Ratna Sagar

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Education, Our Mission

ICSE
Living Science
Physics

Class 10

Chapter 7 Heat

As per the latest ICSE syllabus

9

Revised and Updated

Living Science PHYSICS

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EDUCATION, OUR MISSION

LEARNING OBJECTIVES

Concept of Heat and Temperature

- Concept of temperature
- Units of temperature
- Concept of heat
- Units of heat

Anomalous Expansion of Water

- Hope's experiment to demonstrate anomalous expansion of water
- Practical consequences of anomalous expansion of water

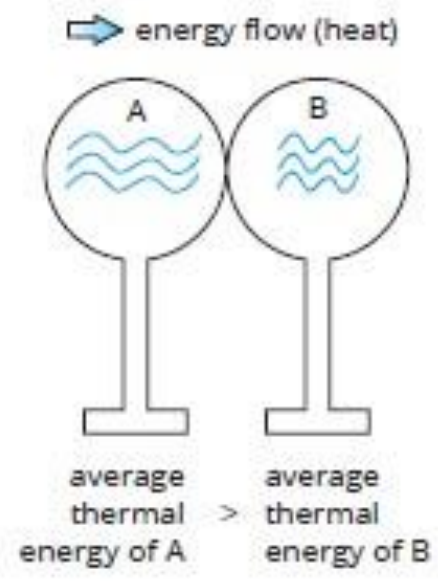
What is temperature?

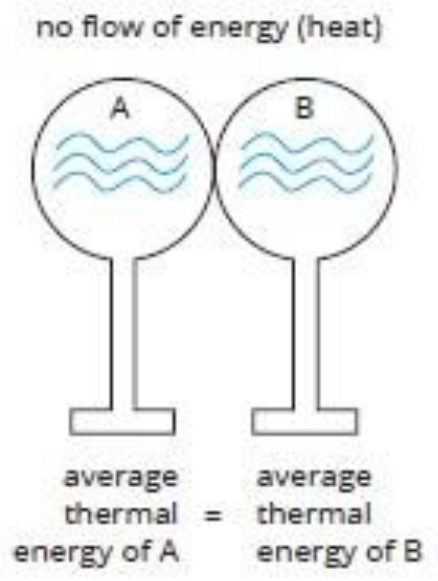
The temperature of a body is its degree of hotness or coldness.

According to the kinetic molecular theory, temperature of a body is the measure of the average kinetic or thermal energy of its molecules.

Concept of Temperature

Temperature is that property of a body which determines the direction of heat flow when it is brought in contact with another body. When two bodies are brought in contact with each other, heat (i.e. energy) flows from the body at a higher temperature to the body at a lower temperature. If two objects are at the same temperature, no heat is exchanged between them when they are brought in contact. When objects at the same temperature in contact with each other do not exchange heat (i.e. energy), is called **thermal equilibrium**.





Heat flows from the body at higher temperature to the body at lower temperature.

Units of temperature

The SI unit of temperature is kelvin (K). The other most common unit of temperature is degree Celsius (°C). They are related as

Temperature on Kelvin scale = Temperature on Celsius scale + 273

or K = °C + 273

Concept of Heat

Heat is the energy that is transferred from one object to another because of temperature difference between them.

1. It is important to note that **matter does not contain heat**. In fact, **heat is neither stored nor contained in a body**. Indeed heat refers to the transfer of thermal energy from one object to another because of difference in temperature.

2. When we rub our hands against each other, they become warm. Here, heat is generated due to the loss of kinetic energy of the hands due to friction. Thus, **heat is a form of energy that can be produced when some form of energy is lost**. In this example, kinetic energy is converted into heat energy.

3. Heat engines work by virtue of heat produced by the burning of fuel like coal or petrol. Here, the heat energy produced by burning a fuel is converted into mechanical energy (kinetic energy) of the vehicle. Thus, **heat is a form of energy that can produce other forms of energy**.

Units of heat

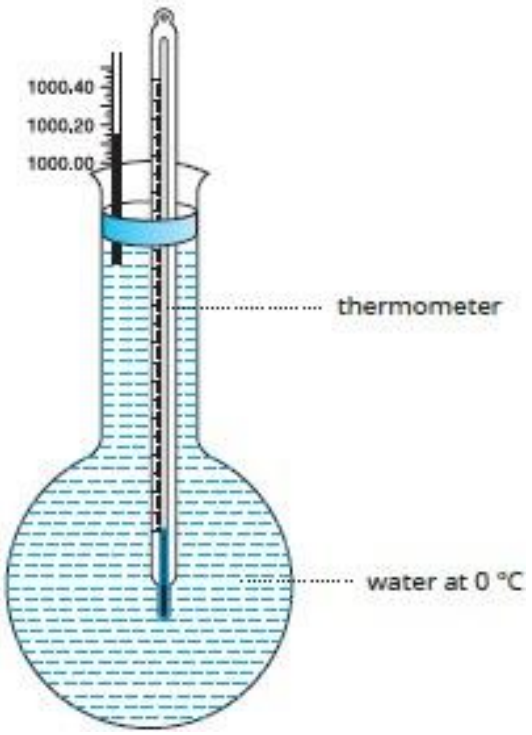
The SI unit of energy is joule (J). Heat is a form of energy, so its SI unit is also joule (J). Generally, a bigger unit called kilojoule (kJ) is used. The non-SI units are calorie (cal) and kilocalorie (kcal).

