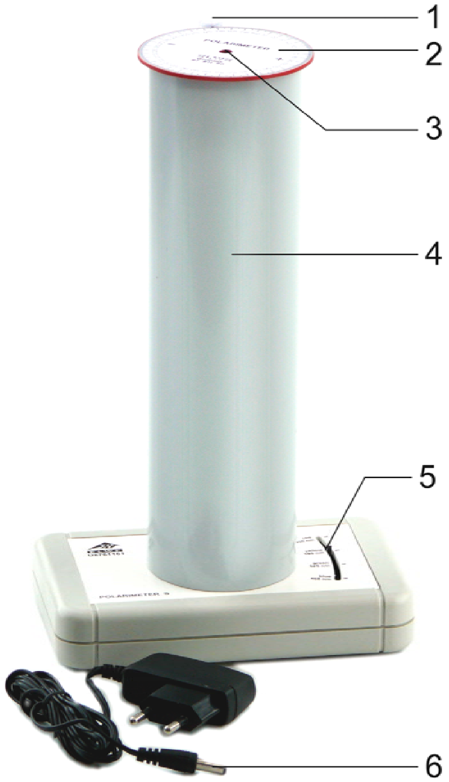
3B SCIENTIFIC® PHYSICS

Polarimeter with 4 LEDs U8761161

Instruction Sheet

06/08 THL/ALF



1 Fixed pointer
2 Analyser
3 Viewing hole
4 Measurement chamber with cylindrical sample cell and polariser
5 LED selector switch
6 Mains adapter

1. Safety instructions

- Do not look into the fully opened measurement chamber at the LEDs when they are brightly lit.
- Only use the instrument with the 12V DC mains adapter supplied.
- If there is any visible damage to the polarimeter or the mains adapter, the instrument must not be used.

2. Description

The polarimeter with 4 LEDs is used for determining the angle and direction of rotation of polarised light transmitted by an optically active substance, and measuring its dependence on the wavelength, sample thickness and sample concentration.

The instrument is illuminated by a system consisting of four monochromatic light-emitting diodes (LEDs). The light emitted from the active LED undergoes linear polarisation by a polariser placed below the entry window of the cylindrical sample cell in the measurement chamber.

The analyser contains a second polarising filter with its polarisation axis at a variable angle to that of the polariser. The angle is 90° when the rotating scale is set to 0° (= 360°). In this position, if there is no optically active substance in the measurement chamber, the transmitted light intensity will be at a minimum.

If an optically active substance is then put into the sample cell, it rotates the plane of polarisation either clockwise or anti-clockwise, causing an increase in the transmitted light intensity (brightness). By re-positioning the analyser, the light intensity can be brought back to its minimum. The angle that is then read off below the fixed pointer is the angle through which the plane of polarisation has been rotated by the sample.

3. Equipment supplied

1 Polarimeter basic instrument

1 Analyser disc

1 Sample cell

1 Mains adapter

1 US mains adapter (only with U8761161-115)

4. Technical data

Wavelengths:	630 nm (red) 580 nm (yellow) 525 nm (green) 468 nm (blue)
Dimensions:	110×190×320 mm^3 approx.
Weight:	1 kg approx.

The polarimeter U8761161-230 is designed for a mains voltage of 230 V (±10 %), whereas U8761161-115 is for 115 V (±10 %).

5. Operation

- Lift the analyser disc from the measurement chamber.
- Take out the cylindrical sample cell and fill it with the liquid sample. It is important to carefully wipe the cell dry, ensuring that no liquid remains on the outside surface.
- Place the sample cell in the measurement chamber, taking care that no liquid is allowed to spill and escape into other parts of the measurement chamber.
- Replace the analyser disc and rotate it so that the pointer is at the 360° position.
- Connect the mains adapter and supply power to the instrument.
- Set the LED selector switch to give the desired wavelength of light.

To measure the angle of rotation of the plane of polarisation transmitted via the optically active sample, look at the spot of light through the viewing hole and rotate the disc so that the brightness is reduced. Adjust it carefully to find the position where the brightness is at a minimum and read the pointer.

A substance that rotates the plane of polarisation of light in the clockwise direction is described as dextro-rotatory. The optical activity of such substances is indicated by the sign (+). The difference between the 360° mark and the angle that one reads on the scale corresponds to the angle by which the plane of polarisation has been rotated.

