

3. 1. Calculation of the pOH:

$$\text{pH} + \text{pOH} = 14$$

$$\text{pOH} = 14 - \text{pH} = 14 - 11.9 = 2.1$$

2. Calculation of the concentration of hydroxide ions:

$$\text{pOH} = -\log[\text{OH}^-]$$

$$[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-2.1} = 7.94 \times 10^{-3} \text{ mol/L}$$

Answer: The pOH is 2.1 and the concentration of the hydroxide ions (OH^-) is $7.9 \times 10^{-3} \text{ mol/L}$.

4. a) Hydrochloric acid (HCl) dissociates completely into ions; therefore, it will have the same concentration as the acid, 4.5 mol/L.

$$b) C_1 V_1 = C_2 V_2$$

$$C_2 = \frac{C_1 V_1}{V_2} = \frac{4.5 \text{ mol/L} \cdot 30 \text{ mL}}{100 \text{ mL}} = 1.35 \text{ mol/L}$$

Since the hydrogen bromide (HBr) dissociates completely into ions, it will have the same concentration as the acid, 1.35 mol/L.

5. 1. Calculation of the pH:

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(3.98 \times 10^{-7}) = 6.400$$

2. Calculation of the concentration of hydroxide ions:

$$K_{\text{water}} = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$$

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{3.98 \times 10^{-7}} = 2.51 \times 10^{-8}$$

Answer: The milk is mildly acidic, because its pH is 6.40. The concentration of the hydroxide ions (OH^-) is $2.51 \times 10^{-8} \text{ mol/L}$.

7. 1. Calculation of the concentration of hydronium ions:

$$\begin{aligned} \text{pH} &= -\log[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-4.72} \\ &= 1.9054 \times 10^{-5} \text{ mol/L} \end{aligned}$$

2. Calculation of the concentration of hydroxide ions:

$$\begin{aligned} K_{\text{water}} &= [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14} \\ [\text{OH}^-] &= \frac{1 \times 10^{-14}}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{1.9054 \times 10^{-5}} \\ &= 5.248 \times 10^{-10} \text{ mol/L} \end{aligned}$$

3. Calculation of the pOH:

$$\text{pOH} = -\log[\text{OH}^-] = -\log(5.248 \times 10^{-10}) = 9.28$$

Answer: The phenol solution ($\text{C}_6\text{H}_6\text{O}$) is acidic.

The concentration of the hydronium ions (H_3O^+) is 1.9×10^{-5} mol/L, the concentration of the hydroxide ions (OH^-) is 5.2×10^{-10} mol/L and the pOH is 9.28.

8. 1. Calculation of the concentration of hydronium and hydroxide ions:

$$\begin{aligned} K_{\text{water}} &= [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 2.5 \times 10^{-14} \\ &= x^2 = 2.5 \times 10^{-14} \\ x &= \sqrt{2.5 \times 10^{-14}} = 1.58 \times 10^{-7} \\ [\text{OH}^-] &= [\text{H}_3\text{O}^+] = 1.6 \times 10^{-7} \text{ mol/L} \end{aligned}$$

2. Calculation of the pH:

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(1.6 \times 10^{-7}) = 6.8$$

Answer: Since the concentration of the two ions is the same, the pH and the pOH will be the same and will be close to 7. As a result, at 37°C, pure water is neutral.

The value of 6.8 is due to uncertainties in calculations and measurements.

9. 1. Calculation of the concentration of hydroxide ions:

$$\text{pOH} = -\log[\text{OH}^-]$$

$$[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-5.81} = 1.548 \times 10^{-6} \text{ mol/L}$$

2. Calculation of the concentration of hydronium ions:

$$K_{\text{water}} = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$$

$$[\text{H}_3\text{O}^+] = \frac{1 \times 10^{-14}}{[\text{OH}^-]} = \frac{1 \times 10^{-14}}{1.548 \times 10^{-6} \text{ mol/L}}$$

$$= 6.545 \times 10^{-9} \text{ mol/L}$$

3. Calculation of the pH:

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(6.545 \times 10^{-9}) = 8.18$$

Answer: The sodium bicarbonate (NaHCO_3) solution is basic. The concentration of the hydronium ions (H_3O^+) is $6.5 \times 10^{-9} \text{ mol/L}$, the concentration of the hydroxide ions (OH^-) is $1.5 \times 10^{-6} \text{ mol/L}$ and the pH is 8.18.

