Experiment

Q1-1

English (Official)

Determination of Refractive Index of Highly Concentrated Solutions of NaCl and Glycerin using Total Internal Reflection (TIR) (14 points)

Please read the general instructions in the separate envelope before you start this experiment.

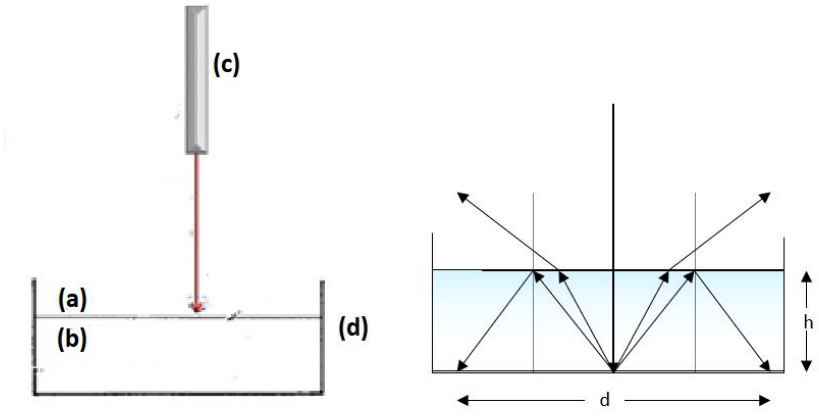
Dependence of Refractive Index of a Solution on Concentration

Introduction:

Basic Principle: When a beam of light is incident on a surface, reflection and refraction take place. When the surface is uneven (rough), these phenomena result in scattering light in all directions. If the surface is that of a transparent medium, then most of the light is transmitted (refracted) and a small portion of it is reflected. If the surface is opaque and polished (like a metallic surface), all the light is reflected.

In this experiment, the green laser light is shone normally into the water inside a container. The container used has vertical walls. The laser beam first meets the smooth top water surface then it gets scattered from the rough bottom surface of container while producing a bright green spot on the bottom surface. This scattered light travels back into the water in all directions. This light again meets the top smooth surface of water and undergoes reflection, refraction and another phenomenon called total internal reflection (**see Figure 1**).

The scattered rays that reach the top surface of the water at an angle greater than the critical angle, get totally internally reflected which results in a bright ring enclosing a dark region.



(a) Air (b) Liquid (c) Laser Pointer (d) Container with Liquid

Figure1: (*Left*) Arrangement to observe the phenomenon. (*Right*) The ray diagram.

From the definition of refractive index and critical angle we have:

$$\mu = \frac{1}{Sin\,(\theta_C)} = \frac{\sqrt{(\frac{d}{4})^2 + (h)^2}}{\frac{d}{4}} = \frac{\sqrt{(d)^2 + 16 \times (h)^2}}{d} \quad ---(1)$$

Where **μ** is the refractive index (RI) of liquid, ***d*** is the diameter of the dark disc and **h** is the height/depth of liquid. This formula can be applied to any transparent liquid medium.

From equation-(1)

$$(d)^2 \times (\mu)^2 = (d)^2 + 16 \times \frac{(V)^2}{(A)^2}$$

Where, **A** is the effective area of the horizontal cross-section of the container and **V** is the volume. $h = \frac{V}{A}$

The diameter (d) as a function of refractive index and area of the container (**A**) is

$$d = \frac{4}{A \times \sqrt{\mu^2 - 1}} \times V = S \times V \quad ----------(2)$$

The diameter is proportional to volume and S is the proportionality constant given by

$$S = \frac{4}{A \times \sqrt{\mu^2 - 1}} \quad ----------(3)$$

Using a liquid whose refractive index we know , we can calculate **A.** The effective area of the horizontal cross-section of the container is given by

$$A = \frac{4}{S \times \sqrt{\mu^2 - 1}} \quad ----------(4)$$

The present experiment is to determine the refractive indices of salt and Glycerin solutions at certain high concentrations, using the refractive index of water (1.33).

Percent Concentration of Solutions:

Percent concentration **volume per volume** (V/V) is defined as the volume of solute in ml in 100 milliliters of solution. Hence 50% solution of any solute is 50 ml of solute in 100 ml of solution).

