Fall solutions

EQUILIBRIUM Calculations Practice

#1 $K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$

$= \frac{(0.25M)^2}{(0.1M)(0.2M)^3}$

$= \boxed{78.1}$

#2

	$2NO_2(g) \longleftrightarrow 2NO(g) + O_2(g)$		
I	5 M	∅	∅
C	-3M	+3.0M	+1.5M
E	2.0M	3.0M	1.5M

Concentrations

① $C = \frac{n}{V} = \frac{5\ mol}{1\ L} = 5M$ $[NO_2]$

② $[O_2] = 1.5\ mol/1\ L = 1.5M$

$1.5M\ O_2 \times \frac{2\ mol\ NO}{1\ mol\ O_2} = 3M$

$K_c = \frac{[NO]^2[O_2]}{[NO_2]^2}$

$K_c = \frac{(3M)^2(1.5M)}{(2)^2}$

$= \boxed{3.375}$

#3

	$4NH_3(g) + 3O_2(g) \longleftrightarrow 2N_2(g) + 6H_2O(g)$			
I	0.015M	0.0150M	∅	∅
C	-0.00392	-0.00294	$+1.96 \times 10^{-3}$	+0.00588M
E	0.01108M	0.01206M	$1.96 \times 10^{-3}M$	0.00588M

$1.96 \times 10^{-3}M\ N_2 \times \frac{6\ mol\ H_2O}{2\ mol\ N_2}$

$= 0.00588M\ H_2O$

$K_c = \frac{[N_2]^2[H_2O]^6}{[NH_3]^4[O_2]^3}$

$K_c = \frac{(1.96 \times 10^{-3})^2(0.00588)^6}{(0.01108)^4(0.01206)^3} = \boxed{6 \times 10^{-6}}$

#4

	$2H_2(g) + 2NO(g) \leftrightarrow N_2(g) + 2H_2O(l)$		
I	2M	2M	∅
C	-0.8M	-0.8M	+0.4M
E	1.2M	1.2M	0.4M

Concentrations

Initially, $[H_2]/[NO]$

$C = \frac{n}{V} = \frac{4\,mol}{2L} = 2M$

At equilibrium, $\frac{0.8\,mol}{2L} = 0.4M$

$0.4M\ N_2 \times \frac{2\,mol\ NO}{1\,mol\ N_2} = 0.8M$

$K_c = \frac{[N_2]}{[H_2]^2[NO]^2}$

$K_c = \frac{(0.4M)}{(1.2M)^2(1.2M)^2}$

$K_c = \boxed{0.19}$

#6

	$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$		
I	1M	2.25M	∅
C	-0.5M	-1M	+0.5M
E	0.5M	1.25M	0.5M

Concentrations

$C = n/V$

$[CO] = 4\,mol/4L = 1M$

$[H_2] = 9\,mol/4L = 2.25M$

at equil,

$[CO] = \frac{2\,mol}{4L} = 0.5M$

$0.5M\ CH_3OH \times \frac{2\,mol\ H_2}{1\,mol\ CH_3OH} = 1M$

$K_{eq} = \frac{[CH_3OH]}{[CO][H_2]^2}$

$= \frac{(0.5M)}{(0.5M)(1.25M)^2} = \boxed{0.64}$

#5

	$2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$		
I	0.3M	0.25M	∅
C	-0.2M	-0.1M	+0.2M
E	0.1	0.15M	0.2M

Concentration

$n = c/v$

Initially, $[SO_2] = \frac{1.2\,mol}{4L} = 0.3M$

$[O_2] = 1\,mol/4L = 0.25M$

At equil.,

$[SO_2] = 0.4\,mol/4L = 0.1M$

$[SO_2]$

$0.2M\ SO_2 \times \frac{1\,mol\ O_2}{2\,mol\ SO_2} = 0.1M$

$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(0.2M)^2}{(0.1M)^2(0.15M)} = \boxed{27}$

#7

	$4HCl_{(g)} + O_{2(g)} \longleftrightarrow 2H_2O_{(g)} + 2Cl_{2(g)}$			
I	1M	1M	∅	∅
C	-0.4M	-0.1M	+0.2M	+0.2M
E	0.6M	0.9M	0.2M	0.2M

$0.2\,M\,H_2O \times \frac{4\ mol\ HCl}{2\ mol\ H_2O} = 0.4\ M$

$K_c = \frac{[H_2O]^2[Cl_2]^2}{[HCl]^4[O_2]}$

$K_c = \frac{(0.2)^2(0.2)^2}{(0.6)^4(0.9)}$

$= \boxed{0.0137}$

#8

	$2NO_{2(g)} \longleftrightarrow 2NO_{(g)} + O_{2(g)}$		
I	2.5	∅	∅
C	-1.5M	+1.5M	+0.75M
E	1M	1.5M	0.75M

Concentration

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

Initially, $[NO_2] = 5\ mol/2L = 2.5M$

equil, $[O_2] = 1.50/2L = 0.75M$.

