Practice: Concentration

% by mass, % by volume, % m/v, molarity and ppm

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Questions originally from: http://msdilalloscience.weebly.com/uploads/6/9/6/2/6962884/concentrations_worksheet_with_main_formulas_on_top.pdf

1. Glucose is a sugar that is found abundantly in nature. What is the percent by mass of a solution made by dissolving 163 g of glucose in 755 g of water? Do you need to know the formula of glucose? Why or why not?

2. What is the mass percent sucrose in a solution obtained by mixing 225 g of an aqueous solution that is 6.25% sucrose by mass with 135 g of an aqueous solution that is 8.20% sucrose by mass?

3. Determine the volume percent of toluene in a solution made by mixing 40.0 mL toluene with 75.0 mL of benzene.

4. What is the concentration of Na^{+}, in parts per million by mass, in 0.00152 M Na_2SO_4?

5. Describe the process you would use in order to prepare 5.00 kg of an aqueous solution that is 8.00% NaCl by mass.

6. What is the mass percent of solute when 4.12 g is dissolved in 100.0 g of water?

7. What is the volume percent of 10.00 g of acetone (d = 0.789 g/mL) in 1.55 L of an acetone-water solution?

8. Convert 0.0035% NaCl by mass into parts per million of NaCl.

9. Convert 2.4 ppm F^- into molarity of fluoride ion.

10. Calculate the molarity of a solution prepared by dissolving 125 mL of pure methanol, CH_3OH (density = 0.791 g/mL) into 275 mL of ethanol.

11. A common solution used by EMTs for keeping veins from collapsing in accident victims is 5% (m/v) dextrose ($C_6H_{12}O_6$) in water.

a) Write a recipe to make 450 mL (one blood unit) of 5% (m/v) dextrose in water.

b) Calculate the molarity of 5% (w/v) dextrose ($C_6H_{12}O_6$) in water.

12. Which is more **concentrated**, vinegar (5% (m/v) acetic acid), or 1 M acetic acid? (Acetic acid is $C_2H_4O_2$).

13. A Pharmacist adds 2.00 mL of distilled water to 4.00g of powdered drug. The final volume of the solution is 3.00mL. What is the percent (m/v) of the solution?

ANSWERS

1. Glucose is a sugar that is found abundantly in nature. What is the percent by mass of a solution made by dissolving 163 g of glucose in 755 g of water? Do you need to know the formula of glucose? Why or why not?

$$\%\,by\ mass = \frac{mass\ of\ solute}{mass\ of\ solution} = \frac{163\,g}{163\,g + 755\,g} = 0.176 = 17.6\%$$

No need to know the formula of glucose, since % by mass only involves the masses used. The formula is only useful if you need to convert to *moles*

2. What is the mass percent sucrose in a solution obtained by mixing 225 g of an aqueous solution that is 6.25% sucrose by mass with 135 g of an aqueous solution that is 8.20% sucrose by mass?

$$Mass\ of\ glucose\ in\ solution\ 1: (225\,g)(0.0625) = 14.0625\,g$$
$$Mass\ of\ glucose\ in\ solution\ 2: (135\,g)(0.0820) = 11.07\,g$$
$$\%\,by\ mass = \frac{mass\ of\ solute\ (sucrose)}{mass\ of\ solution} = \frac{14.0625\,g + 11.07\,g}{225\,g + 135\,g} = \frac{25.1325\,g}{360\,g} = 0.0698 = 6.98\%$$

3. Determine the volume percent of toluene in a solution made by mixing 40.0 mL toluene with 75.0 mL of benzene.

$$\%\,by\ volume = \frac{volume\ of\ solute}{volume\ of\ solution} = \frac{40.0\,mL}{40\,mL + 75\,mL} = 0.348 = 34.8\%$$

4. What is the concentration of Na^+, in parts per million by mass, in 0.00152 M Na_2SO_4?

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

- Suppose we had 1 L of the solution, which will have a mass of about 1 kg (1000 g).
- This litre will contain 0.00152 mol of Na_2SO_4 (that's the definition of "M" = mol/L)
- This means we have 0.00304 mol of Na atoms.

$$mass\ of\ Na = (0.00304\,mol) \times \left(\frac{22.989\,g}{mol}\right) = 0.0699\,g\ of\ Na$$
$$ppm = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^6 = \frac{0.0699\,g}{1000\,g} \times 10^6 = 69.9\ ppm$$

5. Describe the process you would use in order to prepare 5.00 kg of an aqueous solution that is 8.00% NaCl by mass.

8% of a 5.00 kg solution is (5 kg)(0.08) = 0.400 kg = 400 g
So, we need 400 g of solute, and 4.6 kg of solvent (since, together, the total mass must be 5 kg)

So, I would use a balance to weigh out 400 g of NaCl solid into a *big* beaker (5 L at least, since we need 5 kg of solution). Then, I would pour water in until the balance read 5.00 kg.

There is no set volume for 5.00 kg of solution, so using a volumetric flask is a bad idea. You must use a balance since you need 5.00 **kg**.