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Q1-3

English (Official)

Aim:

1. **Determination of refractive index of 30% NaCl solution and Glycerin.**
2. **Determine the dependence of RI on the concentration of Glycerin water solution.**

Equipments: You are supplied with the following equipment for this experiment:

Sr. No.	Item	Specifications	Quantity
01	Green LASER Pointer	Wavelength-532 nm	1 no + 1 spare
02	Burette stand	As shown in final assembly	1 no
03	Beaker	500 ml	3 no
04	Syringe	50 ml	1 no
05	Digital thermometer	To measure Room Temp	1 no
06	Glass stirrer	For making solutions	1 no
07	Container	As shown	1 no
08	Sodium Chloride (NaCl) Solution	30 % from AR grade salt	500 ml
09	Glycerin	AR grade	500 ml
10	Distilled water	Solution + washing	5000 ml
11	Tissue paper		
12	Safety goggle	Polaroid	1 no
13	Divider	Screw adjustable	1 no
14	Steel scale (ruler – optional)	0.5 mm Least Count	1 no
15	Reading lens	High quality	1 no

Warning :

Avoid direct eye exposure and through reflections.

Avoid staring at the laser spot for too long, advise to turn off the laser when it's not used for performing measurements

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Q1-4

English (Official)

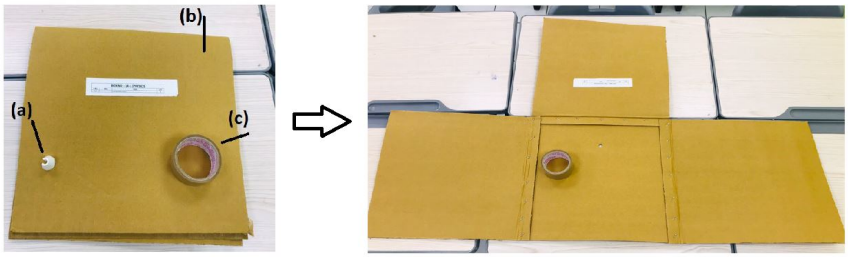
The Experiment

Part-0 Measurement of the room temperature (0.2 points)

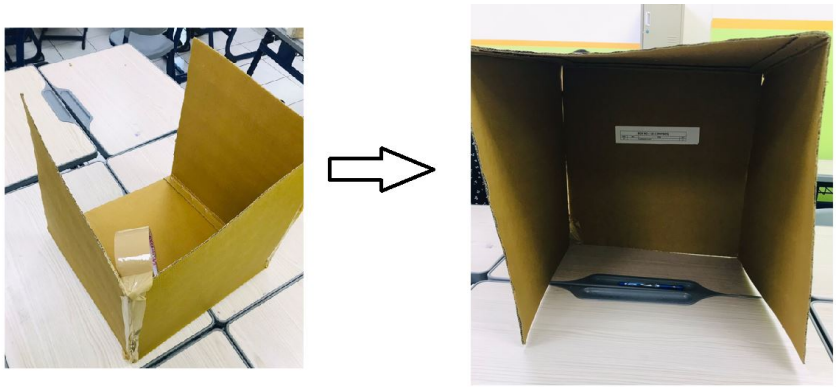
A.0 Measure the room temperature using the thermometer provided and record your reading in the answer sheet. (0.2pt)
(Get the supervisor's sign after taking this reading)

Steps for setting up the equipment .

Step-1: Making a cardboard box.



(a) Cardboard Holder (b) Cardboard Box (c) Tape



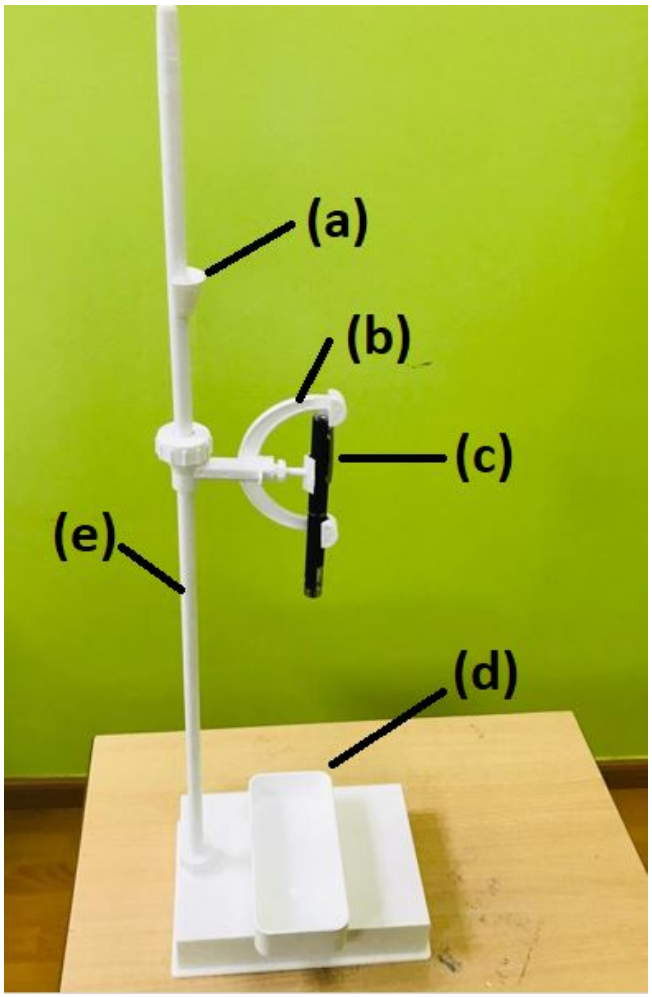
Wear your safety googles all the time. If you are already wearing spectacles, wear the safety googles above that. Do not look directly into the laser light.

