Unit 3 Matter as Solutions, Acids, and Bases
Chapter 6 Acids and Bases
Solutions to Practice Problems

1. a)
Problem
Calculate the pH of a solution having $[H_3O^+(aq)] = 0.0027$ mol/L.

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 0.0027$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using $pH = –\log [H_3O^+(aq)]$.

Act on Your Strategy
$pH = –\log [H_3O^+(aq)] = –\log (0.0027) = –(–2.57) = 2.57$

Solution
The pH is 2.57.

Check Your Solution
The pH is in the acid range as expected given this hydronium ion concentration and the answer has the correct number of significant digits (2).

1. b)
Problem
Calculate the pH of a solution having $[H_3O^+(aq)] = 5.20$ mol/L.

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 5.20$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using $pH = –\log [H_3O^+(aq)]$.

Act on Your Strategy
$pH = –\log [H_3O^+(aq)] = –\log (5.20) = –(0.716) = –0.716$

Solution
The pH is –0.716.

Check Your Solution
The negative pH indicates that the concentration of the solution is beyond the range normally used for the pH scale. The pH is in the acidic range as expected given this acid concentration and the answer has the correct number of significant digits (3).

1. c)
Problem
Calculate the pH of a solution having $[H_3O^+(aq)] = 8.27 \times 10^{-12}$ mol/L.

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 8.27 \times 10^{-12}$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using $pH = -\log [H_3O^+(aq)]$.

Act on Your Strategy
$pH = -\log [H_3O^+(aq)] = -\log (8.27 \times 10^{-12}) = -(-11.082) = 11.082$

Solution
The pH is 11.082.

Check Your Solution
A pH greater than 7 is in the basic range as expected given this hydronium ion concentration and the answer has the correct number of significant digits (3).

1. d)
Problem
Calculate the pH of a solution having $[HI(aq)] = 9.7 \times 10^{-5}$ mol/L.

What is Required?
You must calculate the pH of a solution for which the acid concentration is given.

What is Given?
The acid concentration is $[HI(aq)] = 9.7 \times 10^{-5}$ mol/L.

Plan Your Strategy
$HI(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + I^-(aq)$
Since HI is a strong acid, $[HI(aq)] = [H_3O^+(aq)]$.
Calculate the pH of the solution using $pH = -\log [H_3O^+(aq)]$.

Act on Your Strategy
$[HI(aq)] = [H_3O^+(aq)] = 9.7 \times 10^{-5}$ mol/L
$pH = -\log [H_3O^+(aq)] = -\log (9.7 \times 10^{-5}) = -(-4.01) = 4.01$

Solution
The pH is 4.01.

Check Your Solution
The pH is in the acidic range as expected given that this is an acid solution and the answer has the correct number of significant digits (2).

1. e)
Problem
Calculate the pH of a solution having 1.25×10^{-2} g $HClO_4(g)$ in 770 mL of solution.

What is Required?
You must calculate the pH of a solution for which a given mass of acid is present in a known volume of solution.

What is Given?
The mass of $HClO_4(g) = 1.25 \times 10^{-2}$ g and the volume of solution is 770 mL.

Plan Your Strategy
Write the equation representing the ionization of $HClO_4$ in water. Note the ratio of $[HClO_4(g)]$ to $[H_3O^+(aq)]$. Calculate the molar mass (M) of $HClO_4$. Calculate the number of moles of $HClO_4$ using the relationship $n = \frac{m}{M}$. Convert 770 mL of solution to litres by multiplying by the conversion factor 0.001 L/mL. Calculate the molar concentration of the solution using $C = \frac{n}{V}$.
Calculate the pH of the solution using $\text{pH} = -\log [H_3O^+(aq)]$.

