Assignment 6:

1. Hebden p.60 #31acegj, 32, 35 abcd & p.62 #36, 40, 41, 44-46
2. Given the following equation and data:

   $CB + R \Leftrightarrow CBR$

   $K_{eq} = 12.0$ at 200°C

   $K_{eq} = 20.0$ at 300°C

   Is the forward reaction exothermic or endothermic? Support your answer with explanations.
3. Given the following equation and data:

   $CH_{4(g)} + 2H_2S_{(g)} \Leftrightarrow CS_{2(g)} + 4H_{2(g)}$

   $K_{eq} = 1.0 \times 10^{-2}$ at 500°C

   $K_{eq} = 2.4 \times 10^{-3}$ at 800°C

a) Is the forward reaction endothermic or exothermic? Explain.

b) What effect will increasing the $[H_2S]$ have on the value of K_{eq}?

4. For the following reaction:

   $CO_{2(g)} + H_{2(g)} \Leftrightarrow CO_{(g)} + H_2O_{(g)} \qquad \Delta H = -96$ kJ

   What effect will decreasing the temperature have on the value of K_{eq}? Support your answer with explanations.

VII) Type 1 K_{eq} Problems

For Type 1 K_{eq} problems, the data provided in the question is exclusively equilibrium data.

Example:

1. For the following reaction:

   $2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)} + 192$ kJ

   Equilibrium concentrations were found to be as follows:

   $[SO_2] = 2.0M$, $[O_2] = 0.50M$, $[SO_3] = 1.6M$ ⇐ @ equilibrium

   Calculate the value of K_{eq}.

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(1.6)^2}{(2.0)^2(0.5)} = 1.3$$

Example:

2. At equilibrium, a 2.00L vessel contained 0.750mol CO, 0.276mol H_2O, 0.600mol CO_2, and a $K_{eq} = 0.986$. Calculate the moles of H_2 at equilibrium.

$$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$$

$[CO] = \frac{0.750 mol}{2.00L} = 0.375M$ $\quad [CO_2] = \frac{0.600 mol}{2.00L} = 0.300M$

$[H_2O] = \frac{0.276 mol}{2.00L} = 0.138M$ $\quad [H_2] = ?$

$C = \frac{n}{V}$

$\therefore n = C \cdot V$

$mol\ H_2 = (0.170M)(2.00L)$

$\therefore 0.340\ mol\ H_2$

$K_{eq} = \frac{[CO_2][H_2]}{[CO][H_2O]}$ $\quad 0.986 = \frac{(0.300)[H_2]}{(0.375)(0.138)}$

$[H_2] = \frac{(0.986)(0.375)(0.138)}{0.300}$

$[H_2] = 0.170M$

VIII) Type 2 K_{eq} Problems

Type 2 K_{eq} problems provide some initial data and some equilibrium data for certain substances, which you are to use to calculate the K_{eq} constant. Use an 'ICE' table for assistance.

$C = \frac{n}{V}$ ∴ in a 1L flask mol = molarity.

Example:

1..A mixture of H_2 and I_2 was prepared by placing 0.100mol of H_2 and 0.100mol of I_2 into a 1.00L flask. At equilibrium, the I_2 concentration dropped to 0.020M. Calculate the K_{eq}.

Reaction	$H_{2(g)}$	+	$I_{2(g)}$	⇔	$2HI_{(g)}$
Initial	0.100M		0.100M		0
Change	−0.080M		−0.080M		+0.16M
Equilibrium	0.020M		0.020M		0.16M

no products at start of rxn.

Δ is 0.080M
∴ 2(0.080M) = 0.16M
(+) b/c products are being formed

$\therefore K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.16)^2}{(0.02)(0.02)} = 64$

[conc.] @ equilibrium

Example:

2. $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$

Given: $[N_2]_i = 0.32M$, $[H_2]_i = 0.66M$, $[H_2]_{eq} = 0.30M$

Calculate K_{eq}.

① Fill in "knowns"
② Solve for "change" + apply.
③ Solve for Keq.

R: ①	$N_{2(g)}$	+ $3H_{2(g)}$	⇔ $2NH_{3(g)}$
I	0.32M	0.66M	0M ← products are always zero @ start
C	−0.12M ②	−0.36M	+0.24M
E	0.20M	0.30M	0.24M.

$3H_2 : 2NH_3 \therefore (-0.12M)\times\frac{2}{3} = 0.24M$

$\frac{-0.36}{3} = \Delta[N_2] = -0.12M$ because $3H_2 : 1N_2$

don't forget + exp.

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.24M)^2}{(0.20M)(0.30M)^3}$$

$K_{eq} = 11$

Assignment 7

Type 1 Problems

1. For the following reaction at equilibrium:

$$CH_{4(g)} + H_2O_{(g)} \Leftrightarrow CO_{(g)} + 3H_{2(g)}$$

$[CH_4] = 0.600M$ $[H_2O] = 0.060M$

$[CO] = 0.200M$ $[H_2] = 0.700M$

Calculate the K_{eq} for this reaction. Are the reactants or products favoured?

2. For the following reaction:

$$CO_{(g)} + H_2O_{(l)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$$

At equilibrium in a 1.0L container, 0.020mol of CO, 0.010mol H_2O, 0.030 mol CO_2, and 0.010mol of H_2 are present.

a) Calculate the K_{eq}

b) State whether reactants or products are favoured

c) If H_2 is removed from the system and equilibrium is re-established, how does the value of K_{eq} change?

3. For the following reaction:

$$CO_{(g)} + 2H_{2(g)} \Leftrightarrow CH_3OH_{(g)} \qquad K_{eq} = 1.00$$

At equilibrium in a 2.0L container, 0.420mol CO and 0.100mol H_2 are present. Calculate the number of moles of CH_3OH present.

4. For the following reaction and data:

$$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$$

	$[N_2]$ (M)	$[H_2]$ (M)	$[NH_3]$ (M)
Trial 1	0.200	0.400	0.500
Trial 2	?	0.300	0.600

Find $[N_2]$ in Trial 2.

Type 2 Exercises (ICE diagrams)

5. A mixture consisting of 1.00mol $CO_{(g)}$ and 1.00mol $H_2O_{(g)}$ is placed in a 10.00L container. At equilibrium, 0.665mol $CO_{2(g)}$ and 0.665mol $H_{2(g)}$ are present.

$$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$$

Calculate the K_{eq} for this reaction.

6. When 1.00M HBr is placed into a flask, the following equilibrium is achieved:

$$2HBr_{(g)} \Leftrightarrow H_{2(g)} + Br_{2(g)}$$

At equilibrium, 0.140M H_2 is present. Calculate the K_{eq}.

7. A 5.00L vessel was initially filled with 6.00mol SO_2, 2.50mol NO_2, and 1.00mol SO_3.

$$SO_{2(g)} + NO_{2(g)} \Leftrightarrow SO_{3(g)} + NO_{(g)}$$

At equilibrium, the vessel was found to contain 3.00mol SO_3. What is the K_{eq} for the reaction?

8. 0.50mol of NOCl was introduced into a 1.0L flask and allowed to come to equilibrium:

$$2NOCl_{(g)} \Leftrightarrow 2NO_{(g)} + Cl_{2(g)}$$

At equilibrium, there was 0.10mol of Cl_2. What is the K_{eq} ?