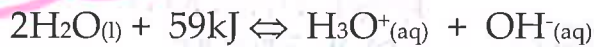


Temperature and pH



At 25°C: $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14}$, so $\text{p}K_w = 14.00$

The pH scale is generally thought of from 0-14 because the $\text{p}K_w$ is 14.

However, this is only the case at 25°C? Why? A temp change will change K_w ∴ $\text{p}K_w$ will also change. AND the pH scale changes

If the temperature is increased, what happens to the equilibrium and the resulting K_w ? What will happen to the pH scale?

- ↑Temp = ↑ rate of the endothermic rxn ∴ Fwd rxn ∴ shift RIGHT
- In this case, both $[\text{H}_3\text{O}^+][\text{OH}^-]$ will increase
- K_w will increase, therefore $\text{p}K_w = -\log(K_w)$ will decrease
- a decrease in $\text{p}K_w$ "shrinks" the pH scale.

What if the temperature is decreased?

- ↓Temp = ↓ rate of endo rxn ∴ shift LEFT to favor exothermic rxn.
- both $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ will decrease
- K_w will decrease, therefore $\text{p}K_w = -\log(K_w)$ will increase
- an increase in $\text{p}K_w$ makes the pH scale larger

Example:

An increase in temperature to 50°C results in a K_w of 5.48×10^{-14} . Calculate the pH, pOH, $[\text{H}_3\text{O}^+]$, and $[\text{OH}^-]$ in pure water. Is the water acidic, basic, or neutral?

$$\text{p}K_w = -\log(5.48 \times 10^{-14}) = 13.261$$

$$\therefore \text{pH scale} = 0 - 13.261$$

$$\text{pH} = \text{pOH} = \frac{13.261}{2} = 6.631$$

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] \text{ and } \text{pH} = \text{pOH}$$

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] = 10^{-(6.631)} = 2.34 \times 10^{-7} \text{ M}$$

* pure water is always neutral as $[\text{H}_3\text{O}^+] = [\text{OH}^-]$

A sample of distilled, pure water has a pH of 7.50. Is the temperature greater than or less than 25°C? Explain.



pure water is neutral, $\text{pH} = \text{pOH}$, ∴ $\text{p}K_w = 7.50 \times 2 = 15.00$

$$\therefore K_w = 10^{-(15.00)} = 1.0 \times 10^{-15}$$

- $1.0 \times 10^{-15} < 1.0 \times 10^{-14}$ ∴ K_w has decreased
- If K_w has ↓ and $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$, then $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ have both decreased ∴ the shift must have been left (exothermic)
- Exothermic rxn favored indicates a ↓ in temp.
- ∴ Temperature < 25°C

Assignment 10:

1) Hebden p. 139 #51, 52

2) Water at a certain temperature has a K_w of 4.4×10^{-15} .

- Is the water at a temperature above or below 25°C ?
- What is the $\text{p}K_w$?
- What would the pH scale be at this temperature?
- Find the $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$.
- Find the pH and pOH.
- Is water at this temperature acidic, basic, or neutral?

XIII) Mixtures of Strong Acids and Bases

Mixing an acid solution with a basic solution produces a solution that can be _____, _____, or _____

depending on the moles of acid compared to the moles of base mixed.

H_3O^+ ions react with OH^- ions to make $2\text{H}_2\text{O}$ molecules, known as neutralization. But if there are more of one ion than the other, the resulting solution will not be neutral.

Example:

- Calculate the pH of a solution obtained by adding 50.0mL of 0.10M HCl to 80.0mL of 0.15M NaOH.