Expansion of Liquids

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In liquids only expansion in volume takes place on heating.

Apparent Expansion of Liquids

When expansion of the container containing liquid, on heating is not taken into account then observed expansion is called apparent expansion of liquids.

- Coefficien[illegible] liquid Ύa is given by

$$(\gamma_a) = \frac{\text{apparent increase in volume}}{\text{original volume} \times \text{rise in temperature}}$$

Real Expansion of Liquids

When expansion of the container, containing liquid, on heating is also taken into account, then observed expansion is called real expansion of liquids.

Coeffici ... d ϒr is given by

$$(\gamma_r) = \frac{\text{real increase in volume}}{\text{original volume} \times \text{rise in temperature}}$$

- Both ϒr, and ϒa are measured in °C-1.
- We can show that ϒ r = ϒa + ϒ g
- where ϒ r , and ϒa are coefficient of real and

VARIATION OF DENSITY WITH TEMPERATURE

$$d\theta = d0/\,(1+\gamma\theta)$$

- Where d0 is the density at 0^0C

- $d_2 - d_1 = d_1\,\gamma\,(t_2 - t_1)$

Where d_2 & d_1 are densities at t_2 & t_1

Expansion of Gases

- Pressure coefficient of a gas is the ratio of increase in pressure for 1^0C

rise in temperature to the pressure at 0^0C, provided the volume of the gas is kept constant.

$$\gamma_P = \frac{P_t - P_0}{P_0 \, \triangle\theta}$$

Volume coefficient of a Gas

Volume coefficient of a gas is the ratio of increase in volume for 1^0C rise in temperature to the volume at 0^0C, provided the pressure of the gas is kept constant.

$$\gamma_v = \frac{V_t - V_0}{V_0 \triangle \theta}$$

$$\gamma_p = \gamma_v = 1/273$$

2. Expansion of Gases

There are two types of coefficient of expansion in gases

(i) Volume Coefficient (γv) At constant pressure, the change in volume per unit volume per degree celsius is called volume coefficient.

$$\gamma_V = \frac{V_2 - V_1}{V_0 (t_2 - t_1)}$$

where V_0, V_1, and V_2 are volumes of the gas at 0°C, t_1°C and t_2°C.

(ii) Pressure Coefficient (γ_p) At constant volume, the change in pressure per unit pressure per degree celsius is called pressure coefficient.

$$\gamma_p = \frac{p_2 - p_1}{p_0 (t_2 - t_1)}$$

where p_0, p_1 and p_2 are pressure of the gas at 0°C, t_1° C and t_2° C.

•Thermal expansion of water

Water has an anomalous property: betwn 0 °C and 4 °C its coefficient expansion is *negative*.

Happens in most solids, liquids & gases

Increase in the size due to an increase in temperature

If temp then size

But Water is an exception, it expands as it becomes a solid!

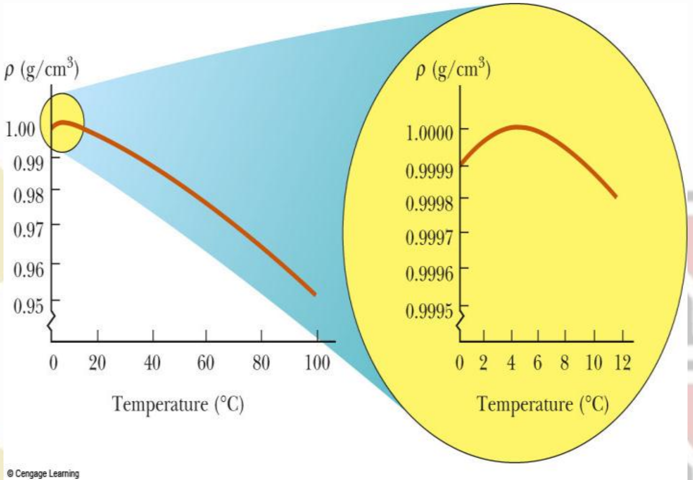
Anomalous Expansion of Water.

(1) Generally matter expands on heating and contracts on cooling. In case of water, it expands on heating if its temperature is greater than 4°C. In the range 0°C to 4°C, water contracts on heating and expands on cooling, i.e. γ is negative. This behaviour of water in the range from 0°C to 4°C is called anomalous expansion.