Switch off the laser light when you are not taking the readings.

Glycerin should be kept covered when not in use.

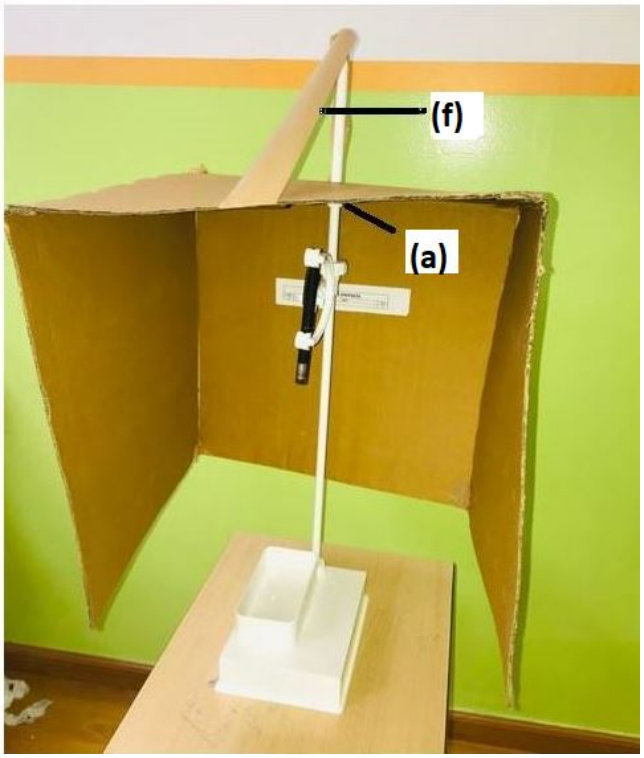
Part 1. Calculation of effective area of cross section (A) of the container using distilled water (3.6 points)

Step-2: Attaching the Green LASER Pointer on the burette stand.
The laser pointer should be vertical .



(a) Cardboard Holder (b) Fisher Clamp (c) Laser (d) Opaque Rectangular container(TIR Container) (e) Stand Rod

Step-3: Attaching the cardboard box on the burette stand.



(a) Cardboard Holder (f) Tape for support

Procedure for Observation:

Apparatus set up:

Clamp the laser light in the burette stand in such a way that the switch is pressed by the middle grip of the stand. (When it is to be switched off, simply rotate the laser around the vertical axis so that the pressure on the switch is released. When it is to be switched on, rotate it back to the original position).

Make sure that the base of the stand on which the container is placed is horizontal.

Switch off the laser light when you are not taking reading.

Place the container below the light so that the laser beam falls on the bottom of the container.

(i) **Add 50 ml of distilled water** into the container. Switch on the laser, a bright ring with a dark disc inside becomes immediately visible.

A.1	(ii) **Using the divider and ruler provided, measure the diameter of the dark disc**. Use the reading lens for better observation of the disc diameter. Record your readings in the **Table 1** of the answer sheet. (iii) **Repeat steps (i) and (ii)** by adding water in steps of 50 ml to **obtain six readings**.	(1.2pt)

A.2	(iv) **Plot a graph on the given graph sheet (Graph 1 - plot 1)** with diameter of the dark disc (d) on the vertical axis and the volume *(V)* of water on the horizontal axis using the given graph page in the answer sheet. **Note : (o,o) will be an additional data point to be plotted on the graph** **(The total number of points to be plotted is 7)** **while plotting use symbol** **(.) dot = water** **For marking the points on the graph**	(1.8pt)

A.3	(v) **Calculate the slope from the graph** (S = d/V)	(0.2pt)

A.4	(vi) **Calculate the effective area (A)** of cross-section of the container from the slope and equation (4)	(0.4pt)

Part 2: Determination of Refractive index of 30% NaCl Solution (3.4 points)

You are supplied 500ml of 30% NaCl Solution.

