Chapter 14: 9, 12, 16, 18, 22, 31, 34, 41, 46, 50, 53, 55 (Use table 1 below), 61, 71a-d, 86

9) a) 0^oC the melting ice cooled the water to its freezing/melting point
b) The system is a dynamic equilibrium: water molecules are freezing to form ice and ice is melting to form water

12) a) No. The equilibrium was disturbed by adding more reactant. $Q < K_{eq}$ so the chemical reaction will shift to the right forming more product

b) The rate of *cis* → *trans* is faster immediately after adding *cis* to the system

c) Assume a 1 L flask

	Cis	*trans*	
I	0.2 mol/L	0	
C	-x	+x	
E	0.2M-x	0.01 mol/L	

x = 0.01 M *cis* at equilibrium = 0.2M – 0.01 M = 0.19M = 0.2 M (sig fig)

16) a) $NH_{3(g)} + ClF_{3(g)} \leftrightarrow 3HF_{(g)} + \frac{1}{2} N_{2(g)} + \frac{1}{2} Cl_{2(g)}$ $K_{eq} = \frac{[HF]^3[N_2]^{1/2}[Cl_2]^{1/2}}{[NH_3][ClF_3]}$

b) $3\ ClO_2^-{}_{(aq)} \leftrightarrow 2ClO_3^-{}_{(aq)} + Cl^-{}_{(aq)}$ $K_{eq} = \frac{[ClO_3^-]^2[Cl^-]}{[ClO_2^-]^3}$

c) $IO_3^-{}_{(aq)} + 6OH^-{}_{(aq)} + Cl_{2(g)} \leftrightarrow IO_6^{-5}{}_{(aq)} + 2\ Cl^-{}_{(aq)} + 3H_2O_{(l)}$ $K_{eq} = \frac{[IO_6^{-5}][Cl^-]^2}{[IO_3^-][OH^-]^6[Cl_2]}$

18) a) $N_2O_{4(g)} + O_{2(g)} \leftrightarrow N_2O_{5(s)} + O_{2(g)}$ $K_{eq} = \frac{[O_2]}{[N_2O_4][O_3]}$

b) $C_{(s)} + 2N_2O_{(g)} \leftrightarrow CO_{2(g)} + 2N_{2(g)}$ $K_{eq} = \frac{[CO_2][N_2]^2}{[N_2O]^2}$

c) $H_2O_{(l)} \leftrightarrow H_2O_{(g)}$ $K_{eq} = [H_2O_{(g)}]$

22) $H_{2(g)} + 1/8S_{8(s)} \leftrightarrow H_2S_{(g)}$ $K_{eq} = \frac{[H_2S]}{[H_2]} = 7.6x10^5$

$8\ H_{2(g)} + S_{8(s)} \leftrightarrow 8\ H_2S_{(g)}$ $K_{eq} = \frac{[H_2S]^8}{[H_2]^8} = (7.6x10^5)^8 = 1.1\ x10^{47}$

31) $PCl_5 \leftrightarrow PCl_3 + Cl_2$ $K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{[1.3x10^{-2}M][3.9x10^{-3}M]}{[4.2\ x10^{-5}M]} = 1.2$

34)

	N_2O_4	$\leftrightarrow 2NO_2$
I	0.01mol/2L	0
C	-x	+ 2x
E	0.005 M -x	2x

0.005M –x = 0.00090M
0.004 M = x

2x = 0.008 M = $[NO_2]$ @ equilibrium

41) $CaCO_{3(s)} \leftrightarrow Ca^{+2}{}_{(aq)} + CO_3{}^{-2}{}_{(aq)}$ $K_{eq} = [Ca^{+2}][CO_3{}^{-2}] = 3.8x10^{-9}$
$AgNO_{3(s)} \leftrightarrow Ag^{+}{}_{(aq)} + NO_3{}^{-}{}_{(aq)}$ $K_{eq} = [Ag^+][NO_3^-] = 2.0 x10^2$ most soluble
$AgCl_{(s)} \leftrightarrow Ag^{+}{}_{(aq)} + Cl^{-}{}_{(aq)}$ $K_{eq} = [Ag^+][Cl^-] = 1.8 x10^{-10}$ least soluble

46)

	H_2	I_2	$\leftrightarrow 2HI$
I	0	0	0.05M
C	+x	+x	-2x
E	x	x	0.05-2x

$K_c = 76\ (600K) = \frac{[HI]^2}{[H_2][I_2]} = \frac{(0.05M-2x)^2}{x^2}$

$76^{1/2} = \frac{(0.05M-2x)}{x}$

x= 0.00467 = 0.005(sig fig)

Equilibrium concentrations	$[H_2]$ = 0.005M	$[I_2]$ = 0.005 M	[HI] = 0.04M

50a)

	N_2O_4	$\leftrightarrow 2NO_2$
I	1 mol/10L	0
C	-x	+ 2x
E	0.1 M -x	2x

$K_c = 40.0\ 503K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[2x]^2}{(0.1-x)}$

$4x^2 + 40 x - 4 = 0$
x = 0.0990

Equilibrium concentration of N_2O_4 = 0.1 – 0.0990 = 9.8 x10^{-4}.
% not dissociated = 9.8x10^{-4}/0.1 * 100 = 0.98% = 1 %

50b)

	N_2O_4	$\leftrightarrow 2NO_2$
I	1 mol/2L	0
C	-x	+ 2x
E	0.5 M -x	2x

$$K_c = 40.0\ 503K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[2x]^2}{(0.5-x)}$$

$$4x^2 + 40x - 20 = 0$$

$$x = 0.477$$

Equilibrium concentration of N_2O_4 = 0.5 – 0.477 = 0.0228

% not dissociated = 0.0228/0.5 * 100 = 4.56% = 5 %

53) $BaSO_{4(s)} \leftrightarrow Ba^{+2}_{(aq)} + SO_4{}^{-2}_{(aq)}$ $BaSO_4$ is a solid so it is not part of Q or K_{eq} and addition of more $BaSO_4$ will not affect the equilibrium. The maximum amount of Ba^{2+} and SO_4^{2-} is already dissolved and in equilibrium with the solid initially present.

