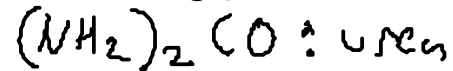


Some sample colligative properties problems from the book...

12.97

p 521

What is the freezing point of a 41% solution of urea in water?



$$\Delta T_F = K_F \times C_m$$

$$p.s.o., K_{F, \text{H}_2\text{O}} = 1.858^\circ\text{C}/m$$

$$T_{F, \text{H}_2\text{O}} = 0.000^\circ\text{C}$$

$$C_m = \frac{\text{mol urea}}{\text{kg water}}$$

We need to find mol urea and kg water. We know mass percentage, so we'll have to start there.

$$41\% \text{ urea} : \frac{41 \text{ g urea}}{100 \text{ g solution}}$$

We need mass WATER to find molality!

$$\text{mass water} = 100 \text{ g} - 41 \text{ g} = 59 \text{ g}$$

Find moles urea using formula weight and mass.



$$\text{H} : 4 \times 1.008$$

$$\text{C} : 1 \times 12.01$$

$$\text{O} : 1 \times 16.00$$

$$\underline{\underline{60.062 \text{ g/mol}}}$$

$$41 \text{ g urea} \times \frac{\text{mol urea}}{60.062 \text{ g urea}} = 0.6826279811 \text{ mol urea}$$

So, C_m is:

$$C_m = \frac{\text{mol urea}}{\text{kg water}} = \frac{0.6826279811 \text{ mol urea}}{0.059 \text{ kg water}} = 11.56996527 \underline{\underline{m}} \text{ urea}$$

$$C_m = \frac{\text{mol urea}}{\text{kg water}} = \frac{0.6826279811 \text{ mol urea}}{0.059 \text{ kg water}} = 11.56996527 \text{ m urea}$$

Now we can find delta Tf:

$$\Delta T_f = K_f \times C_m$$

$$p.s.o., K_{f, H_2O} = 1.858^\circ\text{C}/\text{m}$$

$$\Delta T_f = (1.858^\circ\text{C}/\text{m}) \times (11.56996527 \text{ m urea}) = 21.49699548^\circ\text{C}$$

$$\text{So, } T_f = 0.000^\circ\text{C} - 21.49699548^\circ\text{C} = \boxed{-21^\circ\text{C}}$$

12.105, p 521

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?

$$\Delta T_f = K_f \times C_m$$

$$T_{f, cyc} = 6.55^\circ\text{C}, K_{f, cyc} = 20.0^\circ\text{C}/m$$

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

$$\text{kg cyc}$$

$$\underbrace{\quad}_{5.38\text{g} = 0.00538\text{kg}}$$

First, find C_m , then find mol unknown.

$$(6.55^\circ\text{C} - 5.28^\circ\text{C}) = (20.0^\circ\text{C}) \times C_m$$

$$C_m = 0.0635\text{ m}$$

Now find moles unknown

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

Molecular weight:

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

Molecular weight of unknown.

Find empirical formula from the mass data given

$$28.17\% \text{ Mn}$$

$$100\% - 28.17\% - 30.80\% = 41.03\% \text{ O}$$

$$30.80\% \text{ C}$$

to reduce to whole numbers,
divide each term by the smallest
(in this case, 0.512...)

Convert this mass data to a MOLAR ratio:

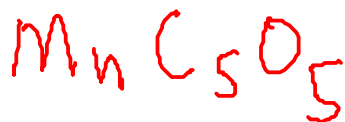
Assume 100g

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

$$30.80 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 2.564529559 \text{ mol C} \quad 5.001 \text{ mol C}$$

$$41.03 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 2.564375 \text{ mol O} \quad 5.001 \text{ mol O}$$

So the EMPIRICAL formula is:



$$\text{Mn} : 1 \times 54.94$$

$$\text{C} : 5 \times 12.01$$

$$\text{O} : 5 \times 16.00$$

$$194.99 \text{ g/mol} ; \text{ compare to MW} = 366 \text{ g/mol}$$

194.99 times 2 is 390, closest to 366. So molecular formula is empirical times 2

