ANSWERS

Gaseous Equilibrium Practice Problems

1. $P_{N_2} = 0.80$ atm $P_{O_2} = 0.20$ atm

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2\,NO_{(g)} \quad K_p = 0.050$$

	N_2	O_2	$2\,NO$
Start	0.80 atm	0.20 atm	0
Δ	$-x$	$-x$	$+2x$
eq.	$0.80-x$	$0.20-x$	$2x$

$$K_p = \frac{P_{NO}^2}{P_{N_2} P_{O_2}} = \frac{(2x)^2}{(.80-x)(.20-x)} = 0.050$$

$$4x^2 = 0.050(.80-x)(.20-x) \quad \text{FOIL}$$
$$4x^2 = 0.050(0.16 - .20x - .80x + x^2)$$
$$4x^2 = 0.0080 - 0.050x + 0.050x^2$$
$-4x^2$
$$0 = 0.0080 - 0.050x - 3.95x^2 \quad -4x^2$$

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{+0.050 \pm \sqrt{(0.050)^2 - 4(-3.95)(.0080)}}{2(-3.95)}$$

$$x = \frac{+0.050 \pm 0.359}{-7.90}$$

$x = -0.05\bar{1}8$ or $x = 0.03\bar{9}1$ atm

$-0.05\bar{1}8$ doesn't make sense

$$P_{N_2} = 0.80 - 0.039 = 0.76 \text{ atm}$$
$$P_{O_2} = 0.20 - 0.039 = 0.16 \text{ atm}$$
$$P_{NO} = 2(.039) = 0.078 \text{ atm}$$

check: $\frac{(.078)^2}{(.76)(.16)} = 0.050$ ✓

2. 4.0 mol NH_3 in 2.0 L ⇒ start
at eq, 2.0 mol NH_3

	$2\,NH_3$	$\rightleftharpoons$	N_2	+	$3H_2$
Start	4.0 mol		0		0
Δ	−2x		+x		+3x
eq.	4.0−2x mol		x mol		3x mol

at eq, 2.0 mol NH_3 = 4.0 − 2x mol
−4.0 −4.0
$\frac{-2.0}{-2} = \frac{-2x}{-2}$ x = 1.0 mol

2.0 mol NH_3 ÷ 2.0 L ⇒ 1.0 M NH_3
1.0 mol N_2 ÷ 2.0 L ⇒ 0.50 M N_2
3(1.0) = 3.0 mol H_2 ÷ 2.0 L = 1.5 M H_2

$$K_c = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.50)(1.5)^3}{(1.0)^2} = 1.7$$

to 2 sf.

3. $H_{2(g)} + S_{(g)} \rightleftharpoons H_2S_{(g)}$ $K_c = 0.068$

Start	0.15 M	1.0 M	0
Δ	−x	−x	+x
eq	0.15−x	1.0−x	x

$$K_c = \frac{[H_2S]}{[H_2][S]} = \frac{x}{(0.15-x)(1.0-x)} = 0.068$$

$$x = 0.068(0.15 - x)(1.0 - x)$$

$$x = 0.068(0.15 - 1.0x - 0.15x + x^2)$$

$$x = 0.0102 - 0.0782x + 0.068x^2$$

$$-x \qquad -x$$

$$0 = 0.0102 - 1.0782x + 0.068x^2$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{+1.0782 \pm \sqrt{(1.0782)^2 - 4(.068)(.0102)}}{2(0.068)}$$

$$x = \frac{1.0782 \pm 1.0769}{0.136} = 15.84 \text{ or } x = 0.00956$$

$x = [H_2S]$ at eq = 9.6×10^{-3} M H_2S

check: $\dfrac{(9.56 \times 10^{-3})}{(0.15 - 9.56 \times 10^{-3})(1.0 - 9.56 \times 10^{-3})} = 0.069$ ✓ close enough.

0.14044 $\qquad$ 0.99044

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4. $2NO_2 \rightleftharpoons N_2O_4$

	$2NO_2$	N_2O_4
start	0	0.100 atm
Δ	+2x	−x
eq	2x atm	0.100 − x atm

$$K_p = \frac{P_{N_2O_4}}{(P_{NO_2})^2} = \frac{0.100 - x}{(2x)^2} = 6.7$$

$$0.100 - x = 6.7(2x)^2 = 6.7(4x^2)$$
$$0.100 - x = 26.8x^2$$
$$0 = 26.8x^2 + x - 0.100$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-1 \pm \sqrt{1^2 - 4(26.8)(0.100)}}{2(26.8)}$$

$$x = \frac{-1 \pm 3.\bar{4}23}{53.6} = 0.04\bar{5}2 \text{ atm}$$

or $x = -0.0825$ atm doesn't make sense

$2x = 2(.04\bar{5}2 \text{ atm}) = 0.09\bar{0}4 \text{ atm } N_2O_2$

$0.100 - x = 0.100 - .04\bar{5}2 \text{ atm} = 0.05\bar{4}8 \text{ atm } N_2O_4$ at equilibrium

check:

$$K_p = \frac{0.05\bar{4}8}{(0.09\bar{0}4)^2} = 6.7 \quad \checkmark$$

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5. 1.00 mole of each in 1.0 L
each initial M is 1.00 M
Which way will it go? calc. Q

$$Q = \frac{[CO][Br_2]}{[COBr_2]} = \frac{(1.00)(1.00)}{(1.00)} = 1.00$$

a) $K = 0.190$ so $Q > K$, Q must decrease to get to equilibrium. Rxn must go backward.

b)

	$COBr_2$	$\rightleftharpoons$	CO	+	Br_2
Start	1.00 M		1.00 M		1.00 M
Δ	+x		−x		−x
eq	1.00 + x		1.00 − x		1.00 − x

$$K_c = 0.190 = \frac{[CO][Br_2]}{[COBr_2]} = \frac{(1.00-x)(1.00-x)}{1.00+x} = 0.190$$

$$(1.00-x)(1.00-x) = 0.190(1.00+x)$$
$$1.00 - 1.00x - 1.00x + x^2 = 0.190 + 0.190x$$
$$-0.190 \quad -0.190x \qquad -0.190 \quad -0.190x$$

$$0.81 - 2.19x + x^2 = 0$$

$$x = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{+2.19 \pm \sqrt{(2.19)^2 - 4(1)(0.81)}}{2(1)}$$

$$x = \frac{+2.19 \pm 1.247}{2} = \cancel{1.72} \text{ or } x = 0.4715 \text{ M}$$

$[COBr_2] = 1.00 + .47 \Rightarrow 1.47\ M$

$[CO] = 1.00 - .47 \Rightarrow 0.53\ M$

$[Br_2] \Rightarrow 0.53\ M$

check $K_c = \frac{(.53)^2}{1.47} = \underline{0.191}$ close enough!