Chemistry 1000 Problem Solving Workshop
Introduction for Instructors

How It Works:

The goal of this workshop is to help students develop strategies for problem solving. Students will work in pairs. In each pair, one student is designated the problem solver and one student is designated the observer. If there is an odd number of students, you will need to have one group with a problem solver and two observers. Do not allow this unless necessary. It is preferable to have two students from different sections work together rather than having two groups of three.

The problem solver is asked to 'think out loud' so that the observer can follow their reasoning. If the problem solver gets stuck, the observer is allowed to ask questions to help them along. These questions are not permitted to give away the answer (even if the observer has worked it out). For each problem, a set of sample questions will be provided to the observer; however, these are not the only questions that can be asked. Once the problem solver has an answer that both students are satisfied with, the pair checks with the instructor. If the answer is correct, they will be given the next problem in the series and switch roles.

If the answer is incorrect, the instructor may offer a question/hint of their own (depending on whether or not they can tell where the error was made) or may simply convey that the answer is incorrect. There are some problems for which there is no 'correct' or 'incorrect' answer and all that is required is a reasonable answer; these are the 'discussion' problems (problems 5 and 6). In cases where a numerical answer is correct but has incorrect sig. fig. and/or units, the instructor should point that out and help the students to correct the issue before continuing with the next problem. It is unlikely to be helpful to just say "right answer; wrong sig. fig." and walk away.

Marking Scheme:

When finished each problem, the students show their answer to the instructor. If correct, the instructor checks the appropriate box on their marking sheet and gives the students the next set. Typically, students are asked to discuss Questions 5 and 6 at the same time then share their best ideas with an instructor to earn the fifth mark (of five) available in this activity.

Make sure to get full names (first and last) from the students when filling in the marking sheet as some students do change lab sections within the first week and we need to know exactly who has completed this activity!

Point out the opportunity for a bonus mark to the students. Collect any questions they submit and return them to Wayne at the next pre-lab meeting so he can pass them along to Susan who will update the activity with any of the questions she likes. :-)

Lab instructors will be provided with an answer key. Because OPUS can be searched by anyone – including students who have not yet completed this activity – we cannot publish the answer key here. Faculty who wish to see the answer key can email susan.lait@uleth.ca.

The odd formatting of this document is to allow pages to be printed with the question on one side and the hints on the back. Each question page is cut in half to save paper.

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Introduction for Students

How It Works:
The goal of this workshop is to help you develop strategies for problem solving. You will work in pairs. In each pair, one student is designated the problem solver and one student is designated the observer. The problem solver is asked to 'think out loud' so that the observer can follow their reasoning. If the problem solver gets stuck, the observer is allowed to ask questions to help them along. These questions are not permitted to give away the answer (even if the observer has worked it out). For each problem, a set of sample questions will be provided to the observer; however, these are not the only questions that can be asked. Once the problem solver has an answer that you are both satisfied with, check in with your instructor. If the answer is correct, you will be given the next problem in the series and switch roles. There are some problems for which there is no 'correct' or 'incorrect' answer and all that is required is a reasonable answer; it will be obvious when this is the case.

You will earn one mark for each problem you and your partner complete (to a maximum of five marks). You may earn a bonus mark on this activity by submitting a "helper question" of your own to your instructor before you leave lab. To get credit, it must:

- be original; cannot duplicate or be overly similar to any questions provided, and
- be clear, coherent and concise. If the wording doesn't make sense, it's not helpful.

General Hints
Given that the purpose of this activity is to help you develop problem solving strategies, it is strongly advised that you follow the recommended set-up (problem solver and helper) rather than devising your own. There are things to be learned from watching/interacting with another person as they work their way through a problem!

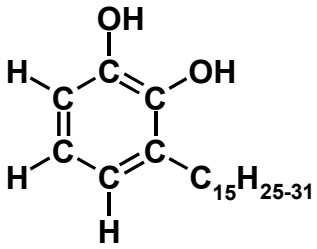
If you or your partner get stuck, try the following BEFORE asking for help. You lab instructor will expect to see evidence that you have tried to work through the problem on your own before they will be willing to help you. Ideally, following these steps will help you to make connections so that you don't wind up needing to ask for help after all.

- Make sure that you are clear on what the question is asking you to do. Try rephrasing it in your own words and see if your partner agrees that that's what is being asked. WRITE OUT THE QUESTION ON YOUR SCRAP PAPER.
- Organize the information you were presented. If there are two different samples, group the information according to each sample. Again, WRITE THIS OUT ON YOUR SCRAP PAPER.
- Try DRAWING A DIAGRAM of the situation being described. Take the information you organized and see where it fits onto your diagram. How does the question being asked relate to the diagram?

The scenario around which this exercise is based is one you are unlikely to have seen before. At the university level, you will often encounter new problems which you will not already know an algorithm to solve. The point of this exercise is not to learn one more algorithm; it's to work on learning how to develop your own. The last couple of questions are verbal rather than numerical; they are not asking you to regurgitate information from the background section; they are asking you to evaluate that information in relation to the numbers you calculated and draw your own conclusions. That is the essence of how science works.

