

KEY

Equilibrium Constant Expression Calculations

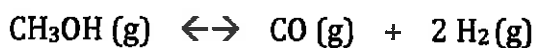
Type I

Calculating Equilibrium Constant Expression

Writing



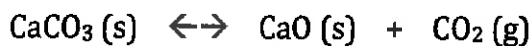
$$K_{eq} = \frac{[\text{S}_2][\text{H}_2]}{[\text{HS}]^2}$$



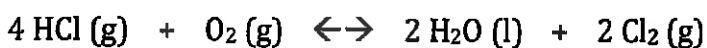
$$K_{eq} = \frac{[\text{CO}][\text{H}_2]^2}{[\text{CH}_3\text{OH}]}$$



$$K_{eq} = \frac{[\text{CO}_2]^3 [\text{H}_2\text{O}]^4}{[\text{C}_3\text{H}_8] [\text{O}_2]^5}$$



$$K_{eq} = [\text{CO}_2]$$



$$K_{eq} = \frac{[\text{Cl}_2]^2}{[\text{HCl}]^4 [\text{O}_2]}$$

Type II
Calculating a concentration given the K_{eq}



$$K_{eq} = \frac{[\text{CO}_2][\text{CF}_4]}{[\text{COF}_2]^2}$$

$$2.00 = \frac{[\text{CO}_2](0.118)}{(0.255)^2}$$

$$[\text{CO}_2] = 1.1 \text{ M}$$

$$K_{eq} = 2.00$$

At Equilibrium

$$[\text{COF}_2] = .255$$

$$[\text{CF}_4] = .118$$

Find $[\text{CO}_2]$



$$K_{eq} = \frac{[\text{I}]^2}{[\text{I}_2]}$$

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

$$[\text{I}] = 0.033 \text{ M}$$

$$K_{eq} = .011$$

At Equilibrium

$$[\text{I}_2] = .10$$

Find $[\text{I}]$

Type III
Calculating equilibrium constant
ICE Table

	CO (g)	+ 2 H ₂ (g)	↔	CH ₃ OH (g)
I	0.50	2x		0
C	-x	-2x		+x
E	0.15	0		0.35

$0.50 - x = 0.15$

$x = 0.50 - 0.15 = 0.35$

ruining calcs.

Initial
[CO] = .50

Equilibrium
[CO] = .15

Find K_{eq}

need [H₂] or assume just the right amount.

so - this problem sucks. 😊

	CO (g)	+ 2 H ₂ (g)	↔	CH ₃ OH (g)
I	0.27	0.49		0
C	-x	-2x		+x
E	0.27-x	0.49-2x		0.11

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

$[CO] = 0.27 - 0.11 = 0.16$

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

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

Initial
[CO] = .27
[H₂] = .49

Equilibrium
[CH₃OH] = .11

Find K_{eq} = 9.43

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

	2 CH ₄ (g)	↔	C ₂ H ₂ (g)	+ 3 H ₂ (g)
I	0.115		0	0
C	-2x		+x	+3x
E	0.115-2x		0.035	0+3x

$x = 0.035$

$[CH_4] = 0.115 - 2(0.035) = 0.045$

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

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

Initial
[CH₄] = .115

Equilibrium
[C₂H₂] = .035

Find K_{eq} = 0.02

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

	2 CH ₄ (g)	↔	C ₂ H ₂ (g)	+ 3 H ₂ (g)
I	0.087		0	0
C	-2x		+x	+3x
E	0.087-2x		0+x	0.012

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

$[CH_4] = 0.087 - 2(0.004) = 0.079$

$[C_2H_2] = 0 + 0.004 = 0.004$

Initial
[CH₄] = .087

Equilibrium
[H₂] = .012

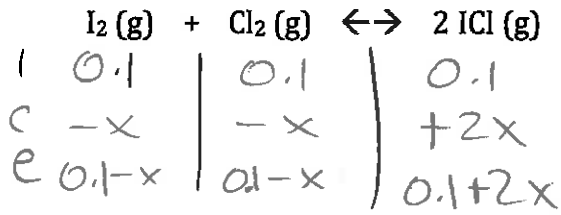
Find K_{eq} = 1.1 × 10⁻⁴

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

Must be @ different temperature or pressure!

