Chemistry 20 – Lesson 26
pH and pOH

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1.

$$[H^+_{(aq)}] \times [OH^-_{(aq)}] = K_w$$

$$[OH^-_{(aq)}] = \frac{K_w}{[H^+_{(aq)}]}$$

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$$[OH^-_{(aq)}] = \frac{1.0 \times 10^{-14}\ (\text{mol}/\text{L})^2}{4.40 \times 10^{-3}\ \text{mol}/\text{L}}$$

$$\boxed{[OH^-_{(aq)}] = 2.27 \times 10^{-12}\ \text{mol}/\text{L}}$$

2.

$$[H^+_{(aq)}] \times [OH^-_{(aq)}] = K_w$$

$$[H^+_{(aq)}] = \frac{K_w}{[OH^-_{(aq)}]}$$

/3

$$[H^+_{(aq)}] = \frac{1.0 \times 10^{-14}\ (\text{mol}/\text{L})^2}{2.99 \times 10^{-4}\ \text{mol}/\text{L}}$$

$$\boxed{[H^+_{(aq)}] = 3.34 \times 10^{-11}\ \text{mol}/\text{L}}$$

3.

$$n_{HCl} = \frac{0.37\,\text{g}}{36.46\ \text{g}/\text{mol}} = 0.010148\text{mol}$$

$$[HCl_{(aq)}] = \frac{0.010148\text{mol}}{0.250\text{L}} = 0.040592\ \text{mol}/\text{L}$$

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$$HCl_{(aq)} \xrightarrow{100\%} H^+_{(aq)} + Cl^-_{(aq)}$$

$$[H^+_{(aq)}] = [HCl_{(aq)}] = 0.040592\ \text{mol}/\text{L}$$

$$[H^+_{(aq)}] \times [OH^-_{(aq)}] = K_w$$

$$[OH^-_{(aq)}] = \frac{K_w}{[H^+_{(aq)}]}$$

$$[OH^-_{(aq)}] = \frac{1.0 \times 10^{-14}\ (\text{mol}/\text{L})^2}{0.040592\ \text{mol}/\text{L}}$$

$$\boxed{[OH^-_{(aq)}] = 2.46 \times 10^{-13}\ \text{mol}/\text{L}}$$

4.

$$Ca(OH)_{2(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2\,OH^-_{(aq)}$$

$$[OH^-_{(aq)}] = 2 \times [Ca(OH)_{2(aq)}]$$

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$$[OH^-_{(aq)}] = 2 \times [6.9 \times 10^{-3}\ \text{mol}/\text{L}]$$

$$[OH^-_{(aq)}] = 1.38 \times 10^{-2}\ \text{mol}/\text{L}$$

$$[H^+_{(aq)}] \times [OH^-_{(aq)}] = K_w$$

$$[H^+_{(aq)}] = \frac{K_w}{[OH^-_{(aq)}]}$$

$$[H^+_{(aq)}] = \frac{1.0 \times 10^{-14}\ (\text{mol}/\text{L})^2}{1.38 \times 10^{-2}\ \text{mol}/\text{L}}$$

$$\boxed{[H^+_{(aq)}] = 7.25 \times 10^{-13}\ \text{mol}/\text{L}}$$

5.

$$n_{KOH} = \frac{20.0\,g}{56.11\,g/mol} = 0.35644\,mol$$

$$[KOH_{(aq)}] = \frac{0.35644\,mol}{0.500\,L} = 0.7128854\,mol/L$$

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$$KOH_{(s)} \longrightarrow K^+_{(aq)} + OH^-_{(aq)}$$

$$[OH^-_{(aq)}] = [KOH_{(aq)}] = 0.7128854\,mol/L$$

$$[H^+_{(aq)}] \times [OH^-_{(aq)}] = K_w$$

$$[H^+_{(aq)}] = \frac{K_w}{[OH^-_{(aq)}]}$$

$$[H^+_{(aq)}] = \frac{1.0 \times 10^{-14}\,(mol/L)^2}{0.7128854\,mol/L}$$

$$\boxed{[H^+_{(aq)}] = 1.403 \times 10^{-14}\,mol/L}$$

6.

(a)

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Food	$[H^+_{(aq)}]$ (mol/L)	$[OH^-_{(aq)}]$ (mol/L)	pH	pOH
oranges	5.5×10^{-3}	**1.8×10^{-12}**	**2.26**	**11.74**
asparagus	**4×10^{-9}**	**3×10^{-6}**	**8.4**	5.6
olives	**5.0×10^{-4}**	2.0×10^{-11}	**3.30**	**10.70**
blackberries	**4.0×10^{-4}**	**2.5×10^{-11}**	**3.40**	10.60

(b) **Oranges** would taste most sour.

