Equilibrium Short Answer Review

(1) $2\,NO + Cl_2 \rightleftharpoons 2\,NOCl$

I	0.40	0.40	∅
C	−0.12	−0.060	+0.12
E	0.28	0.34	0.12

$$K_{eq} = \frac{[0.12]^2}{[0.28]^2[0.34]} = \boxed{0.54}$$

(2) $X + 2Y \leftrightarrow 2Z$

(a)

I	0.20	0.50	∅
C	−0.06	−0.12	+0.12
E	0.14	0.38	0.12

$$K_{eq} = \frac{[0.12]^2}{[0.14](0.38)^2} = \boxed{0.71}$$

(B) $X + 2Y \rightleftharpoons 2Z$

I	0.20	0.50	∅
C	−0.18	−0.36	+0.36
E	0.02	0.14	0.36

$$K_{eq} = \frac{[0.36]^2}{[0.02](0.14)^2} \cong \boxed{300}$$

(c) Because with increased $\boxed{\text{Temperature}}$ the value of Keq increased, the heat term must be on the reactant side ∴ $\boxed{\text{endothermic}}$

(3) $H_2 + I_2 \rightleftharpoons 2HI$

I	5.0×10^{-2}	5.0×10^{-2}	$\varnothing$
C	$-x$	$-x$	$+2x$
E	$5.0\times10^{-2}-x$	$5.0\times10^{-2}-x$	$2x$

$$\sqrt{49.0} = \sqrt{\frac{(2x)^2}{(5.0\times10^{-2}-x)^2}}$$

$$7 = \frac{2x}{5.0\times10^{-2}-x}$$

$$7(5.0\times10^{-2}-x) = 2x$$

$$0.35 - 7x = 2x$$

$$0.35 = 2x + 7x$$

$$\frac{0.35}{9} = \frac{9x}{9}$$

$$\rightarrow x = 0.039$$

$$\therefore 2x = 0.078\ M$$

$$\boxed{[HI]_E = 0.078\ M}$$

(4.) $A(g) + B(g) \rightleftharpoons 2C(g)$

(a)

I	4.0	4.0	$\varnothing$
C	$-x$	$-x$	$+2x$
E	$4.0-x$	$4.0-x$	$2x$

$$\sqrt{72.0} = \frac{(2x)^2}{(4.0-x)^2}$$

$$\cong 8.49 = \frac{2x}{4.0-x}$$

$$8.49(4.0-x) = 2x$$

$$33.9 - 8.49x \cong 2x$$

$$33.9 = 2x + 8.49x$$

$$\frac{33.9}{10.485} = \frac{10.485x}{10.485}$$

$$\rightarrow x = 3.238$$

$$[A] = 4.0 - 3.238$$

$$[A] \cong 0.76\ M \rightsquigarrow \boxed{[A]_E = 0.8\ M}$$

(b) $2x = C \rightarrow 2(3.238\ \frac{mol}{L}) \Rightarrow \frac{6.47\ mol}{\cancel{L}} \times 0.50\cancel{L}$

(actual) $\Rightarrow \boxed{3.2\ mol\ C}$

5.

$$A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$$

	A_2	B_2	$2AB$
I	0.200	0.200	0.400+0.100
C	+x	+x	−2x
E	0.200+x	0.200+x	0.500−2x

$$K_{eq} = \frac{(0.400)^2}{(0.2)(0.2)} = \frac{0.16}{0.04} = \boxed{4.00}$$

$$\sqrt{4} = \sqrt{\frac{(0.500-2x)^2}{(0.200+x)^2}}$$

$$2 = \frac{0.500-2x}{0.200+x}$$

$$2(0.200+x) = 0.500-2x$$

$$0.400 + 2x = 0.500 - 2x$$

$$\frac{4x}{4} = \frac{0.100}{4} \rightarrow \boxed{x = 0.025}$$

$$\therefore 0.500 - 2(0.0250)$$

$$\boxed{[AB] = 0.450M}$$

6. a) $X_2(g) + Y_2(g) \rightleftharpoons 2XY(g)$

$$K_{eq} = \frac{(0.8)^2}{(0.6)(1.6)} = \boxed{0.7}$$

b)

$$K_{eq} = \frac{(1)^2}{(0.5)(1.5)} \approx \boxed{1.33}$$

The reaction is **endothermic** because the products are favoured with an increase in temperature.

