Lesson 13:3A
(Please read the text below and listen to the explanation. Complete the 2 questions enclosed which will be discussed in the class.)

4. Latent heat

1. **The Latent heat of a substance** is the heat energy it absorbs during melting, evaporation or sublimation and also the heat energy it gives out during condensation or freezing process. It causes a change of state of the substance but no changes in temperature.

2. **Specific latent heat of fusion of substance**: heat energy absorbed to change a unit mass of the substance from solid to liquid at a steady temperature.

3. **Specific latent heat of vaporization of substance**: heat energy absorbed to change a unit mass of the substance from liquid to vapour at a steady temperature

   On the reverse process, it is the heat energy released by the substance when changing from liquid to solid or vapour to liquid. Whereas

   - Latent heat of a substance varies with temperature, e.g. latent heat of vaporisation of water at 100°C is lower than that at room temperature.

substances	Melting point °C	Heat of fusion $\times 10^5$ J/kg	Boiling point °C	Heat vaporization $\times 10^5$ J/kg
1. Oxygen	-218.8	0.14	-183	2.1
2. Ethyl alcohol	-114	1.04	78	8.5
3. Water	0	3.33	100	22.6
4. Iron	1808	2.89	3023	63.4
5. Tungsten	3410	1.84	5900	48

5. Determination of specific latent heat using electrical method
a. specific latent heat of vaporisation of a liquid

1. The liquid in the flask is heated electrically by a coil carrying a steady current I and having a p.d. V across it. The rheostat is adjusted when necessary to maintain a constant current.
2. Heat energy is absorbed to evaporate the liquid, to heat the apparatus (e.g. tube) and some is lost to surroundings.
3. At the boiling point, vapour is produced and passing down the inner tube of a condenser where it is changed back to liquid by cold water flowing through the outer tube.
4. After the liquid has been boiling for some time, liquid in the flask is surrounded by vapour, which is at the same temperature as the liquid. Thus, no loss of heat occurs across the flask.
5. Therefore, all the electrical energy released is absorbed to vaporise the liquid and not to heat up apparatus.

6. When a steady state is reached, the rate of vaporisation equals the rate of condensation. This can be attested when the mass of the condensed vapour is collected at a constant rate.

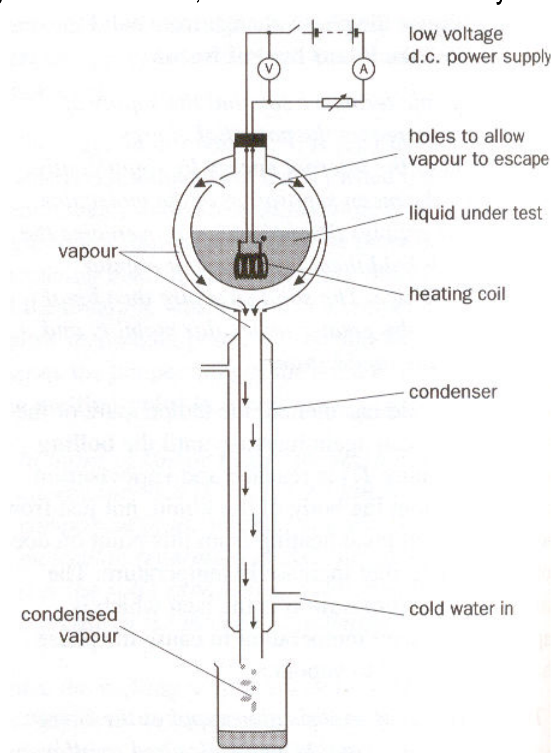
Electrical energy released by the heater = latent heat absorbed to vaporise to liquid + heat loss to surroundings

$$V\,I\,t = m\,l_v + h \text{ --- (7)}$$

7. The mass *m* of condensed liquid is collected over a heating time of *t* and is measured.

   l_v is the specific latent heat of vaporization of the liquid
   h is the heat loss to surroundings

8. Assuming the rate of heat dissipated to surroundings h is constant, it can be eliminated by repeating the experiment using a new heater current and p.d (I_2V_2) with new mass *m* of liquid to be collected during the same period *t*.



   $I_1\,t\,V_1 = m_1\,l_v + h$ ---- (a)
   $I_2\,t\,V_2 = m_2\,l_v + h$ ---- (b)

   (b) - (a):______________________

   $(I_2V_2 - I_1V_1)\,t = (m_2 - m_1)\,l_v$

   Thus, l_v can be determined.

$l_v =$ ---- (8)

Q4: Explain how each of the following conditions affects the measured latent heat of vaporisation, as measured by the apparatus shown above?

a) if the condenser tube is too short.
If the condenser is short, not all the vapour produced can be condensed to water before it flows out of the tube, Therefore, the mass of the water collected is less than the actual value. The measured l_v is larger than the actual one.

b) if the vapour produced does not flow out of the flask esp. in the beginning of boiling process.
The holes may be small such that the vapour produced cannot escape from the flask instead is condensed to water. Therefore, the mass of the water collected is less than the actual value.
The measured l_v is larger than the actual one.

c) if the electric current supplied by the battery is not constant.
If the current supplied is fluctuating, $I_1 t V_1 = m_1 l_v$ cannot be used to determined l_v

d) if the timing starts immediately after circuit is switched on.
The measured time is longer than the actual one as extra time is taken for the water to reach boiling point. Also to heat up the flask before thermal equilibrium is achieved between flask and water in the flask.
The measured l_v is larger than the actual one.

Questions on Specific Latent Heat:

1. An electric method is used to measure the specific latent heat of vaporisation of water. The electric heater is labelled 12 V 50 W. When the water is boiling, the steam produced goes into the condenser through the vertical tube. The condensed water is collected in a beaker. When conditions are steady, 2.0 g of condensed water are collected in 100 s.
   a. Why is it necessary to wait until steady conditions are attained before collecting the condensed water?
   b. Calculate the specific latent heat of vaporisation of water from the results of the experiment. Discuss whether the value obtained is bigger or smaller than the actual value.
   c. To obtain a more accurate value for the specific latent heat, the experiment is repeated using lower power input. The voltage is reduced to 10.5 V and the current through the heater is 3.7 A. When steady conditions are attained, 1.5 g of water is collected in 100 s. Use both sets of results to obtain a more accurate value for the specific latent heat of vaporisation of water.

   [2.5e6 $Jkg^{-1}{}^{o}C^{-1}$, 2.23e6 $Jkg^{-1}{}^{o}C^{-1}$]

2. In an experiment to find the specific latent heat of vaporisation (l_v) of ethanol a student collects 4.8g of condensed ethanol in 60s when electric heater current and p.d. were 3.0 A and 24 V respectively.
   a. Calculate the value of l_v for ethanol from these results. [900kJ/K]
   b. The student feels that the value obtained in (a) is too high and decides to obtain a more accurate value by repeating the experiment using new current and p.d. values of 2.5 A and 20.0 v. He then collects 3.25g of condensed ethanol in 60s. Use both sets of results to obtain a new value for l_v. Why is this value closer to the true value? [852kJ/K]