Calculating Equilibrium Constants

a. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$; $[N_2] = .84M$, $[H_2] = .35M$, $[NH_3] = .031M$

i. $K = \dfrac{[NH_3]^2}{[N_2][H_2]} \rightarrow \dfrac{[.031]^2}{[.84][.35]} =$

. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$; at equil. $HI = 1.87 \cdot 10^{-3}M$

i. started with $H_2 = 1.00 \cdot 10^{-3}M$, $I_2 = 2.00 \cdot 10^{-3}M$ → how do we find at equil?

1. ICE ICE TABLES

	$[H_2]$	$[I_2]$	$[HI]$
Initial	$1.00 \cdot 10^{-3}$	$2.00 \cdot 10^{-3}$	0
Change	$-9.35 \cdot 10^{-4}$	$-9.35 \cdot 10^{-4}$	$+1.87 \cdot 10^{-3}$
Equilibrium	$6.5 \cdot 10^{-5}$	$1.065 \cdot 10^{-3}$	$1.87 \cdot 10^{-3}$

stoichiometry tells that half the product must come from the 2 reactants!

. ethanol (aq) + acetic acid (aq) ⇌ ethyl acetate (g) + H_2O (l)

i. $K = \dfrac{[\text{ethyl acetate}]}{[\text{ethanol}][\text{acetic acid}]} \rightarrow \dfrac{[.25]}{[.75][.75]}$

	[ethanol]	[acetic acid]	[ethyl acetate]
I	1	1	0
C	−.25	−.25	+.25
E	.75	.75	.25

1:1:1 ratio

i. If you know K, you can find equilibrium concentrations

$C(s) + CO_2(g) \rightleftharpoons 2CO(g)$, $K_c = .021$

i.

	$[CO_2]$	$[CO]$
I	1	0
C	−x	+2x
E	1−x	2x

1. $K = \dfrac{[CO]^2}{[CO_2]} \rightarrow \dfrac{(2x)^2}{(1-x)} = .021 \rightarrow 4x^2 = .021 - .021x \rightarrow 4x^2 + .021x - .021 = 0$

2. $\frac{-.021 \pm \sqrt{(.021)^2 - 4(4)(-.021)}}{2(4)} = .70, -.075$ throw out negative!

F. Tricks to Avoid the Quadratic

i. $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$, $6.8 \cdot 10^{-9}$

1 atm

1. $K_p = \frac{P_{CO} P_{Cl_2}}{P_{COCl_2}}$

a.

	P_{COCl_2}	P_{CO}	P_{Cl_2}
I	1 atm	0	0
C	$-x$	$+x$	$+x$
E	$1-x$	x	x

b. $\frac{(x)(x)}{1-x} \rightarrow \frac{x^2}{1-x} = 6.8 \cdot 10^{-9}$, since K_p is small assume that $1-x$ is 1 : $\sqrt{x^2} = \sqrt{6.8 \cdot 10^{-9}}$, $\boxed{x = 8.2 \cdot 10^{-5} \text{ atm}}$

ii. 5% Rule: If $\frac{x}{[\text{init.}]} \cdot 100 \leq 5\%$, then this trick works

1. $\frac{8.2 \cdot 10^{-5}}{1} \cdot 100 \leq 5\%$ ✓

iii. $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$, $K = 1.6 \cdot 10^{-5}$

1 mol in 2L

a.

	NOCl	NO	Cl_2
I	.5 M	0	0
C	$-2x$	$+2x$	$+x$
E	$.5-2x$	$2x$	x

b. $\frac{(2x)^2(x)}{(.5-2x)^2} \rightarrow$ Assume $x \ll .5 \rightarrow \frac{4x^3}{.5^2} = 1.6 \cdot 10^{-5}$, $\boxed{x = .01}$

G. Is it at Equilibrium

i. $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

1. Q, the reaction quotient calculated like equilibrium constant, BUT with actual concentrations