Experiment Name:

To determine the specific heat of a liquid by the method of cooling.

Objective:

The main objective of this lab is to determine the specific heat of a liquid by the method of cooling.

Prelab:

Student should read the lab manual and have clear idea about the objective, time frame and outcomes of the lab.

Outcomes:

After completing this lab work student will be able to answer the following questions:

- What do you mean by the statement specific heat capacity?
- Define specific heat capacity a substance. How do you measure the specific heat capacity of a liquid using the method of cooling?
- On what principal Newton's law of cooling depends?
- Explanation of the theory for determining the specific heat of a liquid by the method of cooling.
- What is the principle of calorimetry?

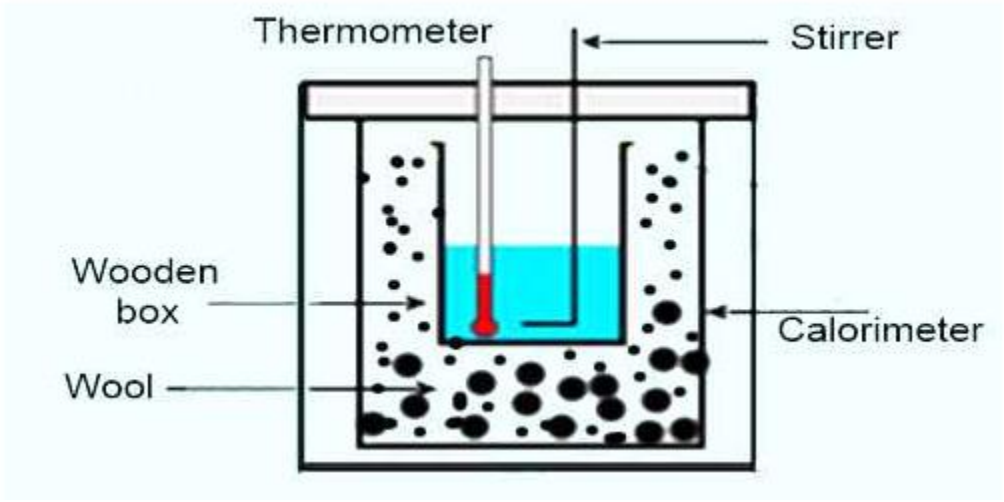
Timing and Length of Investigation (Total 3 Hours):

- **Lab Preparation (15 minutes):**
  - Students will sit for the lab class with preparations and class attendance will be taken.
- **Lecture on Theory (30 minutes):**
  - Teacher will clarify the objective and theory of the experiment.
- **Lecture on Procedure (15 minutes):**
  - Students will learn about the procedure of the experiment through a video lecture.
- **Experimental Work (90 to 100 minutes):**
  - A sample data will be provided to students and teacher will clarify every part of it.
  - Students will do all the calculations and complete the result part.
- **Post Lab Discussion (15 to 20 minutes):**
  - Teacher will summarize the total lab work and have a discussion with the students related with the questions given in the outcomes part.
- **Report Submission:**
  - After completing the lab reports students will upload their lab reports as groups in teams in the same day.

Theory:

The amount of heat, needed to increase the temperature of unit mass of a material by 1°C is called the specific heat of that material. It is denoted by S.

In the same environment, rate of change of cooling of an object is directly proportional to the difference of temperature between the object and the surrounding. This is the theory of cooling method. Difference of temperature of the object and the surrounding must be small. When a liquid is heated of higher temperature and placed to cool. Then the rate of heat lost by a temperature of the liquid is directly proportional to the difference in temperature of the surrounding.



Suppose the mass of the calorimeter along with the stirrer = m kg

Mass of the experimental liquid in the calorimeter = M_1 kg

Specific heat of the liquid = S_1 J $kg^{-1}K^{-1}$

Time taken to cool the liquid from temperature- θ_1^0 to θ_2^0 = t_1 sec

Mass of water having volume equal to that of the liquid = M_2 kg

Specific heat of water = S_2 J kg^{-1} K^{-1}

Time taken to cool water from temperatures, θ_1^0 to θ_2^0 = t_2 sec

So, rate of cooling of the liquid = $[(M_1S_1 + mS)(\theta_1 - \theta_2)] / t_1$ Js^{-1}

and rate of cooling of water = $[(M_2S_2 + mS)(\theta_1 - \theta_2)] / t_2$ Js^{-1}

According to Newton's law of cooling, rate of cooling in these two cases is equal.

so, $[(M_1S_1 + mS)(\theta_1 - \theta_2)] / t_1$ Js^{-1} = $[(M_2S_2 + mS)(\theta_1 - \theta_2)] / t_2$ Js^{-1}

or, $[(M_1S_1 + mS)(\theta_1 - \theta_2)] / t_1 = [(M_2S_2 + mS)(\theta_1 - \theta_2)] / t_2$

$$S_1 = \frac{M_2S_2t_1 + mS(t_1 - t_2)}{M_1}$$

Apparatus: (1) a calorimeter with a stirrer, (2) a chamber having two walls, (3) a sensitive thermometer, (4) balance, (5) burner, (6) stop-watch etc.

Procedure:

(1) Weight is taken of a clean and dry calorimeter along with its stirrer.

(2) Then water is heated in another container between temperature of 70°C to 75°C and that water is poured in the calorimeter up to a fixed mark. This calorimeter is placed in a two-walled chamber.

(3) Water is stirred slowly and slowly by a stirrer and temperature of water is recorded in 1°C interval. As the temperature of water is more than room temperature, so temperature of water gradually decreases. In this way 20 to 25 readings of temperature are recorded and then weight of the calorimeter along with water is taken. From the difference of subtraction of these two readings weight of water is found out.

(4) Now water is thrown away from the calorimeter and it is cleaned and dried. Then experimental heated liquid from 70°C to 75°C is poured in the calorimeter up to the previous mark. The calorimeter along with the liquid is placed inside chamber.

(5) Then the liquid is stirred slowly and following procedure (3) temperature is recorded in each degree interval of temperature. In this way 20-25 readings are taken. Afterwards calorimeter with liquid is taken. From the difference of weights of 3rd and the first one weight of the liquid is found out.

Experimental Data Table:

Table: Time - Temperature record.

