Expansion of Liquids

1. Linear and areal expansions have no significance for a liquid, since shape of liquid depends on shape of vessel.
2. Liquids do not possess any definite shape and require a container to hold them. Hence only cubical expansion is considered.
3. For liquids there are two types of cubical expansion

   i) Coefficient of apparent expansion (γ_a)

   ii) Coefficient of real or absolute expansion (γ_r)
4. Coefficient of apparent expansion of a liquid is the ratio of the apparent increase in volume per 1°C rise of temperature to its initial volume.

   $$\gamma_a = \frac{\text{apparent increase in volume}}{\text{original volume x rise in temperature}}$$

   Unit of γ_a : $^\circ C^{-1}$.
5. Coefficient of real expansion is the ratio between real increase in volume per 1°C rise of temperature and the original volume of the liquid.

   $$\gamma_r = \frac{\text{real increase in volume}}{\text{original volume x rise in temperature}} = \frac{V_2 - V_1}{V_1(t_2 - t_1)}$$

   Unit of γ_r : $^\circ C^{-1}$.
6. $\gamma_r = \gamma_a + \gamma_{vessel} = \gamma_a + 3\alpha$.
7. If γ_v=+ve and $\gamma_r < \gamma_v$, γ_a=-ve, the level decreases continuously when heated.
8. If γ_v=+ve and $\gamma_r = \gamma_v$; γ_a=0, the level will not change when heated.
9. If γ_v=+ve and $\gamma_r > \gamma_v$; γ_a=+ve, the level first falls and then rise when heated.
10. If γ_v=0; $\gamma_r = \gamma_a$, the level will increase continuously when heated.
11. If γ_v=-ve, $\gamma_a > \gamma_r$, the level will increase continuously when heated.
12. The real expansion of a liquid does not depend upon the temperature of the container.
13. The apparent expansion of liquid depends on a) initial volume or liquid, b) rise in temperature c) nature of liquid and d) nature of container.
14. The fraction of the volume of a glass flask that must be filled with mercury so that the volume of the empty space left may be the same at all temperatures is 1/7.

15. If the same liquid is heated in two different vessels x and y then $(r_a)_x + 3\alpha_t = (r_a)_y + 3\alpha_y$

16. In determining γ_r by Dulong and Pettit's method, if h_0 and h_t are heights of liquid is the two limbs of a U - tube maintained at 0°C and t°C $\gamma_r = \frac{h_t - h_0}{h_0 t}$ /°C

17. In determining γ_a by specific gravity bottle method.

Weight of empty bottle = w_1g

Weight of (bottle + liquid) = w_2g

Weight of (bottle + remaining liquid) = w_3g

$$\gamma_{app} = \frac{(w_3 - w_2)}{(w_3 - w_1)(t_2 - t_1)} \text{ /°C}$$

$$\gamma_{app} = \frac{Mass of\ the\ liquid\ expelled}{Mass of\ the\ remaining\ liquid \times Temp.diff.}$$

18. If m_1 is mass of liquid and m_2 is mass of remaining liquid, then $\gamma_a = \frac{m_1 - m_2}{m_2(t_2 - t_1)}$

19. A specific gravity bottle contains m g of liquid of apparent expansion γ at 0°C. if it is heated through t°C, mass of expelled liquid is $x = \frac{\gamma m t}{1 + \gamma t}$

20. When a solid substance is immersed in a liquid at 0°C, the loss of weight is w_0. Now liquid is heated to t°C, loss of weight in the substance is w_t. Then $w_t = w_0\left[1 + (\gamma_s - \gamma_R)t\right]$

21. A solid of negligible volume expansion floats in a liquid. At t_1°C & t_2°C. the fractions f_1, f_2 of volumes of the solid remains submerged in the liquid. The coefficient of volume expansion of liquid is $\gamma_R = \frac{a_2 - a_1}{a_1 t_2 - a_2 t_1}$

22. To keep the volume of empty space in a vessel (volume v_g) constant at all temperatures by pouring certain amount of a liquid of volume v_l, the condition is $v_l\gamma_l = v_g\gamma_g$ where γ_l=coefficient of cubical expansion of liquid and γ_g=coefficient of cubical expansion of vessel.

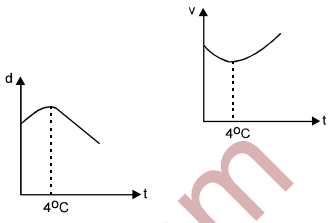
23. The density of a liquid usually decreases when heated. If d_1 and d_2 are the densities of a liquid at 0°C and t°C respectively, then

$d_t = \frac{d_o}{1 + \gamma_r t}$; $d_t = d_o(\tilde{1}\gamma_r t)$;

$$\gamma_r = \frac{d_1 - d_2}{d_1 t_2 - d_2 t_1} / {}^{o}C$$

24. Anomalous Expansion of Water

a) When water at 0°C is heated, its volume decreases up to 4°C and from 4°C its volume increases with the increase of temperature. This peculiar behavior of water is called anomalous expansion of water.



b) Water has maximum density and minimum volume at 4°C.

c) Hope's apparatus is used to demonstrate that water has maximum density at 4°C.

d) Dilatometer is used to prove anomalous expansion of water.

e) Aquatic animals are surviving in cold countries due to the anomalous expansion of water.

f) During winter, in cold countries, even if the temperature falls far below 0°C, the water in the frozen lakes or seas at the bottom remains at 4°C.

g) When water freezes, it expands and consequently water pipes burst in winter.

h) When water at 4°C is filled to the brim of a beaker, then it over flows when it is either cooled or heated.

i) Water has positive coefficient of expansion above 4°C and negative coefficient below 4°C.

j) At 4°C the coefficient of expansion of water is zero.