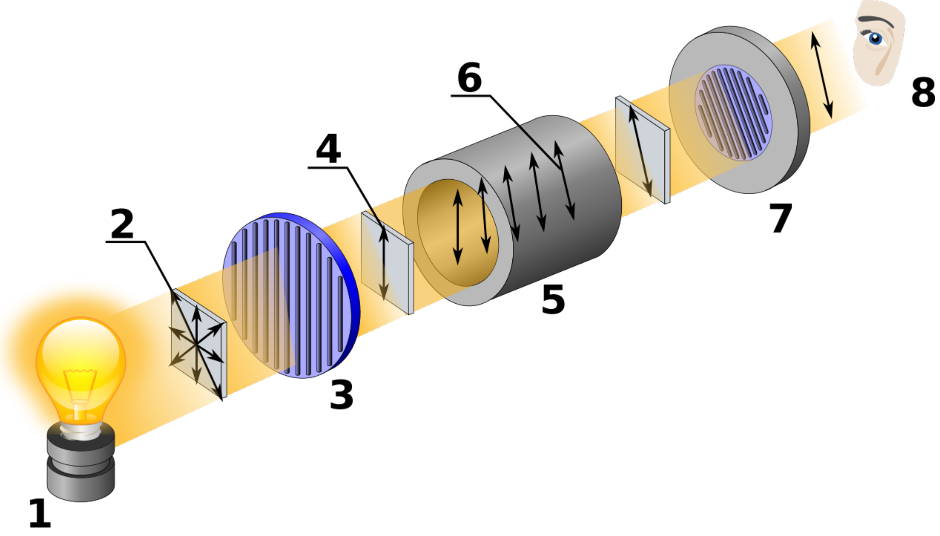
The specific rotation of sugar (sucrose)

When plane-polarized light is passed through an enantiomerically pure solution of chiral molecules[1] or a solution where there is an excess of one enantiomer as compared to the other the plane of polarization of the plane-polarized light changes. The schematic diagram below, downloaded from wikipedia.org,[2] demonstrates this process. Light is emitted from a lamp (1) is not polarized. The light (2) has electric and magnetic field vectors that exist in all possible planes. The polarizing filter (3) filters the light and removes all but one set of electric and magnetic field vectors (4). The polarized light passes through a solution of chiral molecules (5) and the plane of polarization is shifted (6). The degree to which the plane of polarization is shifted can be measured using a second polarizing filter (7).



The **observed rotation**, α, depends on the number of molecules that the polarized light interacts with, the inherent ability for the molecule to interact with polarized light, the wavelength of the light that is used, and the temperature at which the measurement is made. In practice, measurements are made using a specific frequency of light associated with light emitted from excited sodium atoms and typically reported for a given temperature, so those factors are kept constant across measurements. In other words, since the wavelength of light and the temperature are held constant, the observed rotation α depends on the concentration of the solution, the length of the sample tube, and the inherent ability for the molecule to interact with polarized light. A molecule's inherent ability to interact with polarized light is called its **specific rotation**, **$[\alpha]$**. Mathematically, the relationship between observed rotation, the specific rotation, the concentration: and the length of the cell can be written as

$$\alpha = l \; c \; [\alpha]$$

where l is the length of the cell holding the solution in decimeters and c is the concentration of the solution in g per mL of solution.

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[1] An enantiomerically pure solution is a solution that contains only one of the two possible enantiomers.

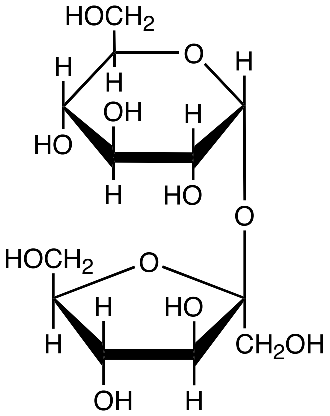
[2] https://en.wikipedia.org/wiki/Specific_rotation#/media/File:Polarimeter_(Optical_rotation).svg

Since chiral molecules can rotate the plane of polarization to the left or the right, the direction that the plane of plane-polarized light is rotated is indicated using a "+" for dextrorotatory rotations (rotations to the right or clockwise) and a "–" for levorotatory rotations (rotations to the left or counterclockwise).[3]

