Ultrasonic wave-velocity in Benzene and Water

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Ultrasonic interferometer

- The liquid is confined between a quartz crystal (placed at the bottom) and a movable metallic reflector (placed at the top). Ultrasonic waves of known frequency are produced by the quartz crystal, and form standing waves in the liquid when the crystal-reflector separation is an integral multiple of $\frac{\lambda}{2}$
- Acoustic resonance translates the standing waves into a current peak.

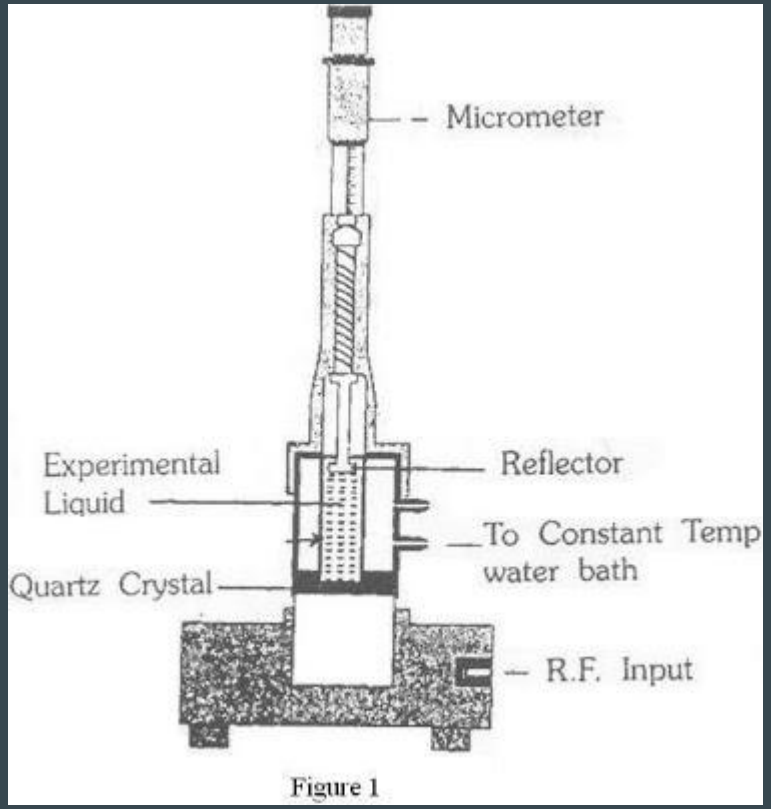

Figure 1

Procedure

- Confine Benzene / Water in the cell and turn on the quartz crystal to produce ultrasound. In this experiment, we use 2 MHz ultrasonic waves.
- Vary the column length using the micrometer gauge that is part of the cell to observe maxima in current.
- Note down the screw-gauge readings at which maximum current is observed.
- Plot the screw-gauge reading as a function of the order ‘n’. The slope should give $\frac{\lambda}{2}$

Data

Data :

i) Benzene -

n	Screw gauge reading at max current (mm)
1	5.10
2	5.40
3	5.75
4	6.05
5	6.40
6	6.75
7	7.05

SBanerjee
11/02/2019

ii) Water -

n	Screw gauge reading at max current (mm)
1	5.38
2	5.78
3	6.15
4	6.53
5	6.92
6	7.28
7	7.65

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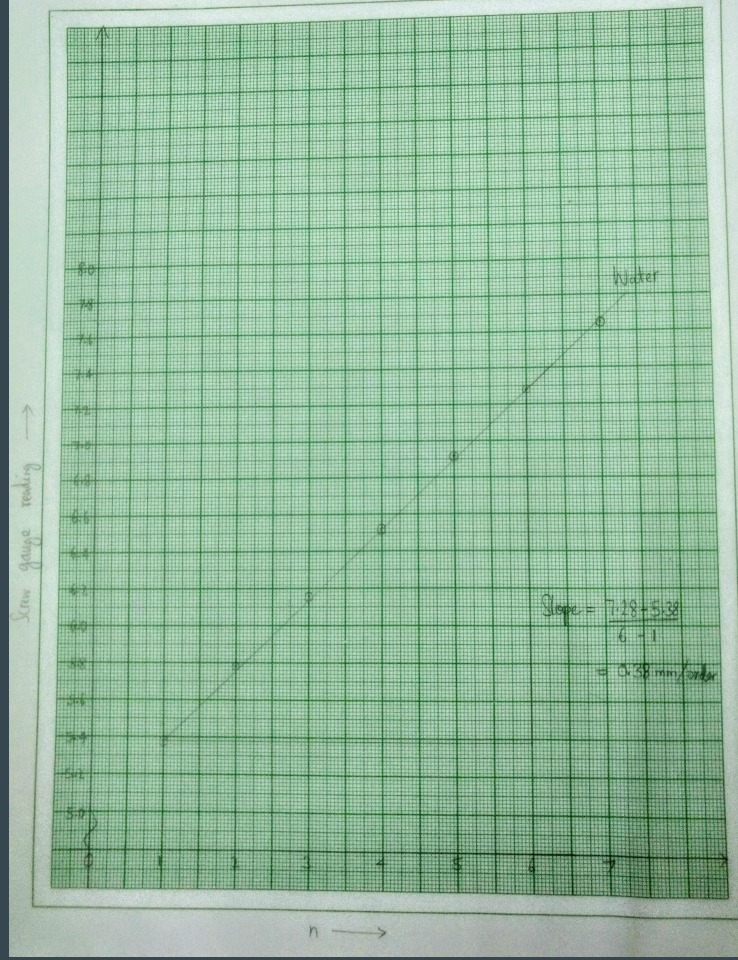
14/02/2019

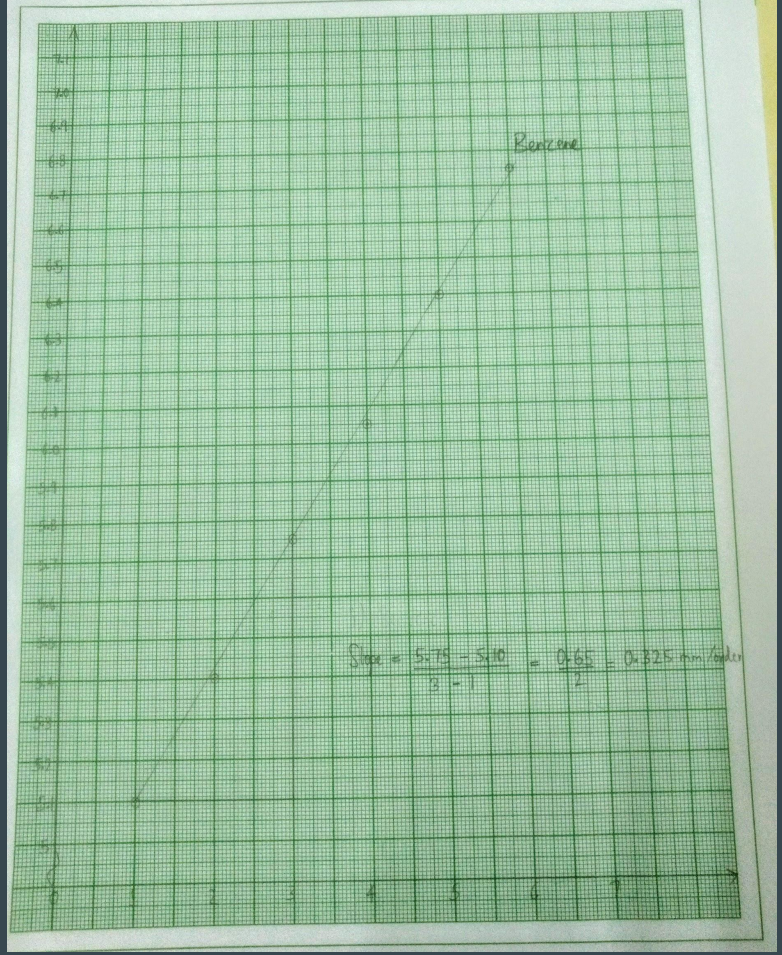
5A) Water

Scale : x : 1 unit = 1 order
y : 1 unit = 0.1 mm



5A) Benzene

Scale : x : 1 unit = 1 order
y : 1 unit = 0.1 mm.



Interpretations and Results

- A good linear relationship is observed between the screw-gauge reading and standing wave order ‘n’

$$\lambda_{benzene} = 0.650\,mm \qquad \lambda_{water} = 0.760\,mm$$

- For 2 MHz ultrasound, this corresponds to velocities of 1300 m/s in Benzene and 1520 m/s in Water.
- Error in velocity is found to be less than 0.2%. This shows that the interferometer can be used to determine ultrasonic wave-velocity with a high degree of accuracy.

