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PHYSICS 10

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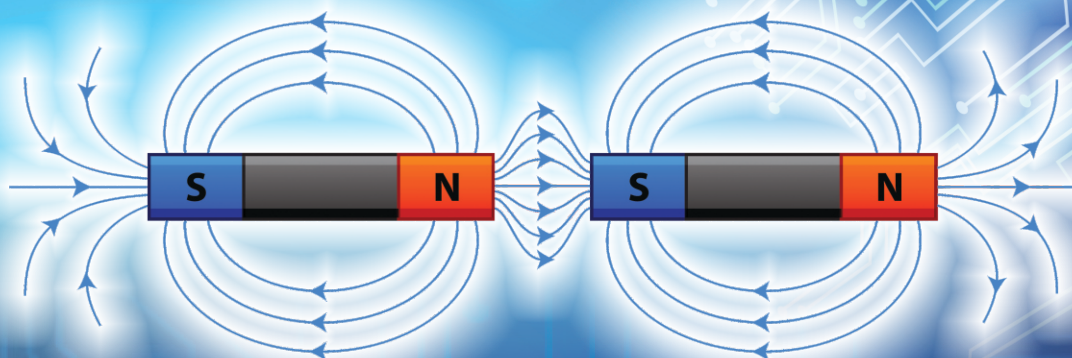

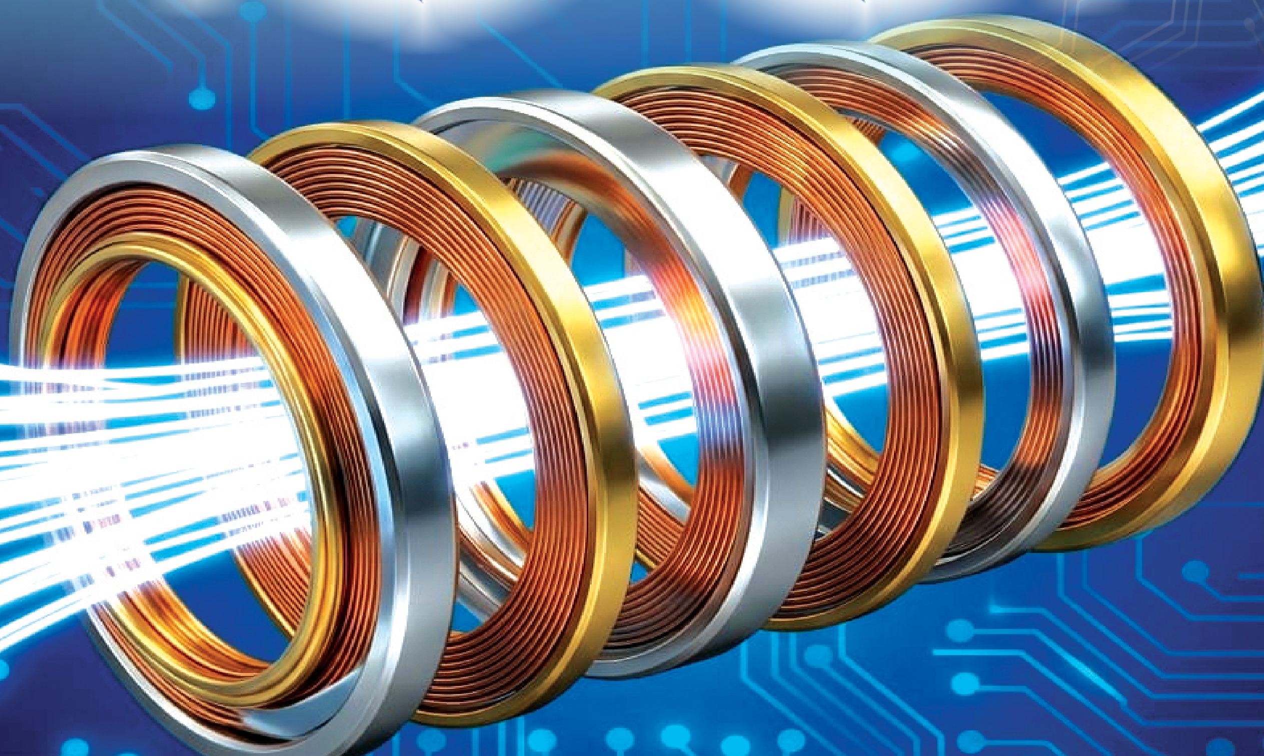

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Letter from the Research & Development (R&D) Department

Dear Respected Educators,

- It gives us great pleasure to present the sample chapter of our newly developed notes for the academic session 2026–27.
- These notes have been prepared with dedication and careful planning by our Research & Development team in line with the latest curriculum requirements.
- Designed to meet modern educational standards and student needs, these notes include accurate textbook solutions, additional questions, exam-focused practice material, and clear explanations to support excellent results.
- We believe that quality guidance and smart preparation lead to student success. Therefore, these notes aim to help students excel academically and compete for top positions.
- We are pleased to share this first chapter so your institution may begin planning and preparation while the complete books are being finalized.
- We sincerely hope these notes will prove valuable for your teachers and students. Your trust continues to inspire us to maintain the highest standards of educational excellence.

With best regards,

Ziyad Khan
Principal
Research & Development Department

CONTENTS

Chapter 10 THERMAL PHYSICS

Key concepts:

i. Thermal expansion
ii. Specific heat capacity
iii. Evaporation
iv. Latent heat
v. Superconductivity

Q.1 Define and explain thermal expansion. Illustrate linear thermal expansion quantitatively. (OR) 10110001

Derive related equation of linear thermal expansion of solid. (OR)

What is linear thermal expansion? Derive expression for the co-efficient of linear thermal expansion of solids.

Ans. Key points: Thermal expansion (Definition, Cause of expansion and contraction, Thermal expansion in solids)

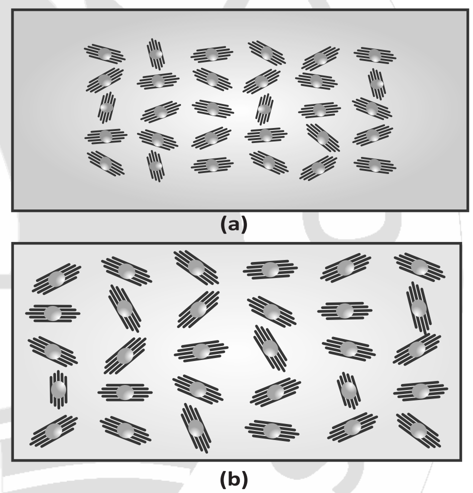


Fig. 10.1: Molecules of an object moving with (a) smaller amplitude at low temperature (b) larger amplitude at higher temperature

Thermal Expansion

Definition: "Thermal expansion is the change in length, area, or volume of a substance when it is heated."

1. Cause of expansion and contraction

- As the temperature rises, the particles within a substance gain more kinetic energy. This causes them to move faster and spread out, leading to expansion of the material (Fig. 10.1-b).
- Conversely, when a substance is cooled, its particles lose energy and move closer together, causing the material to contract (Fig. 10.1-a). This phenomenon is known as thermal contraction.

2. Thermal expansion in solids

When solids are heated, they expand, and this expansion remains almost consistent over a broad temperature range. Change in temperature may cause respective change in length or volume of the solids.

3. Linear Thermal Expansion

Definition: "If length of a solid changes upon heating, then it is called linear thermal expansion."