1 cal = 4.186 J

and 1 kcal = 4.186 kJ

Anomalous Expansion of Water

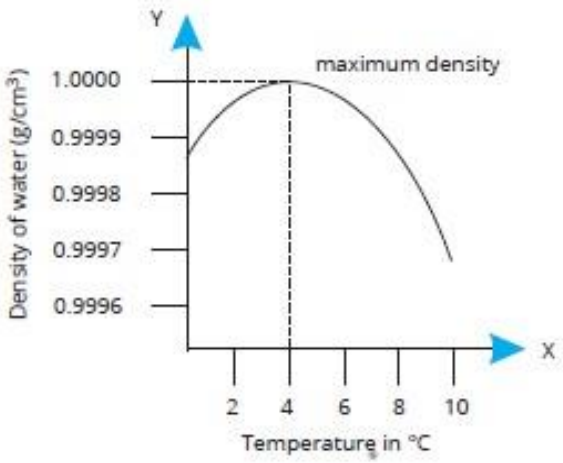
If water initially at a temperature above 4 ° C is cooled, it contracts (just like other liquids) till the temperature of water reaches 4 ° C. On further coolingbelow 4 ° C, it expands (unlike other liquids) instead of contracting. The expansion of water when it is cooled below 4 ° C is known as anomalous expansion of water.



The volume of water increases if we heat it or cool it, provided initially the water is at 4 ° C. Thus, **water has its least volume at 4 ° C**.

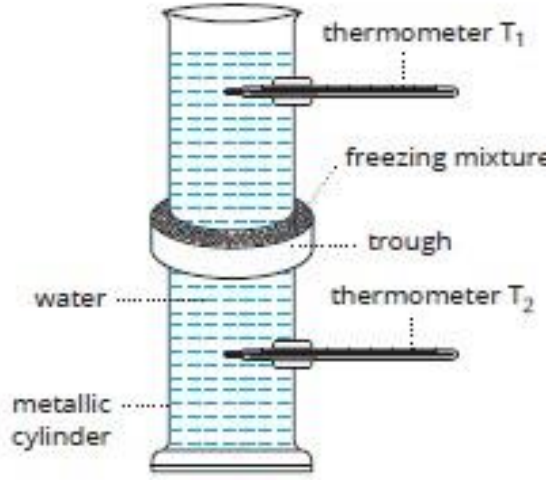
Note: Refer to Table 7.1 for Differences between heat and temperature

Graph showing the variation of density of water with temperature in the 0 ° C – 10 ° C range



It is found that density decreases when water at 4 ° C is heated further. The density also decreases when water at 4 ° C is cooled further. Hence, we can say water has maximum density at 4 ° C. The density of water is 1 g/cm^3 or 1000 kg/m^3 at 4 ° C.

Hope's experiment to demonstrate anomalous expansion of water



Hope's apparatus consists of a tall metallic cylinder (closed at one end) provided with two side openings, Volume of 1000 g one near the top and the other near the bottom, fitted with thermometers T_1 and T_2 in them. The central part of the cylinder is surrounded with a cylindrical trough containing a freezing mixture of ice and salt. The cylinder is filled with water previously cooled to about 10 ° C