Act on Your Strategy
$HClO_4(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + ClO_4^-(aq)$
Since $HClO_4$ is a strong acid, $[HClO_4(g)] = [H_3O^+(aq)]$.
molar mass of $HClO_4$ = 100.46 g/mol
moles of $HClO_4 = n = \frac{m}{M} = \frac{1.25 \times 10^{-2}\text{ g}}{100.46\text{ g/mol}} = 1.24 \times 10^{-4}$ mol = moles $H_3O^+(aq)$
770 mL × 0.001 L/mL = 0.770 L
$C = \frac{n}{V} = \frac{1.24 \times 10^{-4}}{0.770\text{ L}} = 1.62 \times 10^{-4}$ mol/L
$[HClO_4(aq)] = [H_3O^+(aq)] = 1.62 \times 10^{-4}$ mol/L
$\text{pH} = -\log [H_3O^+(aq)] = -\log (1.62 \times 10^{-4}) = -(-3.790) = 3.792$

Solution
The pH is 3.792.

Check Your Solution
The pH is in the acidic range as expected given that this is an acid solution and the answer has the correct number of significant digits (3).

2.
Problem
$[H_3O^+(aq)]$ in a cola drink is about 5.0×10^{-3} mol/L. Calculate the pH of the drink. Is the drink acidic or basic?

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given and state if this drink is acidic or basic.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 5.0 \times 10^{-3}$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using pH = –log $[H_3O^+(aq)]$.

Act on Your Strategy
pH = –log $[H_3O^+(aq)]$ = –log (5.0×10^{-3} mol/L) = –(–2.30) = 2.30
This is an acidic drink.

Solution
The pH is 2.30.

Check Your Solution
Since the pH is less than 7, pH is in the acid range as expected given this hydronium ion concentration and the answer has the correct number of significant digits (2).

3.
Problem
A glass of orange juice has $[H_3O^+(aq)]$ of 2.9×10^{-4} mol/L. Calculate the pH of the drink. Is the drink acidic or basic?

What is Required?
You must calculate the pH of a juice solution for which the hydronium ion concentration is given and state if this drink is acidic or basic.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 2.9 \times 10^{-4}$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using pH = –log $[H_3O^+(aq)]$.

Act on Your Strategy
pH = –log $[H_3O^+(aq)]$ = –log (2.9×10^{-4} mol/L) = –(–3.54) = 3.54

Solution
The pH is 3.54. This is an acidic drink.

Check Your Solution
Since the pH is less than 7, this is an acid solution as expected given this hydronium ion concentration and the answer has the correct number of significant digits (2).

4.
Problem
$[H_3O^+(aq)]$ of a solution of sodium hydroxide is 6.59×10^{-10} mol/L. Calculate the pH of the solution.

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 6.59 \times 10^{-10}$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using pH = –log $[H_3O^+(aq)]$.

Act on Your Strategy
pH = –log $[H_3O^+(aq)]$ = –log (6.59×10^{-10} mol/L) = –(–9.181) = 9.181

Solution
The pH is 9.181.

Check Your Solution
The pH is in the basic range as expected given that this is a sodium hydroxide solution and the answer has the correct number of significant digits (3).

5.
Problem
The concentration of a dilute solution of nitric acid, $HNO_3(aq)$, is 6.30×10^{-3} mol/L. Calculate the pH of the solution.

What is Required?
You must calculate the pH of a solution for which the hydronium ion concentration is given.

What is Given?
The hydronium ion concentration is $[H_3O^+(aq)] = 6.30 \times 10^{-3}$ mol/L.

Plan Your Strategy
Calculate the pH of the solution using pH = –log [H_3O^+(aq)].

Act on Your Strategy
pH = –log [H_3O^+(aq)] = –log (6.30×10^{-3} mol/L) = –(–2.201) = 2.201

Solution
The pH is 2.201.

Check Your Solution
The pH is in the acid range as expected given this acid concentration and the answer has the correct number of significant digits (3).

6.
Problem
A hydrobromic acid solution was made by dissolving 1.36 g of the gas in enough water to make 3.50 L of solution. Determine the pH.

What is Required?
You must calculate the pH of a solution for which a given mass of acid is present in a known volume of solution.

What is Given?
The mass of hydrobromic acid is 1.36 g and the volume of solution is 3.50 L.