$K_{eq} = \frac{[NO]^2[O_2]}{[NO_2]^2}$

$= \frac{(1.5M)^2(0.75M)}{(1M)}$

$= \boxed{1.7}$

#9

	$4NH_{3(g)} + 5O_{2(g)} \longleftrightarrow 4NO_{(g)} + 6H_2O_{(g)}$			
I	2.5M	2.5M	∅	∅
C	-1.6M	-2M	+1.6M	+2.4M
E	0.9M	0.5M	1.6M	2.4M

$2.4\,M\,H_2O \times \frac{4\ mol\ NO}{6\ mol\ H_2O} = 1.6\ M$

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

$K_{eq} = \frac{(1.6)^4(2.4)^6}{(0.9)^4(0.5)^5}$

$K_{eq} = \boxed{6.1 \times 10^4}$

#10

	$SO_{2(g)} \rightleftharpoons$	$S_{2(s)}$	$+ O_{2(g)}$
I	0.05M	∅	∅
C	$-x$		$+x$
E	$0.05-x$		x

$C = \frac{n}{V} = \frac{0.50 mol}{10 L}$

$= 0.05 M$

$K_{eq} = \frac{[O_2]}{[SO_2]}$

$2.4 \times 10^{-2} = \frac{x}{0.05 - x}$

$x = \boxed{0.0012 M}$

At equil,

$[SO_2] = 0.05 - 0.0012 = \boxed{0.0488 M}$

Equilibrium Part Deux

#1

	$2A_{(g)} \rightleftharpoons$	$2B_{(g)}$	+ $C_{(s)}$
I	0.14	0	
C	$-2x$	$2x$	
E	$0.14-2x$		

$$C = \frac{n}{V} = \frac{0.42\ mol}{3L} = 0.14\ M$$

$$K_{eq} = \frac{[B]^2}{[A]^2}$$

$$6.8 \times 10^2 = \frac{(2x)^2}{(0.14-2x)^2}$$

$$\sqrt{6.8 \times 10^2} = \frac{2x}{(0.14-2x)}$$

$$+26.08 = \frac{2x}{0.14-2x}$$

$$3.65 - 52.16x = 2x$$

$$3.65 = 54.16x$$

$$x = 0.06739$$

$$-26.08 = \frac{2x}{0.14-2x}$$

$$-3.65 + 52.16x = 2x$$

$$-3.65 = -50.16x$$

$$x = 0.073$$

Check

$0.14 - 2(0.06739) = 0.005$

check

$0.14 - 2(0.073) = -0.006$

NOT POSSIBLE

ANSWER $[B] = 2(0.06739) = \boxed{0.135}\ M$

#2

	$COCl_2(g)$	$\leftrightarrow$	$CO(g)$	+	$Cl_2(g)$
I	0.25		0		0
C	$-X$		$+X$		$+X$
E	$0.25-X$		$X=0.011M$		$X=0.011M$
	0.239M				

Concentration $c=\frac{n}{V}$

$[COCl_2]=\frac{0.5\,mol}{2\,L}=0.25$

$4.93\times10^{-4}=\frac{x^2}{0.25-x}$ $\quad K_{eq}=\frac{[CO][Cl_2]}{[COCl_2]}$

$1.23\times10^{-4}-4.93\times10^{-4}x=x^2$

$0=1x^2+4.93\times10^{-4}x-1.23\times10^{-4}$

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

$=\frac{-4.93\times10^{-4}\pm\sqrt{(4.93\times10^{-4})^2-4(1)(-1.23\times10^{-4})}}{2(1)}$

$x=0.0108$

$x=-0.012$ NOT POSSIBLE

#3

	$SO_3(g)$	+	$NO(g)$	$\rightleftharpoons$	$NO_2(g)$	+	$SO_2(g)$
I	0.15M		0.15M		0		0
C	$-x$		$-x$		$+x$		$+x$
E	$0.15-x$		$0.15-x$		0.062M		0.062M
	0.088M		0.088M				

Concentration $c=\frac{n}{V}$

$[SO_3]=\frac{0.3\,mol}{2\,L}=0.15M$

$[NO]=\frac{0.3\,mol}{2\,L}=0.15M$

$0.5=\frac{x^2}{(0.15-x)^2}$

$+0.7071=\frac{x}{0.15-x}$

$0.7071(0.15-x)=x$

$0.1061-0.7071x=x$

$\frac{0.1061}{1.7071}=\frac{1.7071x}{1.7071}$

$-0.7071=\frac{x}{0.15-x}$

$-0.1061+0.7071x=x$

$\frac{-0.1061}{0.2929}=\frac{0.2929x}{0.2929}$

$x=-0.362$ NOT POSSIBLE

#4

	$2HI_{(g)} \rightleftharpoons$	$H_{2(g)}$ +	$I_{2(g)}$
I	0.09M	0	0
C	$-2x$	x	x
E	$0.09-2x$		0.0096M