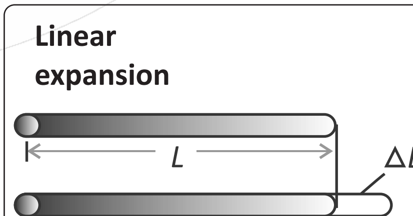


Fig. 10.2: Linear expansion in a metal rod

Derivation of expression

Consider a metal rod as shown in Fig. 10.2 with an initial length L_o at a temperature T_o When heated to a temperature T, its new length become L. Thus, the increase in length of the rod is:

$$\Delta L = L - L_o$$

And the rise in temperature is: $\Delta T = T - T_o$

It has been observed that the change in length ΔL of a solid is directly proportional to its original length L_o and the temperature change ΔT. Thus,

$$\Delta L \propto L_o \Delta T$$

Or $$\Delta L = \alpha L_o \Delta T$$

$$\alpha = \Delta L / L_o \Delta T$$

Or $$L - L_o = \alpha L_o \Delta T$$

Or $$L = L_o(1 + \alpha \Delta T) \quad \ldots\ldots\ldots\ldots(10.1)$$

- Here α is called the coefficient of linear thermal expansion of the material.
- The value of 'α' of different solid materials is different.

Q.2 Define and explain volume thermal expansion of a solid. 10110002

(OR) Define volume thermal expansion. Derive an expression for volume thermal expansion of solids.

Ans. Key points: Volume Thermal Expansion, (Definition, Derivation)

Volume Thermal Expansion

Definition: "The volume of a solid increases when its temperature rises. This is known as volume thermal expansion."

Derivation of expression

Suppose a solid has an initial volume V_o at a temperature T_o. When heated to a temperature T, its new volume becomes; $\Delta V = V - V_o$ and the rise in temperature is: $\Delta T = T - T_o$.

It has been observed that, the increase in volume ΔV is directly proportional to its original volume V_o and the temperature change ΔT, thus

$$\Delta V \propto V_o \Delta T$$

Or $$\Delta V = \beta V_o \Delta T$$

Or $$V - V_o = \beta V_o \Delta T$$

Or $$V = V_o(1 + \beta \Delta T) \quad \ldots\ldots\ldots\ldots(10.2)$$

Table 10.1: Values of some coefficient of linear expansion (α) of different solid materials

Substance	α (K^{-1})
Aluminium	2.4×10^{-5}
Brass	1.9×10^{-5}
Copper	1.7×10^{-5}
Steel	1.2×10^{-5}
Silver	1.93×10^{-5}
Gold	1.3×10^{-5}
Platinum	8.6×10^{-5}
Tungsten	0.4×10^{-5}
Glass (pyrex)	0.4×10^{-5}
Glass (Ordinary)	0.9×10^{-5}
Concrete	1.2×10^{-5}

- Here β is called coefficient of volume expansion which determines how much a material expands with temperature.
- Different solids have different values of β, meaning some expand more than others when heated.

Mathematically,

$$\beta = \frac{\Delta V}{V_o \Delta T}$$

- In solids, atoms are arranged in a tight, regular pattern. As the temperature rises, each atom pushes slightly harder against its neighbours due to increased vibration. Since there is no room to move inwards, the structure expands outward instead.

Q.3 Explain thermal expansion in liquids. **10110003(a)**

Ans. Key points: Thermal expansion in liquids, (Explanation, Example)

<u>Thermal expansion in liquids</u>

Definition: "When a liquid is heated, its volume increases, this is called thermal expansion in liquid. This happens because the heat energy makes the liquid molecules move faster, causing them to spread apart and take up more space."

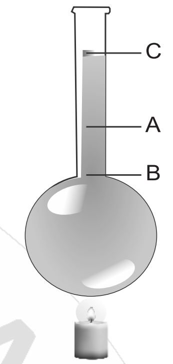


Fig. 10.3: Thermal expansion of a liquid

1. <u>Explanation</u>

- Unlike solids, which have a fixed shape and expand in a limited way, liquids do not have a definite shape, so they expand freely in all directions when their temperature rises.
- The degree to which a liquid expands depends on its specific coefficient of volumetric expansion, a property unique to each substance. This expansion is quantified by the formula:

$\Delta V = \beta V_o \Delta T$ …………………… (10.3)

where ΔV is the change in volume, β is the volume expansion coefficient, V_o is the original volume, and ΔT is the temperature change.

2. <u>Explanation with example</u>

- A common example of thermal expansion in liquid as seen in flask (Fig 10.3). When the flask is heated, the glass expands leading to decrease in liquid level from A to B which is known as expansion of flask (AB).
- As the liquid heats up, it expands and the level rises from B to C which is known as real expansion (BC). Where AC is an apparent expansion. Remember that real expansion is always greater than apparent expansion.

BC = AC + AB

Tidbit

Liquids do not have a fixed shape, so they expand more freely than solids. That is why we should not fill a bottle of water to the top before freezing it, it might crack.

Q.4 Explain thermal expansion in gases in detail. **10110003(b)**

Ans. Key points: Thermal expansion in gases, (Definition, Explanation, Behaviour of a gas, Importance, Dangers of uncontrolled expansion)

<u>Thermal expansion in gases</u>

Definition: "When temperature of a gas increases, its volume increases as long as the pressure remains same. This is called thermal expansion of the gas."

1. <u>Explanation</u>

- As the temperature of a gas increases, the kinetic energy of its particles also increases. This causes the gas molecules to move faster and collide more frequently and forcefully with the walls of the container.
- Thus, collisions exert pressure, on the container walls.

2. <u>Behaviour of a Gas in Flexible and non-flexible Container</u>

- If a gas is in a non-flexible container, the increased collisions lead to a rise in pressure.

- However, in a flexible container, the volume can expand instead, allowing pressure to remain constant.
- This behaviour aligns with Charles' law, which states that the volume of a gas is directly proportional to its temperature at constant pressure.

3. **Importance**

- The expansion of gases plays an important role in daily life and various industries. For example, in a hot air balloon, the air inside is heated, causing it to expand and become lighter than the cooler air outside. This makes the balloon to rise (Fig. 10.4).
- Similarly, in car engines, fuel burns and produces hot gases that expand quickly, pushing the pistons and making the vehicle move.
- In weather patterns, warm air expands and rises, affecting air pressure and causing winds and weather changes.

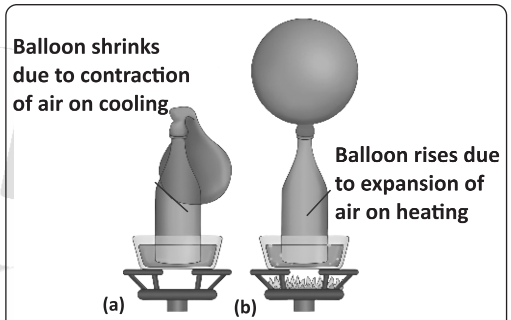


Fig. 10.4: Thermal expansion of gas in a balloon (a) Before heating (b) After heating

4. **Dangers of uncontrolled expansion**

The uncontrolled expansion of gases can be dangerous. For instance, aerosol cans and gas cylinders can explode if exposed to high temperatures because the gas inside expands beyond what the container can withstand.

Q.5 Discuss practical applications and consequences of thermal expansion in everyday life. 10110005

Ans. Key points: Practical applications and consequences of thermal expansion

Practical applications and consequences of thermal expansion

When materials expand or contract due to temperature changes, it can lead to structural, mechanical, and functional consequences. Thermal expansion is commonly used in our daily life such as:

1. **Applications**

a. **Thermometers:** In thermometers, thermal expansion in a narrow tube helps in the measurement of temperature.

b. **Hot Air Balloon:** The expansion of heated air is intentionally used to make the balloon rise. Heating the air inside causes it to expand, reducing its density so it lifts the balloon (Fig.10.5).

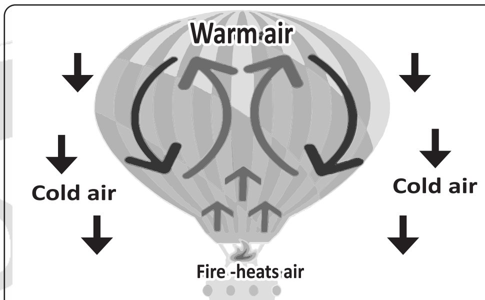


Fig. 10.5: When hot air balloon is heated, air inside the balloon expands and becomes less dense, causing the balloon to rise.

2. **Consequences**

a. **Gaps in Railway Tracks:** Steel tracks of the rails expand on hot days. Without room to expand, the tracks may bend or twist a phenomenon called "sun kinks" which can cause train derailments. Small gaps are left between railway tracks to allow them to expand in summer, preventing them from bending (Fig. 10.6-a).

b. **Bridges:** Bridges have small gaps called expansion joints that allow them to expand in hot weather and contract in cold weather without breaking (Fig. 10.6-b).

Fig. 10.6: (a) Expansion gaps in railway tracks (b) Expansion joints in bridges

c. **Metal Lids on Jars:** When a metal lid is stuck on a glass jar, running warm water over it makes the lid expand slightly, making it easier to open.

d. **Gas Containers (like aerosols or propane tanks):** Gases expand significantly when heated. If containers are exposed to heat (like being left in the Sun), pressure can build up inside and causes explosions. Warning labels advise users to store these containers away from heat, and pressure relief valves are often included.

e. **Pipes and Plumbing:** Water pipes can expand and contract, especially with hot water. This may lead to pipe bursts or joint leaks if not properly accounted for. Flexible joints and loops are used in piping systems to absorb movement.

Brain Teaser

Q. Why do not train tracks buckle in winter but do in summer even though the metal is the same?

Ans. Train tracks are made of steel, which undergoes thermal expansion when heated. In summer, the rise in temperature causes the tracks to expand significantly; if there is insufficient room for this expansion, the tracks buckle or twist. In winter, the low temperatures cause the tracks to contract rather than expand, so there is no risk of them buckling in winter.

Q.6 Define and explain specific heat of solids. 10110006

Ans. Key points: Specific heat, (Definition, Units, Formula, Explanation, Specific heat capacity of solids)

<u>Specific heat of a substance</u>

Definition: "Specific heat capacity (c) is the amount of heat energy needed to increase the temperature of 1 kg of a substance by 1 °C (or 1 K)."

Units

The SI units of specific heat capacity are J kg^{-1} K^{-1}.

Formula

$$Q = m\,c\,\Delta T \quad \text{.......................(10.4)}$$

Where

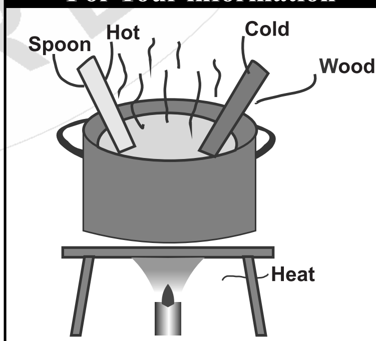
Q = heat energy

m = mass of the substance

ΔT = change in temperature

c = specific heat capacity

For Your information



Metal heats up quickly due to its low specific heat capacity, while wood stays normal because of its higher specific heart capacity.

Explanation

The energy required to heat a material depends on three factors:

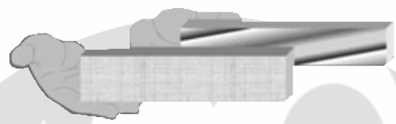
a. Mass of the substance b. Change of temperature c. Nature of the material

Some substances absorb heat more easily than others. For example, heating 1 kg of water by 1 °C requires more energy than heating 1 kg of alcohol by the same amount. This relationship is expressed using the formula: $Q = m\,c\,\Delta T$.

Do You Know?

Q. Why does metal feel colder than wood when touched, if they are both at the same temperature?

Ans. This sensation occurs because metal is a good conductor of heat, whereas wood is an insulator. When you touch a piece of metal, it rapidly conducts heat away from your hand, making it feel cold. In contrast, wood does not conduct heat away from your hand effectively, so it feels warmer to the touch even when it is at the exact same temperature as the metal.



Specific heat capacity of solids

- The specific heat capacity of solids is the heat energy needed to raise the temperature of 1 kg of a solid by 1 °C.
- Materials with a high specific heat capacity, such as wood and rubber require more heat to increase their temperature, making them useful in applications like cooking utensils and thermal insulation.
- On the other hand, metals like steel and copper have low specific heat capacities, i.e; they heat up and cool down quickly, so they are used in making cooking items, kettles, radiators, and heat engines.

Q.7 Define and explain specific heat of liquids. Discuss everyday effect due to large specific heat of water. **10110007**

Ans. Key points: Specific heat of liquids, (Definition, Explanation, Effects of large specific heat capacity of water)

Specific heat of liquids

Definition: "The specific heat capacity of a liquid is the amount of heat energy needed to raise the temperature of 1 kg of the liquid by 1°C or 1 K."

1. Explanation

- Different liquids have different specific heat capacities based on their molecular structure and ability to store heat.
- One of the most important liquids in this regard is water, which has a high specific heat capacity of 4200 J kg^{-1} K^{-1}. This means water can absorb and store a large amount of heat with only a small temperature increase. Because of this property, water is widely used in cooling systems, heating systems, and as a natural temperature stabilizer.
- Other liquids, such as alcohol and mercury, have lower specific heat capacities, meaning they heat up and cool down more quickly than water.

2. Effects of Large Specific Heat Capacity of Water

- Large water bodies like oceans and lakes absorb heat during the day and release it slowly at night, preventing drastic temperature changes. This is why coastal areas have milder climates compared to inland regions. Since water has a specific heat capacity of 4,200 J kg^{-1} K^{-1}, while dry soil has only 810 J kg^{-1} K^{-1}.

- Soil heats up five times faster than the same mass of water under the same heat. As a result, land temperatures rise and fall more quickly than sea temperatures, making seasonal temperature changes less extreme in coastal areas.
- Water's high specific heat capacity also makes it useful for storing and transferring heat.
- In an automobile engine, the cooling system uses water to absorb and carry away the heat produced during the engine operation.
- The pump circulates water through jackets around the engine cylinders, where it absorbs heat (Fig. 10.7). This heated water then flows through the thermostat, which regulates its movement based on temperature. If the water is too hot, the thermostat opens, allowing it to enter the radiator.
- In the radiator, a fan draws in outside air, which cools the water passing through it. The cooled water then returns to the engine to absorb more heat, and this cycle is repeated.
- A pressure release cap ensures that the system remains safe by releasing excess pressure.
- This property helps water to carry away engine heat efficiently, preventing overheating and ensuring smooth engine performance.