Plan Your Strategy
Write the chemical formula for hydrobromic acid. Write the equation representing the ionization of hydrobromic acid in water. Note the ratio of hydrobromic acid to [H_3O^+(aq)]. Calculate the molar mass (*M*) of hydrobromic acid. Calculate the number of moles of hydrobromic acid using the relationship $n = \frac{m}{M}$. Calculate the molar concentration of the hydrobromic acid solution using $C = \frac{n}{V}$. Calculate the pH of the solution using pH = –log [H_3O^+(aq)].

Act on Your Strategy
The chemical formula for hydrobromic acid is HBr.
The molar mass of HBr = 80.91 g/mol
$HBr(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + Br^-(aq)$
Since HBr is a strong acid, [HBr(g)] = [H_3O^+(aq)].

moles of HBr = $n = \frac{m}{M} = \frac{1.36\,\text{g}}{80.91\,\text{g/mol}} = 1.68 \times 10^{-3}$ mol = moles of H_3O^+(aq)

$C = \frac{n}{V} = \frac{1.68 \times 10^{-2}}{3.50\,\text{L}} = 4.80 \times 10^{-3}$ mol/L

[HBr(aq)] = [H_3O^+(aq)] = 4.80×10^{-3} mol/L

$pH = -\log [H_3O^+(aq)] = -\log (4.80 \times 10^{-3}) = -(-2.319) = 2.319$

Solution
The pH is 2.319.

Check Your Solution
The pH is in the acidic range as expected given that this is an acid solution and the answer has the correct number of significant digits (3).

7. a)
Problem
Calculate the pOH of a solution having $[OH^-(aq)] = 0.0062$ mol/L.

What is Required?
You must calculate the pOH of a solution for which the hydroxide ion concentration is known.

What is Given?
You know that $[OH^-(aq)] = 0.0062$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log[OH^-(aq)]$.

Act on Your Strategy
$pOH = -\log[OH^-(aq)] = -\log (0.0062 \text{ mol/L}) = -(-2.21) = 2.21$

Solution
The pOH is 2.21.

Check Your Solution
The pOH is less than 7 as expected for a solution having this $[OH^-(aq)]$ and has the correct number of significant digits (2).

7. b)
Problem
Calculate the pOH of a solution having $[OH^-(aq)] = 3.95$ mol/L.

What is Required?
You must calculate the pOH of a solution for which the hydroxide ion concentration is known.

What is Given?
You know that $[OH^-(aq)] = 3.95$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log[OH^-(aq)]$.

Act on Your Strategy
$pOH = -\log[OH^-(aq)] = -\log(3.95\ mol/L) = -(0.597) = -0.597$

Solution
The pOH is –0.597.

Check Your Solution
The negative pOH indicates that the concentration of the solution is beyond the range normally used for the pOH scale. The pOH is in the basic range as expected given this $[OH^-(aq)]$ concentration and the answer has the correct number of significant digits (3).

7. c)
Problem
Calculate the pOH of a solution having $[OH^-(aq)] = 5 \times 10^{-11}$ mol/L.

What is Required?
You must calculate the pOH of a solution for which the hydroxide ion concentration is known.

What is Given?
You know that $[OH^-(aq)] = 5 \times 10^{-11}$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log[OH^-(aq)]$.

Act on Your Strategy
$pOH = -\log[OH^-(aq)] = -\log(5 \times 10^{-11}\ mol/L) = -(-10.3) = 10.3$

Solution
The pOH is 10.3.

Check Your Solution
The pOH is greater than 7 as expected for a solution having this $[OH^-(aq)]$ and has the correct number of significant digits (1).

7. d)
Problem
Calculate the pOH of a solution having $[NaOH(aq)] = 2.4 \times 10^{-3}$ mol/L.

What is Required?
You must calculate the pOH of a solution for which the concentration of NaOH is known.

What is Given?
You know that $[NaOH(aq)] = 2.4 \times 10^{-3}$ mol/L.

Plan Your Strategy
Write the equation for the dissociation of NaOH in water.

Note the ratio between [NaOH(aq)] and [OH^-(aq)].
Use the equation pOH = –log [OH^-(aq)].

