Having studied molecular architecture in Unit 28, you are prepared to apply your understanding to quantitative and qualitative analysis of some compounds as well as increase your understanding of crystal formation.

**Polarimetry.** Molecules with chiral centers will rotate polarized light. A chiral center is an atom (carbon for our experiment) that has four different atoms or combination of atoms attached to it (see Unit 28). Those molecules with such carbon atoms are said to be optically active. One such common molecule is ordinary sucrose, table sugar. Others include d-glucose (dextrose), l-glucose (levulose), and d-limonene (citrus peel oil). The degree that the light is rotated can be a measure of how much sucrose molecules are present in the solution and thus the concentration. Below is a polarimeter consisting of two polarizing lens on each end with a cell containing the sugar solution between.

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polarizer 1

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<p>| |</p>
<table>
<thead>
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<p>| |</p>
<table>
<thead>
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<th></th>
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</thead>
<tbody>
<tr>
<td>cell containing water or the sample</td>
</tr>
</tbody>
</table>

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polarizer 2
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The cell is first filled with just water and the first polarizer is turned to darken the center line in the polarimeter or exclude the light source viewed through the polarimeter. Then an equivalent cell with the sugar solution is placed between the polarizers and the first polarizer is turned to achieve the same dark line in the center or darkened light source. This degree reading is subtracted from the reading with the water to get the degrees the sugar solution rotated the light. The standard cell used is a 1 dm optical cell with flat ends that allow the light source to transverse a standard 1 dm length. The rotation in such a cell provides the standard optical rotation that can be looked up in standard reference sources. However, any transparent container can be used if it is used for both the water and sample measurement.
Polar Liquids. When a Lewis structure reveals an unsymmetrical geometric shape for a molecule polarity of the molecule occurs. This means that the electronegative nature of an atom (pull on the electrons) surrounding a central atom pulls on the electrons more than opposing atoms. This results in a build up of atoms on one side of the molecule. This build up produces a partial negative charge (negative pole) on the side of the electron build up. On the opposite side of the molecule a partial positive charge emerges. This dipole (positive and negative) causes the molecule to become a miniature magnet with opposing poles of charge. In some molecules, multiple positive and/or negative poles can develop. Such unsymmetrical molecules that exhibit this polarity include water, ammonia, and alcohol. Some molecules are symmetrical such as carbon tetrachloride. Many organic compounds have very little polarity, such as alkanes (hexane, heptane, or octane).

Polar substances mix with polar substances and non-polar substances mix with non-polar substances. In other words, like mixes with like substances. Polar solids (e.g. ionic salts) dissolve or mix with polar solvents (e.g. water, alcohol, glycols). Non-polar liquids (e.g. oils, alkanes, carbon tetrachloride) mix with each other but not with polar liquids. Polar substances can mix with non-polar substances if an intermediate that mixes with both is used. This is sometimes called a wetting agent.

We will measure first the degree of polarity of several substances. This can be done by producing a small stream of liquid and placing an item with a build up static charge near the stream. If the liquid is polar a sharp deflection of the stream toward the charged item will occur. The degree of deflection gives us an estimate of the degree of polarity. The amount of deflection is dependent on the degree of charge on the charged item, the density of the liquid, and the liquid's polarity.

We will also explore the miscibility (ability to mix) of various polar and non-polar substances. You will then be given an unknown substance that you must classify as polar or non-polar based on its solubility in known solvents.
Procedure

**Part : Polarimeter**

1. Place a water sample in the polarimeter, with an adequate light source, and rotate the first polarizer until the maximum darkness occurs. Read the degrees of rotation on the scale of the first polarizer.

2. Then fill a similar or the same container with the 20% sugar (sucrose or a glucose enantiomer). Rotate the first polarizer (to the right for sucrose and d-glucose, to the left for l-glucose) until the same maximum darkness occurs of the light source. Read the degrees of rotation on the scale of the first polarizer.

3. Fill the container (or use a similar container) with an unknown sugar solution and measure the optical rotation in a similar manner. Read the degrees of rotation and subtract from the reading for water to get the degrees of rotation for the unknown sample.

4. By comparing the optical rotation of the known 20% solution to the optical rotation of the unknown solution, determine the percent sugar in the unknown solution.

