12. Practice Problem (page 375)

A physiotherapist makes a footbath solution by dissolving 120 g of magnesium sulfate (Epsom salts), $MgSO_4(s)$, in 3.00 kg of water. Calculate the percent (m/m) of magnesium sulfate in the solution. (**Hint:** Remember to use the mass of *solution*.)

What Is Required?

You need to determine the percent (m/m) concentration of a magnesium sulfate solution.

What Is Given?

You know the mass of the magnesium sulfate solute: 120 g
You know the mass of the solvent: 3.00 kg

Plan Your Strategy

Convert the mass from kilograms to grams: $1\ kg = 1 \times 10^3\ g$
Determine the mass of solution by adding the mass of solute to the mass of solvent.
Write the formula for percent (m/m) concentration.
Substitute the data into the expression to calculate the concentration.

Act on Your Strategy

Mass conversion:

$$\text{mass of solvent} = 3.00\ \cancel{\text{kg}} \times 1 \times 10^3\ \text{g}/\cancel{\text{kg}}$$
$$= 3000\ \text{g}$$

$$\text{mass of solution} = \text{mass of solvent} + \text{mass of solute}$$
$$= 3000\ \text{g} + 120\ \text{g}$$
$$= 3120\ \text{g}$$

Percent (m/m) concentration:

$$\text{percent (m/m)} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$$
$$= \frac{120\ \cancel{\text{g}}}{3120\ \cancel{\text{g}}} \times 100\%$$
$$= 3.846\%$$
$$= 3.85\%$$

The concentration of the solution is 3.85% (m/m).

Check Your Solution
Rounding off and estimating, the concentration in percent (m/m) is about 4% and the mass of solution is about 3000 g.
Four percent of 3000 is about 120 g. The estimate is close to the calculated value and seems reasonable. The calculated answer correctly shows three significant digits.

13. Practice Problem (page 375)
How much chromium, nickel, and iron would you need to make a 500 kg batch of 18/8 stainless steel, which is steel made with 18% (m/m) chromium and 8% (m/m) nickel in iron?

What Is Required?
You need to determine the mass of chromium, iron, and nickel needed to make stainless steel.

What Is Given?
You know the mass of the solution: 500 kg
You know the percent (m/m) of the component elements:
18% chromium
8% nickel
74% iron (the difference between the concentration of the solution (100%) and the sum of the concentrations of chromium and nickel)

Plan Your Strategy
Write the formula for percent (m/m) concentration.
Rearrange the formula to solve for the mass of solute.
Substitute the data into the expression and solve for the mass of each solute, *m*.

Act on Your Strategy
Formula for percent (m/m) concentration:

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

Rearranged formula to solve for the mass of solute:

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

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

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

• Substitution to calculate the mass of the chromium solute, m_{Cr}:

$$m_{Cr} = \frac{18\,\% \times 500\text{ kg}}{100\,\%}$$

$$= 90\text{ kg}$$

Check Your Solution
Using rounded-off values, and working backward to estimate the mass of solute $CCl_4(\ell)$:
15% (m/m) × 85 g solution = 12.75 g
This estimated answer agrees with the given mass of solute, $CCl_4(\ell)$. The calculated answer is reasonable and correctly shows three significant digits.

16. Practice Problem (page 375)
Since pure gold is quite soft, gold jewellery is usually made with an alloy. An 18 karat gold alloy contains 75% (m/m) gold. How much of this alloy can a jeweller make with 8.00 g of pure gold?

What Is Required?
You must determine the mass of a solution of gold alloy.

What Is Given?
You know the mass of gold solute: 8.00 g:
You know the percent (m/m) concentration of the solution: 75%

Plan Your Strategy
Write the formula for percent (m/m) concentration.
Rearrange the formula to solve for the mass of solution.
Substitute the data into the expression and calculate the mass of the alloy, *m*.

Act on Your Strategy
Formula for percent (m/m) concentration:

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

Rearranged formula to solve for the mass of solution:

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

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

Substitution to calculate the mass of the gold alloy, *m*:

$$m = \frac{8.00 \text{ g} \times 100 \cancel{\%}}{75 \cancel{\%}}$$

$$= 10.66 \text{ g}$$

$$= 11 \text{ g}$$

The mass of the gold alloy is 11 g.