Act on Your Strategy
NaOH(aq) → Na^+(aq) + OH^-(aq)
[NaOH(aq)] = [OH^-(aq)]
pOH = –log [OH^-(aq)] = –log (2.4×10^{-3} mol/L) = –(–2.619) = 2.62

Solution
The pOH is 2.62.

Check Your Solution
The pOH is less than 7 as expected for a solution of sodium hydroxide and has the correct number of significant digits (2).

7. e)
Problem
Calculate the pOH of 2.95 g of KOH(s) dissolved to make 100 mL of solution.

What is Required?
You must calculate the pOH of a solution for which the mass of KOH(s) and the total volume of solution are known.

What is Given?
You know that the mass of KOH is 2.95 g and the volume of solution is 100 mL.

Plan Your Strategy
Write the equation representing for the dissociation of KOH(s) when it is added to water.
Note the ratio of [KOH(s)] to [OH^-(aq)].
Calculate the molar mass (M) of KOH.
Calculate the number of moles of KOH using the relationship $n = \frac{m}{M}$.
Convert 100 mL KOH(aq) to litres by multiplying by the conversion factor 0.001 L/mL
Calculate the molar concentration of the solution using $C = \frac{n}{V}$.
Calculate the pH of the solution using pOH = –log [OH^-(aq)].

Act on Your Strategy
KOH(s) → K^+(aq) + OH^-(aq)
[KOH(s)] = [OH^-(aq)]
molar mass KOH = M = 56.11 g/mol
moles of KOH = $n = \frac{m}{M} = \frac{2.95\,\text{g}}{56.11\,\text{g/mol}}$ = 0.0526 mol = moles of OH^-(aq)
volume of solution = V =100 mL KOH(aq) × 0.001 L/mL = 0.100 L KOH(aq)

$C = \frac{n}{V} = \frac{0.0526\,\text{mol}}{0.100\,\text{L}}$ = 0.526 mol/L

$[OH^-(aq)]$ = 0.526 mol/L

pOH = –log $[OH^-(aq)]$ = –log (0.526) = –(–0.279) = 0.279

Solution

The pOH is 0.279.

Check Your Solution

The pH is in the basic range as expected given that KOH is a basic substance and the answer has the correct number of significant digits (3).

7. f)

Problem

Calculate the pOH of 0.42 g of $Sr(OH)_2(s)$ dissolved to make 600 mL of solution.

What is Required?

You must calculate the pOH of a solution when the mass of $Sr(OH)_2(s)$ and the total volume of solution are known..

What is Given?

You know that the mass of $Sr(OH)_2$ is 0.42 g and the volume of solution is 600 mL.

Plan Your Strategy

Write the equation representing the dissociation of $Sr(OH)_2(s)$ when it is added to water.

Note the ratio of $[Sr(OH)_2(s)]$ to $[OH^-(aq)]$. Calculate the molar mass (M) of $Sr(OH)_2$.

Calculate the number of moles of $Sr(OH)_2$ using the relationship $n = \frac{m}{M}$.

Convert 100 mL $Sr(OH)_2(aq)$ to litres by multiplying by the conversion factor 0.001 L/mL

Calculate the molar concentration of the solution using $C = \frac{n}{V}$. Calculate $[OH^-(aq)]$.

Calculate the pH of the solution using pOH = –log $[OH^-(aq)]$.

Act on Your Strategy

$Sr(OH)_2(s) \rightarrow Sr^{2+}(aq) + 2OH^-(aq)$

$[OH^-(aq)] = 2 \times [Sr(OH)_2(s)]$

molar mass $Sr(OH)_2$ = M = 121.64 g/mol

moles of $Sr(OH)_2$ = $n = \frac{m}{M} = \frac{0.42\,\text{g}}{121.64\,\text{g/mol}}$ = 0.00345 mol

volume of solution = V = 600 mL $Sr(OH)_2(s)$ × 0.001 L/mL = 0.600 L $Sr(OH)_2(s)$

$[Sr(OH)_2(s)] = C = \frac{n}{V} = \frac{0.00345\,\text{mol}}{0.600\,\text{L}}$ = 0.005755 mol/L

Therefore $[OH^-(aq)]$ = 2 × 0.005755 mol/L = 0.0115 mol/L

pOH = –log $[OH^-(aq)]$ = –log (0.0115) = –(–1.939) = 1.94

Solution
The pOH is 1.94.

