Worksheet 7.3: Solutions pH and K_w	

No.	Answer
1	see table below

In acidic solutions	$[H_3O^+]$	>	$[OH^-]$
In basic solutions	$[H_3O^+]$	<	10^{-7} mol L^{-1}
In neutral solutions	$[OH^-]$	=	10^{-7} mol L^{-1}
In acidic solutions	$[H_3O^+]$	>	10^{-7} mol L^{-1}
In basic solutions	$[H_3O^+]$	<	$[OH^-]$
In acidic solutions	$[OH^-]$	<	10^{-7} mol L^{-1}
In basic solutions	$[OH^-]$	>	10^{-7} mol L^{-1}

2

Water undergoes self-ionisation according to the following equation:

$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

As the mole ratio of $H_3O^+(aq)$ to $OH^-(aq)$ in this equation is 1:1, the molar concentrations of $H_3O^+(aq)$ and $OH^-(aq)$ must remain equal in pure water.

3

a $CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

b 1000 times (The pH scale is logarithmic, and a change of 1 pH unit equals a 10-fold change in $[H_3O^+]$.)

4

a **i** HNO_3 is a strong, monoprotic acid. It completely ionises in water.

$\therefore [H_3O^+] = [HNO_3] = 0.50 \text{ mol L}^{-1}$

$\therefore \text{pH} = -\log_{10}[H_3O^+] = -\log_{10}(0.50) = 0.3$

ii $Ba(OH)_2$ completely dissociates in water to produce 2 OH^- ions per unit of $Ba(OH)_2$.

$[OH^-] = 2 \times 0.050 = 0.10 = 10^{-1} \text{ mol L}^{-1}$

$[H_3O^+] \times [OH^-] = 10^{-14}$

$\therefore 10^{-1} \times [H_3O^+] = 10^{-14}$

$\therefore [H_3O^+] = 10^{-13} \text{ mol L}^{-1}$

$\therefore \text{pH} = -\log_{10}[H_3O^+] = -\log_{10} 10^{-13} = 13$

b They could have different acid strengths (e.g. one strong, one weak) or be different acid types (e.g. one monoprotic, one diprotic).

5

$K_w = [H_3O^+]\,[OH^-]$

6

1.0 g in 1.0 mL, $\therefore$ 1000 g in 1.0 L, $\therefore \dfrac{1000}{18.016} = 55.5$ mol in 1.0 L

$\therefore$ 56 mol L^{-1}

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No.	Answer
7	**a** As this is an endothermic reaction in the forward direction, an increase in temperature will cause the reaction to proceed forward, thus increasing the concentrations of both H_3O^+ and OH^- ions. Therefore the equilibrium constant, K_w, will increase with an increase in temperature. **b** As pH is defined in terms of the concentration of H_3O^+ ions, an increase in temperature results in a higher concentration of H_3O^+ and so a lower pH value for pure water. **c** The concentrations of both H_3O^+ and OH^- will increase to precisely the same extent with an increase in temperature, as can be seen from the stoichiometric 1:1 ratio in the equation. Thus, although both K_w and pH change with temperature, the water will remain neutral. (Pure water is always neutral, but it only has a pH of precisely 7 at 25°C.)
8	**a** $[H_3O^+] = 10^{-pH} = 10^{-6.7} = 2.0 \times 10^{-7}$ mol L^{-1} **b** $[OH^-] = [H_3O^+] = 10^{-pH} = 10^{-6.85} = 1.4 \times 10^{-7}$ mol L^{-1} **c** $K_w = [H_3O^+][OH^-] = [H_3O^+]^2 = (10^{-pH})^2 = (10^{-7.1})^2 = 10^{-14.2} = 6.3 \text{ x } 10^{-15}$

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