**Part 2: Polar Liquids**

1. You will find 4 or 5 labeled burettes filled with various pure substances. Produce a small stream of liquid flowing at about the same rate from each burette simultaneously.

2. Rub a piece of rubber with fur (or rub a glass rod with silk to produce a positive charge) or pass a comb or brush through your hair to produce a negative charge.

3. Place the charge item near each stream and estimate the degree of deflection of the stream.
Rank the liquids in order of estimated degree of polarity. Keep in mind the density of the compounds in doing this. If you have the same deflection between two molecules but one has a higher density, the compound with the higher mass or density will have the greater polarity.

4. Using the burette labeled "Unknown" determine the estimated polarity determine its ranking compared to the results in step 3.

Part 3: Solubility of Polar/Non-polar Substances

1. Using your small test tubes, mix various combinations of water, ethanol or methanol, propanol, ethylene glycol, hexane, carbon tetrachloride, and an organic oil (glycerin, cooking oil, etc.)

2. Given the results in Part 1 above as to the degree of polarity of some of these substances, determine which are polar, non-polar, or in between based on their solubility in each other. Remember, like mixes with like.

3. Rank the substances tested in order of polarity. Mix the unknown with these substances and based on its ability to mix determine the degree of polarity or ranking compared to the known substances.

4. Mix a polar and non-polar substance as determined above to get two distinct layers. Find a third substance that can be added to allow the two layers to mix (or finding a wetting agent).
1. If a water sample in a polarimeter produced an angle of rotation of 5.3° and a 20% sucrose solution produced an angle of 23.6°, what is the optical rotation of the 20% sucrose solution?

2. If an unknown sucrose solution gave a rotation of 16.4° in the same experiment above, what is the % sucrose in the unknown? Remember to subtract the water measurement. How could the water measurement be eliminated?

3. If a small stream of liquid A was strongly deflected by a charged object, liquid B was moderately deflected, and liquid C was weakly deflected rank the liquids in order of polarity. (Assume densities and charges are all equal.)

4. If another liquid D was strongly deflected in question 3 but had a larger density than liquid A, which would have the greater polarity?

5. If another liquid E in question 3 and 4 above dissolved or mixed with liquid B and C but not with liquids A or D, how would you classify it's polarity?

6. What could you mix with liquids D and C above to get them to be miscible?
Unit 29 Polarimetry and Polar Liquids
Lab Report for Unit 29

<table>
<thead>
<tr>
<th>Name</th>
<th>Section</th>
<th>Date</th>
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Part 1: Polarimeter

<table>
<thead>
<tr>
<th>Deg. Water</th>
<th>Deg. 20%</th>
<th>Rot. 20%</th>
<th>Deg. UKN</th>
<th>Rot. UKN</th>
</tr>
</thead>
<tbody>
<tr>
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Part 2: Polar Liquids

Rank the following in degree of deflection and polarity by a charged item.
1=lowest deflection or polarity, 10=highest deflection or polarity

<table>
<thead>
<tr>
<th>Liquid</th>
<th>deflection</th>
<th>polarity</th>
<th>rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>methanol</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>hexane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>carbon tetrachloride</td>
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<td></td>
<td></td>
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<tr>
<td>Unknown</td>
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### Part 3: Solubility of Polar/Non-polar Substances

Determine the degree of miscibility for combination of the following using the following abbreviations:

- **M** = completely miscible
- **?** = partially miscible
- **X** = not miscible

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Methanol/ethanol</th>
<th>Propanol</th>
<th>Ethylene glycol</th>
<th>Hexane</th>
<th>CCl₄</th>
<th>Oil</th>
<th>Water</th>
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<tbody>
<tr>
<td>Methanol or ethanol</td>
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<td>Propanol</td>
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<td>Ethylene glycol</td>
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<td>Hexane</td>
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<tr>
<td>Carbon tetrachloride</td>
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<td>Organic oil</td>
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<td>Unknown</td>
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**Rank polarity using 1=lowest polarity**

<table>
<thead>
<tr>
<th>Water</th>
<th>Methanol or ethanol</th>
<th>Propanol</th>
<th>Ethylene glycol</th>
<th>Hexane</th>
<th>CCl₄</th>
<th>Oil</th>
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Unknown rank_______________________