55) $H_{2(g)} + Br_{2(g)} \leftrightarrow 2HBr_{(g)}$ $\Delta H = -103.7$ kJ

Table 1: Problem 55

Change	**$[Br_2]$**	**[HBr]**	**K_c**
Some H_2 added to container	Decrease	Increase	No change
The temperature of the gasses in the container is increased	Increase	Decrease	decrease

61) butane ↔ 2-methylpropane $K_c = \frac{[\text{2-methylpropane}]}{[\text{butane}]} = \frac{[0.025\ M]}{[0.01M]} = 2.5$

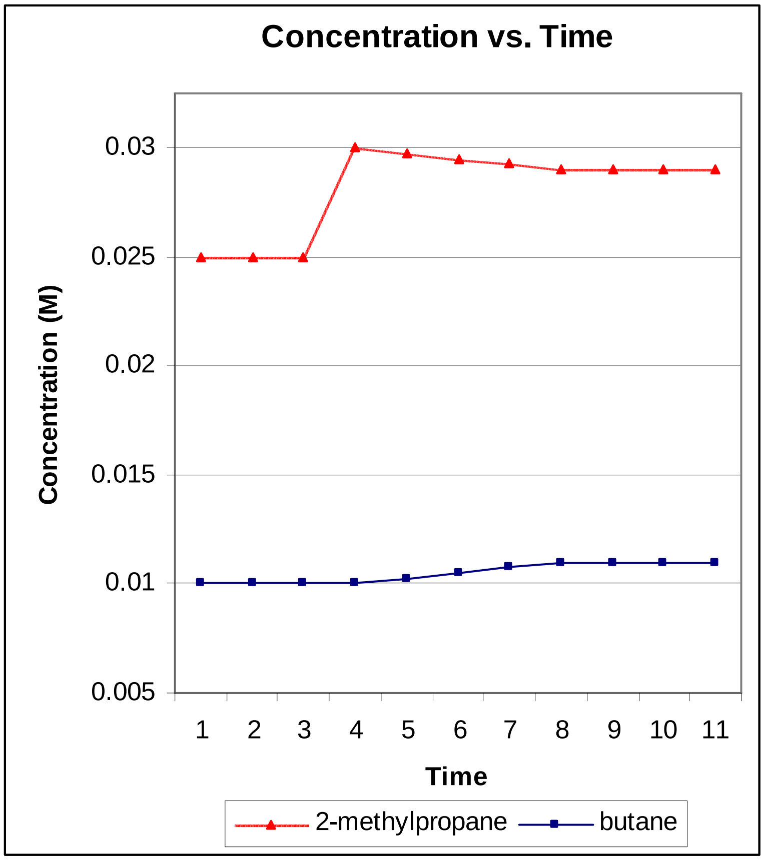
	butane	2-methylpropane
I	0.01	0.025 + 0.005mol/L
C	+x	-x
E	0.01 +x	0.03 - x

$$2.5 = \frac{(0.03 - x)}{(0.01 + x)}$$

$$3.5x = 0.005$$

$$x = 0.0014$$

Equilibrium concentrations [butane] = 0.011; [2-methylpropane] = 0.029



71 Ni + 4CO → $Ni(CO)_4$
0.125 2.05g

a)

0.125 g Ni	1 mol Ni	1 mol $Ni(CO)_4$	170.6934 g
	58.6934 g Ni	1mol Ni	1 mol $Ni(CO)_4$

= 0.364 g $Ni(CO)_4$ limiting reagent

2.05 CO	1 mol CO	1 mol $Ni(CO)_4$	170.6934 g
	28 g CO	4 mol CO	1 mol $Ni(CO)_4$

= 3.12 g $Ni(CO)_4$

0.364 g $Ni(CO)_4$ can be made

b) $Ni(CO)_{4(g)} \rightarrow Ni_{(s)} + 4\ CO_{(g)}$

$\Delta H_{rxn} = \sum n\Delta H^o_{f\ products} - \sum n\Delta H^o_{f\ reactants}$

$= [4\text{ mol CO }(-110.525\text{ kJ/mol}) + 0] - [1\text{ mol }Ni(CO)_4(-602.9\text{ kJ/mol})]$

$= 160.8$ kJ

c)

	$Ni(CO)_{4(g)}$	$\leftrightarrow Ni_{(s)} + 4\ CO_{(g)}$
I	0.01 M	0
C	-x	+4x
E	0.00001 M	4x

$0.01 - x = 0.00001$

$x = 0.00999$

[CO] at equilibrium = 4x = 4(0.00999) = 0.03996 M

d) $K_{eq} = \dfrac{[CO]^4}{[Ni(CO)_4]} = \dfrac{[0.03996]^4}{[0.00001]} = 0.25$

86) $K_{eq} = \dfrac{[NO]^2}{[N_2][O_2]} = \dfrac{6^2}{(1)(3)} = 12$