KEY

Equilibrium Constant Expression Calculations

Type I

~~Calculating~~ Writing Equilibrium Constant Expression

$2\ HS\ (g) \leftrightarrow H_2\ (g) + S_2\ (g)$

$$K_{eq} = \frac{[S_2][H_2]}{[HS]^2}$$

$CH_3OH\ (g) \leftrightarrow CO\ (g) + 2\ H_2\ (g)$

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

$C_3H_8\ (g) + 5\ O_2\ (g) \leftrightarrow 3\ CO_2\ (g) + 4\ H_2O\ (g)$

$$K_{eq} = \frac{[CO_2]^3[H_2O]^4}{[C_3H_8][O_2]^5}$$

$CaCO_3\ (s) \leftrightarrow CaO\ (s) + CO_2\ (g)$

$$K_{eq} = [CO_2]$$

$4\ HCl\ (g) + O_2\ (g) \leftrightarrow 2\ H_2O\ (l) + 2\ Cl_2\ (g)$

$$K_{eq} = \frac{[Cl_2]^2}{[HCl]^4[O_2]}$$

Type II
Calculating a concentration given the K_{eq}

$2\ COF_2\ (g) \leftrightarrow CO_2\ (g) + CF_4\ (g)$

$K_{eq} = 2.00$

At Equilibrium
$[COF_2] = .255$
$[CF_4] = .118$

Find $[CO_2]$

$$K_{eq} = \frac{[CO_2][CF_4]}{[COF_2]^2}$$

$$2.00 = \frac{[CO_2](0.118)}{(0.255)^2}$$

$$[CO_2] = 1.1M$$

$I_2\ (g) \leftrightarrow 2\ I\ (g)$

$K_{eq} = .011$

At Equilibrium
$[I_2] = .10$

Find $[I]$

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

$$0.011 = \frac{[I]^2}{(0.10)}$$

$$[I] = 0.033M$$

Type III
Calculating equilibrium constant
ICE Table

	$CO(g)$	+ $2H_2(g)$	$\leftrightarrow$ $CH_3OH(g)$
I	0.50	2x	0
C	−x	−2x	+x
E	0.15	0	0.35

Initial
[CO] = .50

Equilibrium
[CO] = .15

Find K_{eq}

need $[H_2]$ or assume it's the right amount.

$0.50 - x = 0.15$

$x = 0.50 - 0.15 = 0.35$

ruins calcs so — this problem sucks. ☺

	$CO(g)$	+ $2H_2(g)$	$\leftrightarrow$ $CH_3OH(g)$
I	0.27	0.49	0
C	−x	−2x	+x
E	0.27−x	0.49−2x	0.11

$0 + x = 0.11 \quad x = 0.11$

eg [CO] = 0.27 − 0.11 = 0.16

$[H_2] = 0.49 - (2(0.11)) = 0.27$

Initial
[CO] = .27
$[H_2]$ = .49

Equilibrium
$[CH_3OH]$ = .11

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

$K_{eq} = \frac{(0.11)}{(0.16)(0.27)^2}$

Find K_{eq} = 9.43

	$2CH_4(g)$	$\leftrightarrow$ $C_2H_2(g)$	+ $3H_2(g)$
I	0.115	0	0
C	−2x	+x	+3x
E	0.115−2x	0.035	0+3x
		x = 0.035	

eg [CH_4] = 0.115 − 2(0.035) = 0.045

$[H_2] = 0 + 3(0.035) = 0.105$

Initial
$[CH_4]$ = .115

Equilibrium
$[C_2H_2]$ = .035

$K_{eq} = \frac{[C_2H_2][H_2]^3}{[CH_4]^2}$

$K_{eq} = \frac{(0.035)(0.105)^3}{(0.045)^2}$

Find K_{eq} = 0.02

	$2CH_4(g)$	$\leftrightarrow$ $C_2H_2(g)$	+ $3H_2(g)$
I	0.087	0	0
C	−2x	+x	+3x
E	0.087−2x	0+x	0.012

$0 + 3x = 0.012 \quad x = \frac{0.012}{3} = 0.004$

eg [CH_4] = 0.087 − 2(0.004) = 0.079

$[C_2H_2] = 0 + 0.004 = 0.004$

Initial
$[CH_4]$ = .087

Equilibrium
$[H_2]$ = .012

$K_{eq} = \frac{(0.004)(0.012)^3}{(0.079)^2}$

Find K_{eq} = 1.1×10^{-6}

must be @ different temperature or pressure!