No. of. observations	Time (min)	Temperature (^{0}C)	
		Water	**Liquid**
1.			
2.			
3.			
4.			
5.			
6.			
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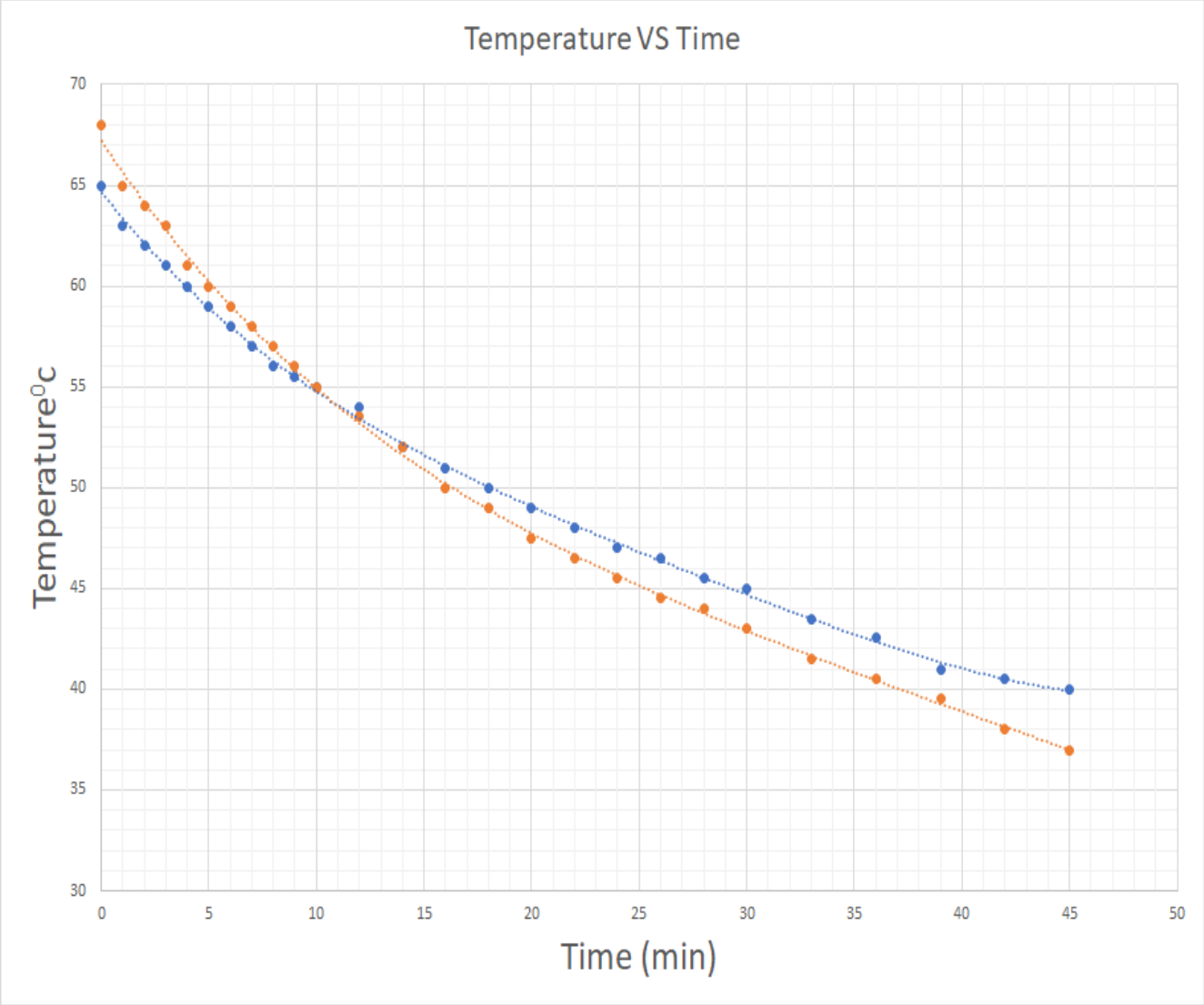

Observation and Manipulation:

Mass of the calorimeter + stirrer, m = 67.4 gm

Sp. heat of the material of the calorimeter, s = 0.0909 cal /gm- ^{0}C

Mass of the calorimeter + stirrer +water, m_2 = 152.2 gm

Mass of the water, $M_2 = m_2 - m$ = 84.8 gm

Mass of the calorimeter + stirrer +liquid, m_1 = 150.5 gm

Mass of the liquid, $M_1 = m_1 - m$ = 83.1- gm

Calculation:

$$S_1 = \frac{M_2 S_2 t_1 + ms(t_1 - t_2)}{M_1 t_2}$$ ---------- cal/g -^oC

Result:

Specific heat of given liquid = ---------- cal/g -^oC

Precautions:

(1) Calorimeter should be clean and dry.

(2) Weight should be accurate.

(3) Temperature should be measured accurately.

(4) Measurement of time should be accurate.

Discussions:

(1) If the calorimeter is not clean and dry, its weight is not accurate, and readings of temperature and time are not accurate, then experimental accurate.

(2) If equal volumes of water and liquid are not taken then error will appear in the result.

(3) Bottom of the calorimeter is to be made black. As a result, heat radiation capacity increases.

(4) No volatile liquid is to be taken.

Oral questions:

1. State Newton's law of cooling and express this law mathematically.
2. Does the Newton’s law of cooling hold good for all temperature differences?
3. How is Newton's law of cooling different from Stefan's law of heat radiation?
4. What is the shape of cooling curve?
5. Find the specific heat of a solid/liquid using Newton's law of cooling apparatus.