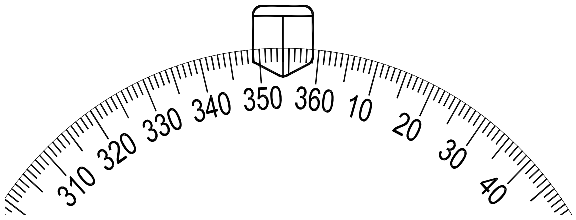


Fig.1 Example of a scale reading for a dextro-rotatory substance (+6°)

A substance that rotates the plane of polarisation of light in the anti-clockwise direction is described as laevo-rotatory. The optical activity of such substances is indicated by the sign (-). For a laevo-rotatory substance the angle of rotation can be read directly off the scale.

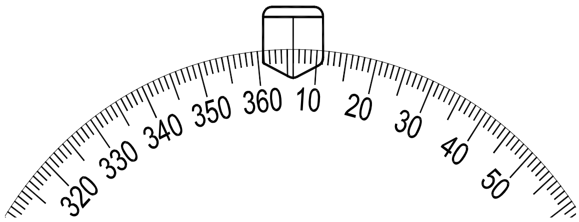


Fig.2 Example of a scale reading for a laevo-rotatory substance (-6°)

6. Sample experiments

6.1 Measure the optical activity of a saccharose solution as a function of the concentration, the sample thickness, and the colour of the light

- Prepare a sugar solution (10 g in 100 ml), by weighing out 10 g of ordinary sugar, dissolving it in about 60 cm^3 of distilled water, and making the volume up to 100 cm^3 in the cylindrical sample cell.

- Measure the sample thickness and place the sample cell in the measurement chamber.

Note:

100 ml of liquid in the sample cell corresponds to a sample thickness of 1.9 dm, 75 ml to 1.43 dm, 50 ml to 0.96 dm, and 25 ml to 0.44 dm.

- Measure the angle of rotation for each of the different LEDs.
- In the next step, keep the concentration the same but reduce the sample thickness to 1.43 dm (75 ml) and repeat the measurement.
- Make further measurements with sample thicknesses of 0.96 dm (50 ml) and 0.44 dm (25 ml).
- Finally, prepare sugar solutions of higher concentrations (20 g, 30 g and 40 g in 100 ml) and measure the angles of rotation in the same way as in the first series.
- Set out the results in a table and plot graphs of the angle of rotation as a function of concentration and sample thickness for each light colour.

6.2 Determine the specific rotation of saccharose

The specific rotation $[\alpha]$ is a constant for any given substance, and for a given light wavelength λ and temperature T it is defined by the equation:

$$[\alpha]_{\lambda}^{T} = \frac{\alpha}{c \cdot l} \qquad (1)$$

α = observed angle of rotation

c = concentration of the dissolved substance

l = thickness of the sample solution.

Values given in the literature are usually those for the yellow D line of sodium (λ = 589 nm) at a temperature of 20 °C.

- Prepare the sugar solution (50 g in 100 ml), by weighing out 50 g of sugar, dissolving it in about 60 cm^3 of distilled water, and making the volume up to 100 cm^3 in the cylindrical sample cell.
- Measure the sample thickness and place the sample cell in the measurement chamber.
- Measure the angle of rotation with yellow light.
- Calculate the specific rotation using Equation 1 and compare it with the quoted value.

Quoted values $[\alpha]_D^{20}$ for specific rotation:

Saccharose +66.5°

D-glucose +52.7°

D-fructose -92.4°

(Values from Aebi, *Einführung in die praktische Biochemie [Introduction to Practical Biochemistry]*, Karger 1982.)

6.3 Inversion of saccharose

Acids cause saccharose to split into D-glucose and D-fructose, releasing the two components in equal quantities. During this process the dextro-rotation is steadily reduced until finally the angle of rotation becomes negative (anti-clockwise). This phenomenon is called inversion. The resulting glucose/fructose mixture is therefore called invert sugar, and is a constituent of some food products, such as synthetic honey.

- Start to prepare a sugar solution (30 g in 100 ml), by first weighing out 30 g of sugar and dissolving it in about 60 cm^3 of distilled water (50° C).
- Carefully (wearing safety goggles) add 15 ml of 25% hydrochloric acid.
- Make up the volume to 100 cm^3 in the sample cell and place it in the measurement chamber.
- Immediately start a stop-watch and measure the angle of rotation.
- Repeat the measurement of the angle of rotation at intervals of 5 minutes and compile all the results in a table.
- After 30 minutes, bring your series of measurements to an end and plot the inversion curve.

6.4 Measure the concentration of a substance of known specific rotation - example: cane sugar in cola

- Fill the sample cell with 100 ml of cola.
- Using the yellow LED, determine the angle of rotation and its direction.
- Calculate the sugar content using the following equation obtained by rearrangement of Equation 1:

$$c = \frac{\alpha}{[\alpha] \cdot l} \left[\frac{g}{cm^3} \right]$$

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