K_{eq}

Type IV
Calculating equilibrium constant
Perfect Square

	I_2 (g)	+	Cl_2 (g)	↔	2 ICl (g)
I	0.1		0.1		0.1
C	−x		−x		+2x
E	0.1−x		0.1−x		0.1+2x

$$81.9 = \frac{(0.1+2x)^2}{(0.1-x)(0.1-x)}$$

$$\sqrt{81.9} = \frac{(0.1+2x)^2}{(0.1-x)^2}$$

$$9.05 = \frac{0.1+2x}{0.1-x}$$

$$(0.1-x)9.05 = 0.1+2x$$

$K = 81.9$

$$K_{eq} = \frac{[ICl]^2}{[I_2][Cl_2]}$$

Initial
$[I_2] = .100$
$[Cl_2] = .100$
$[ICl] = .100$

Find
Equilibrium Concentrations

$$0.905 - 9.05x = 0.1 + 2x$$
$$+9.05x \quad -0.1$$

$$\frac{0.805 = 11.05x}{11.05}$$

$$x = 0.072$$

@eq:
$[I_2] = 0.1 - 0.072 = 0.028M$
$[Cl_2] = 0.1 - 0.072 = 0.028M$
$[ICl] = 0.1 + (2(0.072)) = 0.244M$

	I_2 (g)	+	Cl_2 (g)	↔	2 ICl (g)
I	0.15		0.15		0.0
C	−x		−x		+2x
E	0.15−x		0.15−x		0+2x

$$81.9 = \frac{(0+2x)^2}{(0.15-x)^2}$$

$$9.05 = \frac{2x}{0.15-x}$$

$$9.05(0.15-x) = 2x$$

$K = 81.9$

Initial
$[I_2] = .15$
$[Cl_2] = .15$
$[ICl] = 0.0$

Find
Equilibrium Concentrations

$$1.36 - 9.05x = 2x$$
$$+9.05x$$

$$\frac{1.36 = 11.05x}{11.05}$$

$$x = 0.123$$

@ eq.
$[I_2] = 0.15 - 0.123 = 0.027$
$[Cl_2] = 0.15 - 0.123 = 0.027$
$[ICl] = 2(0.123) = 0.246$

Type IV
Calculating equilibrium constant
Perfect Square

	N_2 (g)	+	O_2 (g)	↔	2 NO (g)
I	0.2		0.2		0
C	−x		−x		+2x
E	0.2−x		0.2−x		0+2x

$$0.10 = \frac{(0+2x)^2}{(0.2-x)(0.2-x)}$$

$$0.32 = \frac{2x}{0.2-x}$$

$$0.064 - 0.32x = 2x$$
$$+0.32x$$

$$\frac{0.064}{6.25} = \frac{6.25x}{6.25}$$

$X = 0.01$

K = .10

Initial
$[N_2]$ = .200
$[O_2]$ = .200
[NO] = 0.0

Find
Equilibrium Concentrations

@ equilibrium

$[N_2] = 0.2 - 0.01 = 0.19\ M$

$[O_2] = 0.2 - 0.01 = 0.19\ M$

$[NO] = 2(0.01) = 0.02\ M$

	N_2 (g)	+	O_2 (g)	↔	2 NO (g)
I	0		0		0.01
C	+x		+x		−2x
E	x		x		0.01−2x

$$0.55 = \frac{(0.01-2x)^2}{x^2}$$

$$0.74 = \frac{0.01-2x}{x}$$

$$0.74x = 0.01 - 2x$$
$$+2x$$

$$\frac{2.74x}{2.74} = \frac{0.01}{2.74}$$

$X = 0.004$

K = .055

Initial
$[N_2]$ = 0.0
$[O_2]$ = 0.0
[NO] = .0100

Find
Equilibrium Concentrations

@ eq

$[N_2] = 0.004\ M$

$[O_2] = 0.004\ M$

$[NO] = 0.01 - 2(0.004)$
$= 0.002\ M$

$$ax^2 + bx + c = 0$$

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

Type IV
Calculating equilibrium constant
Quadratic Formula

$$K_{eq} = \frac{[NO_2]^2}{[N_2O_4]}$$

$K = .36$

	N_2O_4 (g)	↔	$2\,NO_2$ (g)
I	0.025		0
C	$-x$		$+2x$
E	$0.025 - x$		$2x$

Initial
$[N_2O_4] = .0250$

Find
Equilibrium Concentrations

$$0.36 = \frac{(2x)^2}{0.025 - x}$$

$$0.009 - 0.36x = 4x^2$$

$$0 = 4x^2 + 0.36x - 0.009$$

$$x = \frac{-0.36 \pm \sqrt{0.36^2 - 4(4)(-0.009)}}{2(4)}$$

$$x = \frac{-0.36 \pm 0.523}{8}$$

$x = 0.02$ or $x = -0.11$

So... @ eq. $[N_2O_4] = 0.025 - 0.02 = 0.005\,M$

$[NO_2] = 2(0.02) = 0.04\,M$

	N_2O_4 (g)	↔	$2\,NO_2$ (g)
I	0		0.100
C	$+x$		$-x$
E	x		$0.1 - x$

$K = .36$

Initial
$[NO_2] = .100$

Find
Equilibrium Concentrations

$$0.36 = \frac{(0.1 - x)^2}{x}$$

$$0.36x = 0.01 - 0.1x - 0.1x + x^2$$

$$-0.36x$$

$$x^2 - 0.56x + 0.01 = 0$$

$$x = \frac{0.56 \pm \sqrt{(-0.56)^2 - 4(1)(0.01)}}{2(1)}$$

$$x = \frac{0.56 \pm 0.523}{2}$$

$x = 0.54$ (can't be, too big) or $x = 0.0185$

@ eq.

$[N_2O_4] = 0.0185\,M$

$[NO_2] = 0.1 - 0.0185 = 0.0815\,M$