7.

$$n_{NaOH} = \frac{26\,g}{40.00\,g/mol} = 0.65\,mol$$

$$[NaOH_{(aq)}] = \frac{0.65\,mol}{0.150\,L} = 4.33\,mol/L$$

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$$NaOH_{(s)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

$$[OH^-_{(aq)}] = [NaOH_{(aq)}] = 4.33\,mol/L$$

$$pOH = -\log[OH^-]$$

$$pOH = -\log[4.33\,mol/L]$$

$$\boxed{pOH = -0.64}$$

Note that negative values for pH and pOH are possible. Further, a negative pH or pOH indicates a very concentrated acidic or basic solution.

$$pH + pOH = 14$$

$$pH = 14 - pOH = 14 - (-0.64)$$

$$\boxed{pH = 14.64}$$

8.

$$pH + pOH = 14$$

$$pOH = 14 - pH = 14 - (11.50)$$

$$pOH = 2.50$$

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$$[OH^-_{(aq)}] = 10^{-pOH}$$

$$[OH^-_{(aq)}] = 10^{-2.50}$$

$$[OH^-_{(aq)}] = 3.2 \times 10^{-3}\,mol/L$$

$$n_{KOH} = 3.2 \times 10^{-3}\,mol/L\,(0.500\,L)$$

$$n_{KOH} = 1.6 \times 10^{-3}\,mol$$

$$m_{KOH} = 1.6 \times 10^{-3}\,mol\,(56.11\,g/mol)$$

$$\boxed{m_{KOH} = 0.089\,g}$$

9.

(a) neutral? **$[H^+] = [OH^-]$**

/3 (b) acidic? **$[H^+] > [OH^-]$**

(c) basic? **$[H^+] < [OH^-]$**

10.

$$\left[H^+_{(aq)}\right] = \frac{K_w}{\left[OH^-_{(aq)}\right]}$$

/6 $$\left[H^+_{(aq)}\right] = \frac{1.0\times10^{-14}\ (\text{mol}/\text{L})^2}{2.5\times10^{-7}\ \text{mol}/\text{L}}$$

$$\boxed{\left[H^+_{(aq)}\right] = 4.0\times10^{-8}\ \text{mol}/\text{L}}$$

$$pH = -\log[H^+]$$

$$pH = -\log[4.0\times10^{-8}\ \text{mol}/\text{L}]$$

$$\boxed{pH = 7.40}$$

11.

$$[H^+_{(aq)}] = 10^{-pH}$$

/3 $$[H^+_{(aq)}] = 10^{-5.6}$$

$$\boxed{\left[H^+_{(aq)}\right] = 2.5\times10^{-6}\ \text{mol}/\text{L}}$$

12.

/2 If the pH decreases by 1, the concentration has increased by a factor of 10. Therefore, a change of 3 pH units is equivalent to a 1000 fold change in concentration.

13.

$$[H^+_{(aq)}] = 10^{-pH}$$

$$[H^+_{(aq)}] = 10^{-1.57}$$

$$[H^+_{(aq)}] = 2.7\times10^{-2}\ \text{mol}/\text{L}$$

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$$HCl_{(aq)} \xrightarrow{100\%} H^+_{(aq)} + Cl^-_{(aq)}$$

$$\left[HCl_{(aq)}\right] = \left[H^+_{(aq)}\right] = 2.7\times10^{-2}\ \text{mol}/\text{L}$$

$$n_{HCl} = 2.7\times10^{-2}\ \text{mol}/\text{L}\,(0.250\text{L})$$

$$n_{HCl} = 0.0067288\text{mol}$$

$$m_{HCl} = 0.0067288\text{mol}(36.46\ \text{g}/\text{mol})$$

$$\boxed{m_{HCl} = 0.25\,\text{g}}$$

14.

$$n_{CH_3COOH} = \frac{60.0\,\text{kg}}{60.06\ \text{g}/\text{mol}} = 0.999\,\text{kmol}$$

$$\left[HCl_{(aq)}\right] = \frac{0.999\,\text{kmol}}{1.25\,\text{kL}} = 0.7992\ \text{mol}/\text{L}$$

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$$CH_3COOH_{(aq)} \xrightarrow{1.3\%} H^+_{(aq)} + CH_3COO^-_{(aq)}$$

$$\left[H^+_{(aq)}\right] = 0.013\left[0.7992\right] = 0.0103896\ \text{mol}/\text{L}$$

$$pH = -\log[H^+]$$

$$pH = -\log[0.0103896\ \text{mol}/\text{L}]$$

$$\boxed{pH = 1.98}$$

$$pH + pOH = 14$$

$$pOH = 14 - pH = 14 - 1.98$$

$$\boxed{pOH = 12.02}$$

15.

$$pH + pOH = 14$$
$$pOH = 14 - pH = 14 - 10.35$$
$$pOH = 3.65$$

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$$[OH^-_{(aq)}] = 10^{-pOH}$$
$$[OH^-_{(aq)}] = 10^{-3.65}$$
$$[OH^-_{(aq)}] = 2.24 \times 10^{-4}\ {}^{mol}\!/\!_{L}$$

$$n_{NaOH} = 2.24 \times 10^{-4}\ {}^{mol}\!/\!_{L}(2.00L)$$
$$n_{NaOH} = 4.48 \times 10^{-4}\,mol$$

$$m_{NaOH} = 4.48 \times 10^{-4}\,mol(40.00\ {}^{g}\!/\!_{mol})$$
$$\boxed{m_{NaOH} = 0.018\,g}$$