Check Your Solution
The pOH is in the basic range as expected given that $Sr(OH)_2$ is a basic substance and the answer has the correct number of significant digits (2).

8.
Problem
The $[OH^-(aq)]$ in seawater is about 2.0×10^{-6} mol/L. Calculate the pOH of seawater. Is the seawater acidic or basic?

What is Required?
You must calculate the pOH of seawater for which the hydroxide ion concentration is known.

What is Given?
You know that $[OH^-(aq)] = 2.0 \times 10^{-6}$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log [OH^-(aq)]$

Act on Your Strategy
$pOH = -\log[OH^-(aq)] = -\log (2.0 \times 10^{-6} \text{ mol/L}) = -(-5.70) = 5.70$

Solution
The pOH is 5.70. The solution is basic.

Check Your Solution
Since the pOH is less than 7, the solution is basic and the answer has the correct number of significant digits (2).

9.
Problem
A harsh liquid soap has $[OH^-(aq)]$ of 2.5×10^{-4} mol/L. Calculate the pOH of the soap. Is the soap acidic or basic?

What is Required?
You must calculate the pOH of a liquid soap when the hydroxide concentration is known.

What is Given?
You know that $[OH^-(aq)] = 2.5 \times 10^{-4}$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log [OH^-(aq)]$.

Act on Your Strategy
pOH = –log[OH^-(aq)] = –log (2.5×10^{-4} mol/L) = –(–3.60) = 3.60

Solution
The pOH is 3.60. The solution is basic.

Check Your Solution
Since the pOH is less than 7, the solution is basic and the answer has the correct number of significant digits (2).

10.
Problem
[NaOH(aq)] in a dilute solution is 3.47×10^{-3} mol/L. Calculate the pOH of the solution.

What is Required?
You must calculate the pOH of a solution of NaOH for which the concentration is known.

What is Given?
You know that [NaOH(aq)] = 3.47×10^{-3} mol/L.
Write the dissociation equation for NaOH in water and note the ratio between [NaOH(aq)] and [OH^-(aq)].
Calculate the concentration of [OH^-(aq)]

Plan Your Strategy
NaOH(aq) $\rightarrow$ Na^+(aq) + OH^-(aq)
[NaOH(aq)] = [OH^-(aq)]
Use the equation pOH = –log[OH^-(aq)]

Act on Your Strategy
pOH = –log[OH^-(aq)] = –log (3.47×10^{-3} mol/L) = –(–2.460) = 2.460

Solution
The pOH is 2.460.

Check Your Solution
The pOH is less than 7 as expected for a solution of NaOH and has the correct number of significant digits (3).

11.
Problem
[OH^-(aq)] of a solution of hydrochloric acid, HCl(aq), is = 9.6×10^{-11} mol/L. Calculate the pOH of the solution.

What is Required?
You must calculate the pOH of a solution for which the hydroxide ion concentration is known.

What is Given?
You know that $[OH^-(aq)] = 9.6 \times 10^{-11}$ mol/L.

Plan Your Strategy
Use the equation $pOH = -\log[OH^-(aq)]$

Act on Your Strategy
$pOH = -\log[OH^-(aq)] = -\log(9.6\times 10^{-11} \text{ mol/L}) = -(-10.02) = 10.02$

Solution
The pOH is 10.02.

Check Your Solution
The pOH is greater than 7 as expected for an acid solution at this concentration and has the correct number of significant digits (2).

12.
Problem
If 9.20 mg of cesium hydroxide is dissolved in 225 mL of solution, determine its pOH.

What is Required?
You must calculate the pOH of a solution for which the mass of cesium hydroxide and the total volume of solution are known.

What is Given?
You know that the mass of cesium hydroxide is 9.20 mg and the volume of solution is 225 mL.

