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[TP] The reaction $3 A(aq) \rightleftharpoons 2 B(aq)$ is at equilibrium, with $[A]_e = 0.10 \text{ M}$ and $[B]_e = 2.0 \text{ M}$ and so $K = 4000$.
Then 0.05 M of A is added.

At the moment of this change, the value of $[A]$ will be ...

33% 1. 0.05 M
33% 2. 0.10 M
33% 3. 0.15 M

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Response Counter

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Lecture 14 CH102 A1 (MWF 9:05 am)
Wednesday, February 21, 2018

- Knowing K **does not** fix individual concentrations
- Disturbing equilibrium (Le Chatelier)

Being ch14: Acid-base equilibria

- The pH of water

Next: Composition of water. Weak acids and strong acids. Getting weak acid K_a values.
 $\text{p}K_a = -\log(K_a)$; Using K_a to get $[\text{H}_3\text{O}^+]$. Titration: What happens when some OH^- is added to an acid

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Knowing K does not fix individual concentrations

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Chapter 13 equilibrium calculations

Pages 505—507 illustrate how to calculate equilibrium concentrations by solving polynomial (quadratic, etc.) equations for the change in concentration.

This is doable but can be time consuming.

We will not need to use this method.

Rather, in chapter 14, we will learn to use an **approximate method** that is broadly applicable to aqueous **acid-base equilibria**.

Here, in chapter 13, we will illustrate equilibration by providing the equilibrium values.

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Equilibration examples

Essential lesson:
Knowing K does not fix individual equilibrium concentrations.

Let's see how this works for

$$\text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2 \text{HI}(g), K = 33$$

for three different sets of **initial concentrations**

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Worked Example 13.5, p 505

$$\text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2 \text{HI}(g), K = 33$$

Different starting points ...

	$\text{H}_2(g)$	$\text{I}_2(g)$	$\text{HI}(g)$	Q
Initial	0.00600	0.00600	0	0
Initial	0.00600	0	0.00200	∞
Initial	0.00600	0.0000100	0.00200	66.7

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Worked Example 13.5, p 505

$$\text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2 \text{HI}(g), K = 33$$

Different starting points ...
different equilibrium concentrations

	$\text{H}_2(g)$	$\text{I}_2(g)$	$\text{HI}(g)$	Q
Equilibrium	0.00155	0.00155	0.00890	33
Equilibrium	0.00602	0.0000194	0.00196	33
Equilibrium	0.00601	0.0000198	0.00198	33

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Disturbing equilibrium

Essential idea: A system at equilibrium responds to a disturbance by ...

partially offsetting the disturbance.



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[TP] The reaction $3 A(aq) \rightleftharpoons 2 B(aq)$ is at equilibrium, with $[A]_e = 0.10 \text{ M}$ and $[B]_e = 2.0 \text{ M}$ and so $K = 4000$.
Then 0.05 M of A is added.

At the moment of this change, the value of $[A]$ will be ...

33% 1. 0.05 M
33% 2. 0.10 M
33% 3. 0.15 M



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[TP] The reaction $3 A(aq) \rightleftharpoons 2 B(aq)$ is at equilibrium, with $[A]_e = 0.10 \text{ M}$ and $[B]_e = 2.0 \text{ M}$ and so $K = 4000$.
Then 0.05 M of A is added.

At the moment of this change, the value of Q will be ...

33% 1. > 4000
33% 2. $= 4000$
33% 3. < 4000



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Then 0.05 M of A is added.

At the moment of this change, the system will ...

33% 1. have too much reactant
33% 2. still be at equilibrium
33% 3. have too much product



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[TP] The reaction $3 A(aq) \rightleftharpoons 2 B(aq)$ is at equilibrium, with $[A]_e = 0.10 \text{ M}$ and $[B]_e = 2.0 \text{ M}$ and so $K = 4000$.
Then 0.05 M of A is added.

After the system is once again at equilibrium, $[A]_e$ must be ...

33% 1. $< 0.10 \text{ M}$
33% 2. $= 0.10 \text{ M}$
33% 3. $> 0.10 \text{ M}$

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[Quiz] The reaction $3 A(aq) \rightleftharpoons 2 B(aq)$ is at equilibrium, with $[A]_e = 0.10 \text{ M}$ and $[B]_e = 2.0 \text{ M}$ and so $K = 4000$. Then 0.05 M of A is added. After the system is once again at equilibrium, $[B]_e$ **must** be ...

33% 1. $< 2.0 \text{ M}$
33% 2. $= 2.0 \text{ M}$
33% 3. $> 2.0 \text{ M}$

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Disturbing equilibrium

Essential idea: A system at equilibrium responds to a disturbance by **partially offsetting** the disturbance.

This behavior is called **Le Chatelier's principle**.

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Begin ch14:
Acid-base equilibria in aqueous solutions

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The pH of water

Write down the **chemical equilibrium** that accounts for the pH of water.

$$\text{H}_2\text{O}(l) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_3\text{O}^+(aq) + \text{OH}^-(aq)$$

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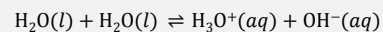
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The pH of water

Write down the **reaction quotient** for the water autoionization equilibrium,



$$Q_w = [\text{H}_3\text{O}^+][\text{OH}^-]$$

$$K_w = [\text{H}_3\text{O}^+]_e[\text{OH}^-]_e$$



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The pH of water

Pure water at 50 °C is measured to have a pH of 6.63.

Write down the value of $[\text{H}_3\text{O}^+]_e$ at 50 °C.

$$[\text{H}_3\text{O}^+]_e = 10^{-6.63} = 2.34 \times 10^{-7}$$



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The pH of water

Pure water at 50 °C is measured to have a pH of 6.63.

Write down the value of $[\text{OH}^-]_e$ at 50 °C.

$$[\text{OH}^-]_e = [\text{H}_3\text{O}^+]_e = 10^{-6.63} = 2.34 \times 10^{-7}$$



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The pH of water

Pure water at 50 °C is measured to have a pH of 6.63.

Write down the value of the **reaction quotient** of the water autoionization at equilibrium at 50 °C.

$$Q_{w,e} = K_w = [\text{H}_3\text{O}^+]_e[\text{OH}^-]_e = (10^{-6.63})^2 = 5.48 \times 10^{-14}$$



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[TP] Pure water at 50 °C is measured to have a pH of 6.63.
This means that pure water at 50 °C is ...

- 33% 1. acidic
- 33% 2. neutral
- 33% 3. basic



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[TP] Pure water at 10 °C has $[H_3O^+] = 5.39 \times 10^{-8}$.
This means that pure water at 10 °C is ...

- 33% 1. acidic
- 33% 2. neutral
- 33% 3. basic



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[Quiz] The pH of pure water is different at different temperatures.
This means that as temperature changes ...

- 20% 1. the proportions of $H_3O^+(aq)$ and $OH^-(aq)$ to one another in pure water change
- 20% 2. the acidity of pure water changes
- 20% 3. the value of the equilibrium constant changes
- 20% 4. All of the above
- 20% 5. None of the above

Response
Counter

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