Section 8.3 Concentrations of Solutions

Solutions for Selected Review Questions

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3. Review Question (page 382)

A 50 g sample of seawater is found to contain 0.02 g of sodium chloride.

a. State the concentration of sodium as a mass percent.

b. Express the concentration of sodium in parts per million.

a. $$\text{percent (m/m)} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$

$$= \frac{0.02\ \cancel{g}\ [\text{NaCl}]}{50\ \cancel{g}\ [\text{seawater}]} \times 100\%$$

$$= 0.04\%$$

b. $$\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

$$= \frac{0.02\ \cancel{g}\ [\text{NaCl}]}{50\ \cancel{g}\ [\text{seawater}]} \times 10^6$$

$$= 400$$

4. Review Question (page 382)

Calcium carbonate, $CaCO_3(aq)$, may be naturally present in household water supplies. Suppose that a toilet tank holds 6.0 L of water, and the water contains 90 ppm of calcium carbonate. What mass of calcium carbonate is in the water in the tank?

What Is Required?

You need to determine the mass of calcium carbonate in the water.

What Is Given?

You know the volume of water: 6.0 L

You know the mass of 1 L of water: 1 kg

You know the concentration of calcium carbonate in the water: 90 ppm

Plan Your Strategy

Determine the mass (in grams) of 6.0 L of water.

Write the formula for ppm.

Rearrange the equation to solve for the mass of solute.

Substitute the data into the equation to calculate the mass of solute.

Act on Your Strategy

$$\text{mass of water (in grams)} = 6.0 \cancel{L} \times \frac{1 \cancel{kg}}{1 \cancel{L}} \times 1 \times 10^3 \text{ g/} \cancel{kg}$$

$$= 6000 \text{ g}$$

Formula for ppm:

$$\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$$

Rearranged formula for the mass of solute:

$$\text{ppm} \times \text{mass of solution} = \cancel{\text{mass of solution}} \times \frac{\text{mass of solute}}{\cancel{\text{mass of solution}}} \times 10^6$$

$$\text{ppm} \times \text{mass of solution} = \text{mass of solute} \times 10^6$$

$$\text{mass of solute} = \frac{\text{ppm} \times \text{mass of solution}}{10^6}$$

Substitution to solve for mass of solute:

$$\text{mass of solute} = \frac{\text{ppm} \times \text{mass of solution}}{10^6}$$

$$= \frac{90 \times 6.0 \times 10^3 \text{ g}}{10^6}$$

$$= 0.54 \text{ g}$$

The mass of calcium carbonate in the water is 0.54 g.

Check Your Solution

The amount of dissolved calcium carbonate is expected to be small if the concentration is measured in ppm. The answer is a small value and seems reasonable. The answer correctly shows two significant digits.

5. Review Question (page 382)

Aldrin and dieldrin are pesticides that used to be allowed for the control of soil insects. In Ontario, the maximum allowable total concentration of aldrin plus dieldrin in drinking water is 0.7 ppb. If a 250 mL sample of drinking water is found to contain 0.0001 mg of aldrin and dieldrin, does the concentration exceed the standard? Explain.

What Is Required?

You need to determine if the concentration of pesticide exceeds the allowable standard.

What Is Given?
You know the volume of the sample of water: 250 mL
You know the mass of dissolved pesticide: 1×10^{-4} mg
You know the maximum allowable concentration of pesticide in the water: 0.7 ppb
You know the mass of 1 mL of water: 1 g

Plan Your Strategy
Determine the mass of the sample of water.
Convert the mass of pesticide (solute) to grams: 1 mg = 1×10^{-3} g
Substitute the data into the expression for ppb.

Act on Your Strategy

$$\text{mass of water (solution)} = 250 \cancel{\text{mL}} \times 1 \text{ g/} \cancel{\text{mL}}$$
$$= 250 \text{ g}$$

$$\text{mass of solute} = 1 \times 10^{-4} \cancel{\text{mg}} \times 1 \times 10^{-3} \text{ g/} \cancel{\text{mg}}$$
$$= 1 \times 10^{-7} \text{ g}$$

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$
$$= \frac{1 \times 10^{-7} \cancel{\text{g}}}{250 \cancel{\text{g}}} \times 10^9$$
$$= 0.4 \text{ ppb}$$

The concentration of pesticide in the water is 0.4 ppb. This is below the acceptable level of 0.7 ppb.

Check Your Solution
The units are correct and the calculated value is in the range expected for the small mass given in the data. The answer seems reasonable and correctly shows one significant digit.

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$

$$= \frac{4.5\ \cancel{g}\text{[salt]}}{1.0 \times 10^8\ \cancel{g}\text{[water]}} \times 10^9$$

$$= 4.5 \times 10^1 \text{ ppb}$$

$$= 45 \text{ ppb}$$

The salt concentration in the swimming pool is 45 ppb.

Check Your Solution
The units are correct. Concentration in ppb is a small unit of concentration and the answer is expected to be large. The answer correctly shows two significant digits.

13. Review Question (page 382)
The concentration of dissolved iron(II) ions, $Fe^{2+}(aq)$, in a sample of ground water is 7.2×10^{-5} mol/L. Is this concentration an acceptable level if the recommended maximum level is 300 ppb? Show your work, and explain your reasoning.

What Is Required?
You need to determine if the $Fe^{2+}(aq)$ concentration is within an acceptable level.

What Is Given?
You know the $Fe^{2+}(aq)$ concentration: 7.2×10^{-5} mol/L
You know the maximum acceptable level of $Fe^{2+}(aq)$: 300 ppb

Plan Your Strategy
Use the molar mass for iron (from the periodic table) and the relationship $m = n \times M$ to calculate the concentration of $Fe^{2+}(aq)$ in g/L.
For dilute solutions, the density is 1 g/mL. The mass of 1 L of solution is 1000 g.
Write the equation for ppb.
Substitute the mass of solute, $Fe^{2+}(aq)$, in grams and the mass of solution in grams into the expression for ppb and solve.
Compare the calculated concentration in ppb with the maximum accepted level for $Fe^{2+}(aq)$.

Act on Your Strategy

$M_{Fe^{2+}} = 55.85$ g/mol

Mass, m, of $Fe^{2+}(aq)$ in 1 L of solution:

$$m_{Fe^{2+}} = n \times M$$
$$= 7.2 \times 10^{-5} \cancel{\text{mol}} \times 55.85 \text{ g/} \cancel{\text{mol}}$$
$$= 4.0212 \times 10^{-3} \text{ g}$$

mass of solution = 1000 g

Formula for ppb:

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$

Substitution to solve for ppb:

$$\text{ppb} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^9$$
$$= \frac{4.0212 \times 10^{-3} \cancel{\text{g}}\ [Fe^{2+}]}{1.0 \times 10^3 \cancel{\text{g}}\ [\text{solution}]} \times 10^9$$
$$= 4.0212 \times 10^3$$
$$= 4.0212 \times 10^3$$
$$= 4.0 \times 10^3$$

This concentration of 4.0×10^3 ppb for $Fe^{2+}(aq)$ exceeds the acceptable level of 300 ppb.

Check Your Solution

The units are correct and the answer correctly shows two significant digits. The answer seems reasonable.

14. Review Question (page 382)

A pharmacist dilutes a 10% (m/v) saline solution until the final volume is four times the initial volume. Find the molar concentration of sodium chloride in the diluted solution.

What Is Required?

You need to determine the molar concentration of the diluted solution.