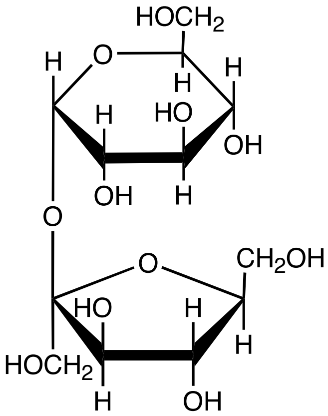
Because specific rotation depends on the temperature at which the measurement is made and the frequency of light used, when reporting specific rotation the frequency of light and the temperature are indicated immediately after the symbol for specific rotation. For example, the specific rotation for (*R*)-2-methyl-1-butanol using the D line from a sodium lamp (589 nm) at 20 °C is reported as follows:

$$[\alpha]^{20\ °\mathrm{C}}_{\mathrm{D}} = +5.75$$

In this activity, the specific rotation of a commonly available chiral molecule, sucrose, will be determined. Sucrose and its mirror image are pictured to the right, and clearly, sucrose's mirror image is not superimposable on the original. This is because sucrose is chiral.

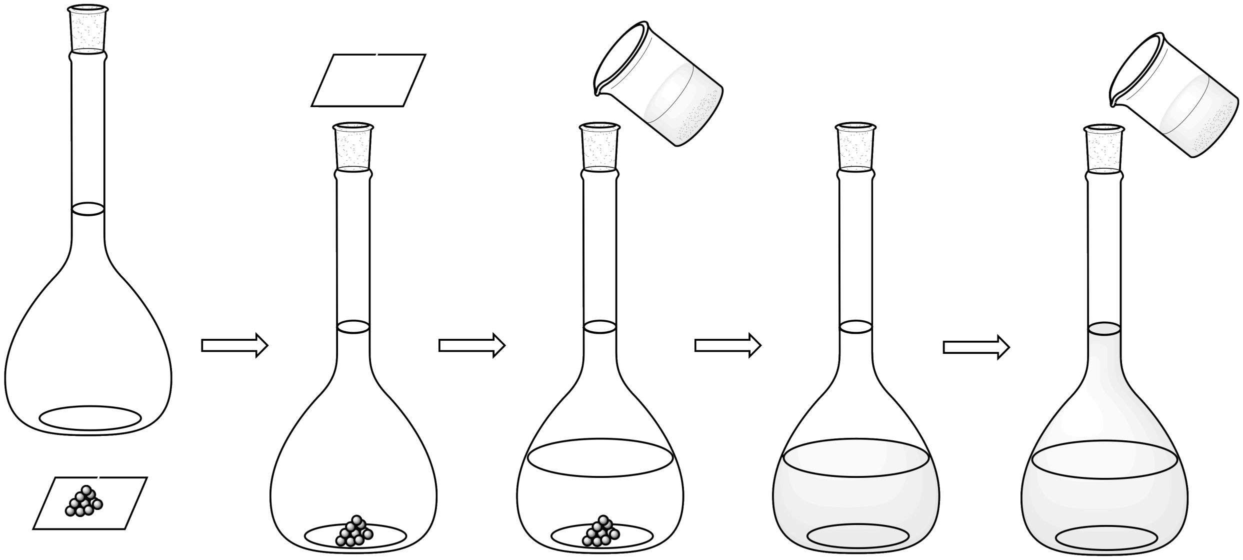


sucrose



sucrose's mirror image

The first step to measuring the specific rotation of sucrose is to make a solution with a known concentration. To make solutions with known concentrations volumetric flasks are used. The mass of solute is carefully measured on a balance, and the solute is transferred to the volumetric flask. Some solvent is added to the flask and the flask is agitated to dissolve the solute. Once the solute has dissolved the volumetric is filled with solvent until the level of the solution reaches the mark on the flask.



Using the provided volumetric flasks prepare an aqueous sucrose solution with a known concentration. Sucrose solutions with a concentration of 0.20 to 0.3 g/mL produce reasonable values for the observed rotation. More concentrated solutions can be made as the solubility of sucrose in water is 2.1 g/mL at 25 °C.[4] Of course, the more concentrated the solution the longer it takes to dissolve the solute.

Measure the observed rotation, **α**, for your solution and determine the specific rotation, **[α]**, of sucrose. Refer back to page 1 for the relationship between **α** and **[α]**.

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[4] https://pubchem.ncbi.nlm.nih.gov/compound/Sucrose#section=Solubility

Name ___________________________

List all the data (the volume of volumetric flask, the mass of sugar used, path length of the cell, and the observed rotation) that you used to determine the specific rotation of sucrose and describe how how made the sucrose solution.

The specific rotation of sucrose is ____________________________