Plan Your Strategy
Write the chemical formula for cesium hydroxide. Write the equation representing for the dissociation of CsOH(s) when it is added to water. Note the ratio of $[CsOH(s)]$ to $[OH^-(aq)]$. Calculate the molar mass (M) of CsOH. Convert 9.20 mg to grams by multiplying by the conversion factor 0.001 g/mg. Calculate the number of moles of CsOH using the relationship $n = \frac{m}{M}$. Convert 225 mL CsOH(aq) to litres by multiplying by the conversion factor 0.001 L/mL

Determine the $[OH^-(aq)]$. Calculate the molar concentration of the solution using $C = \frac{n}{V}$.

Calculate the pH of the solution using $pOH = -\log[OH^-(aq)]$.

Act on Your Strategy
cesium hydroxide = CsOH
$CsOH(s) \rightarrow Cs^+(aq) + OH^-(aq)$
$[CsOH(s)] = [OH^-(aq)]$.
molar mass CsOH = M = 149.92 g/mol
9.20 mg CsOH × 0.001 g/mg = 0.0092 g

moles of CsOH = $n = \dfrac{m}{M} = \dfrac{0.0092\,\text{g}}{149.92\,\text{g/mol}} = 6.14 \times 10^{-5}$ mol = moles of OH^-(aq)

volume of solution = V =225 mL CsOH(aq) × 0.001 L/mL = 0.225 L KOH(aq)

concentration of CsOH = $C = \dfrac{n}{V} = \dfrac{6.14 \times 10^{-5}\text{ mol}}{0.225\,\text{L}} = 2.73 \times 10^{-4}$ mol/L

$[OH^-(aq)] = 2.73 \times 10^{-4}$ mol/L
pOH = $-\log [OH^-(aq)] = -\log (2.73 \times 10^{-4}) = -(-3.564) = 3.564$

Solution
The pOH is 3.564.

Check Your Solution
The pH is in the basic range as expected given that CsOH is a basic substance and the answer has the correct number of significant digits (3).

13. a)
Problem
Calculate the $[H_3O^+(aq)]$ if pH = 3.9.

What is Required?
You must calculate the $[H_3O^+(aq)]$ from a pH value.

What is Given ?
pH = 3.9

Plan Your Strategy
Use the equation: $[H_3O^+(aq)] = 10^{-pH}$.

Act on Your Strategy
$[H_3O^+(aq)] = 10^{-pH} = 10^{-3.9} = 1 \times 10^{-4}$ mol/L

Solution
The $[H_3O^+(aq)]$ is 1×10^{-4} mol/L. The solution is acidic.

Check Your Solution
For an acidic solution of pH = 3.9, the hydronium ion concentration should be between 1×10^{-3} and 1×10^{-4}. This answer seems reasonable and has the correct number of significant digits (1).

13. b)
Problem
Calculate the $[H_3O^+(aq)]$ if pOH = 5.22.

What is Required?
You must calculate the $[H_3O^+(aq)]$ from a pOH value.

What is Given ?
pOH = 5.22

Plan Your Strategy
Determine the pH of the solution using the expression pH = 14 – pOH.
Calculate the hydronium ion concentration using the equation: $[H_3O^+(aq)] = 10^{-pH}$.

Act on Your Strategy
pH = 14 – pOH = 14 – 5.22 = 8.78
$[H_3O^+(aq)] = 10^{-pH} = 10^{-8.78} = 1.7 \times 10^{-9}$ mol/L

Solution
The $[H_3O^+(aq)]$ is 1.7×10^{-9} mol/L.

Check Your Solution
For a basic solution of pOH = 5.22, the hydroxide ion concentration should be between 1×10^{-5} and 1×10^{-6}. The hydronium ion concentration then is expected to be between 1×10^{-9} and 1×10^{-8}. This answer seems reasonable and has the correct number of significant digits (2).

13. c)
Problem
Calculate the $[OH^-(aq)]$ if pOH = 5.422.

What is Required?
You must calculate the $[OH^-(aq)]$ from a pOH value.

What is Given ?
pOH = 5.422

Plan Your Strategy
Calculate the hydroxide ion concentration using the equation: $[OH^-(aq)] = 10^{-pOH}$.