11. 1. Calculation of the concentration of hydronium ions:

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-2.73} = 1.862 \times 10^{-3} \text{ mol/L}$$

2. Calculation of the concentration of hydroxide ions:

$$K_{\text{water}} = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$$

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{1.862 \times 10^{-3}}$$

$$= 5.37 \times 10^{-12} \text{ mol/L}$$

Answer: The concentration of the hydronium ions (H_3O^+) is $1.9 \times 10^{-3} \text{ mol/L}$ and the concentration of the hydroxide ions (OH^-) is $5.4 \times 10^{-12} \text{ mol/L}$.

12. $\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(2.9 \times 10^{-4}) = 3.54$

Answer: This juice is acidic, because its pH is 3.54.

15. a) Since all of the acid dissolves, the concentration of the hydronium ions is 0.45 mol/L.

$$K_{water} = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$$
$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{0.45}$$
$$= 2.2 \times 10^{-14} \text{ mol/L}$$

Answer: The concentration of the hydronium ions (H_3O^+) is 0.45 mol/L and the concentration of the hydroxide ions (OH^-) is 2.2×10^{-14} mol/L.

- b) Since all of the base dissolves, the concentration of the hydroxide ions is 1.1 mol/L.

$$K_{water} = [\text{H}_3\text{O}^+] \cdot [\text{OH}^-] = 1 \times 10^{-14}$$
$$[\text{H}_3\text{O}^+] = \frac{1 \times 10^{-14}}{[\text{OH}^-]} = \frac{1 \times 10^{-14}}{1.1}$$
$$= 9.1 \times 10^{-15} \text{ mol/L}$$

Answer: The concentration of the hydronium ions (H_3O^+) is 9.1×10^{-15} mol/L, and the concentration of the hydroxide ions (OH^-) is 1.1 mol/L.

$$18. \quad K_{water} = [H_3O^+] \cdot [OH^-] = 1 \times 10^{-14}$$

$$[H_3O^+] = \frac{1 \times 10^{-14}}{[OH^-]} = \frac{1 \times 10^{-14}}{5.6 \times 10^{-14}} = 0.18 \text{ mol/L.}$$

$$19. \quad K_{water} = [H_3O^+] \cdot [OH^-] = 1 \times 10^{-14}$$

$$[OH^-] = \frac{1 \times 10^{-14}}{[H_3O^+]} = \frac{1 \times 10^{-14}}{1.7 \times 10^{-14}} = 0.5882 \text{ mol/L}$$

Because:



The concentration of $Ca(OH)_2$ will be half of what the concentration of OH^- . Therefore $[Ca(OH)_2] = \underline{\underline{0.2941 \text{ mol/L}}}$

21.

	$[H_3O^+]$ (mol/L)	pH	$[OH^-]$ (mol/L)	pOH	Acidic or basic
a)	3.7×10^{-5}	4.43	2.7×10^{-10}	9.57	Acidic
b)	3.9×10^{-11}	10.41	2.6×10^{-4}	3.59	Basic
c)	1.41×10^{-13}	12.85	7.0×10^{-2}	1.15	Basic
d)	7.94×10^{-6}	5.10	1.3×10^{-9}	8.90	Acidic

31. 1. *Calculation of the pH:*

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(1.30) = -0.1139$$

2. *Calculation of the pOH:*

$$\text{pH} + \text{pOH} = 14$$

$$\text{pOH} = 14 - \text{pH} = 14 - (-0.1139) = 14.1139$$

3. *Calculation of the concentration of hydroxide ions:*

$$\text{pOH} = -\log[\text{OH}^-]$$

$$[\text{OH}^-] = 10^{-\text{pOH}} = 10^{-14.1139} = 7.693 \times 10^{-15} \text{ mol/L}$$

Answer: It is impossible to find this concentration since a negative pH does not exist.