**Answer Key for Problem Set Dealing with Concentration Units**

1 a. The formula for sodium sulfate is Na2SO4.

The mass of solute is 15.0 g Na2SO4. The mass of solvent (water) is 400.0 g, so the mass of solution is:

15.0 g Na2SO4 + 400.0 g H2O = 415.0 g solution

1 b. The molar mass of Na2SO4. must be calculated to find the moles of Na2SO4.

Molar mass of Na2SO4. = 2 AW of Na + AW of S + 4 AW of O (where AW = atomic weight)

= 2(22.99 g/mol) + 32.07 g/mol + 4(16.00 g/mol) = 142.05 g Na2SO4./mol Na2SO4.

Find the moles of Na2SO4.:

Find the volume of solution in liters. Recall from part a, the mass of solution is 415.0g.

Calculate the molarity:

1 c. The moles of Na2SO4 is already known from part b. Find the kilograms of solvent (water):

Calculate the molality of Na2SO4 :

1 d. Calculate the parts per thousand of Na2SO4 from the mass of solute and mass of solution:

1 e. Parts per million may also be expressed as mg solute/L solution. In this case, converting the molarity to ppm will be the simplest route:

1 e. For the mole fraction of sulfate, we need to have:

Find the moles of Na+ :

Find the moles of SO42- :

Find the moles of H2O:

Calculate the mole fraction of sulfate:

2 a. Assume exactly 1 liter (1000 mL) of solution, which is the quantity present in the denominator of the known concentration unit (molarity). This also means you have 12.0 mol HCl present. Convert the moles of HCl to a mass of HCl:

Find the mass of solution using the density of the solution:

Calculate the mass percent of HCl:

2 b. Find the mass of solvent:

1107 g solution – 437.5 g HCl = 670 g H2O

Convert the mass of solvent to kilograms:

Calculate the molality:

2 c. Find the moles of H2O:

Calculate the mole fraction of HCl:

3 a. Assume exactly 1 kg (1000 g) of water (solvent), which is the quantity present in the denominator of the known concentration unit (molality). This also means you have 0.300 mol Ca(NO3)2.

To find the mass of calcium nitrate, you need the molar mass of Ca(NO3)2:

Molar mass of Ca(NO3)2 = AW of Ca + 2 AW of N + 6 AW of O (where AW = atomic weight)

= 40.08 g/mol + 2(14.01 g/mol) + 6(16.00 g/mol) = 164.10 g Ca(NO3)2/mol Ca(NO3)2

Calculate the mass of Ca(NO3)2 :

Find the mass of solution:

mass of solution = 49.2 g Ca(NO3)2 + 1000.0 g H2O = 1049.2 g solution

Calculate the mass percent of Ca(NO3)2 :

3 b. To find the mass of nitrate ion, you need the molar mass of nitrate ion (NO3¯ ):

Molar mass of NO3¯ = AW of N + 3 AW of O (where AW = atomic weight)

= 14.01 g/mol + 3(16.00 g/mol) = 62.01 g NO3¯/mol NO3¯

Calculate the mass of nitrate ion:

Calculate the mass percent of nitrate ion:

3 c. Find the mass of calcium ion:

Calculate the mass percent of calcium ion:

Notice how the sum of %Ca2+ and %NO3¯ sum to the %Ca(NO3)2.

3 d. Convert the mass of solution to volume of solution in liters:

Calculate the molarity:

3 e. Calculate the molarity of nitrate ions:

3 f. Find the moles of calcium ion:

Find the moles of nitrate ion:

Find the moles of water:

Calculate the mole fraction of calcium ion:

3 g. Calculate the mole fraction of nitrate ion:

4. Recall that parts per million may also be expressed as mg solute/liter of solution or mg solute per kilograms solution. Either case will work here because the density of the solution is given as 1.00 g/mL. Assume exactly 1 liter of solution (1000 g solution) so that the mass of solute (25.0 mg of magnesium ion) is known.

4 a. Convert milligrams of magnesium ion to grams magnesium ion:

Calculate the w/w% magnesium ion:

4 b. Find the number of grams of chloride ion keeping in mind the chemical formula of magnesium chloride is MgCl2:

Calculate the w/w% of Cl¯:

4 c. Find the number of grams of magnesium chloride:

Calculate the w/w % MgCl2:

4 d. Find the moles of magnesium chloride:

Calculate the molarity of

4 e. Calculate the molarity of magnesium ions:

4 f. Calculate the molarity of chloride ions:

4 g. Find the mass of water:

1000 g solution – 0.0979 g MgCl2 = 999.9021 g H2O

Convert this mass to kilograms:

Calculate the molality of MgCl2: