A compound (containing Mn, C, O) is 28.17% Mn, 30.80% C. A solution of the compound containing 0.125 g in 5.38 g cyclohexane freezes at 5.28 C. What is the molecular formula?

$\Delta T_f = K_f \times C_m$

$T_{f,cyc} = 6.55°C$, $K_f = 20.0\,°C/m$

(see p509, 10th)

$C_m = \frac{\text{mol unknown}}{\text{kg cyc}}$

kg cyc: $5.38\,g = 0.00538\,kg$

We'll need to find the MOLECULAR WEIGHT to determine the molecular formula. To do THAT, we need to find out how many moles of unknown are present.

$$(6.55°C - 5.28°C) = (20.0\,°C/m)\,C_m$$

$$C_m = 0.0635\,m$$

$$0.0635\,m = \frac{\text{mol unknown}}{0.00538\,\text{kg cyc}} = 3.4163 \times 10^{-4}\,\text{mol unk}$$

Now, find molecular weight

$$\frac{\text{mass unknown}}{\text{mol unknown}} = \frac{0.125\,g\ \text{unk}}{3.4163 \times 10^{-4}\,\text{mol unk}} = 366\ g/mol$$

MOLECULAR WEIGHT of unknown!

Find the EMPIRICAL (smallest ratio) formula from the mass data given:

28.17 % Mn   100% − 28.17% − 30.80% = 41.03% O

30.80 % C

Convert this mass percents to a MOLAR ratio:

Assume 100 g basis,

To reduce this ratio to small whole numbers (for the formula), let's divide each term by the smallest one (in this case, the Mn's 0.512...)

$28.17\,g\,Mn \times \frac{mol\,Mn}{54.94\,g\,Mn} = 0.5127411722\,mol\,Mn$ 1 mol Mn

$30.80\,g\,C \times \frac{mol\,C}{12.01\,g\,C} = 2.564529559\,mol\,C$ 5.001 mol C

$41.03\,g\,O \times \frac{mol\,O}{16.00\,g\,O} = 2.564375\,mol\,O$ 5.001 mol O

So the EMPIRICAL FORMULA is ... MnC_5O_5

Mn : 1 x 54.94
C : 5 x 12.01
O : 5 x 16.00

194.99 g/mol ; compare to 366 g/mol

195 times 2 is 390 ... which is the closest we'll get to 366.

$Mn_2C_{10}O_{10}$

56 grams of a sample contain 0.51 mole fraction propane and the remainder butane. What are the masses of propane and butane in the sample?

Know: $X_{C_3H_8} = 0.51$

$X_{C_4H_{10}} = 1 - 0.51 = 0.49$

need: mass C_3H_8, mass C_4H_{10} in 56 g

How do we get from MOLE FRACTION to MASS? Let's try changing units ...

$$X_{C_3H_8} = 0.51 = \frac{\text{mol } C_3H_8}{\text{total moles}}$$

Let's assume ... FOR NOW ... that we have a mole of the mixture.

$$\text{mol}_{C_3H_8} = 0.51 \times 1 = 0.51 \text{ mol } C_3H_8$$

$$\text{mol}_{C_4H_{10}} = 0.49 \times 1 = 0.49 \text{ mol } C_4H_{10}$$

Now, let's change these to masses. We'll need formula weights.

C_3H_8: 44.094 g/mol

C_4H_{10}: 58.12 g/mol

$$g\ C_3H_8 = 0.51 \text{ mol} \times \frac{44.094 \text{ g}}{\text{mol}} = 22.48794 \text{ g } C_3H_8$$

$$g\ C_4H_{10} = 0.49 \text{ mol} \times \frac{58.12 \text{ g}}{\text{mol}} = \frac{28.4788 \text{ g } C_4H_{10}}{50.96674 \text{ g total}}$$

Use the ratio of mass butane/ mass total to find the actual butane content of the sample!

$$g\ C_3H_8 = 0.51\ mol \times \frac{44.094\ g}{mol} = 22.48794\ g\ C_3H_8$$

$$g\ C_4H_{10} = 0.49\ mol \times \frac{58.12\ g}{mol} = \frac{28.4788\ g\ C_4H_{10}}{50.96674\ g\ total}$$

So, for propane:

$$56\ g \times \frac{22.48794\ g\ C_3H_8}{50.96674\ g\ total} = 24.7\ g\ C_3H_8$$

And for butane:

$$56\ g \times \frac{28.4788\ g\ C_4H_{10}}{50.96674\ g\ total} = 31.3\ g\ C_4H_{10}$$

So the composition of the sample is 25 g propane, 31 grams butane!

Commercial sulfuric acid (98% by mass) is 18 M. What is the density of the solution, and what is the molality?

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want:

$$\text{density} = \frac{\text{mass solution}}{\text{vol solution}}$$

$$\text{molality} = \frac{\text{mol } H_2SO_4}{\text{kg } H_2O}$$

know:

$$18\,M = \frac{\text{mol } H_2SO_4}{\text{L solution}}$$

$$98\% = \frac{\text{g } H_2SO_4}{100\text{g solution}}$$

Let's assume a liter of solution:

$$\frac{18 \text{ mol } H_2SO_4}{L} \times 1\,L = 18 \text{ mol } H_2SO_4$$

We need to find the mass of solution, so we'll have to calculate the mass of sulfuric acid

H_2SO_4 : 98.086 g/mol

$$18 \text{ mol } H_2SO_4 \times \frac{98.086\text{ g}}{\text{mol}} = 1765.548\text{ g } H_2SO_4$$

Now, we need to find the MASS of the SOLUTION:

$$1765.548\text{ g} = 0.98 \times \text{mass solution}$$

... since the solution is 98% sulfuric acid

$$\text{mass solution} = 1801.579592\text{ g}$$

Now, find density:

$$\text{density} = \frac{\text{mass solution}}{\text{vol solution}} = \frac{1801.763265\text{ g}}{1000\text{ mL}} = \boxed{1.8\text{ g/mL}}$$

$$\text{molality} = \frac{\text{mol } H_2SO_4}{\text{kg } H_2O}$$

We can solve the rest of the problem several different ways from this point, but let's just keep our assumption of 1 L of the acid.

If we do that, we know the moles sulfuric acid, and we've already calculated the mass of solution and the mass of acid.

Find mass water by subtraction:

$$1801.579592\text{ g} - 1765.548\text{ g} = 36.03159184\text{ g } H_2O$$

$$\text{molality} = \frac{\text{mol } H_2SO_4}{\text{kg } H_2O} = \frac{18\text{ mol } H_2SO_4}{0.03603159184\text{ kg}} = 5\bar{0}0\text{ m } H_2SO_4$$