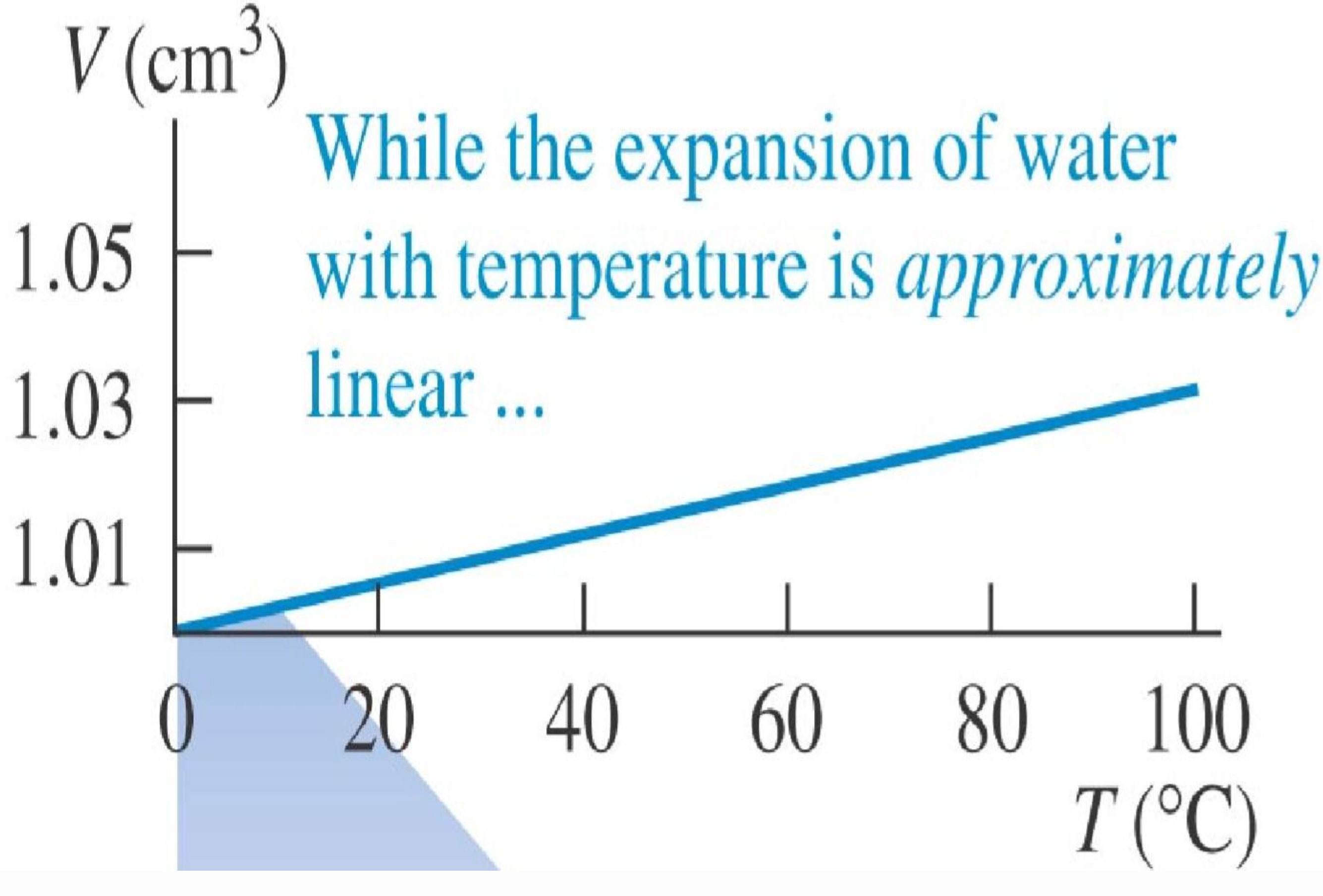
(2) The anomalous behaviour of water arises due to the fact that water has three types of