Act on Your Strategy
$[OH^-(aq)] = 10^{-pOH} = 10^{-5.422} = 3.78 \times 10^{-6}$ mol/L

Solution
The $[OH^-(aq)]$ is 3.78×10^{-6} mol/L. The solution is basic.

Check Your Solution
For a basic solution of pOH = 5.422, the hydroxide ion concentration should be between 1×10^{-5} and 1×10^{-6}. This answer seems reasonable and has the correct number of significant digits (3).

13. d)
Problem
Calculate the $[OH^-(aq)]$ if pH = 2.65.

What is Required?
You must calculate the $[OH^-(aq)]$ from a pH value.

What is Given ?
pH = 2.65

Plan Your Strategy
Determine the pOH of the solution using the expression pOH = 14 – pH.
Calculate the hydronium ion concentration using the equation: $[H_3O^+(aq)] = 10^{-pOH}$.

Act on Your Strategy
$pOH = 14 - pH = 14 - 2.65 = 11.35$
$[OH^-(aq)] = 10^{-pOH} = 10^{-11.35} = 4.5\times 10^{-12}$ mol/L

Solution
The $[OH^-(aq)]$ is 4.5×10^{-12} mol/L. The solution is acidic.

Check Your Solution
For an acidic solution of pH = 2.65, the hydronium ion concentration should be between 1×10^{-3} and 1×10^{-2}. The hydroxide ion concentration then is expected to be between 1×10^{-11} and 1×10^{-12}. This answer seems reasonable and has the correct number of significant digits (2).

14.
Problem
The lowest recorded pH of rain falling in Fort McMurray, Alberta was measured at 4.80. Calculate $[H_3O^+(aq)]$.

What is Required?
You must calculate the $[H_3O^+(aq)]$ from a pH value.

What is Given ?
pH = 4.80

Plan Your Strategy
Use the equation: $[H_3O^+(aq)] = 10^{-pH}$.

Act on Your Strategy
$[H_3O^+(aq)] = 10^{-pH} = 10^{-4.80} = 1.6 \times 10^{-5}$ mol/L

Solution

The $[H_3O^+(aq)]$ is 1.6×10^{-5} mol/L.

Check Your Solution
For an acidic solution of pH = 4.80, the hydronium ion concentration should be between 1×10^{-4} and 1×10^{-5}. This answer seems reasonable and has the correct number of significant digits (2).

15.
Problem
The pOH of spaghetti sauce is 9.79. Determine $[H_3O^+(aq)]$.

What is Required?
You must calculate the $[H_3O^+(aq)]$ from a pOH value.

What is Given ?
pOH = 9.79

Plan Your Strategy
Determine the pH of the solution using the expression pH = 14 – pOH.
Calculate the hydronium ion concentration using the equation: $[H_3O^+(aq)] = 10^{-pH}$.

Act on Your Strategy
pH = 14 – pOH = 14 – 9.79 = 4.21
$[H_3O^+(aq)] = 10^{-pH} = 10^{-4.21} = 6.2 \times 10^{-5}$ mol/L

Solution
The $[H_3O^+(aq)]$ is 6.2×10^{-5} mol/L.

Check Your Solution
For a solution of pOH = 9.79, the hydroxide ion concentration should be between 1×10^{-9} and 1×10^{-10}. The hydronium ion concentration then is expected to be between 1×10^{-5} and 1×10^{-4}. This answer seems reasonable and has the correct number of significant digits (2).

16.
Problem
One brand of glass cleaner has a pH of 11.18. Determine the concentration of hydroxide ions.

What is Required?
You must calculate the $[OH^-(aq)]$ from a pH value.

What is Given ?
pH = 11.18

Plan Your Strategy
Determine the pOH of the solution using the expression pOH = 14 – pH.

Calculate the hydronium ion concentration using the equation: $[H_3O^+(aq)] = 10^{-pOH}$.

Act on Your Strategy
$pOH = 14 - pH = 14 - 11.18 = 2.82$
$[OH^-(aq)] = 10^{-pOH} = 10^{-2.82} = 1.5 \times 10^{-3}$ mol/L

Solution
The $[OH^-(aq)]$ is 1.5×10^{-3} mol/L.