Latent heat of vaporization of Liquid Nitrogen

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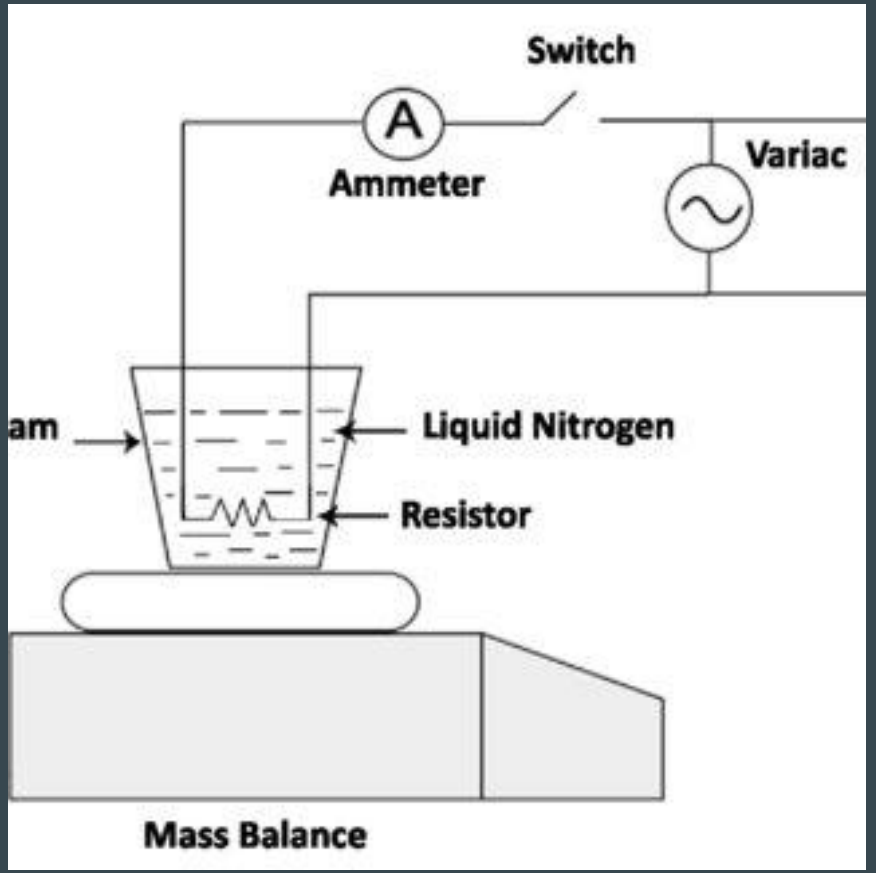
Basic Theory

$$Q = mL = IVt$$

- When the heater is off, the liquid nitrogen bulk is assumed to be in thermal equilibrium with the environment, at its boiling point.
- When the heater is switched on, the heat produced is absorbed as latent heat for vaporization.

