Case Study - 4

2. It is our common experience that most substances expand on heating and contract on cooling. A change in the temperature of a body causes change in its dimensions. The increase in the dimensions of a body due to the increase in its temperature is called thermal expansion. The expansion in length is called linear expansion. The expansion in area is called area expansion. The expansion in volume is called volume expansion. If the substance is in the form of a long rod, then for small change in temperature, ΔT, the fractional change in length, ΔL/L, is directly proportional to ΔT.

$$\Delta L/L = \alpha_1 \Delta T$$

Where α_1 is known as the coefficient of linear expansion (or linear expansivity) and is characteristic of the material of the rod.
Similarly, we consider the fractional change in volume, ΔV/V of a substance for temperature change ΔT and define the coefficient of volume expansion (or volume expansivity), α_V as $\alpha_V = (\Delta V/V) * 1/\Delta T$. Here α_V is also a characteristic of the substance but is not strictly a constant. It depends in general on temperature. It is seen that α_V becomes constant only at a high temperature. Relation between α_V and α_1 is given by $\alpha_{V=3}\ \alpha_{1.}$ What happens by preventing the thermal expansion of a rod by fixing its ends rigidly? Clearly, the rod acquires a compressive strain due to the external forces provided by the rigid support at the ends. The corresponding stress set up in the rod is called thermal stress. Answer the following

1. **Relation between α_V and α_1 is given by**
   a. $\alpha_{V=3}\ \alpha_1$
   b. $\alpha_{V=4}\ \alpha_1$
   c. $\alpha_{V=2}\ \alpha_1$
   d. None of these

2. **If the substance is in the form of a long rod, then for small change in temperature, ΔT, the fractional change in length, ΔL/L, is directly proportional to**
   a. ΔT
   b. T
   c. ΔV
   d. None of these

3. **Define linear expansion**

4. **Define thermal stress**

5. **Define coefficient of linear expansion**

Answer key- 4

1. A

2. A

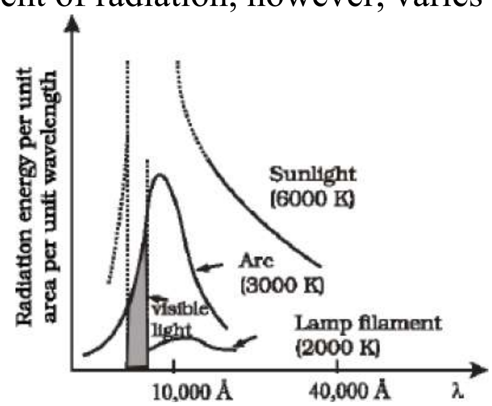
3. Linear expansion is defined as fractional change in length of material due to change in temperature.
4. Stress arises due to change in temperature is called thermal stress. When temperature changes then there is change in linear dimensions if we prevent this thermal expansion then stress produced in body called as thermal stress.

5. Coefficient of linear expansion is defined as ratio of fractional change in length ($\Delta L/L$) to the change in temperature (ΔT). Represented by α_1 and given by,

$$\alpha_1 = \frac{\Delta L/L}{\Delta T}$$

Case Study - 5

The important thing about thermal radiation at any temperature is that it is not of one (or a few) wavelength(s) but has a continuous spectrum from the small to the long wavelengths. The
energy content of radiation, however, varies for different wavelengths.



Notice that the wavelength λ_m for which energy is the maximum decreases with increasing temperature. The relation between lm and T is given by what is known as Wien's Displacement
Law λ_m*T= constant. The value of the constant (Wien's constant) is 2.9×10^{-3} m K. This law explains why the color of a piece of iron heated in a hot flame first becomes dull red, then reddish yellow, and finally white hot. Wien's law is useful for estimating the surface temperatures of celestial bodies like, the moon, Sun and other stars. Energy can be transferred by radiation over large distances, without a

medium (i.e., in vacuum). The total electromagnetic energy radiated by a body at absolute temperature T is proportional to its size, its ability to radiate (called emissivity) and most importantly to its temperature. For a body, which is a perfect radiator, the energy emitted per unit time (H) is given by $H= A\sigma T^4$ .Where A is the area and T is the absolute temperature of the body. This relation obtained experimentally by Stefan and later proved theoretically by Boltzmann is known as Stefan- Boltzmann law and the constant σ is called Stefan-Boltzmann constant. Its value in SI units is 5.67×10^{-8} W m^{-2} K^{-4}.

The earth's surface is a source of thermal radiation as it absorbs energy received from the Sun. The wavelength of this radiation lies in the long wavelength (infrared) region. But a large portion of this radiation is absorbed by greenhouse gases, namely, carbon dioxide (CO2); methane (CH4); nitrous oxide (N2O); chlorofluorocarbon (CFxClx); and tropospheric ozone (O3). This heats up the atmosphere which, in turn, gives more energy to earth, resulting in warmer surface. This increases the intensity of radiation from the surface. The cycle of processes described above is repeated until no radiation is available for absorption. The net result is heating up of earth's surface and atmosphere. This is known as Greenhouse Effect. Without the Greenhouse Effect, the temperature of the earth would have been –18°C. Due to human activities, making the earth warmer. According to an estimate, average temperature of earth has increased by 0.3 to 0.6°C, since the beginning of this century because of this enhancement. By the middle of the next century, the earth's global temperature may be 1 to 3°C higher than today. This global warming may cause problem for human life, plants and animals. Because of global warming, ice caps are melting faster, sea level is rising, and weather pattern is changing. Many coastal cities are at the risk of getting submerged. The enhanced Greenhouse Effect may also result in expansion of deserts. All over the world, efforts are being made to minimize the effect of global warming.

1. **The value of the constant (Wien's constant) is**
   a. 2.9×10^{-4} m K
   b. 2.9×10^{-3} m K
   c. 2.9×10^{-5} m K
   d. None of these

2. **SI unit of Stefan-Boltzmann constant is**
   a. W m^{-2} K^{-3}.
   b. W m^{-1} K^{-4}.
   c. W m^{-2} K^{-4}.
   d. None of these

3. **State Wien's Displacement law.**
4. **State Stefan- Boltzmann law.**

5. **Explain green house effect**

Answer key-5

1. B

2. C

3. . The relation between λm and T is given by what is known as Wien's Displacement Law That is Wavelength λ_m for which energy is the maximum is inversely proportional to temperature. λ_m*T= constant. The value of the constant (Wien's constant) is
   2.9×10^{-3} mk.

4. The total electromagnetic energy radiated by a body at absolute temperature T is proportional to its size, its ability to radiate (called emissivity) and most importantly to its temperature. For a body, which is a perfect radiator, the energy emitted per unit time (H) is directly proportional to area and fourth power of temperature of body and given by

$H= A\sigma T^4$.

Where A is the area and T is the absolute temperature of the body.

5. From sun is called green house effect. Temperature of earth increases due to trapping of heat coming from sun to earth's surface is a source of thermal radiation. The wavelength of this radiation lies in the long wavelength region. But a large portion of this radiation is absorbed by greenhouse gases, these heats up the atmosphere.