Check Your Solution
For a solution of pH = 11.18, the hydronium ion concentration should be between 1×10^{-11} and 1×10^{-12}. The hydroxide ion concentration then is expected to be between 1×10^{-3} and 1×10^{-2}. This answer seems reasonable and has the correct number of significant digits (2).

17.
Problem
The pOH of oven cleaner is often as low as 0.50. What mass of sodium hydroxide would have to be dissolved to make 100 mL of a solution with the same pOH?

What is Required?
You must calculate the mass of sodium hydroxide required to make up a solution of a given pOH value.

What is Given ?
The pOH = 0.50 and the volume of solution is 100 mL.

Plan Your Strategy
Calculate the hydroxide ion concentration using the equation: $[OH^-(aq)] = 10^{-pOH}$.
Write the chemical formula and determine the molar mass (M) of sodium hydroxide.
Write the dissociation equation for NaOH(s) in water and note the mole ratio between NaOH and $OH^-(aq)$. Convert 100 mL to litres using the conversion factor 1000 mL = 1 L and use the relationship $n = C \times V$ to calculate the number of moles of sodium hydroxide required. Calculate the mass of sodium hydroxide using the equation $m = n \times M$.

Act on Your Strategy
$[OH^-(aq)] = 10^{-pOH} = 10^{-0.50} = 3.2 \times 10^{-1}$ mol/L
sodium hydroxide = NaOH $M = 40.00$ g/mol
$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$. The ratio of NaOH(s) to $OH^-(aq)$ is 1:1.
100 mL × 0.001 L/mL = 0.100 L NaOH(aq)
moles $OH^-(aq)$ = moles of NaOH = $n = C \times V = 3.2 \times 10^{-1}$ mol/L × 0.100 L = 3.2×10^{-2} mol
mass of NaOH = $m = n \times M = 3.2 \times 10^{-2}$ mol × 40.00 g/mol = 1.3 g

Solution
The mass of NaOH needed is 1.3 g.

Check Your Solution
This answer seems reasonable and has the correct units (g) and number of significant digits (2).

18.
Problem
If lemon juice has a pOH of 11.80, determine the mass of HCl(g) that would have to be dissolved in 50 mL of solution to make a solution of the same pOH.

What is Required?
You must calculate mass of HCl required to make up a certain volume of solution of a given pOH value.

What is Given ?
The pOH = 11.80 and the volume of solution is 50 mL.

Plan Your Strategy
Calculate the pH of the solution using the relationship pH = 14 – pOH. Calculate the hydronium ion concentration using the equation: $[H_3O^+(aq)] = 10^{-pH}$.
Write the ionization equation for hydrochloric acid in water and note the mole ratio between HCl(aq) and $H_3O^+(aq)$. Determine the molar mass (*M*) of hydrochloric acid. Convert 50 mL to litres using the conversion factor 1000 mL = 1 L and use the relationship $n = C \times V$ to calculate number of moles of HCl required. Calculate the mass of HCl using the equation $m = n \times M$.

Act on Your Strategy
pH = 14 – 11.80 = 2.2
$[H_3O^+(aq)] = 10^{-pH} = 10^{-2.2} = 6.31 \times 10^{-3}$ mol/L
molar mass HCl = M = 36.46 g/mol
$HCl(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + Cl^-(aq)$
The mole ratio of HCl to $H_3O^+(aq)$ is 1:1.
50 mL × 0.001 L/mL = 0.050 L HCl(aq)
moles $H_3O^+(aq)$ = moles of HCl = $n = C \times V = 6.31 \times 10^{-3}$ mol/L × 0.050 L = 3.155×10^{-4} mol
mass of HCl = $m = n \times M = 3.155 \times 10^{-4}$ mol × 36.46 g/mol = 1.15×10^{-2} g

Solution
The mass of HCl(g) needed is 1.2×10^{-2} g.

Check Your Solution
This answer seems reasonable and has the correct units (g) and number of significant digits (2).