THEORY

Specific latent heat of vaporization

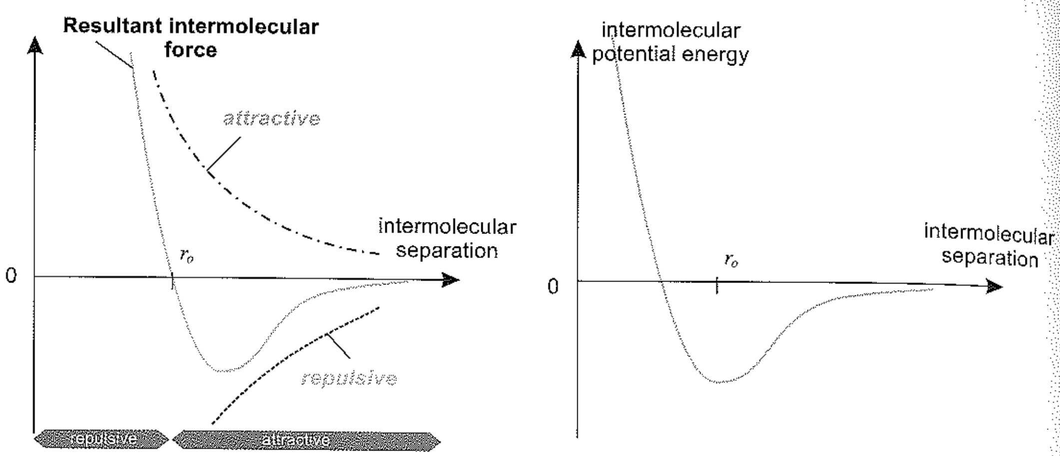


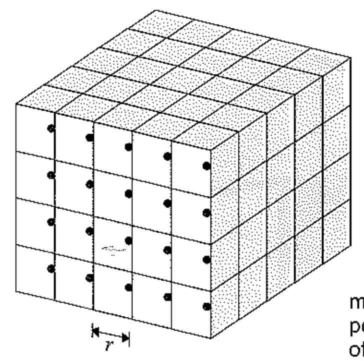
Fig.a

In liquid state, molecules are bound together by strong intermolecular force (of course, in equilibrium, the resultant intermolecular force is zero because there is also repulsive component. See Fig.a). Therefore, energy must be supplied to separate the molecules. If the energy is required to vaporize liquid of mass m at the boiling point is E, the **specific latent heat (slh) of vaporization** of the liquid is given by $E = m\, l_v$ .....(1). The standard value of l_v for water is 2.26×10^6 J kg^{-1}.

In this experiment, we shall determine the slh of vaporization of water by the method of mixture. Steam is generated and allowed to condense in a calorimeter with water of mass m_w initially. The heat released from the steam will raise the temperature of the water in the calorimeter from T_1 to T_2. The energy gained by the water, the caloriometer and the stirrer is $E = m_w c_w (T_2 - T_1) + m_c c_c (T_2 - T_1)$ .....(2), where m_c is the total mass of the calorimeter, c_w and c_c are the specific heat capacities of water and aluminum respectively.

The mass of steam (m_{steam}) collected is measured by the triple-beam balance. Since the final temperature is T_2, the total loss in energy is $E' = m_{\text{steam}} l_v + m_{\text{steam}} c_w (100 - T_2)$ .....(3) By conservation of energy, the slh of vaporization of water can be determined.

Change in molecular separation during vaporization



molecules can be regarded as points located at the centers of cubes of side r

Fig.b

When a liquid boils, there is a large increase in volume. In technical terms, we say that the average separation between the molecules increases.

Suppose a liquid consists of N molecules and has volume V. Since each molecule can be regarded a single point, the volume that it occupies is effectively a cube. Thus, the average separation between molecules is the distance between the centers of two adjacent cubes. Therefore, the volume occupied by a molecule is $V_m = r^3$, where r is the side of the cube. If there are N molecules, the measured volume is $V = NV_m = N\,r^3$. Thus, the average separation between molecules is $r = \sqrt[3]{\frac{V}{N}}$ ....(4). This expression is true for molecules in all three states. Therefore, the ratio of molecular separation in gaseous form to that in liquid form is $\frac{r_g}{r_l} = \sqrt[3]{\frac{V_g}{V_l}}$ ....(5). By finding the percent increase in volume during boiling, the percent increase in the molecular separation can be obtained.

In this experiment, we shall find the percent increase in separation between the hexane molecules during vaporization. A small amount of hexane (b.p. less than 80°C) is ejected into hot water. As hexane does not dissolve in water, the expansion causes the same volume of water to displace. Using equation (5), the percent increase in molecular separation can be found.