. (3) At 4°C, density of water is maximum while its specific volume is minimum. During winter when the water at the surface of a lake cools below 4°C by cool air, it expands and becomes lighter than water below. Therefore the water cooled below 4°C stays on the surface and freezes when the temperature of surroundings falls below 0°C. Thus the lake freezes first at the surface and water in contact with ice has temperature 0°C while at the bottom of the lake 4°C [as

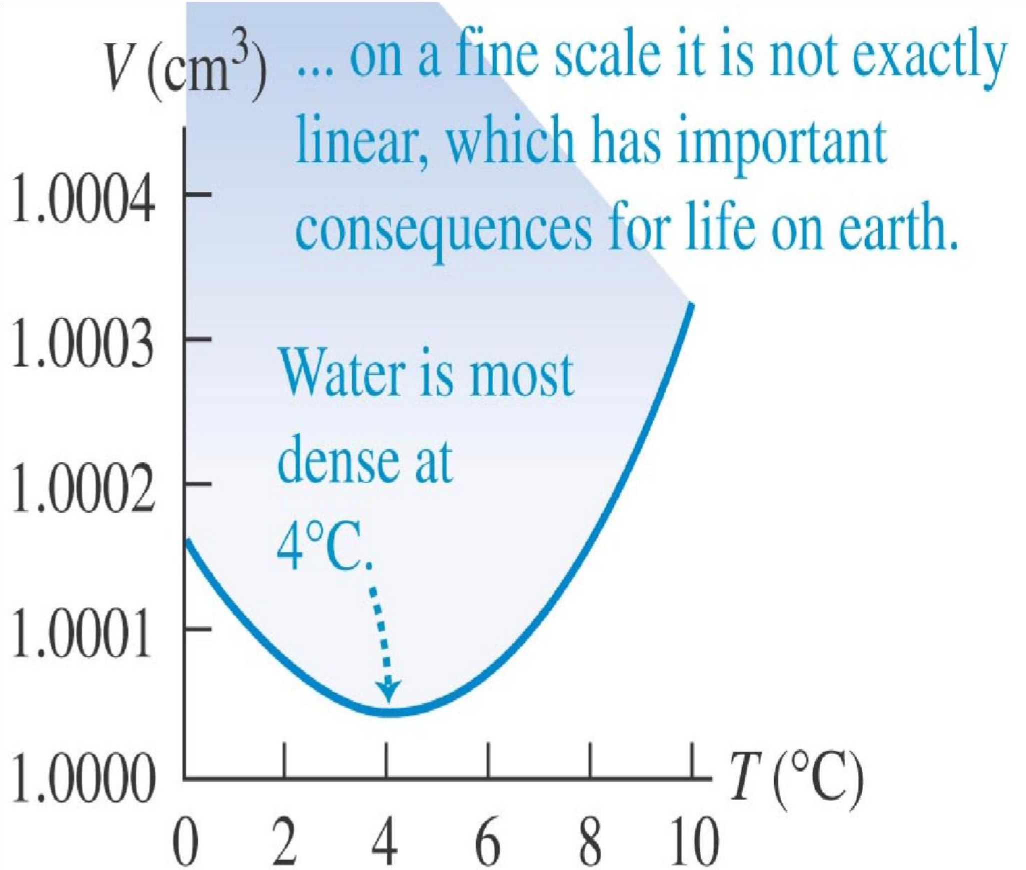
Unusual Behavior of Water



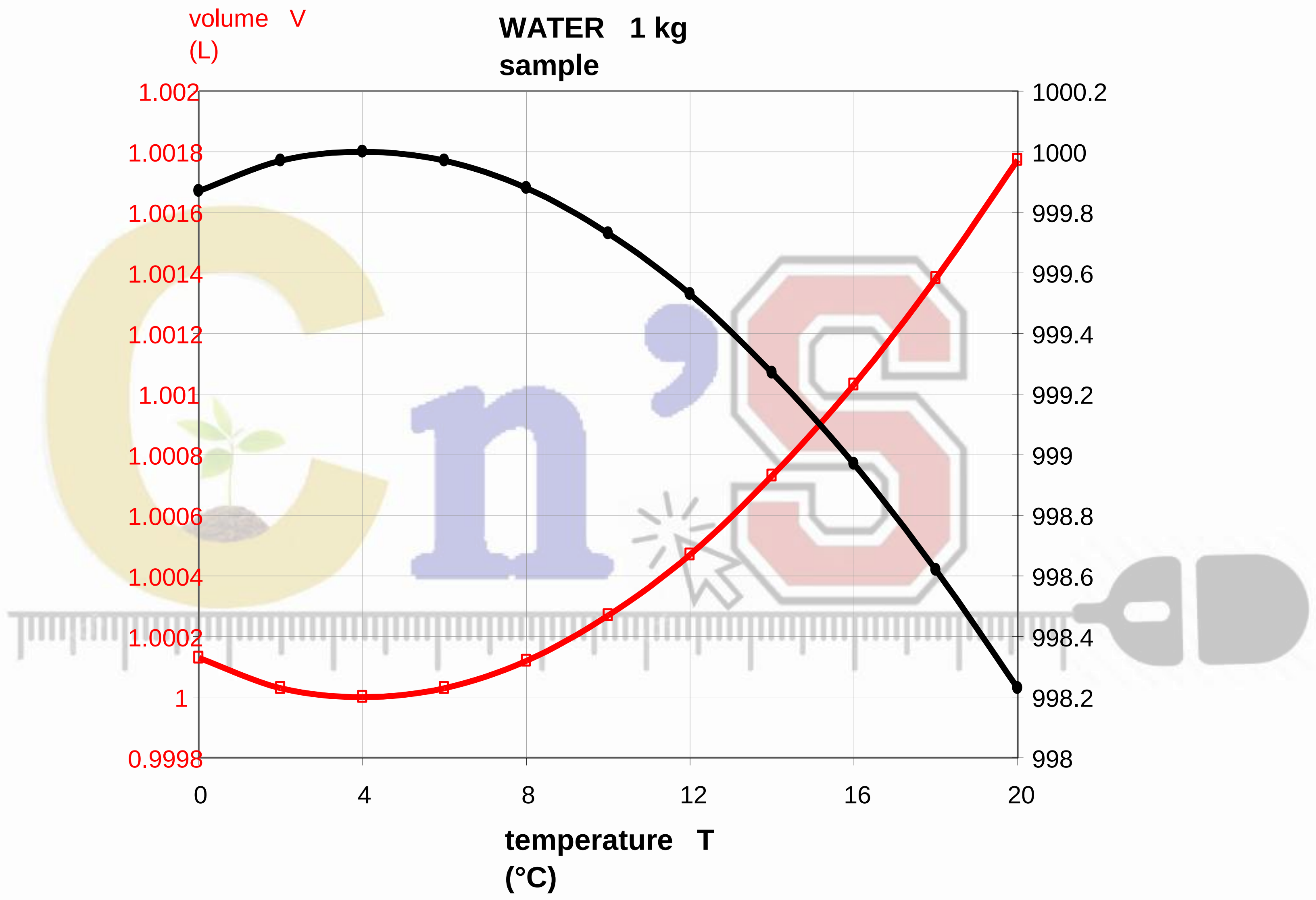
- As the temperature of water increases from 0ºC to 4 ºC, it contracts and its density increases
- Above 4 ºC, water exhibits the expected expansion with increasing temperature
- Maximum density of water is 1000 kg/m^3 at 4 ºC



V (cm³)
While the expansion of water
with temperature is *approximately*
linear ...
1.05
1.03
1.01
0
20
40
60
80
100
T (°C)



V (cm³)
... on a fine scale it is not exactly linear, which has important consequences for life on earth.
1.0004
1.0003
1.0002
1.0001
1.0000
Water is most dense at 4°C.
T (°C)
0
2
4
6
8
10



WATER 1 kg sample
volume V (L)
1.002
1.0018
1.0016
1.0014
1.0012
1.001
1.0008
1.0006
1.0004
1.0002
1
0.9998
1000.2
1000
999.8
999.6
999.4
999.2
999
998.8
998.6
998.4
998.2
998
0
4
8
12
16
20
temperature T (°C)

Consequence: lakes freeze from the top down

- Above 4 °C water cools at surface and sinks (greater density
- Below 4 °C, water cools but stays at surface – Water at bottom stays warmer.
- Below 0 °C ice forms; ice is also less dense than water.
- Life can remain alive under the ice.