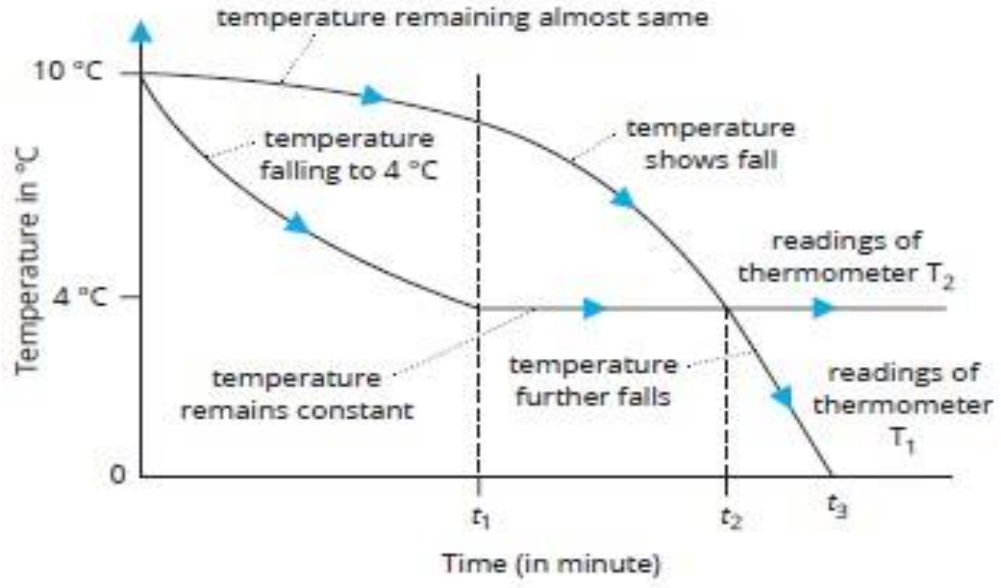
Observations: As water in the cylinder is cooled by the freezing mixture, the changes in the temperatures shown by the two thermometers are carefully observed.

1. Initially both the thermometers show the same temperature, i.e. 10 ° C.

2. First, the temperature shown by the lower thermometer T_2 slowly falls to **4 ° C**, while the temperature shown by the upper thermometer T_1 remains almost unchanged during this time, i.e. up to time t_1 .

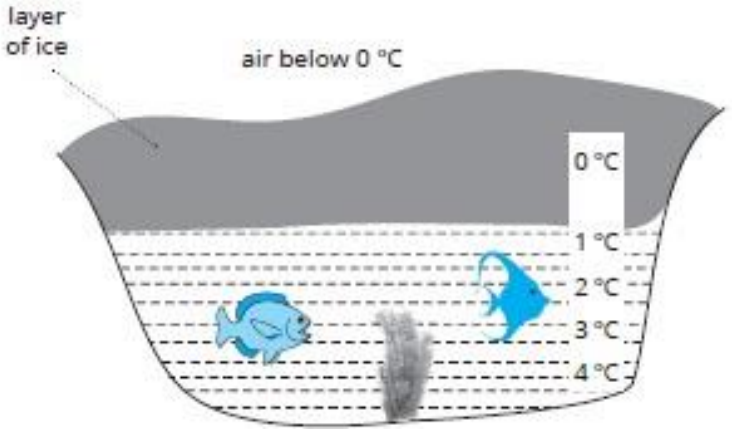
3. Now, the temperature shown by the thermometer T_2 remains constant at 4 ° C, while the temperature shown by the upper thermometer T_1 slowly goes down until it reaches **0 ° C**, i.e. up to time t_3.

4. After some time, a thin crust of ice is formed on the surface of water in the cylinder.



5. If graphs for time (in minutes) and temperature for both the thermometers are drawn, then the two graphs intersect at **4 ° C**.

Practical consequences of anomalous expansion of water



1. Survival of aquatic life in frozen water bodies: In cold countries, during winters, as the atmospheric temperature starts falling below **0 ° C**, **the water bodies** (like ponds, lakes and rivers) **freeze from the top to form solid ice, whereas the waterbelow the surface stays at 4 ° C**.

Thus, fish and other aquatic life can easily survive in frozen water bodies, as water below the surface stays at **4 ° C**.

2. Bursting of water pipelines: During winters, water pipelines often burst in cold countries because water freezes at sub-zero temperature and thus it expands (anomalous expansion of water). Since, there is no space within the pipes, expanding ice exerts tremendous pressure and bursts open the steel water pipelines. It is for the same reason that people in cold countries leave the taps dripping at night so as to provide sufficient space for the expansion of freezing water.

3. Damaging of fruit and vegetables: During winters, due to extremely cold weather, fruit and vegetables get damaged because the water present in the cells expands on freezing (anomalous expansion of water). It exerts tremendous pressure and bursts open the cell walls.

4. Frost bite: During severe winter, the water in the cells of human beings (especially in the exposed parts) freezes. It expands (anomalous expansion of water) exerting tremendous pressure and bursts open the cells.

SUMMARY...

1. Temperature: According to the kinetic molecular theory, the temperature of a body is the measure of the average kinetic or thermal energy of its molecules.

2. Direction of flow of heat: When two bodies are brought in contact with each other, heat flows from the body at higher temperature to the body at lower temperature.

3. Thermal equilibrium: When objects at the same temperature are brought in contact with each other, they do not exchange heat. This condition is called thermal equilibrium.

4. Heat: Heat is the energy that is transferred from one object to another because of temperature difference between them.

5. Anomalous expansion of water: The expansion of water when it is cooled below 4 °C is known as anomalous expansion of water.

6. Property of water: At 4 °C, water has the least volume and maximum density.

7. Hope's apparatus: It is used for demonstrating the anomalous expansion of water.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