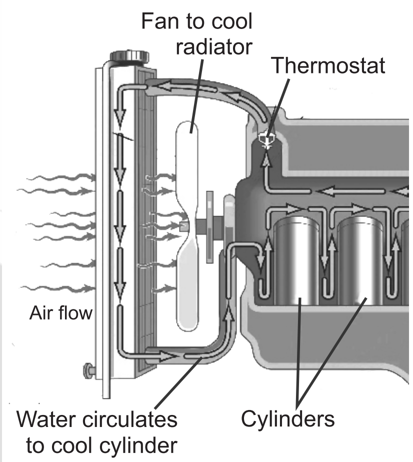


Fig. 10.7: Cooling system of automobile

Q.8 Define the following terms involved in change of state of a substance. **10110008**

1. Melting 2. Boiling
3. Condensation 4. Solidification

Ans. Key points: Change in state, Role of intermolecular force and order of thermal expansion

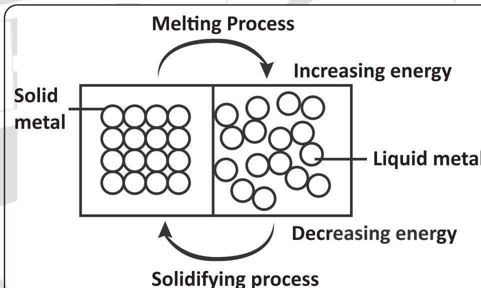


Fig. 10.8: Phase Changes

Change in State

1. Melting

Definition: "Converting from a solid to liquid is called melting."

When a substance absorbs energy, the atoms and molecules move more rapidly and hence need more space and separation between atoms or molecules. It may lead to turn from a solid to liquid, called melting.

2. Boiling

Converting the liquid to gas is known as boiling.

3. Condensation

Definition: "Converting from a gas to liquid is called condensation.

The atoms and molecules will slow down by losing energy and hence there is less space and separation between them. It may lead to turn a gas to liquid, called condensation.

4. Solidification

Converting a liquid to solid is known as solidification.

Role of intermolecular force and order of thermal expansion

- Keep in mind that intermolecular forces are the strongest in solids due to least separation and weakest in the gases, as the molecules are far apart as compared to liquids and solids.
- This is the reason that the gases exhibit the greatest relative thermal expansion while solids have the least expansion.

Q.9 Define and explain evaporation. Discuss different factors affecting evaporation. **10110009**

Ans. Key points: Evaporation, (Definition, Explanation, Factors)

Evaporation

Definition: "Evaporation is a natural process by which a liquid changes into a gas at its surface without boiling."

1. Explanation

- It occurs at all temperatures but is faster at higher temperatures. This change occurs at the surface of the liquid, where some of the particles have enough energy to escape into the air as vapour.
- Evaporation does not require the entire liquid to be heated, it can occur at room temperature.
- For instance, when water is spilled on the floor, it gradually disappears as it turns into water vapour.
- This process plays a key role in everyday life and in nature. It helps in drying wet clothes, and cooling our bodies through sweating.

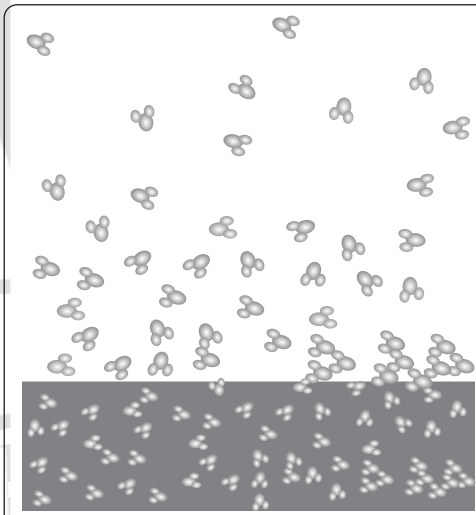


Fig. 10.9: Evaporation process (molecules at the surface of a liquid gain enough energy to escape into the air as vapour, leading to evaporation)

2. Factors affecting evaporation

Several key factors influence how quickly or slowly evaporation takes place:

a. **Temperature:** The higher the temperature, the faster evaporation occurs. When heat is added, the molecules in the liquid move more energetically, increasing the chances of them escaping into the air as vapour e.g. water evaporates faster on hot summer day than on a cold winter day.

b. **Surface Area:** A larger surface area allows more liquid to be exposed to the air, which speeds up evaporation. For example, water in a wide, shallow dish will evaporate quicker than the same amount in a tall, narrow container.

> **Tidbit**
> Evaporation from our skin takes away body heat, keeping us cool. That is our body's natural way of managing temperature.

c. **Air Movement (Wind Speed):** Wind or air movement helps to carry away the vapour molecules from the surface of the liquid. This prevents saturation of the air above the liquid and allows more molecules to evaporate (Fig. 10.9) e.g. clothes dry faster on a windy day.

d. **Humidity of the Surrounding Air:** If the air is already full of moisture (high humidity), evaporation slows down. But in dry air, the process occurs more rapidly because the air can absorb more water vapour e.g. clothes take longer time to dry in humid weather.

e. **Nature of the Liquid:** Different liquids evaporate at different rates based on their molecular structure. For instance, alcohol evaporates faster than water because its molecules require less energy to escape into the air.

f. **Pressure:** Lower atmospheric pressure can enhance evaporation since there is less force pushing down on the liquid surface, making it easier for molecules to escape e.g. water evaporates faster at the top of mountain than at sea level.

Q.10 Discuss how cooling is produced by evaporation? Describe the use of cooling caused by evaporation in refrigeration process to avoid harmful CFCS. Also differentiate between evaporation and boiling. **10110010**

Ans. Key points: Cooling caused by evaporation, Refrigeration without Chlorofluorocarbons (CFCs), Difference between evaporation and boiling

Cooling Caused by Evaporation

- During evaporation, the molecules that evaporate take away heat from the remaining liquid. This process cools the liquid down because the higher-energy molecules leave, leaving behind cooler molecules.
- For example, when we sweat, the sweat on our skin evaporates, taking heat away from our body and making us feel cooler.

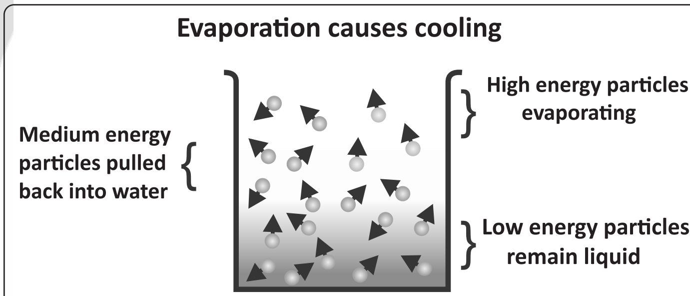


Fig. 10.10: High-energy molecules escape from the liquid surface a vapour, leaving behind lower-energy particles.

- Similarly, wet clothes dry faster on a hot day because water evaporates quickly, cooling the clothes as it evaporates.
- This cooling effect due to evaporation is important in everyday life and in nature, helping to regulate temperatures and keep things cool (Fig.10.10).

Brain Teaser

Q. If evaporation produces cooling, why does not boiling water feel cold?

Ans. While evaporation causes cooling by allowing high-energy particles to escape from the surface, boiling is a different process that requires a continuous supply of external heat. To boil water, it must be heated to its boiling point (100°C), meaning the liquid absorbs a large amount of thermal energy. Because the entire body of water is at a very high temperature, it feels hot despite the phase change occurring.

