5.8: The Polarimetry Experiment

In measuring optical rotation, plane-polarized light travels down a long tube containing the sample. If it is a liquid, the sample may be placed in the tube as a pure liquid (it is sometimes called a neat sample). Usually, the sample is dissolved in a solvent and the resulting solution is placed in the tube.

There are important factors affecting the outcome of the experiment.

- Optical rotation depends on the number of molecules encountered by the light during the experiment.
- Two factors can be controlled in the experiment and must be accounted for when comparing an experimental result to a reported value.

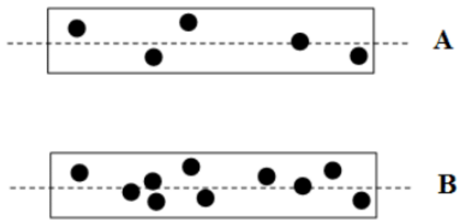

Figure 5.8.1: The effect of concentration on optical rotation.

- The more concentrated the sample (the more molecules per unit volume), the more molecules will be encountered.
- Concentrated solutions and neat samples will have higher optical rotations than dilute solutions.
- The value of the optical rotation must be corrected for concentration.

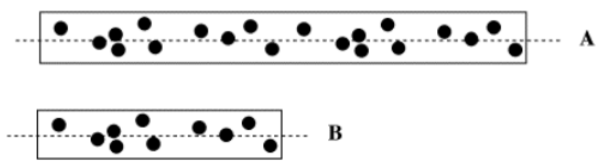

Figure 5.8.2: The effect of path length on optical rotation.

- The longer the path of light through a solution of molecules, the more molecules will be encountered by the light, and the greater the optical rotation.
- The value of the optical rotation must be corrected for the length of the cell used to hold the sample.

In summary:

$$[\alpha] = \frac{\alpha}{c \times l}$$

- a is the measured optical rotation.
- c is the sample concentration in grams per deciliter (1 dL = 10 mL).
- That is, c = m / V (m = mass in g, V = volume in dL).
- l is the cell length in decimeters (1 dm = 10 cm = 100 mm)
- The square brackets mean the optical rotation has been corrected for these variables.

Exercise 5.8.1

A pure sample of the naturally-occurring, chiral compound A (0.250 g) is dissolved in acetone (2.0 mL) and the solution is placed in a 0.5 dm cell. Three polarimetry readings are recorded with the sample: 0.775^o, 0.806^o, 0.682^o.

a) What is [a]?

b) What would be the [a] value of the opposite enantiomer?

Answer a:

$$[a] = \frac{a}{(c)(l)}$$

$$c = (\frac{0.250g}{2mL})(\frac{10mL}{1dL}) = 1.25\frac{g}{dL}$$

$$a = \frac{0.775^o + 0.806^o + 0.682^o}{3} = 0.754^o$$

$$[a] = \frac{a}{(c)(l)} = \frac{0.754^o}{(1.25\frac{g}{dL})(0.5dm)} = +1.21^o$$

Answer b:

-1.21^o

Exercise 5.8.2

A pure sample of the (+) enantiomer of compound B shows [a] = 32^o. What would be the observed a if a solution of the sample was made by dissolving 0.150 g in 1.0 mL of dichloromethane and was then placed in a 0.5 dm cell?

Answer

$$[a] = \frac{a}{(c)(l)}$$

$$[a] = 32^o$$

$$c = (\frac{0.150g}{1mL})(\frac{10mL}{1dL}) = 1.5\frac{g}{dL}$$

$$[a] = \frac{a}{(c)(l)} = 32^o = \frac{a}{(1.5\frac{g}{dL})(0.5dm}$$

Solve for a.

$$a = +24^o$$