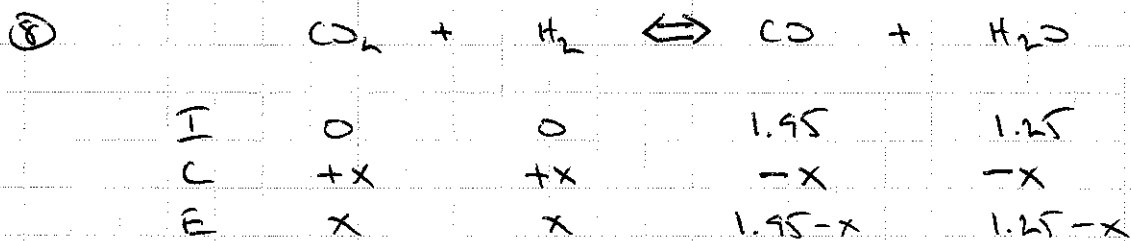
$= \dfrac{(1.1)(0.4)}{(0.85)(0.85)}$

$K_{eq} = 0.609$

$[H_2]_{eq} = x$

$= 0.85 \text{ M}$

$[CO]_{eq} = 1.95 - x$

$= 1.95 - 0.85$

$= 1.1 \text{ M}$

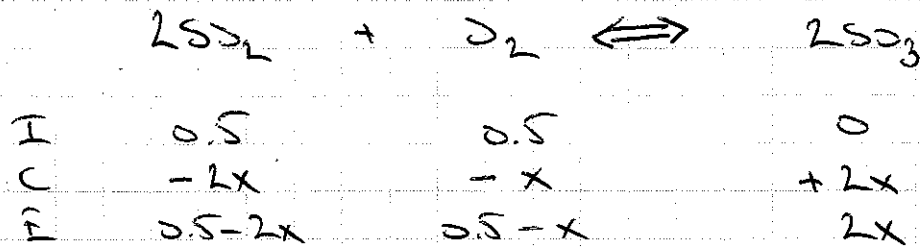$[H_2O]_{eq} = 1.25 - x$

$= 1.25 - 0.85$

$= 0.4 \text{ M}$

⑨ $[SO_2]_{initial} = \dfrac{1 \text{ mol}}{2 \text{ L}} = 0.5 \text{ M}$

$[O_2]_{initial} = \dfrac{1 \text{ mol}}{2 \text{ L}} = 0.5 \text{ M}$

$$2SO_2 \quad + \quad O_2 \quad \Longleftrightarrow \quad 2SO_3$$

I	0.5	0.5	0
C	$-2x$	$-x$	$+2x$
E	$0.5-2x$	$0.5-x$	$2x$

$[SO_3]_{eq} = 0.150 \text{ M}$

∴ $2x = 0.150$
   $x = 0.075$

$[SO_2]_{eq} = 0.5-2x$
$\qquad = 0.5 - 2(0.075)$
$\qquad = 0.35 \text{ M}$

$[O_2]_{eq} = 0.5-x$
$\qquad = 0.5 - 0.075$
$\qquad = 0.425 \text{ M}$

$K_{eq} = \dfrac{[SO_3]^2}{[SO_2]^2 [O_2]}$

$\quad = \dfrac{(0.15)^2}{(0.35)^2 (0.425)}$

$K_{eq} = 0.432$

(10) $[NOCl]_{initial} = \dfrac{0.5\ mol}{1\ L} = 0.5\ M$
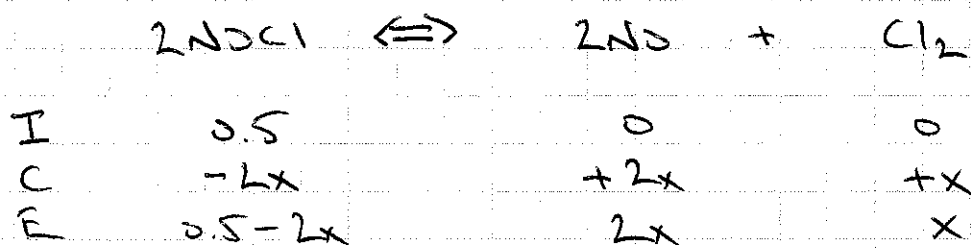
$$2NOCl \rightleftharpoons 2NO + Cl_2$$