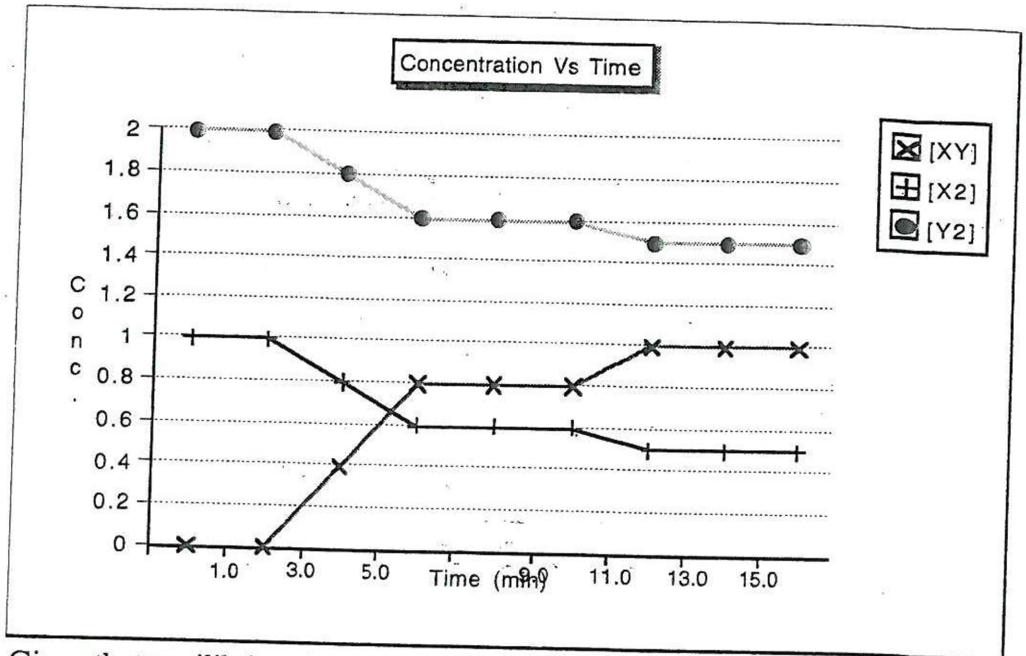
(7.) $2H_2S_{(g)} \rightleftharpoons 2H_{2(g)} + S_{2(g)}$ $K_{eq} = 4.2 \times 10^{-4}$

$$\text{Trial } K_{eq} = \frac{[0.200]^2[0.015]}{[0.050]^2} = \boxed{0.24}$$

B/c Trial K_{eq} > K_{eq} the reaction is NOT @ equilibrium and it must shift to the <u>REACTANTS</u> to reach equilibrium.

6. The following graph shows what happens when 1.0 mole of $X_{2(g)}$ and 2.0 moles of $Y_{2(g)}$ are added to a 1.0 L container at 25°C. The equilibrium equation is:

$$X_{2(g)} + Y_{2(g)} \Leftrightarrow 2XY_{(g)}$$



a) Given that equilibrium is reached in 6.0 minutes, using the graph above, calculate the value of the equilibrium constant K_{eq}.

b) At 10.0 minutes after the start, the temperature was increased to 40°C. From this information and the graph, determine whether this reaction is endothermic or exothermic.

(4 marks)

7. Consider the following equilibrium:

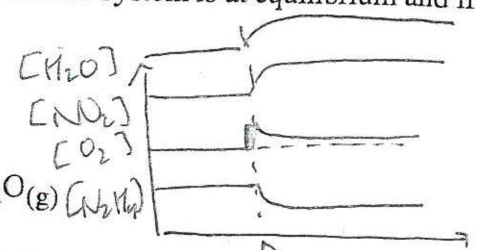
$$2H_2S_{(g)} \Leftrightarrow 2H_{2(g)} + S_{2(g)} \qquad K_{eq} = 4.2 \times 10^{-4}$$

0.050 mol of H_2S, 0.200 mol of H_2 and 0.015 mol of S_2 are placed in a 1.00L flask. Using appropriate calculations show whether or not the system is at equilibrium and if not which way it will shift to achieve equilibrium.

