Temperature and pH

$$2H_2O_{(l)} + 59kJ \Leftrightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$$

At 25°C: $K_w = [H_3O^+]\,[OH^-] = 1.0 \times 10^{-14}$, so $pK_w = 14.00$

The pH scale is generally thought of from 0-14 because the pK_w is 14. However, this is only the case at 25°C? Why? A temp change will change Kw ∴ pKw will also change. AND the pH scale changes

↑Temp 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 $[H_3O^+][OH^-]$ will increase
- Kw will increase, therefore $pK_w = -\log(K_w)$ will decrease
- a decrease in pKw "shrinks" the pH scale.

↓Temp What if the temperature is decreased?

- ↓temp = ↓ rate of endo rxn ∴ shift LEFT to favor exothermic rxn.
- both $[H_3O^+]$ and $[OH^-]$ will decrease
- Kw will decrease, therefore $pK_w = -\log(K_w)$ will increase
- an increase in pKw 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, $[H_3O^+]$, and $[OH^-]$ in pure water. Is the water acidic, basic, or neutral?

→ $[H_3O^+] = [OH^-]$ and pH = pOH

$pK_w = -\log(5.48 \times 10^{-14}) = 13.261$

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

$[H_3O^+] = [OH^-] = 10^{\wedge}(6.631) = 2.34 \times 10^{-7} M$

∴ pH scale = 0 – 13.261

*pure water is always neutral as $[H_3O^+] = [OH^-]$

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

$$2H_2O_{(l)} + 59kJ \Leftrightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$$

pure water is neutral, pH = pOH, ∴ $pK_w = 7.50 \times 2 = 15.00$

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

- $1.0 \times 10^{-15} < 1.0 \times 10^{-14}$ ∴ Kw has decreased
- If Kw has ↓ and $K_w = [H_3O^+][OH^-]$, then $[H_3O^+]$ and $[OH^-]$ 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}.

a) Is the water at a temperature above or below 25°C?
b) What is the pK_w?
c) What would the pH scale be at this temperature?
d) Find the $[H_3O^+]$ and $[OH^-]$.
e) Find the pH and pOH.
f) 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 $2H_2O$ molecules, known as neutralization. But if there are more of one ion than the other, the resulting solution will not be neutral.

Example:

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