1. Refrigeration without Chlorofluorocarbons (CFCs)

- In modern refrigeration systems, the cooling effect caused by evaporation plays an important role in lowering temperatures without relying on harmful CFCs (chlorofluorocarbons).
- These systems use environmentally friendly refrigerants that evaporate at low temperatures inside the cooling coils.
- As the refrigerant evaporates, it absorbs a large amount of heat from the surrounding area (such as inside a refrigerator), causing the temperature to drop.

Tidbit

Refrigerators use an amazing trick: they cool by le ng special liquids evaporate inside coils. No harmful CFCs needed today, modern coolants are more eco - friendly.

- This absorbed heat is then carried away as the vapour is compressed and condensed back into a liquid outside the cooling compartment (Fig. 10.11).
- This cycle of evaporation and condensation enables continuous cooling, while avoiding the environmental damage once caused by ozone-depleting CFCs.

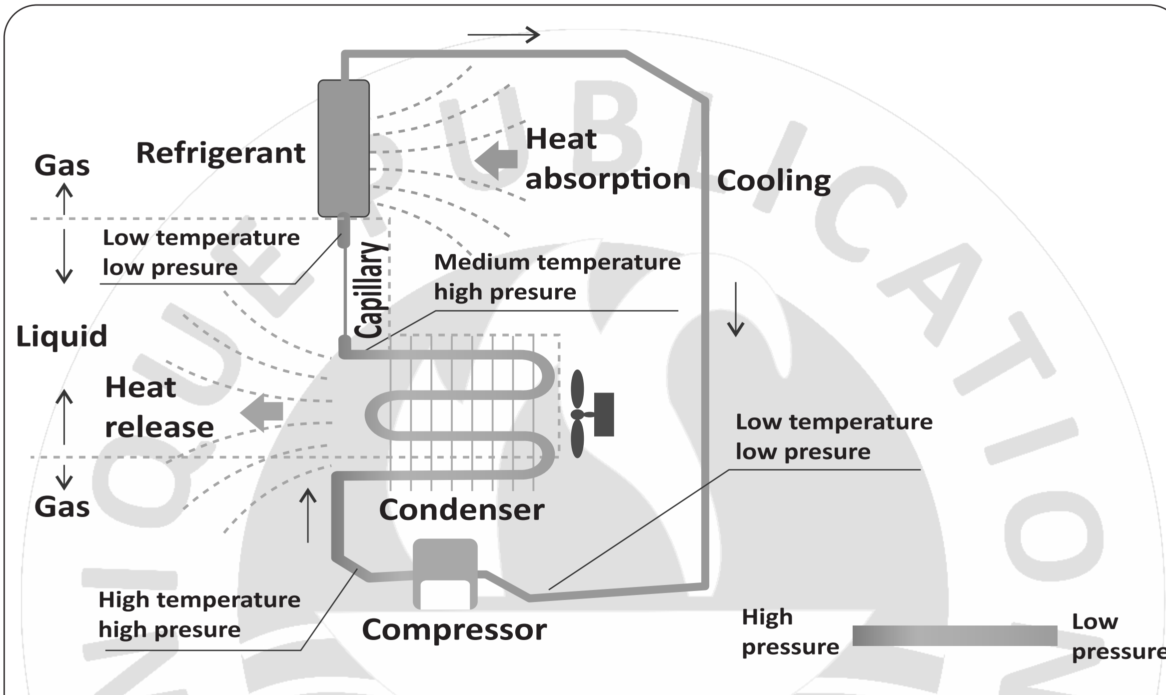


Fig 10.11: Block diagram of refrigerator

2. Difference between evaporation and boiling

Properties	Properties	Boiling
Occur	At the surface of liquid	Throughout the liquid
Temperature	At any temperature	Only at boiling point of liquid
Energy source	Uses surrounding energy	Uses continuous external heat source
Rate/speed	Generally slower and depends on many factors	Fast process (after reaching boiling point)
Process Completion Time	It takes longer to be completed	It is quick process than evaporation
Effect of pressure	Less effected by external	Highly effected by external pressure
Formation of Bubble	No bubble formation	Bubbles are formed throughout the liquid and rise from the surface
Dependence on surface area	Depends on surface area	Does not depend on surface area
Effect on temperature of surrounding	Causes cooling in surrounding	Increases temperature of surrounding

Q.11 What is a latent heat? Define latent heat of fusion and latent heat of vaporization. How can these be determined experimentally by sketching temperature – time graph on heating? 10110011

Ans. Key points: Latent heat, Latent Heat of Fusion, Latent Heat of Vaporization, Experiments

Latent Heat

Definition: "Latent heat is the heat energy required to change the state of a substance without changing its temperature."

Tidbit

When ice melts or water boils, energy is working hard behind the scenes to break bonds between molecules but the thermometer does not show any rise in temperature?

Importance

This heat is used to break or form bonds between particles instead of increasing their movement.

1. Latent Heat of Fusion

Definition: "Latent heat of fusion is the heat energy required to convert 1 kg of a solid into a liquid at its melting point while keeping the temperature constant."

a. Explanation

- When a solid melts into a liquid, it absorbs heat without rise in temperature.
- This heat is used to break the strong bonds between solid particles, allowing them to move more freely as a liquid.
- The temperature remains constant until the entire solid has melted.
- The latent heat of fusion is calculated using the formula:

b. Formula

$$Q = m\,L_f \quad \text{.......................(10.5)}$$

Where

L_f = Latent heat of fusion

Q = Heat energy

m = Mass of the substance

Do You Know?

The number of protons in the nucleus is what defines an element. Change the number of protons, and you change the element itself!

c. Example

Ice at 0 °C absorbs heat but remains at 0 °C until it completely melts into water. The latent heat of fusion of ice is 3.36×10^5 J kg^{-1}, meaning 3.36×10^5 joules of heat is needed to melt 1 kg of ice into water at 0 °C.

d. Experiment 1

- This involves placing small ice pieces in a beaker over a stand.
- Suspending a thermometer to measure temperature.
- Heating the beaker causes the ice to melt, keeping the mixture at 0 °C until all ice melts.
- Note the time taken for complete melting.

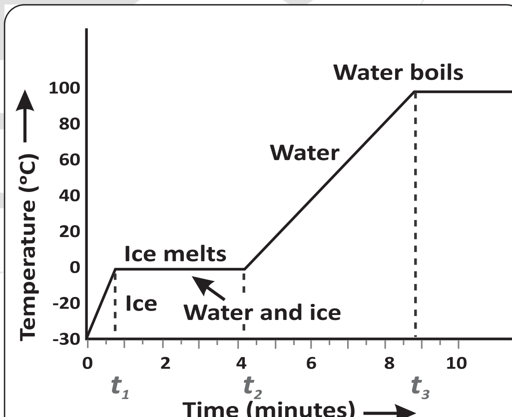


Fig. 10.12: Temperature-time graph as ice changes into water that boils as heating continues.

- Further heating causes water temperature to rise from 0 °C to 100 °C.
- Record the time for this increase.
- Plot a temperature-time graph (Fig. 10.12) and calculate the latent heat of fusion of ice using collected data.

$$Q = m\ L_f \Rightarrow L_f = \frac{Q}{m}$$

Here

$$Q = c\ m\ \Delta T$$
$$= m_w c_w (T_1 - T_2)$$

2. Latent Heat of Vaporization

Definition: "Latent heat of vaporization is the heat energy needed to change 1 kg of a liquid into gas at its boiling point without changing the temperature."

a. Explanation

- When a liquid changes into gas, it absorbs heat, but its temperature remains constant until the entire liquid has evaporated.
- This heat is used to break the bonds between liquid molecules, allowing them to escape as gas.
- The latent heat of vaporization of water is 2.26×10^6 J kg^{-1}. This means 2.26×10^6 J of heat energy is needed to convert 1 kg of water into steam at 100 °C.

b. Formula

The latent heat of vaporization is expressed as:

$Q = m\ L_V$ ....(10.6)

Where L_V is Latent heat of vaporization, Q is heat energy and m is the mass of the substance.