(3 marks)

8. Consider the following equilibrium: (2 marks)

$$N_2H_{4(g)} + 2O_{2(g)} \leftrightarrows 2NO_{2(g)} + 2H_2O_{(g)}$$



More oxygen is added to the above equilibrium. After the system re-establishes equilibrium, identify the substance(s), if any, that have a net

a) increase in concentration [O_2], [H_2O], [NO_2]

b) decrease in concentration [N_2H_4]

9. Given the following equilibrium: $H_{2(g)} + I_{2(g)} \leftrightarrows 2HI_{(g)}$ (4 marks)

Initially, 0.200 mole H_2 and 0.200 mole I_2 were placed into a 1.00L container. At equilibrium, the [I_2] is 0.040 M. Calculate the Keq. (on last page)

10. Consider the following equilibrium: $2CrO_4^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \rightleftharpoons Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)}$

yellow ↑ orange

When HCl is added, the solution turns orange. Explain why this colour change occurs. (2 marks)

$HCl \rightarrow \boxed{H^+} + Cl^-$; ∴ ↑[H+]

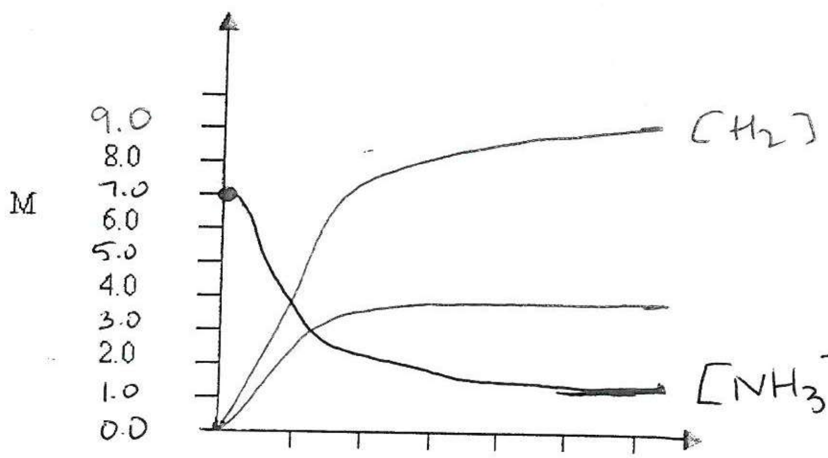
reaction will shift to the products (orange) to counteract the added H+ (use it up)

11. Consider the following equilibrium system:

$$N_{2(g)} + 3H_{2(g)} \leftrightarrows 2NH_{3(g)} + \text{energy}$$

(6 marks)

A 1.00 L container is filled with 7.0 mole NH_3 and the system proceeds to equilibrium as indicated by the graph. (starts @ 7.0 M ; ends @ 1.0 M)



a) Draw and label the graph for N_2 and H_2 (Hint: use a RICE table!)

R	$N_{2(g)}$ +	$3H_{2(g)}$ ⇆	$2NH_{3(g)}$
I	Ø	Ø	7.0
C	+3.0(1x)	+9.0 (3x)	- 6.0 (2x)
E	3.0	9.0	1.0

b) Calculate the Keq for the above reaction.

$$Keq = \frac{[1.0]^2}{[3.0][9.0]^3} = \boxed{4.6 \cdot 10^{-4}}$$

12. Consider the following equilibrium $2NO_{(g)} + O_{2(g)} \leftrightarrows 2NO_{2(g)}$ Keq = 1.5 (2 marks)

0.800 mole NO, 0.600 moles O_2, and 0.400 moles NO_2 are placed in a vessel that 2.0 L. Show by calculation that the reaction is not at equilibrium? What will happen to $[O_2]$ as equilibrium is approached? (on last page)

9.

R	$H_2(g)$	$+ I_2(g)$	$\rightleftharpoons 2HI(g)$
I	0.200	0.200	$\varnothing$
C	−0.160	−0.160	+0.320
E	0.040	0.040	0.320

$$k_{eq} = \frac{[0.320]^2}{[0.040]^2} = \boxed{64.0}$$

12.

$$\text{"Q"} = \frac{[NO_2]_G^2}{[NO]_G^2 \cdot [O_2]_G} = ?$$

$$[NO_2]_G = \frac{0.400\ \text{mol}}{2.0\ \text{L}} = 0.20\text{M}$$

$$[NO]_G = \frac{0.800\ \text{mol}}{2.0\ \text{L}} = 0.40\text{M}$$

$$[O_2]_G = \frac{0.600\ \text{mol}}{2.0\ \text{L}} = 0.30\ \text{M}$$

$$= \frac{[0.20]^2}{[0.40]^2 \cdot [0.30]} = 0.83$$

B/c "Q" < keq (0.83 < 1.5) the rxn is NOT @ equilibrium. In order to achieve equilibrium the rxn must shift to the PRODUCTS ∴ $[O_2]$ will decrease (as it is a reactant)