

EQUILIBRIUM CALCULATIONS

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Two types of questions:

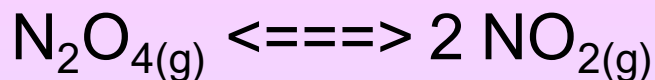
1. calculating K_{eq} from known concentration values

2. calculating concentration values when K_{eq} is given

EQUILIBRIUM CALCULATIONS

Calculating K_{eq}

Example #1



At 25°C, the equilibrium concentrations are:

$$[\text{N}_2\text{O}_4] = 0.0292 \text{ mol / L}$$

$$[\text{NO}_2] = 0.0116 \text{ mol / L}$$

Calculate K_{eq} at 25°C.

$$K_{eq} = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

$$= \frac{[0.0116]^2}{[0.0292]}$$

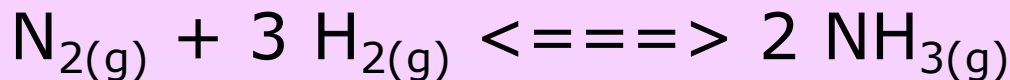
$$= 4.61 \times 10^{-3}$$

$$\therefore k_{eq} = 4.61 \times 10^{-3}$$

EQUILIBRIUM CALCULATIONS

Calculating K_{eq}

Example #2



At 200°C, the concentrations at equilibrium are:

$[\text{N}_2] = 2.12$, $[\text{H}_2] = 1.75$, and $[\text{NH}_3] = 84.3$

Calculate K_{eq} at 200°C.

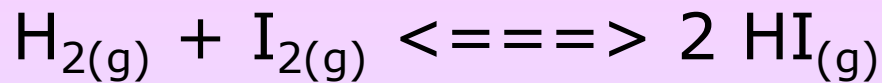
$$\begin{aligned} K_{eq} &= \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \\ &= \frac{[84.3]^2}{[2.12][1.75]^3} \\ &= 625 \end{aligned}$$

∴ the k_{eq} is 625

EQUILIBRIUM CALCULATIONS

Calculating K_{eq}

Example #3



Initial moles in a 2.00 L flask:

$[\text{H}_2] = 0.200 \text{ mol}$ and $[\text{I}_2] = 0.200 \text{ mol}$

At equilibrium, $[\text{I}_2] = 0.020 \text{ mol / L}$.

a) What is K_{eq} at steady conditions?

b) What percent of iodine vapour reacted?

EQUILIBRIUM CALCULATIONS

ICE tables

Whenever questions involve initial conditions changing to reach equilibrium, ICE tables are a good method to organize your information.

I = initial concentrations

C = change in concentrations

E = equilibrium concentrations

EQUILIBRIUM CALCULATIONS

Calculating K_{eq} - Example #3

Initial moles in a 2.00 L flask: $[H_2] = 0.200$ mol and $[I_2] = 0.200$ mol
At equilibrium, $[I_2] = 0.020$ mol / L.

	$H_{2(g)}$	+	$I_{2(g)}$	\rightleftharpoons	$2 HI_{(g)}$
I	$0.2/2 = 0.1M$		$0.1M$		$0.0M$
C	-x		-x		2x
E	$0.02M$		$0.02M$		$0.16M$

a) What is K_{eq} at steady conditions?

b) What percent of iodine vapour reacted?

$$\begin{aligned} \text{a)} \quad K_{eq} &= \frac{[HI]^2}{[H_2][I_2]} \\ &= \frac{[0.16]^2}{[0.02][0.02]} \\ &= 64 \end{aligned}$$

$$\therefore K_{eq} = 64$$

$$\begin{aligned} \text{b)} \quad \%I_2 \text{ reacted} &= \frac{0.08}{0.1} \times 100\% \\ &= 80\% \end{aligned}$$

$$\therefore \%I_2 \text{ reacted} = 80\%$$

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% Reaction

$$\% \text{ reaction} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

- Actual yield: measured @ equilibrium
- Theoretical yield:
 - Maximum possible yield
 - Calculated with stoichiometry
 - Based on assumptions of forward reaction

EQUILIBRIUM CALCULATIONS

Calculating K_{eq}

Example #4

2.00 mol of HI in 2.00 L flask at 425°C react to produce H_2 and I_2 . At equilibrium, $[H_2]$ and $[I_2] = 0.214 \text{ mol / L}$.

What is K_{eq} for this reaction?

EQUILIBRIUM CALCULATIONS

Calculating K_{eq} - Example #4

2.00 mol of HI in 2.00 L flask at 425°C react to produce H_2 and I_2 . At equilibrium, $[H_2]$ and $[I_2] = 0.214 \text{ mol / L}$.

What is K_{eq} for this reaction?



I	1M		0M	0M
C	-2x		+x	+x
E	1-2x		0.214M	0.214M

$$1-2x$$

$$1-2(0.214) \\ = 0.572$$

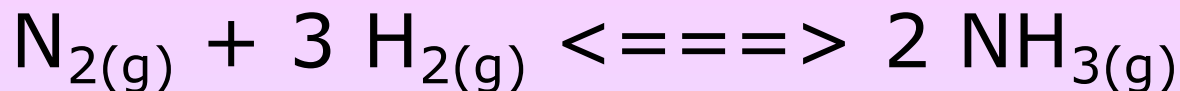
$$\begin{aligned} K_{eq} &= \frac{[H_2][I_2]}{[HI]^2} \\ &= \frac{[0.214][0.214]}{[0.572]^2} \\ &= 0.140 \end{aligned}$$

\therefore the K_{eq} is 0.140

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Calculating K_{eq}

Example #5



Initial concentrations:

$$[\text{N}_2] = 0.32 \text{ M and } [\text{H}_2] = 0.66 \text{ M}$$

What is K_{eq} when equilibrium $[\text{H}_2]$ is 0.30 M?

EQUILIBRIUM CALCULATIONS

Calculating K_{eq} - Example #5

Initial concentrations: $[N_2] = 0.32 \text{ M}$ and $[H_2] = 0.66 \text{ M}$

What is K_{eq} when equilibrium $[H_2]$ is 0.30 M ?

	$N_{2(g)}$	+	$3 H_{2(g)}$	\rightleftharpoons	$2 NH_{3(g)}$
I	0.32M		0.66M		0
C	-x		-3x		+2x
E	0.20		0.30M		0.24

$$\begin{aligned}0.66 - 3x &= 0.30 \\0.66 - 0.30 &= 3x \\x &= 0.12\end{aligned}$$

$$\begin{aligned}K_{eq} &= \frac{[NH_3]^2}{[N_2][H_2]^3} \\&= \frac{[0.24]^2}{[0.20][0.30]^3} \\&= 11\end{aligned}$$

$$\therefore K_{eq} = 11$$

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Calculating K_{eq} - Example #6

Calculate K_{eq} .

	$2 \text{ C}_{(s)}$	$+ \text{ O}_{2(g)}$	\rightleftharpoons	$2 \text{ CO}_{(g)}$
I	10	8		20
C	N/A	+7		-14
E		15		6

$$\begin{aligned} 8-x &= 15 \\ x &= 8-15 \\ x &= -7 \end{aligned}$$

$$\begin{aligned} K_{eq} &= \frac{[\text{CO}]^2}{[\text{O}_2]} \\ &= \frac{[6]^2}{[15]} \\ &= 2.4 \end{aligned}$$

$$\therefore K_{eq} = 2$$