

Concentration of Solutions

Solubility

Concentration

Dilute

Concentrated

Mass/Volume Percent

[Percent (m/v)] (liquid solution)

Mass/Mass Percent

[Percent (m/m)] (solid solution)

$$\text{Mass/Volume Percent} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100\%$$

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A chemist slowly evaporated 1.80 L of a 1.75% (m/v) solution of calcium nitrate. What mass of solute should the chemist obtain?

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?

Volume/Volume Percent [Percent (v/v)]

Concentration of Very Small Quantities

Gasoline sold in Ontario must contain at least 5.0% (v/v) ethanol. How much ethanol is a driver likely to get when buying 30 L of gasoline?

A sample of lake water has a mass of 310 g and contains 2.24 mg of dissolved oxygen. Calculate the oxygen concentration in parts per million.

Molar Concentration [symbol : c, unit $\frac{mol}{L}$]

What volume of 0.25 mol/L solution can be made using 14 g of sodium hydroxide?

A student dissolved 0.212 mol of iron(III) chloride, $FeCl_3(s)$, to make a 175 mL solution. Find the molar concentration of the solution and the concentrations of the ions in the solution.

Concentration of Solutions

Mass/Volume Calculations

1. What is the concentration in percent (m/v) of each solution?
 - a. 14.2 g of potassium chloride (used as a salt substitute) dissolved in 450 mL of solution
 - b. 31.5 g of calcium nitrate (used to make explosives) dissolved in 1.80 L of solution
 - c. 1.72 g of potassium permanganate (used to bleach stone-washed blue jeans) dissolved in 60 mL of solution
2. A solution of hydrochloric acid was formed by dissolving 1.52 g of hydrogen chloride gas in enough water to make 24.1 mL of solution. What is the concentration in percent (m/v) of the solution?
3. At 25°C, a saturated solution of carbon dioxide gas in water has a concentration of 0.145% (m/v). What mass of carbon dioxide is present in 250 mL of the solution?
4. Ringer's solution contains three dissolved salts in the same proportions as they are found in blood. The salts and their concentrations (m/v) are as follows: 0.86% NaCl, 0.03% KCl, and 0.033% CaCl₂. Suppose a patient needs to receive 350 mL of Ringer's solution by an intravenous drip. What mass of each salt does the pharmacist need to make the solution?

Mass/Mass Calculations

5. Calculate the mass/mass percent of solute for each solution.
 - a. 17 g of sulphuric acid in 65 g of solution
 - b. 18.37 g of sodium chloride dissolved in 92.2 g of water (**Remember a solution is both solute and solvent!**)
 - c. 12.9 g of carbon tetrachloride dissolved in 72.5 g of benzene
6. If 55 g of potassium hydroxide is dissolved in 100 g of water, what is the concentration of the solution expressed as mass/mass percent?
7. Steel is an alloy of iron and about 1.7% carbon. It also contains small amounts of other materials, such as manganese and phosphorus. What mass of carbon is needed to make a 5.0 kg sample of steel?
8. Stainless steel is a variety of steel that resists corrosion. Your cutlery at home may be made of this material. Stainless steel must contain at least 10.5% chromium. What mass of chromium is needed to make a stainless steel form with a mass of 60.5 g?
9. 18-carat white gold is an alloy. It contains 75% gold, 12.5% silver, and 12.5% copper. A piece of jewellery, made of 18-carat white gold, has a mass of 20 g. How much pure gold does it contain?

Volume/Volume Calculations

10. 60 mL of ethanol is diluted with water to a final volume of 400 mL. What is the percent by volume of ethanol in the solution?
11. Milk fat is present in milk. Whole milk usually contains about 5.0% milk fat by volume. If you drink a glass of milk with a volume of 250 mL, what volume of milk fat have you consumed?
12. Both antifreeze and engine coolant contain ethylene glycol. A manufacturer sells a concentrated solution that contains 75% (v/v) ethylene glycol in water. According to the label, a 1:1 mixture of the concentrate with water will provide protection against freezing down to -37°C. A motorist adds 1 L of diluted solution to a car radiator. What is the percent (v/v) of ethylene glycol in the diluted solution?
13. The average adult human body contains about 5 L of blood. Of this volume, only about 0.72% consists of leukocytes (white blood cells). These essential blood cells fight infection in the body. What volume of pure leukocyte cells is present in the body of a small child with only 2.5 L of blood?
14. Vinegar is sold as a 5% (v/v) solution of acetic acid in water. How much water should be added to 15 mL of pure acetic acid (a liquid at room temperature) to make a 5% (v/v) solution of acetic acid? Note: Assume that when water and acetic acid are mixed, the total volume of the solution is the sum of the volumes of each.

Concentration of Very Small Quantities

15. Symptoms of mercury poisoning become apparent after a person has accumulated more than 20 mg of mercury in the body.
 - a. Express this amount as parts per million for a 60 kg person.
 - b. Express this amount as parts per billion.
 - c. Express this amount as a (m/m) percent.

16. The use of the pesticide DDT has been banned in Canada since 1969 because of its damaging effect on wildlife. In 1967, the concentration of DDT in an average lake trout, taken from Lake Simcoe in Ontario, was 16 ppm. Total it is less than 1 ppm. What mass of DDT would have been present in a 2.5 kg trout with DDT present at 16 ppm?
17. The concentration of chlorine in a swimming pool is generally kept in the range of 1.4 to 4.0 mg/L. The water in a certain pool has 3.0 mg/L of chlorine. Express this value as parts per million. (Hint: 1 L of water has a mass of 1000 g.)
18. Water supplies with dissolved calcium carbonate greater than 500 mg/L are considered unacceptable for most domestic purposes. Express this concentration in parts per million.