Workshop II: Virtual Lab Experiments

These problems utilize The IrYdium Project's Virtual Laboratory, a simulation developed here at Carnegie Mellon that permits students to freely mix together solutions and see the results of their experiments. We'll be using it today to practice the Stoichiometry topics covered in class.

After choosing a machine and logging in, you'll want to type the command:

```
/afs/andrew/course/09/107/vlab
```

from a terminal to start the Virtual Laboratory. Note that the software will only run on the Sun workstations as it has not been installed in the Linux and Windows clusters. However, you should feel free to run the software on your own machine, either as a Java applet or as a locally installed application (see the website http://ir.chem.cmu.edu/).

In class, we'll explain how to use the software with a short demonstration. Also, detailed instructions on how to use the laboratory can be found within the User Guide, which is available within the lab (accessible via the Help menu) or as a printable PDF document from the website above. If you have any questions or experience any problems using this outside of class, please send email to help@ir.chem.cmu.edu.

For today’s activities, the virtual lab is set to precise transfer mode. In this mode, you can pour exact amounts of solutions between the vessels. This allows you to work without focusing on lab technique or proper choice of glassware.

Please do problems 1-4 in class today, and turn in your completed worksheets. If you have time, you can also try the extra problem.

1.) (2 pts) Using the Virtual Laboratory, prepare a 0.025M solution of Glucose by diluting the 1.00 M Glucose solution located in the stockroom. Please tell us which solutions you mixed together, and the amount of each.

Solutions and amounts mixed together _____________________________________________
2.) (4pts) When Sodium Chloride (NaCl) is dissolved in water it produces a sodium ion (Na⁺) and a chloride ion (Cl⁻). Similarly, when silver nitrate (Ag(NO₃)) is dissolved in water, it produces a silver ion (Ag⁺) and a nitrate ion (NO₃⁻). When Ag⁺ and Cl⁻ are in the same solution, they join to form a solid AgCl. This formation of a solid is called precipitation. The chemical reaction can be written,

\[
\text{Ag}^+_{(aq)} + \text{Cl}^-_{(aq)} \leftrightarrow \text{AgCl}_{(s)}
\]

The Na⁺ and NO₃⁻, while present in solution, do not participate in the reaction. They are referred to as “spectator” ions.

In the stockroom, you will find two solutions:

AgNO₃ solution: This was formed by dissolving 1.00g of AgNO₃ in 100.0 ml of water.
NaCl solution: This was formed by dissolving 0.50g of NaCl in 100.0 ml of water.

a) (1pts) Calculate the concentration of Ag⁺ and NO₃⁻ in the AgNO₃ solution. Please show your work, and check your result against the virtual lab. (Note that [X] is shorthand notation for the concentration of X in M (moles/l).)

\[
[\text{Ag}^+] = \ldots \text{M} \quad [\text{NO}_3^-] = \ldots \text{M}
\]

b) (1pt) Calculate the concentration of Na⁺ and Cl⁻ in the NaCl solution. Please show your work, and check your result against the virtual lab.

\[
[\text{Na}^+] = \ldots \text{M} \quad [\text{Cl}^-] = \ldots \text{M}
\]
c) (2pts) When the above two solutions are mixed together, calculate the amount of AgCl produced (in grams). Also calculate the concentrations of the ions remaining in solution. Please show your work and check your answers against the virtual lab.

Amount of AgCl produced = ___________________g

[Na\(^+\)] = ______________M \hspace{1cm} [Cl\(^-\)] = ______________M

[Ag\(^+\)] = ______________M \hspace{1cm} [NO\(_3\)]\(^-\) = ______________M
3.) (2pts) Given four substances A, B, C, and D that are known to react in some weird and mysterious way (an oracle relayed this information to you within a dream), design and perform virtual lab experiments to determine the reaction between these substances, including the stoichiometric coefficients. You will find 1.00M solutions of each of these chemical reagents in the stockroom.

The chemical reaction is: ______________________________________________________.
4.) (2pts) A lot of research is being done on molecules that bind to DNA. The figure to the left shows one common binding mode, in which the molecule sticks into a groove of DNA. The binding is especially interesting if it is sequence specific, such that the molecule binds only to specific sequences of DNA base pairs. Such molecules can be used as diagnostics to indicate if a certain type of DNA is present in a sample. Often the molecule will change color when it binds since this, for example, makes it easy to identify genes associated with certain viral infections. Another use of molecules that bind to DNA is to create drugs that bind to specific genes and prevent them from being expressed.

You work for a new startup biotechnology company. They have invented a new molecular dye, code-named Dye<sub>a</sub>, that binds selectively to a portion of viral DNA that we will call DNA<sub>a</sub>. The Dye is red in it's unbound form, but is clear (transparent, or white from the perspective of the virtual lab) when it's in it's bound form. Dye<sub>a</sub> reacts with DNA<sub>a</sub> according to the reaction,

\[
\text{Dye}_a + \text{DNA}_a \rightarrow \text{Dye}_a\text{-DNA}_a
\]

color: red uncolored uncolored

where Dye<sub>a</sub>-DNA<sub>a</sub> means a single molecule consisting of Dye<sub>a</sub> bound to DNA<sub>a</sub>.

One day, amidst your scramble to get to a meeting on time, you accidentally left a solution of DNA<sub>a</sub> on your workbench, and due to your short memory span you don't remember the concentration of this solution. You will find this solution and a 1.00 \( \mu \text{M} \) solution of Dye<sub>a</sub> in the stockroom.

Use the virtual lab to experimentally determine the concentration of the solution of DNA<sub>a</sub>. Note that in this problem, you will not be able to use any of the solution viewers to read the concentrations of the solutions. Please briefly describe your approach and give your result below.

\[ [\text{DNA}_a] = \text{______________________________} \text{M} \]
Bonus) This problem is for the truly brave who have lots of extra time!

The stockroom contains 1.00 M solutions of A, B, D, F, and H. These react as follows

\[
\begin{align*}
A + B & \rightarrow C \\
C + D & \rightarrow 2E \\
2E + 3F & \rightarrow G \\
4G + H & \rightarrow I
\end{align*}
\]

The chemicals A, B, D, F, and H are all clear, but the chemical C is green, E is red, G is blue, and I is yellow.

Your task is to prepare 50ml solutions of A, B, D, F, and H. When A is poured into B, you should obtain a blue solution containing only C. When this is poured into D, you should get a red solution containing only E. Pouring this into F should give a green solution containing only G. Finally, pouring this into H should give a yellow solution containing only I.