General Chemistry Lab Time To Learn Solutions

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I have often wondered why many students in upper division chemistry labs still have trouble preparing the various types of solutions used in their experiments. A previous article in *this Journal* (*1*) accurately addressed the situation for classical and instrumental analysis; however, I believe this problem developed earlier and that the remedy is to nip it in the bud. To test the students' "faith" in their understanding of formulating solutions, I play the devil's advocate and question them on the difference between a molar and molal solution. Using a deliberately deceptive misintoning of expression and somewhat misdirecting statements, they are prompted to answer the question—"Is a 1 molar solution the same as a 1 molal solution?" The answer is always the correct "no". Continuing to test their faith, the questioning becomes—"What if the solute and solvent are the same for each solution?" The answer is still a confident "no". Continuing further, "What if the solute is the same, the solvent is the same, and the solvent is water? Remember that 1 L and 1 kg of water are the same by definition" (they are told to neglect the temperature dependence of density for sake of the discussion at hand). Now their answer is "yes". Then to sum up their understanding—"So if we were to weigh 1 mole of glucose, which is 180 g, and this is the same for both solutions, and if we specifically use water as the solvent, and because of this special property of water where 1 L = 1 kg (again for simplicity), then in this special case, when and only when water is the solvent, the concentration in molarity is equivalent to the concentration in molality?" A five-year tally of the position of students in sophomore and junior chemistry labs has a 90% acceptance of these solutions' equal concentration when water is the solvent.

Solutions are contained in all general chemistry texts and are no doubt presented in general chemistry courses. Texts have many problems devoted to the solutions themselves and also to concepts that reintroduce solutions, for example, the colligative laws and the equilibrium constant. From my experience, when solutions are presented in lecture, the only difficulties that exist are those usual to new material. These problems are overcome with study, and use of solutions in succeeding chapters presents no difficulties. Why then the difficulty in understanding a solution's formulation several chemistry courses later? I believe the answer is simple. General chemistry lecture presents principles; the lab tests them. Equipment, reagents, *solutions,* and computer work stations are provided to save time and to get to the matter at hand. The solutions that are required for the experiment usually are provided, not formulated by the student (*1*). Hence, this subtle difference between molar and molal is missed, even if explained in lecture and pictorially demonstrated in general chemistry texts. The students never grasped the essence that molar is a "diluted to" solution, while molal is an "added to" solution. Maybe the "solution" to this laboratory void is to provide sufficient lab time in general chemistry for students to prepare their own solutions.

Literature Cited

1. Quigley, M. N. *J. Chem. Educ.* **1991**, *68*, 505.