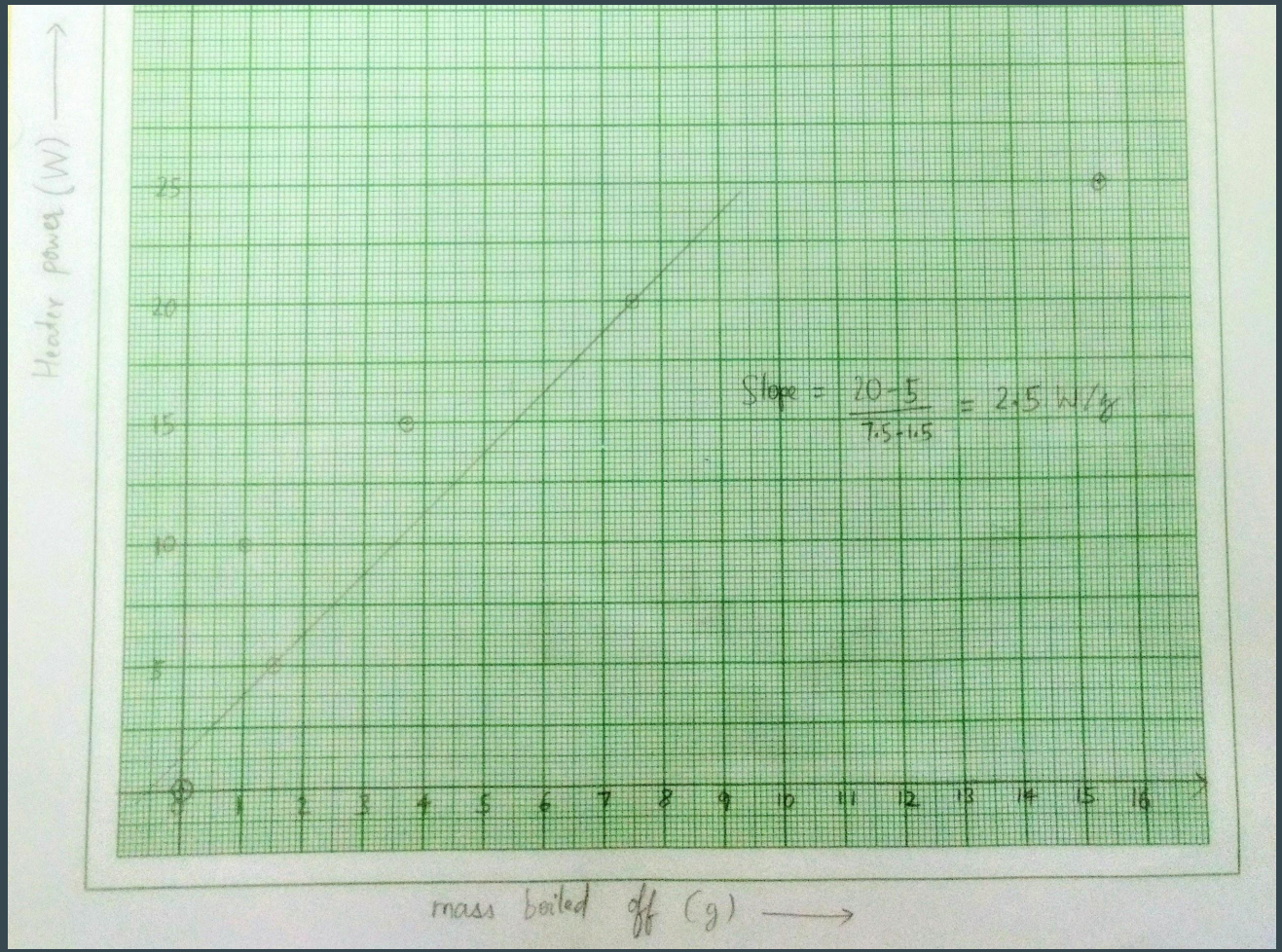


Procedure

- Liquid Nitrogen is poured into an insulating polystyrene box. The heater current is fixed at 0.5 A.
- The voltage across the heating device is varied from 10 V to 50 V in steps of 10 V.
- For each voltage, we take four readings corresponding to four 60 s intervals. For example - Say for 10 V. In the first 60 s, we measure the mass boiled off with the heater on, next 60 s with the heater off, next 60 s with the heater on, and again for 60 s with the heater off. Then move to 20 V and repeat.
- Interpret the above data to obtain a table between the heater power (IV) and the mass boiled off due to latent heat.

Data

V (V)	Mass boiled off (g) using Latent Heat	P = IV (Watts)
10	1.5	5
20	1.0	10
30	3.7	15
40	7.5	20
50	15.5	25


Heater power (W) ⟶
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Slope = 20-5 / 7.5-1.5 = 2.5 W/g
mass boiled off (g) ⟶

Interpretations and Results

- In a restricted domain, the graph is linear. The slope of the graph gives (L/t) and hence L. We find that L = 35.85 cal/g as compared to an established value of 40 cal/g. The percentage error is found out to be 2.6% $\Rightarrow$ L = (35.85 ± 0.93) cal/g.

- The graph is concave if we consider the entire domain on the x axis (boiled mass). A possible interpretation is the following - As the vapour pressure inside the box increases, the boiling point of liquid nitrogen increases, decreasing the latent heat of vaporization (which is proportional to the slope at each point of our Power vs boiled mass curve)., Hence we expect the slope to decrease since data is taken over a period of 20 mins.

Thank You