	2NOCl	2NO	Cl_2
I	0.5	0	0
C	$-2x$	$+2x$	$+x$
E	$0.5-2x$	$2x$	x

$[Cl_2]_{eq} = \dfrac{0.1\ mol}{1\ L} = 0.1\ M$

$\therefore\quad x = 0.1$

$[NOCl]_{eq} = 0.5-2x$ $\qquad\qquad$ $[NO]_{eq} = 2x$

$\qquad\qquad = 0.5-2(0.1)$ $\qquad\qquad\qquad = 2(0.1)$

$\qquad\qquad = 0.3\ M$ $\qquad\qquad\qquad\qquad = 0.2\ M$

$K_{eq} = \dfrac{[NO]^2[Cl_2]}{[NOCl]^2}$

$\qquad = \dfrac{(0.2)^2(0.1)}{(0.3)^2}$

$K_{eq} = 0.044$

⑪　a)　$[I_2]$ initial $= \dfrac{2 \text{ mol}}{10 \text{ L}} = 0.2$ M

$[F_2]$ initial $= \dfrac{3 \text{ mol}}{10 \text{ L}} = 0.3$ M

$$3 I_2 \quad + \quad 6 F_2 \quad \Longleftrightarrow \quad 2 IF_5 \quad + \quad I_4 F_2$$

	$3I_2$	$6F_2$	$2IF_5$	I_4F_2
I	0.2	0.3	0	0
C	$-3x$	$-6x$	$+2x$	$+x$
E	$0.2-3x$	$0.3-6x$	$2x$	x
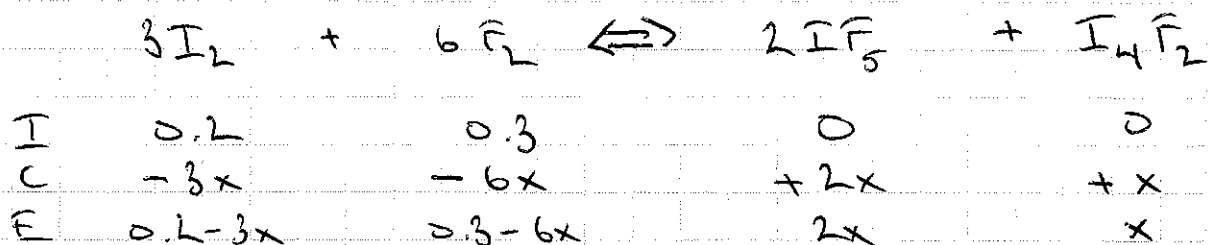
$[I_4F_2]_{eq} = 0.020$ M 　　　　　$[I_2]_{eq} = 0.2 - 3x$

∴　$x = 0.020$ 　　　　　　　　　　　$= 0.2 - 3(0.02)$

　　　　　　　　　　　　　　　　　　　$= 0.14$ M

$[F_2]_{eq} = 0.3 - 6x$ 　　　　　　　$[IF_5] = 2x$
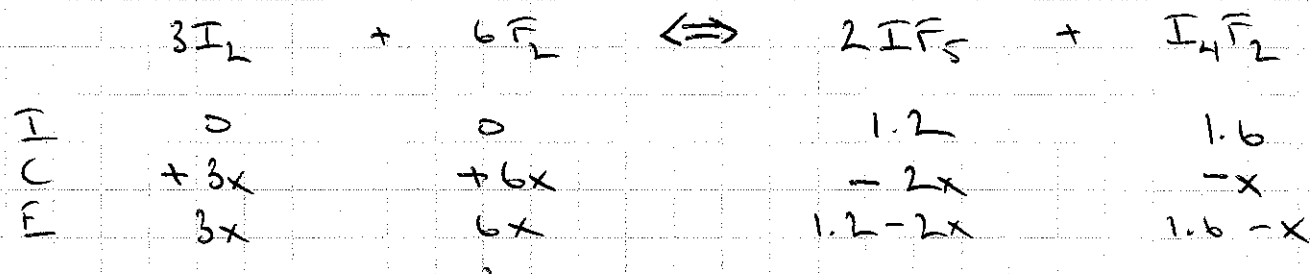
　　　　$= 0.3 - 6(0.02)$ 　　　　　　　$= 2(0.02)$