The Topic:
Homeopathy is a branch of alternative medicine based on the idea that 'like cures like'. For example, since a cold gives a person a runny nose and watery eyes, it can be treated by a very dilute solution of onion extract (which can also give a person a runny nose and watery eyes). Since a strong dose of the treatment gives the same symptoms as the condition being treated, homeopathic medicines are always dilute solutions and homeopaths believe that the more dilute the solution, the more effective it is as a treatment. Because these solutions are so dilute, they are not subject to the same regulations as pharmaceuticals.

In homeopathy, rhus tox is commonly prescribed for strains and sprains. This extract of poison ivy can also be prescribed for the flu and arthritis. The active ingredient in poison ivy (i.e. the thing that makes it itchy) is urushiol oil. Urushiol oil from poison ivy consists primarily of a mixture of compounds that have molecular formulas of $C_{21}H_{30}O_2$, $C_{21}H_{32}O_2$, $C_{21}H_{34}O_2$ and $C_{21}H_{36}O_2$. They all have very similar structures, as shown below:



This oil is soluble in ethanol but not in water, so the initial solution is prepared by doing a 100-fold dilution of the oil into ethanol. This solution is then shaken and diluted 100-fold again repeatedly. At some point, the solvent used for dilution is switched from ethanol to water. Commonly prescribed solutions include 30C (prepared via 30 sequential 100-fold dilutions) and 100C (100 sequential 100-fold dilutions).

Problem 1
What does it mean to dilute a solution by a factor of 100? Suggest one method by which such a dilution could be done. Use urushiol oil as the solute and ethanol as the solvent in your method. Part of your answer should include an indication of: what amount of solute you would mix with what amount of solvent to prepare a certain amount of solution.

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Possible Questions to Help with Problem 1

Note that these questions are intended to get the problem solver talking about the problem. They may ask the problem solver something they already know, but in answering out loud, the problem solver may find that something in their answer helps them with the overall problem. No question that you come up with will be "too easy" as long as it relates to the problem. Once the problem solver gets going, though, let them continue to think out loud without interruption. Only ask another question if they get stuck again.

While this exercise focuses on 'thinking out loud', if you or the problem solver is a visual learner, sketching diagrams may be helpful for many of the problems – and is therefore a good thing to suggest if you can't think of any other questions.

- What is a dilution?
- How could the number 100 relate to diluting something?
- Is it more helpful to think about the volume of ethanol mixed with the urushiol oil or the total volume of solution to make?
- What's a nice easy amount of something to dilute? (a number that'll keep the math simple)
- What would be a good volume of solution to make? (again, looking to keep the math simple)

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Problem 2
Suppose that a stock solution is prepared by dissolving 1 mL of poison ivy extract in enough ethanol to make a total volume of 100 mL. The density of the extract is approximately 0.97 g/mL. For the sake of simplifying the calculation, we will assume that the extract is pure urushiol oil that all has the molecular formula $C_{21}H_{32}O_2$.

Calculate the concentration of urushiol oil in this stock solution.

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- What is concentration?
- What units could you report concentration in? *(Note that there is more than one correct answer to this question – g/mL or g/L will be easiest for this question but mol/L will make later questions easier… If using mol/L, a good follow-up question would be "How would you find the molar mass of urushiol oil?")*
- Can you use units to help you work out a formula to calculate concentration?
- Does it matter that the question didn't tell you how much ethanol to use?
- Why were you told the density of the extract?
- Why were you told the molecular formula of the extract? *(Note that it's necessary for some answers to this question, but not others. Record it anyway; you'll need it for later problems.)*
- Would it help to sort the information in the question to information about the extract vs. information about the stock solution being prepared?

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Problem 3
A 30C solution of rhus tox is prepared from urushiol oil. *(For a definition of "30C", see the information for this workshop given in the lab manual. The solution prepared in Problem 2 would be a 1C solution.)*

Calculate the concentration of urushiol oil in the rhus tox.

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Calculate the concentration of urushiol oil in the rhus tox.

Possible Questions to Help with Problem 3

- It might help to organize the information you already have from Problem 2 and the original instructions page.
- What did the lab manual say a 30C solution was?
- What does the term “sequential dilutions” mean?
- Given that the solution prepared in Problem 2 is a 1C solution, it might help to calculate the concentration of the 2C solution from there, then calculate the concentration of the 3C solution and so on and look for a trend.

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What volume of 30C rhus tox would you have to consume in order to be reasonably certain that you had consumed at least one molecule of the urushiol oil?

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Possible Questions to Help with Problem 4

- What was the concentration of the rhus tox solution calculated in Problem 3?
- What is the general formula for concentration? (i.e. How would you normally calculate concentration?)
- Can you rearrange the concentration formula to get volume?
- How can you connect number of molecules to concentration and volume?
- What was the molecular formula for urushiol oil?
- Is there any other information you need that is not provided in the problem? If so, where could you find it?

Possible Questions to Help with Problem 4

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Problem 6

The argument made in favour of homeopathic medicines is that the water 'remembers' the original substance being dissolved in it. Given what you know of the structure of water, does this seem like a reasonable suggestion? How might you test it? If you're stuck for ideas on your own, team up with another pair that has also finished Problems 1-5 to brainstorm ideas.

Problem 6

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