- Table 10.2 shows the melting point, boiling point, latent heat of fusion, and latent heat of vaporization of some common substances.

Table 10.2: Melting point, boiling point, latent heat of fusion, and latent heat of vaporization of some common substances

Substance	Melting point (°C)	Boiling point (°C)	Heat of fusion (J g^{-1})	Heat of vaporization (J g^{-1})
Aluminium	660	2250	39.7	10500
Copper	1083	2595	205.0	4810
Gold	1063	2660	64.0	1580
Helium	-270	-269	5.5	21
Lead	327	1750	23.0	858
Mercury	-39	357	11.7	270
Nitrogen	-210	-196	25.5	200
Oxygen	-219	-183	13.8	210
Water	0	100	336.0	2260

c. Experiment 2

- Take boiling water in a beaker.
- Continue heating water until all the water changes into steam note down temperature.
- Note the time which the water in the beaker takes to change completely into steam at its boiling point 100 °C.

Extend the temperature-time graph as shown in Fig. 10.13. Calculate the latent heat vaporization by collected data using formula.

$$L_V = \frac{Q}{m}$$

Here

$$Q = m_c c_w \Delta T$$

$$\Delta T = T_2 - T_1$$

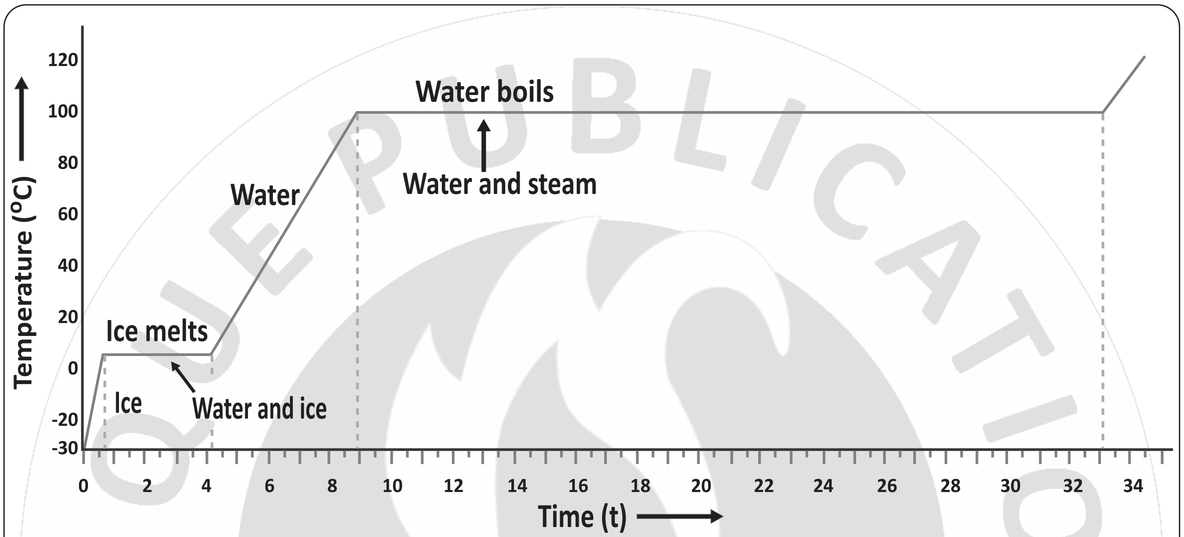


Fig 10.13: Temperature-time graph as ice changes into water and water into steam on heating

Q.12 Define and explain superconductivity. (OR) What is superconductivity? Explain its working and applications. **10110012**

Ans. Key points: Superconductivity, (Explanation, Materials, Uses)

Superconductivity

- Superconductivity is a special property of some materials where they have zero electrical resistance when cooled below a certain temperature, called the critical temperature.
- In this state, electricity flows without any energy loss, making superconductors very efficient.

1. Explanation

Since there are no collisions, electric current flows without facing any resistance as superconductors have zero electrical resistance. Figure 10.14 shows the variation of electrical resistivity with temperature for a superconductor and a normal metal. The resistivity of a superconductor drops to zero below the critical temperature (T_c), whereas a normal metal shows a gradual decrease in resistivity.

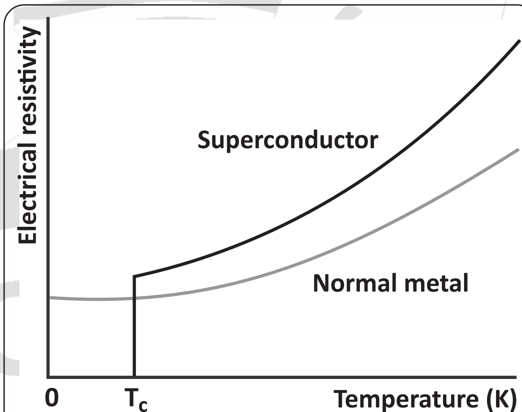


Fig. 10.14: Variation of electrical resistivity with temperature for a superconductor and normal metal

2. Materials That Show Superconductivity

Some metals and ceramics become superconductors at extremely low temperatures.

a. Mercury – Becomes superconducting below 4.2 K.

b. Lead – Becomes superconducting below 7.2 K.
c. High-temperature superconductors (ceramics) work at higher temperatures, such as 135 K.

3. Uses of Superconductors

Superconductors are used in advanced technologies, including:

a. MRI Machines: To generate strong magnetic fields for medical imaging.
b. Maglev Trains: Use of superconductors to float the train above tracks, reducing friction.
c. Particle Accelerators: Help scientists study fundamental particles. Superconductors are important for future technologies, making electrical systems more efficient and powerful.

Brain Teaser

Q. Why do superconductors need extreme cold temperature to work?

Ans. Superconductors only exhibit property of zero electrical resistance when they are cooled below a specific "critical temperature" (T_c). At these extremely low temperatures, often near absolute zero, the material undergoes a change where electricity can flow without any energy loss. If the temperature rises above this critical point, the material loses its superconducting ability and behaves like a normal metal with resistance.

Formula Sheet

Sr. #	Formula	Description
1	$L = L_o(1+\alpha\Delta T)$	Final length after heating
2	$\Delta L = \alpha L_o \Delta T$,	Change in length
3	$\alpha = \frac{\Delta L}{L_o \Delta T}$	Co-efficient of linear thermal expansion
4	$V = V_o(1+\beta\Delta T)$	Final volume after heating
5	$\Delta V = \beta V_o \Delta T$	Change in volume
6	$\beta = \frac{\Delta V}{V_o \Delta T}$	Co-efficient of volume thermal expansion
7	Real expansion = apparent expansion + expansion of vessel	Real expansion
8	$Q = mc\Delta T$	Quantity of heat in terms of specific heat
9	$Q = mH_f$	Quantity of heat in terms of latent heat of fusion
10	$Q = mH_V$	Quantity of heat in terms of latent heat of vaporization

Solved Examples

Example 10.1: A metal rod of length 1.5 m expands by 0.025 m when heated from 30 °C to 180 °C. Calculate its coefficient of linear expansion. **10110013**

Solution:

Given that;

L_o = Initial length = 1.5 m

ΔL = Change in length = 0.025 m

To find;

α = Coefficient of linear expansion=?