K_{eq}

Type IV
Calculating equilibrium constant
Perfect Square



$K = 81.9$

Initial
 $[\text{I}_2] = .100$
 $[\text{Cl}_2] = .100$
 $[\text{ICl}] = .100$

$$K_{\text{eq}} = \frac{[\text{ICl}]^2}{[\text{I}_2][\text{Cl}_2]}$$

Find
Equilibrium Concentrations

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

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

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

$$+9.05x \quad -0.1$$

$$\left(9.05 = \frac{0.1+2x}{0.1-x}\right) 0.1-x$$

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

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

$$x = 0.072$$

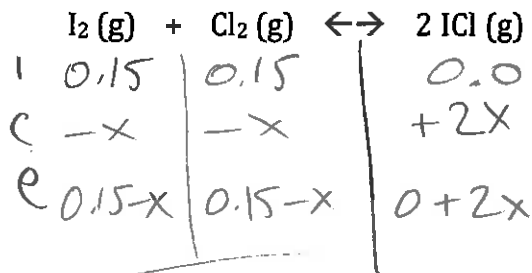
@eq:

$$[\text{I}_2] = 0.1 - 0.072 = 0.028 \text{ M}$$

$$[\text{Cl}_2] = 0.1 - 0.072 = 0.028 \text{ M}$$

$$[\text{ICl}] = 0.1 + (2(0.072)) = 0.244 \text{ M}$$

$K = 81.9$



Initial
 $[\text{I}_2] = .15$
 $[\text{Cl}_2] = .15$
 $[\text{ICl}] = 0.0$

Find
Equilibrium Concentrations

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

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

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

$$1.36 - 9.05x = 2x$$

$$+9.05x$$

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

$$x = 0.123$$

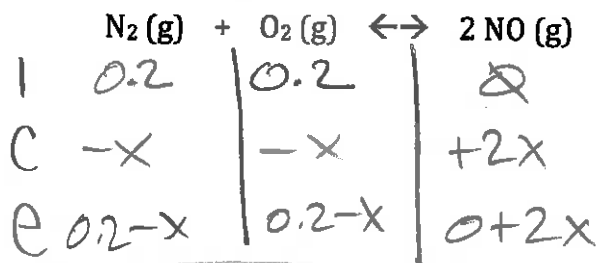
@ eq.

$$[\text{I}_2] = 0.15 - 0.123 = 0.027$$

$$[\text{Cl}_2] = 0.15 - 0.123 = 0.027$$

$$[\text{ICl}] = 2(0.123) = 0.246$$

Type IV
Calculating equilibrium constant
Perfect Square



$K = .10$

Initial

$[N_2] = .200$

$[O_2] = .200$

$[NO] = 0.0$

Find

Equilibrium Concentrations

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

$x = 0.01$

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

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

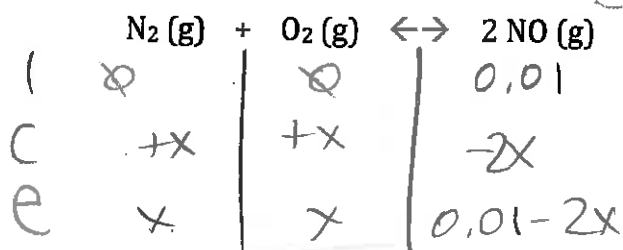
$$0.064 = 6.25x$$

@ equilibrium

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

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

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



$K = .055$

Initial

$[N_2] = 0.0$

$[O_2] = 0.0$

$[NO] = .0100$

Find

Equilibrium Concentrations

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

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

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

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

$x = 0.004$

@ eq

$[N_2] = 0.004 M$

$[O_2] = 0.004 M$

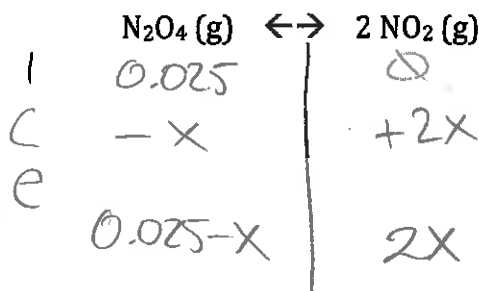
$[NO] = 0.01 - 2(0.004)$
 $= 0.002 M$

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

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

Type IV
Calculating equilibrium constant
Quadratic Formula

$$K_{eq} = \frac{[NO_2]^2}{[N_2O_4]} \quad K = .36$$



Initial
[N₂O₄] = .0250

Find
Equilibrium Concentrations

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

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

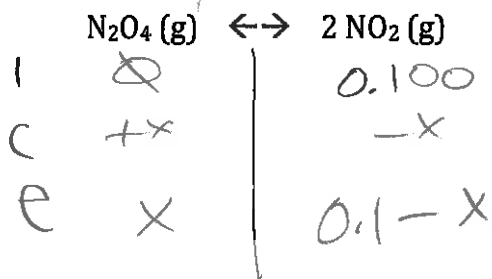
$$x = \frac{-0.36 \pm 0.523}{8}$$

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

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

$$x = 0.02 \quad \text{or} \quad x = -0.11$$

So... @ eq. $[N_2O_4] = 0.025 - 0.02 = 0.005 M$
 $[NO_2] = 2(0.02) = 0.04 M$



K = .36

Initial
[NO₂] = .100

Find
Equilibrium Concentrations

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

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

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

$$-0.36x$$

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

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

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

@ eq.
 $[N_2O_4] = 0.0185 M$

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