Name **Section #**

Latent Heat of Vaporization, H_V

Introduction

Water and steam are at equilibrium at 100°C yet energy is required to transform or vaporize the hot water into steam. (Energy is released when the steam condenses into hot water.) In the case for water the latent heat of vaporization, H_v is equal to 2260 kJ/kg.

You will add a mass, m of steam at 100°C from a dry steam line to a mass, M of cold water (T_i at approximately15°C) until the final temperature T of the mixture is about 40°C. By determining M, m, ΔT_M (the water's temperature change), and ΔT_m (the condensed steam's temperature change), you will be able to calculate an experimental value for water's heat of vaporization and then compare it to the accepted value for H_v listed above.

Theory

ΔQ_M represent the heat gained by the cold water in warming up $\Delta Q_M = c_w M \Delta T_M$, $c_w = 4.186$ kJ/kg, and $\Delta T_M = (T - T_i)$;
ΔQ_c is the heat change of the steam in condensing, $\Delta Q_c = m(-H_v)$, the minus sign is because heat is lost; and
ΔQ_m is the heat change of the condensed steam (now water) cooling down from 100°C to the equilibrium temperature T, $\Delta Q_m = c_w m \Delta T_m$, and $\Delta T_m = (T - 100°\text{C})$ which is negative.
By conservation of energy all these gains should total to zero, $\Delta Q_M + \Delta Q_c + \Delta Q_m = 0$ so that, $-\Delta Q_c (= -m(-H_v)) = \Delta Q_M + \Delta Q_m$.

Rearranging the terms we obtain, $H_v = \dfrac{\Delta Q_M + \Delta Q_m}{m}$

Procedure

- Determine the mass of an empty cup then pour in cold water until the cup is ¾ full, remeasure the mass and subtract the mass of the cup. Enter your result in kilograms in the table below under the column marked M (for the water's mass.) For example, a number such as 290 g should be entered as 0.290 kg. Carefully measure the water's original temperature T_i and enter it in the appropriate column.
- Insert the nozzle of the dry steam line sufficiently deep into the water so that no steam is lost to the air. Be sure that the glass section of the line has been emptied of hot water from condensed steam before inserting the nozzle into your cup. Allow your cup and its contents to reach a temperature of 40°C before removing the nozzle. Stir the water in your cup with the thermometer until the temperature reaches a maximum and drops. Record the maximum temperature in the column labeled T.
- Measure the mass of the mixture after the steam has been added. The difference between the original and final measurements is the steam's mass. Enter this result in the column labeled m. (Note: A mass such as 24 g should be entered as 0.024 kg.) The temperature change of the cold water should be entered in the column labeled ΔT_M, while that of the

condensed steam's temperature change in cooling down from 100°C to the final equilibrium temperature T should be placed under ΔT_m . This latter number will be negative.

- Calculate the heat gained by the water, the (negative) heat 'gained' by the by the condensed steam, and enter your data in the columns labeled ΔQ_M and ΔQ_m , respectively.
- Calculate the latent heat of vaporization for water and enter your result under H_v . Repeat the above procedure for two or three additional trials as time permits, using fresh cold water each time.
- Determine the average value for water's latent heat of vaporization and summarize your results in the second table.

Trial	M	T_i	T	ΔT_M	ΔQ_M	m	ΔT_m	ΔQ_m	H_v
1									
2									
3									
4									

Average H_v	
Accepted Value	2260 kJ/kg
Percent Difference	

Questions

1. What kind of internal energy change would account for the large value of H_v ?

2. Would H_v be the same for all substances? Use the reference table to support your answer.

3. What do you suppose is the reason for your answer to question #2?

4. Why is H_v calculated in kJ/kg instead of in kilojoules?

5. Why would using warm water or hot water for the experiment make the results less accurate?