Concentration

$C = \frac{n}{V} = \frac{0.18\,mol}{2\,L} = 0.09M$

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

$1.85 \times 10^{-2} = \frac{x^2}{(0.09-2x)^2}$

$+0.136 = \frac{x}{(0.09-2x)}$

$0.01224 - 0.272x = x$

$\frac{0.01224}{1.272} = \frac{1.272x}{1.272}$

$x = 0.0096M$

$-0.136 = \frac{x}{(0.09-2x)}$

$-0.01224 + 0.272x = x$

$\frac{-0.01224}{0.728} = \frac{0.728x}{0.728}$

$x = -0.00618$ NOT POSSIBLE

Answer : $[I_2] = 0.0096M$

#5 a)

	$CO_{(g)}$ +	$H_2O_{(g)} \longleftrightarrow$	$CO_{2(g)}$ +	$H_{2(g)}$
I	2M	2M	∅	∅
C	$-x$	$-x$	$+x$	$+x$
E	$2-x$	$2-x$		

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

$1.56 = \frac{x^2}{(2-x)^2}$

$+1.25 = \frac{x}{2-x}$

$2.5 - 1.25x = x$

$\frac{2.5}{2.25} = \frac{2.25x}{2.25}$

$x = 1.11$

OR

$-1.25 = \frac{x}{2-x}$

$-2.5 + 1.25x = x$

$-2.5 = -0.25x$

$x = 10$

OR

$[CO]/[H_2O] = 2 - 1.11_M = 0.$

$[CO]/[H_2O] = 2 - 10 = -8M$

NOT POSSIBL

$[CO_2]/[H_2] = 1.11M$

b)

	$CO(g) + H_2O(g) \rightleftarrows CO_2(g) + H_2(g)$			
I	2M	1M	∅	∅
C	−x	−x	+x	+x
E	2−x	1−x		

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

$$1.56 = \frac{x^2}{(2-x)(1-x)}$$

$$1.56 = \frac{x^2}{2-3x+x^2}$$

$$3.12 - 4.68x + 1.56x^2 = x^2$$

$$3.12 - 4.68x + 0.56x^2 = 0$$

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

$$x = \frac{4.68 \pm \sqrt{4.68^2 - 4(0.56)(3.12)}}{2(0.56)}$$

$X = 7.63$ OR $X = 0.731$

$[CO]/[H_2O] = 2 - 0.731$ OR $2 - 7$

$= \boxed{1.269}$ M $= -5.$

$[H_2O] = 0.269$ M.

$[CO_2][H_2] = \boxed{0.731}$

#6

R	$N_{2(g)}$	+ $O_{2(g)}$	$\leftrightarrow$ $2NO_{(g)}$
I	0.2M	0.15M	$\emptyset$
C	$-x$	$-x$	$+2x$
E	$0.2-x$	$0.15-x$	

$C = \frac{n}{V} = \frac{0.2\,mol}{1\,L} = 0.2M$

$= \frac{0.15\,mol}{1\,L} = 0.15M$

$4.1 \times 10^{-4} = \frac{(2x)^2}{(0.2-x)(0.15-x)}$ $\quad K_{eq} = \frac{[NO]^2}{[N_2][O_2]}$

$4.1 \times 10^{-4} = \frac{4x^2}{0.03 - 0.35x + x^2}$

$1.23 \times 10^{-5} - 1.435 \times 10^{-4} x + 4.1 \times 10^{-4} x^2 = 4x^2$

$0 = 3.9996x^2 + 1.435 \times 10^{-4} - 1.23 \times 10^{-5}$

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

$x = \frac{-1.435 \times 10^{-4} \pm \sqrt{(1.435 \times 10^{-4})^2 - 4(3.9996)(-1.23 \times 10^{-5})}}{2(3.9996)}$

$x = \frac{-1.435 \times 10^{-4} + 0.014}{2(3.9996)}$ $\quad x = \frac{-1.435 \times 10^{-4} - 0.014}{2(3.9996)}$

$x = 0.001736$ $\quad x = -0.001768$ not possible

ANSWER: $[N_2]$: $0.2 - 0.0017 = 0.198$

$[O_2]$: $0.15 - 0.0017 = 0.148$

$[NO]$: $2(0.0017) = 0.0034$