　　　　$= 0.18$ M 　　　　　　　　　　$= 0.04$ M

$$K_{eq} = \frac{[IF_5]^2 [I_4F_2]}{[I_2]^3 [F_2]^6}$$

$$= \frac{(0.04)^2 (0.02)}{(0.14)^3 (0.18)^6}$$

$$K_{eq} = 343$$

⑪ b) $[IF_5] = \dfrac{6\,mol}{5L} = 1.2\,M$ $\left.\vphantom{\begin{array}{c}a\\b\end{array}}\right\}$ initial

$[I_4F_2] = \dfrac{8\,mol}{5L} = 1.6\,M$

$$3I_2 \quad + \quad 6F_2 \quad \Longleftrightarrow \quad 2IF_5 \quad + \quad I_4F_2$$

	$3I_2$	$6F_2$	$2IF_5$	I_4F_2
I	0	0	1.2	1.6
C	$+3x$	$+6x$	$-2x$	$-x$
E	$3x$	$6x$	$1.2-2x$	$1.6-x$

$[I_4F_2]_{eq} = \dfrac{6\,mol}{5L} = 1.2\,M$

$\therefore \quad 1.6 - x = 1.2$

$1.6 - 1.2 = x$

$x = 0.4$

$[I_2] = 3x$ $[F_2] = 6x$ $[IF_5] = 1.2 - 2x$
$\quad = 3(0.4)$ $\quad = 6(0.4)$ $\quad = 1.2 - 2(0.4)$

$\quad = 1.2\,M$ $\quad = 2.4\,M$ $\quad = 0.4\,M$

$K_{eq} = \dfrac{[IF_5]^2 [I_4F_2]}{[I_2]^3 [F_2]^6}$
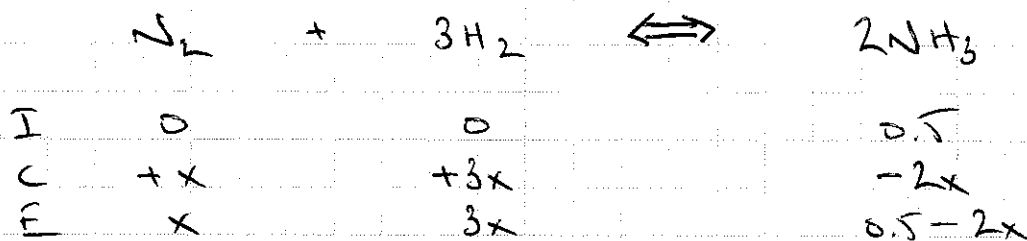
$\quad = \dfrac{(0.4)^2 (1.2)}{(1.2)^3 (2.4)^6}$

$K_{eq} = 0.00058$

c) Exothermic

* if a reaction is exothermic, K_{eq} will decrease when the temperature increases.

if a reaction is endothermic, K_{eq} will increase when the temperature increases.

(12) a) $[NH_3]$ initial $= \dfrac{2 \text{ mol}}{4 \text{ L}} = 0.5$ M

$$N_2 \quad + \quad 3H_2 \quad \Longleftrightarrow \quad 2NH_3$$

	N_2	$3H_2$	$2NH_3$
I	0	0	0.5
C	$+x$	$+3x$	$-2x$
E	x	$3x$	$0.5-2x$

$[NH_3] eq = 0.1$ M $\qquad\qquad [N_2] eq = x$

so $\quad 0.5 - 2x = 0.1 \qquad\qquad\qquad = 0.2$ M

$\qquad 0.5 - 0.1 = 2x \qquad\qquad [H_2] eq = 3x$

$\qquad\qquad 0.4 = 2x \qquad\qquad\qquad\qquad = 3(0.2)$

$\qquad\qquad\qquad x = 0.2 \qquad\qquad\qquad\qquad = 0.6$ M

$K_{eq} = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$

$\quad = \dfrac{(0.1)^2}{(0.2)(0.6)^3}$

$K_{eq} = 0.231$

b) 　　　$K_{eq} = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$

$0.231 = \dfrac{(0.01)^2}{(0.45)[H_2]^3}$

$[H_2]^3 = \dfrac{(0.01)^2}{(0.45)(0.231)}$

$= 0.00096$

$[H_2] = 0.099 \ M$