6. What is the mass percent of solute when 4.12 g is dissolved in 100.0 g of water?

$$\%\,by\ mass = \frac{mass\ of\ solute}{mass\ of\ solution} = \frac{4.12\,g}{4.12\,g + 100\,g} = 0.0396 = 3.96\,\%$$

Hopefully by this point, you didn't forget to use mass of *solution*.

7. What is the volume percent of 10.00 g of acetone (d = 0.789 g/mL) in 1.55 L of an acetone-water solution?

$$Volume\ of\ acetone\ used\ is \frac{10.00\,g}{0.789\,g/mL} = 12.67\,mL$$

$$\%\,by\ volume = \frac{volume\ of\ solute}{volume\ of\ solution} = \frac{12.67\,mL}{1550\,mL} = 0.00817 = 0.82\,\%$$

8. Convert 0.0035% NaCl by mass into parts per million of NaCl.

0.0035% by mass means 0.0035 g of NaCl per 100 g of solution

- You can also just prove this to yourself another way. Assume you have 100 g of solution (or any other mass for that matter) and use $\%\,by\ mass = \frac{mass\ of\ solute}{mass\ of\ solution}$ to figure out the mass of solute

$$ppm = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^6 = \frac{0.0035\,g}{100\,g} \times 10^6 = 35\ ppm$$

9. Convert 2.4 ppm F^- into molarity of fluoride ion.

This means we have 2.4 g of F for every 10^6 g of solution. We can assume that 10^6 g of solution is 10^6 mL, which is 10^3 L (divide by 1000).

2.4 g of F is $\frac{2.4\,g}{19.00\,g/mol}=0.126\,mol$

$$Molarity=\frac{moles\ of\ solute}{Volume\ of\ solution\ in\ Litres}=\frac{0.126\,mol}{10^3\,L}=0.000126\,mol/L=1.26\times10^{-4}\,M$$

10. Calculate the molarity of a solution prepared by dissolving 125 mL of pure methanol, CH_3OH (density = 0.791 g/mL) into 275 mL of ethanol.

$$Moles\ of\ methanol=(125\,mL)\times\frac{0.791\,g}{1\,mL}\times\frac{1\,mol}{32.05\,g}=3.085\,mol$$

Assuming that the total volume is 125 mL + 275 mL = 400 mL,

$$Molarity=\frac{moles\ of\ solute}{Volume\ of\ solution\ in\ Litres}=\frac{3.085\,mol}{0.4\,L}=7.71\,mol/L$$

11. A common solution used by EMTs for keeping veins from collapsing in accident victims is 5% (m/v) dextrose ($C_6H_{12}O_6$) in water.

a) Write a recipe to make 450 mL (one blood unit) of 5% (m/v) dextrose in water.

5% m/v means there is 5 g of dextrose in 100 mL of solution.

So, we need this much dextrose: $450\,mL\times\frac{5\,g\ dextrose}{100\,mL}=22.5\,g\ dextrose$

So, the steps are:

1. Use a balance to mass 22.5 g of solid dextrose
2. Put this mass of dextrose into a 450 mL volumetric flask
3. Fill the flask up to the etched line that indicates exactly 450.00 mL

We use a volumetric flask here because the volume of the solution is important.

b) Calculate the molarity of 5% (w/v) dextrose ($C_6H_{12}O_6$) in water.

Moles of dextrose: $22.5\,g \times \frac{1\,mol}{180.18\,g} = 0.1249\,mol$

Molarity of dextrose: $\frac{moles\ of\ solute}{volume\ of\ solution\ in\ litres} = \frac{0.1249\,mol}{0.450\,L} = 0.278\,mol/L$

12. Which is more **concentrated**, vinegar (5% (m/v) acetic acid), or 1 M acetic acid? (Acetic acid is $C_2H_4O_2$).

Let's convert the molarity into m/v (since in the previous question we did it the opposite way). You can just replicate 11(b) if you want to convert 5% m/v into molarity)

1 M = 1 mol of acetic acid per 1 L of solution.

1 mol of acetic acid is 60.06 g (this is the definition of molar mass)

$$\%\,m/v = \frac{mass\ of\ solute\ in\ grams}{volume\ of\ solution\ in\ mL} = \frac{60.06\,g}{1000\,mL} = 0.06006 = 6.01\,\%\,m/v$$

So, the 1 M solution is slightly more concentrated.

13. A Pharmacist adds 2.00 mL of distilled water to 4.00g of powdered drug. The final volume of the solution is 3.00mL. What is the percent (m/v) of the solution?

$$\%\,m/v = \frac{mass\ of\ solute\ in\ grams}{volume\ of\ solution\ in\ mL} = \frac{4.00\,g}{3.00\,mL} = 1.33 = 133\,\%\,m/v$$

YES, it is possible to have a mass/volume percent of greater than 100. If you have more than 1 g of solute per mL of solution, this will happen. Just a weird quirk of this particular unit of measurement. This can NOT happen for mass/mass percent or volume/volume percent.