Check Your Solution
Using rounded values, and working backward to estimate the mass of solution:

$$\frac{8 \not{g}\ \text{[solute]}}{11 \not{g}\ \text{[solution]}} \times 100\% = 73\%$$

This estimated answer agrees closely with the given percent (m/m) concentration. The calculated answer is reasonable and correctly shows two significant digits.

17. Practice Problem (page 375)
Surgical steel is an iron alloy that is easy to clean and sterilize. It contains 12 to 14% (m/m) chromium. Calculate the minimum mass of chromium in a 40 g instrument made from surgical steel.

What Is Required?
You need to determine the minimum mass of chromium in stainless steel.

What Is Given?
You know the mass of the stainless steel solution: 40 g
You know the minimum percent (m/m) of the chromium solute: 12%

Plan Your Strategy
Write the formula for percent (m/m) concentration.
Rearrange the equation to solve for the mass of solute.
Substitute the given data into the expression to calculate the minimum mass of the chromium solute, *m*.

Act on Your Strategy
Formula for percent (m/m) concentration:

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

Rearranged formula to solve for the mass of solute:

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

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

Substitution to calculate the mass of the chromium solute:

$$m = \frac{12 \not{\%} \times 40\ \text{g}}{100 \not{\%}}$$
$$= 4.8\ \text{g}$$

Check Your Solution

Using rounded values, and working backward to estimate the mass of solute:

$7 \times 10^{-4}\%\ (\text{m/m}) \times 1.5 \times 10^{2}\ \text{g} = 1 \times 10^{-3}\ \text{g}$ or about 1 mg

This estimated answer approximates the given mass of solute. The calculated answer is reasonable and correctly shows three significant digits.

20. Practice Problem (page 375)

A mining company in Sudbury reported mining 6.91×10^{5} t of ore, from which it extracted 1.68×10^{3} t of nickel, 1.6×10^{4} t of copper, and 1.6 t of platinum. What is the percent (m/m) concentration of each metal in the ore?

What Is Required?

You need to calculate the percent (m/m) concentrations of nickel, copper, and platinum in an ore.

What Is Given?

You know the mass of each metal in the ore:
1.68×10^{3} t of nickel
1.6×10^{4} t of copper
1.6 t of platinum
You know the mass of the ore (solution): 6.91×10^{5} t

Plan Your Strategy

Write the formula for percent (m/m) concentration.
Substitute the data into the expression to calculate the concentration of each metal.

Act on Your Strategy

- concentration of nickel

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

$$= \frac{1.68 \times 10^{3}\ \cancel{t}}{6.91 \times 10^{5}\ \cancel{t}} \times 100\%$$

$$= 0.24312\%$$

$$= 0.243\%$$

The concentration of nickel in the ore is 0.243% (m/m).

• concentration of copper

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

$$= \frac{1.6 \times 10^4 \text{ t}}{6.91 \times 10^5 \text{ t}} \times 100\%$$

$$= 2.315\%$$

$$= 2.3\%$$

The concentration of copper in the ore is 2.3% (m/m).

• concentration of platinum

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

$$= \frac{1.6 \text{ t}}{6.91 \times 10^5 \text{ t}} \times 100\%$$

$$= 2.315 \times 10^{-4}\%$$

$$= 2.3 \times 10^{-4}\%$$

The concentration of nickel in the ore is 2.3×10^{-4}% (m/m).

Check Your Solution

The amounts of each metal differ approximately by a number of powers of ten. The percent (m/m) concentrations differ by the same powers of ten. The calculated answers seem reasonable and are expressed to the correct number of significant digits.

Section 8.3 Concentrations of Solutions

Solutions for Practice Problems

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21. Practice Problem (page 376)

The rubbing alcohol that is sold in pharmacies is usually a 70% (v/v) aqueous solution of isopropyl alcohol. What volume of isopropyl alcohol is present in a 500 mL bottle of this solution?

What Is Required?

You need to determine the volume of isopropyl alcohol (solute) in a bottle of rubbing alcohol.