ΔT = Change in temperature = 180 °C–30 °C = 150 °C or 150 K

Using the formula:

$\alpha = \Delta L / L_o \Delta T$

Substituting the values

$\alpha = 0.025m / 1.5m \times 150K$

$\alpha = \frac{0.025}{225} = 1.11 \times 10^{-4} K^{-1}$

The co-efficient of linear expansion of metal rod is $1.11 \times 10^{-4}\ K^{-1}$.

Example 10.2: How much heat is required to melt 600 g of ice at 0 °C into water at 0 °C? 10110014

Latent heat of fusion of ice is 336 J g^{-1}.

Solution:

Given that;

Mass of ice m = 600g = 0.600kg

Latent heat of fusion of ice = L_f

$= 3.36 \times 10^5\ J\ kg^{-1}$

To find;

Heat required

Q = ?

Using the formula

$Q = m \times L_f$

Substituting the values

$Q = 0.600kg \times 3.36\ 10^5\ J\ kg^{-1}$

Q = 201,600 J

Or Q = 201.6 kJ

The heat required to melt is 201.6 KJ.

Multiple Choice Questions Exercise

1. **When the temperature of a rod of copper is increased, its length:** 10110015
   (a) remains the same
   (b) increases
   (c) decreases
   (d) becomes double
2. **The amount by which unit length of a material increases when the temperature is raised to 1°C, is called the coefficient of:** 10110016
   (a) cubic expansion
   (b) volume expansion
   (c) linear expansion
   (d) none of these
3. **What does liquid turn into once it is evaporated?** 10110017
   (a) Gas (b) Water Vapour
   (c) Air (d) Both (a) and (b)
4. **Which property determines how much heat a solid can absorb before its temperature changes significantly?** 10110018
   (a) Density
   (b) Specific heat capacity
   (c) Colour
   (d) Hardness
5. **High-temperature superconductors typically involve which type of material?** 10110019
   (a) Pure metals
   (b) Organic compounds
   (c) Ceramics
   (d) Liquid crystals

Answer Key

1	b	2	c	3	d	4	b	5	c

SLO Based Additional MCQs + Past papers MCQs of Punjab Boards

Thermal Expansion

1. **The formula for linear thermal expansion of a solid is:** 10110020
   (a) $L = L_o(1 + \beta\Delta T)$
   (b) $L = L_o(1 + \alpha\Delta T)$
   (c) $L = L_o(1 - \alpha\Delta T)$
   (d) $L = \alpha L_o \Delta T$

2. Which relationship correctly represents the thermal expansion of liquids? 10110021

(a) $\beta_r = \beta_a - \beta_f$

(b) $\beta_a = \beta_r + \beta_f$

(c) $\beta_r = \beta_a + \beta_f$

(d) $B_f = \beta_r - \beta_a$

3. Small gaps are left between railway tracks to prevent: 10110022

(a) Rusting
(b) Contraction in winter
(c) Buckling due to expansion
(d) Vibration

4. In the linear expansion formula, the symbol α represents: 10110023

(a) Coefficient of volume expansion
(b) Change in length
(c) Coefficient of linear thermal expansion
(d) Specific heat capacity

Specific Heat Capacity

5. The SI unit of specific heat capacity is: 10110024

(a) $J\,kg^{-1}$ (b) $J\,k^{-1}$
(c) $J\,kg^{-1}K^{-1}$ (d) $JkgK$

6. The specific heat capacity of water is: 10110025

(a) $810\ J\,kg^{-1}K^{-2}$ (b) $2100\ J\,kg^{-1}K$
(c) $4200\ J\,kg^{-1}K^{-1}$ (d) $33600\ J\,kg^{-1}K^{-1}$

7. Soil heats up faster than water because the specific heat capacity of dry soil is: 10110026

(a) Higher than water
(b) Equal to water
(c) Lower than water
(d) Zero

Evaporation

8. Evaporation is a process where a liquid changes into gas: 10110027

(a) At its boiling point only
(b) Without boiling
(c) At $100°C$ only
(d) By absorbing latent heat of fusion

9. Which of the following factors does not increase the rate of evaporation? 10110028

(a) Higher temperature
(b) Larger surface area
(c) High humidity
(d) Air movement (Wind)

Latent Heat

10. The heat energy required to change a solid into a liquid at its melting point without changing temperature is called: 10110029

(a) Specific heat capacity
(b) Latent heat of fusion
(c) Latent heat of vaporization
(d) Coefficient of expansion

11. The value of latent heat of fusion of ice is: 10110030

(a) $2.26\times10^6\ J\,kg^{-1}$

(b) $3.36\times10^5\ J\,kg^{-1}$

(c) $4200\ J\,kg^{-1}$

(d) $334\ J\,kg^{-1}$

12. The latent heat of vaporization of water is: 10110031

(a) $3.36\times10^5\ J\,kg^{-1}$ (b) $4.2\times10^3\ J\,kg^{-1}$
(c) $2.26\times10^6\ J\,kg^{-1}$ (d) $2.26\times10^5\ J\,kg^{-1}$

Superconductivity

13. Superconductivity is a state where materials exhibit: 10110032

(a) High electrical resistance
(b) Zero electrical resistance
(c) Zero thermal expansion
(d) Infinite density

14. Mercury becomes a superconductor at a critical temperature of: 10110033

(a) 7.2 K (b) 0 K
(c) 4.2 K (d) 100 K

15. Which of the following is an application of superconductors? 10110034

(a) Electric heaters (b) Filament bulbs
(c) MRI Machines (d) Diesel engines

Answer Key

1	b	2	c	3	c	4	c	5	c	6	c	7	c	8	b
9	c	10	b	11	b	12	c	13	b	14	c	15	c		

Exercise Short Questions

10.1 What factors influence the thermal expansion of solids? **10110035**

Ans. The expansion of a solid depends on its original length (L_0), the temperature change (ΔT), and the thermal expansion coefficient (α).

Formula: $\Delta L = \alpha L_o \Delta T$

Factors:

- **Original length (L_o):** Longer rod expands more
- **Temperature change (ΔT):** Larger ΔT gives larger expansion
- **Thermal expansion coefficient (α):** Different materials have different α values (Aluminium has higher α than steel, so expands more)

10.2 What is latent heat of fusion?

Ans. Latent Heat of Fusion **10110036**

The heat energy required to convert 1 kg of a solid into a liquid at its melting point while keeping the temperature constant is called Latent heat of fusion. This energy is used to break bonds between solid particles, so the temperature stays constant during melting.

Formula

$$Q = mL_f$$

Unit: J/kg

10.3 How do different materials exhibit varying thermal expansion behaviours? **10110037**

Ans. Different materials expand by different amount on heating their atoms are bonded with different strengths. Materials with weaker bonding expand more, while those with strong bonding expand less.

Gases expand more than liquids and solids due to their weak bonding.

10.4 How does evaporation contribute to cooling processes in everyday life? **10110038**

Ans. Evaporation causes cooling because the faster (higher energy) molecules of a liquid escape into the air during evaporation. These molecules take heat energy with them, so the remaining liquid loses heat and becomes cooler.

Example

When sweat evaporates from our skin, it absorbs heat from the body to change into vapor. As a result, the body loses heat and we feel cool. This process helps regulate body temperature, especially in hot weather.

