

2.2.1-Thermal expansion of solids, liquids and gases

Thermal expansion:

Thermal expansion is the increase of the size (length, area, or volume) of a body due to a change in temperature, usually a rise

Qualitative description of the thermal expansion of solids, liquids and gases at constant pressure

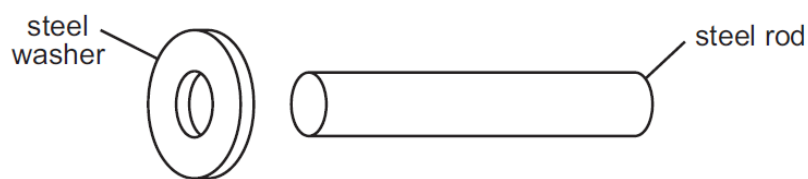
- When a solid is heated at constant pressure, it does expand a little and some heat is required for doing the mechanical work associated with this expansion.
- As a liquid is heated at constant pressure, its temperature increases. This trend continues until the boiling point of the liquid is reached. No further rise in temperature of the liquid can be induced by heating due to increase in kinetic energy.
- If the pressure of a gas is kept constant, then increasing its temperature will also increase its volume. This is called thermal expansion of a gas and is a similar process to the expansion of liquids and a solids when they are heated (although their expansion is much less noticeable compared to a gas). When heated under constant pressure, the gas particles collide harder with the container surfaces, forcing them out, and allowing the gas to expand. This can be seen when warming the gas in a gas syringe.

Some everyday applications and consequences of thermal expansion:

EXAMPLE:1

M/J/04/P1-Q17-ANSWER:AND M/J/12-P11-Q17-ANDWER:D

An engineer wants to fix a steel washer on to a steel rod. The rod is just too big to fit into the hole of the washer.



How can the engineer fit the washer onto the rod?

- A cool the washer and put it over the rod
- B cool the washer and rod to the same temperature and push them together
- C heat the rod and then place it in the hole
- D heat the washer and place it over the rod

EXPLANATION:

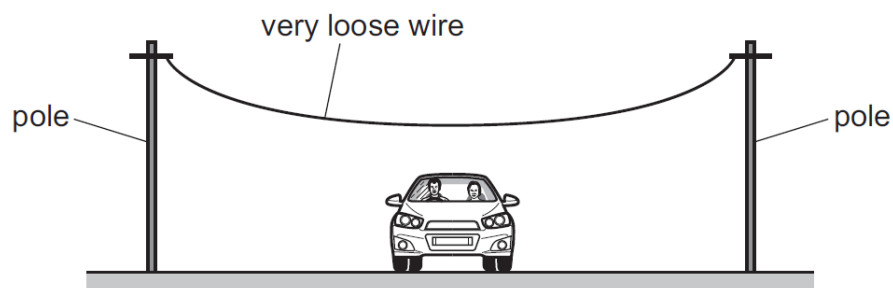
The engineer will heat the washer and then place it over the rod. This is because, heating the washer will make it expand and thus it will become bigger in size than before. This will help him in fitting the washer over the steel rod

EXAMPLE:2

M/J/14-P11-Q14-ANSWER:D

A telephone engineer connects a wire between two poles when the weather is very cold.

He makes the wire very loose. The wire passes over a road.



The weather changes and it becomes very hot.

What could happen to the wire and why?

	what could happen	why
A	it breaks	it contracts
B	it breaks	it expands
C	it sags and touches cars on the road	it contracts
D	it sags and touches cars on the road	it expands

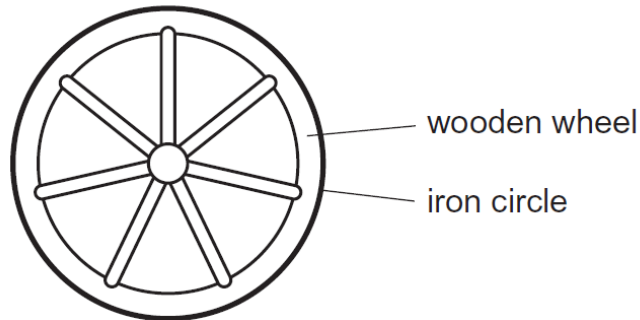
EXPLANATION:

The wire would sag and touch the car on roads due to an increase in the length of the wire [thermal expansion] caused due to heat.

EXAMPLE:3

M/J/07-P1-Q17-ANSWER:B

A wooden wheel can be strengthened by putting a tight circle of iron around it.



Which action would make it easier to fit the circle over the wood?

- A** cooling the iron circle
- B** heating the iron circle
- C** heating the wooden wheel
- D** heating the wooden wheel and cooling the iron circle

EXPLANATION:

Heating the iron circle would expand it temporarily. Then it could be quickly fixed on the wooden wheel. Upon cooling, the iron circle would contract, going back to its original size and thus fit tightly in the wooden wheel.

Relative order of magnitudes of the expansion of solids, liquids and gases as their temperatures rise

STATE	RELATIVE EXPANSION	REASON
SOLID	Least	The particles in a solid are held together by strong forces of attraction. Hence the inter-molecular distance between the solid particles is too small. Hence when solids are heated, the particles are only able to vibrate in their mean positions. Hence they expand the least when heated.
LIQUID	Moderate	The particles in a liquid are held together by weak forces of attraction. Hence the inter-molecular distance between the liquid particles is too large as compared to the solid particles. Hence when the liquids are heated, the particles are only able to slide past over each other and thus occupy a larger volume when heated. Hence they expand moderately when heated.
GAS	Large	The particles in a gas are held together by very weak forces of attraction. Hence the inter-molecular distance between the gas particles is very large as compared to the solid and liquid particles. Hence when the gas is heated, the particles are only able to move more rapidly and thus occupy a much larger volume when heated. Hence they expand very much more when heated.