(i) Clean the container dry it by dabbing it with tissue paper.

B.1	(ii) Using the salt solution with fixed concentration, follow the steps (i) to (iii) of **Part 1**. Enter your readings in **Table 2** of your answer sheet.	(1.2pt)
B.2	(iii) **Plot a graph on the same graph sheet** in the answer sheet **(Graph 1 - plot 2)** overlapping graph plotted in Part 1) with diameter on the vertical axis and volume on the horizontal axis. Label the points for distinction. **Note : (o,o) will be an additional data point to be plotted on the graph** **(The total number of points to be plotted is 7)** **while plotting use symbol** **(+) plus = NaCl solution** **For marking the points on the graph**	(1.6pt)
B.3	(iv) **Calculate the slope from the graph**	(0.2pt)
B.4	(v) **Calculate the refractive index** of 30% NaCl solution from the slope and the value of **A** calculated in **Part 1**.	(0.4pt)

Part 3-A: Determination of refractive index of Glycerin (3.4 points)

You are supplied with 500 ml of Glycerin.

(i) Clean the container and dry it by dabbing it with tissue paper.

C-1.1	(ii) Using the pure glycerin provided **follow the steps (i) to (iii) of Part 1**. Enter your readings in **Table 3a** of your answer sheet.	(1.2pt)

C-1.2	(iii) **Plot a graph on the same graph sheet** in the answer sheet **(Graph 1 - plot 3)** overlapping graph plotted in Part 1 and 2) with diameter on the vertical axis and volume on the horizontal axis. Label the points for distinction. **Note : (o,o) will be an additional data point to be plotted on the graph** **(The total number of points to be plotted is 7)** **while plotting use symbol** **(*) star = Glycerin** **For marking the points on the graph**	(1.6pt)

(iv) **Do not disturb this solution at this point as it is required for part 3B of this experiment.**

C-1.3	(v) **Calculate the slope from the graph.**	(0.2pt)

C-1.4	(vi) **Calculate the refractive index of glycerin from the slope calculated in this part of experiment and the value of A already calculated in Part 1 of this experiment.**	(0.4pt)

Part 3B: Relation between Refractive index and concentration of Glycerin solution. (3.4 points)

Glycerin is miscible with water in all proportions; however, it takes thorough stirring to obtain a homogeneous mixture. In this part you will be measuring the refractive index of different concentrations of aqueous solutions of Glycerin.

(i) Using the syringe provided, remove 150 ml of Glycerin from the container, so the remaining amount of glycerin is 150 ml in the container.

C-2.1 (ii) Measure d and enter values of volume and diameter in Table 3b in the answer sheet**.** (1.6pt)
(iii) Now add 50 ml of water to the container, stir the mixture gently and thoroughly to make
a homogeneous solution.
(iv) Calculate the new concentration of the solution.
(v) Measure the diameter of the ring and record values of volume, diameter and concentration in Table 3b in the answer sheet.
(vi) Repeat steps (iii) to (v) for two more dilutions.

Calculate the values of S and Refractive Indices of the solutions and enter the values in the Table 3b in the answer sheet.

C-2.2 (vii) **Plot the values refractive index on the vertical axis against the concentration on the horizontal axis (graph -2)** in the answer sheet. (1.4pt)
Note : (o,1.33) will be an additional data point to be plotted on the graph . (The total number of points to be plotted is 5)

At this stage you have measured the refractive indices of 30 % NaCl solution and glycerin. You have also determined the relation between concentration and refractive index for glycerin solutions.

Answer the following questions in the answer sheet by choosing correct option:

C-2.3 **How does the refractive index change with the concentration of glycerin solutions?** (0.2pt)
a. Increases with concentration
b. Decreases with concentration
c. Does not change with concentration

C-2.4 **How would you expect the refractive index of NaCl solution to change with concentration?** (0.2pt)
a. Expected to increase with concentration
b. Expected to decreases with concentration
c. Expected not to change with concentration