Friday worksheet 1 – solutions, concentrations

The concentration of a solution is a measure of the amount of solute that has been dissolved in a given amount of solvent. Ok, sounds simple enough, however, there are many ways to measure concentration. Here is just a few.
a. %w/v (the mass of a solute in 100mL of solution)
b. %v/v (the volume in ml of a solute in 100 mL of solution)
c. %w/w (the mass of solute in 100 g of solution)
d. ppm (parts per million and it is the amount of solute in mg found in 1.0 litre or 1.0 kg of solution)
e. Molarity (mol of solute in 1.0 litre of solution)

Basically all forms will give the right amount of solute in a given amount of solution, however, some conversion of units is necessary to make sense of concentration.

The amount of ethanol in a given volume of wine is given in %v/v. 12.0% indicates 12 mL of ethanol in 100mL of wine.

Conversion of units is the secret here.
Example 1. Calculate the salt concentration, in %w/v of a 25.0 mL solution that contains 0.58g of NaCl.

$$\%\ w/v = \frac{\text{solute mass in g}}{\text{solution volume in mL}} \times 100\ \%$$

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$$\text{ppm} = \frac{\text{mass of solute in mg}}{\text{solution volume in L}}$$

$$\text{Molarity (M)} = \frac{\text{solute in mol}}{\text{solution volume in L}}$$

Step 1 look at the units the question asks the answer to be in then look at the units given in the question. If they are not the same then it's time to change them.
=> Since the units do not need to be converted we can skip this step and go to the formula.
=> %w/v = (0.58g/ 25.0Ml) x 100 = 2.32%W/V

Example 2. Calculate the salt concentration, in mol/L, of a 25.0 mL solution that contains 0.58g of NaCl.
Step 1 look at the units the question asks the answer to be given in then look at the units given in the question. If they are not the same then it's time to change them.
=> Since the units are not the same they need to be converted .
=> mol of NaCl = 0.58 / 58.44 = 0.993 mol
=> 25.0 mL = 0.0250L
Step 2 Apply the formula
=> Molarity(M) = mol/Litre = 0.993/0.0250 = 40M

Example 3. Calculate the salt concentration, in ppm, of a 250.0 mL solution that contains 0.058g of NaCl.
Step 1 look at the units the question asks the answer to be given in then look at the units given in the question. If they are not the same then it's time to change them.
=> Since the units are not the same they need to be converted .
=> Convert mass of NaCl to mg
=> 0.058g = 58mg
=> convert mL to L
=>25.0mL = 0.25L
Step 2 apply the formula
=> ppm = mg/L = 58/0.25 = 232ppm.

1. A 300.0 mL sample of waste water was analysed and found to contain 0.0330 grams of lead. Calculate the concentration of lead in:
   a. ppm
      Step 1 convert to the appropriate units.
      => 0.0330g =33.0 mg
      => 300.0 mL = 0.300L
      Step 2 calculate the ppm
      => 33.0/0.300 = 110ppm

   b. %w/v
      => (0.0330g / 300.0mL) X 100 = 0.0110%

   c. Molar concentration (mol/L) of lead in the water

   Step 1 convert to the appropriate units.
   => 0.0330g / 207.2 g/mol = 1.59 X 10^{-4}mol
   => 300.0 mL = 0.300L
   Step 2 calculate the ppm
   => 1.59 X 10^{-4}mol /0.300 = 5.31 X 10^{-4}mol/L

2. A brand of wine has the alcohol (ethanol) content clearly labelled as 13.5%v/v. Given that the density of ethanol, at room temperature, is 0.7892 g/mL calculate the concentration of ethanol in:
   a. %w/v
      Step 1 Convert the volume of ethanol in 100mL of wine into mass using the density.
      => mass = density X volume
      => mass(g) = 0.7892g/mL X 13.5mL = 10.65g
      Step 2 Apply the formula
      => (10.65 / 100 mL) X 100 = 10.7%w/v
   b. Mol/L
      Step 1 convert the units
      => 10.65g of ethanol = (10.65/46.0) = 0.232 mol
      step 2 apply the formula
      => 0.232 mol/ 0.100L = 2.32 mol/L = 2.32M

3. A 0.12M solution of nitric acid needs to be relabelled to reflect the concentration of nitric acid in %w/v. Calculate the concentration of the acid in %w/v.
   Step 1 Convert the units
   => 0.12 mol of nitric acid are present in 1L
   => 0.12 mol = 0.12 X 63.0 = 7.56g
   => 1L = 1000mL
   Step 2 Apply the formula
   => (7.56g/1000mL) X 100 = 0.756%w/v

4. Shark meat is a very important food source for humans. Being an apex predator, pollutants tend to concentrate more rapidly in the shark's body. A 0.571 g sample of shark meat was analysed and found to contain 5.67 X 10^{-4} grams of mercury.

Find the mercury content in the shark meat in:

a. %w/w

=> %w/w = (5.67 X 10^{-4}/0.571) X 100

=> 0.0993%w/w

b. ppm

ppm =mg/kg

Step 1 convert the units.

=> 5.6 X 10^{-4} grams = 0.56 mg

=> 0.571 g of sample = 0.000571 kg

Step 2 apply the formula

ppm = mg/kg = 0.56mg of mercury / 0.000571 kg sample = 980ppm

5. Waste water near a factory that manufactures car batteries is analysed. It is found to have a lead concentration of 34 ppm. Calculate the concentration of lead in the waste water in mol/L.

=> 34mg/L = 34 ppm of lead

Step 1 convert the units

=> 34mg = 34 X 10^{-3}g / 207.2 = 1.64 X 10^{-4} mol of lead

=> No need to convert volume as ppm and molarity use unit of L.

Step 2 apply the formula

=> M =mol/L = 1.64 X 10^{-4}M

6. A sample of seawater taken from the Bay has an NaCl concentration of 0.600 M.

a. Calculate the concentration of NaCl in ppm.

Step 1 convert the units

=> mol/L = mg/L

=>0.600 mol of NaCl = 0.600 X 58.5 = 35.1 g

=> convert g to mg = 35.1 X 1000 = 35100ppm

Step 2 calculate ppm

=> mg/L = 35100/1L = 35100ppm.

b. If the EPA recommends that drinking water should not exceed 20 ppm, how many times more salty is seawater compared to drinking water?

=> 35100 / 20 = 1755 times more salty than drinking water.