10.5 What is latent heat of vaporization, and how is it calculated? **10110039**

Ans. The heat energy needed to change 1 kg of a liquid into gas at its boiling point without changing the temperature is called Latent heat of vaporization. When a liquid boils, it absorbs heat without a temperature rise until all the liquid has evaporated.

Formula

$$Q = mL_v$$

Unit

J/kg

SLO Based Additional Short Questions + Past papers Short Questions of Punjab Boards

Thermal Expansion

Q.1 Define thermal expansion and explain why it occurs? 10110040

Ans. The change in length, area, or volume of a substance when it is heated is called Thermal expansion.

Reason:

As the temperature rises, the particles within a substance gain more kinetic energy. This causes them to move faster and spread out, leading to the expansion of the material. Conversely, cooling causes particles to lose energy and move closer together, resulting in contraction.

Q.2 Define the coefficient of linear thermal expansion. Write its formula and SI units. 10110041

Ans. The fractional change in length per degree change in temperature for a specific material is called the coefficient of linear thermal expansion.

Formula

$$\Delta L = \alpha L_o \Delta T$$

Here α is coefficient of linear expansion

SI Unit

K^{-1} (Per Kelvin)

Q.3 Define linear thermal expansion and volume thermal expansion? Write their formulas. 10110042

Ans. Linear Thermal Expansion and Volume Thermal Expansion

The expansion in length due to heating is called linear thermal expansion. It is given by $\Delta L = \alpha L_o \Delta T$. Where α is the co-efficient of linear thermal expansion.

Volume thermal expansion is the increase in volume of a solid or liquid when heated. It is given by:

$$\Delta V = \beta V_o \Delta T$$

Where β is the coefficient of volume expansion.

Q.4 Differentiate between real and apparent expansion of liquids. 10110043

Ans.

Real Expansion	Apparent Expansion
• This is the actual increase in the volume of the liquid itself, independent of the container's expansion. • Real expansion is always greater than apparent expansion. • It accounts for both the thermal expansion of the liquid and the container. • **Formula:** Real expansion = apparent expansion + expansion of vessel	• When a liquid is heated in a container, the container also expands. The observed rise in liquid level, which is less than the actual expansion, is called apparent expansion. • Apparent expansion is always smaller than real expansion. • It only accounts for the visible change in liquid level due to unequal expansion rates. • The difference between real and apparent expansion equals the expansion of the flask itself.

Q.5 Why are gaps left in railway tracks? 10110044

Ans. Steel tracks expand on hot days. If no room is left for this expansion, the tracks may bend or twist—a phenomenon known as "sun kinks"—which can cause train derailments. Small gaps are left between tracks to allow for this expansion safely.

Q.6 Explain the principle behind the rising of a hot air balloon. 10110045

Ans. When the air inside a balloon is heated, it expands and becomes less dense (lighter) than the cooler air outside. This difference in density creates an upward lift, causing the balloon to rise.

Specific Heat Capacity

Q.7 Define specific heat capacity and write its SI unit. 10110046

Ans. Specific heat capacity is the amount of heat energy needed to increase the temperature of 1kg of a substance by (or 1K).

Formula

$Q = m c \Delta T$

c = specific heat capacity

SI Unit: $J\ kg^{-1}\ K^{-1}$ (Joules per kilogram per Kelvin)

Q.8 Why does the temperature of land rise faster than that of the sea during the day? 10110047

Ans. Water has a high specific heat capacity (4200 $J\ kg^{-1}\ K^{-1}$), compared to dry soil (810 $J\ kg^{-1}\ K^{-1}$). This means soil heats up five times faster than the same mass of water under the same heat, causing land temperatures to rise more quickly than sea temperatures.

Q.9 How does water help in the cooling system of an automobile? 10110048

Ans. Water is used because of its high specific heat capacity (4200 $J\ kg^{-1}\ K^{-1}$), allowing it to absorb a large amount of heat with only a small rise in temperature.

- Water circulates around the engine cylinders, absorbing heat.
- The heated water moves to the radiator, where it is cooled by air drawn in by a fan.
- The cooled water returns to the engine to repeat the cycle.

Q. Why does water have a high specific heat capacity? 10110049(a)

Ans. Water can absorb and store a large amount of heat with only a small temperature increase due to its molecular structure, making it effective for temperature regulation.

Evaporation

Q.10 Define evaporation and explain how it causes cooling? 10110049(b)

Ans. The process by which a liquid change into a gas at its surface without boiling is called Evaporation.

Cooling Effect:

It occurs when more energetic particles escape from the surface of the liquid as vapors. As these high-energy particles leave, the remaining liquid has lower average kinetic energy, resulting in a drop in temperature (cooling).

Q.11 List the factors that affect the rate of evaporation with brief detail. 10110050

Ans. Temperature: Higher temperature increases the rate of evaporation.

Surface Area: Larger surface area speeds up evaporation.

Air Movement (Wind): Wind carries away vapor's molecules, preventing saturation and speeding up the process.

Humidity: High humidity slows down evaporation; dry air speeds it up.

Nature of Liquid: Liquids with weaker molecular forces (like alcohol) evaporate faster than water.

Q.12 How does a refrigerator cool food without using CFCs? 10110051

Ans. Environmentally friendly refrigerants are used to evaporate at low temperatures inside cooling coils. As the refrigerant evaporates, it absorbs a large amount of heat from inside the refrigerator. The vapour is then compressed and condensed back into a liquid outside the compartment, releasing the heat.

Latent Heat and Change in State

Q.13 Define Latent Heat of Fusion and state its value for ice. 10110052

Ans. The heat energy required to convert 1 kg of a solid into a liquid at its melting point while keeping the temperature constant is called Latent heat of fusion.

Formula

$$Q = mH_V$$

$H_f =$ latent heat of fusion

Value for Ice: The latent heat of fusion of ice is 3.36×10^5 J kg^{-1} (or 336 J g^{-1})

Q.14 Why does the temperature of ice remain same while it is melting, even though heat is applied? 10110053

Ans. The heat absorbed during melting is used to break the strong bonds between solid particles rather than increasing their kinetic energy. Therefore, the temperature remains constant until the entire solid has melted.

Q.15 Define Latent Heat of Vaporization and state its value required to vaporize water. 10110054

Ans. Latent heat of vaporization is the heat energy needed to change 1 kg of a liquid into gas at its boiling point without changing the temperature.

Formula

$$Q = mH_V$$

$H_V =$ latent heat of vaporization

Value for Water: The latent heat of vaporization of water is 2.26×10^6 J kg^{-1} (or 2260 J g^{-1})

Q.16 What is superconductivity? Give examples of superconducting materials. 10110055

Ans. Superconductivity is a state in which materials exhibit zero electrical resistance. This occurs when the material is cooled below a specific temperature.

Examples

Mercury (becomes superconductor below 4.2 K) and Lead (below 7.2 K).

Q.17 What is the critical temperature? Give example. 10110056

Ans. The temperature below which a material exhibits zero electrical resistance is called **critical temperature** for e.g. the critical temperature Hg is 4.2 K.

Q.18 Write applications for superconducting materials. 10110057

Ans. MRI Machines: Generating strong magnetic fields for medical imaging.

Maglev Trains: Floating trains above tracks to reduce friction.

Particle Accelerators: They help scientists study fundamental particles. Superconducting magnets accelerate particles to nearly the speed of light.

Constructed Response Questions

10.1 Why do bridges need expansion joints but glass jars with metal lids do not, even though both experience temperature changes? Discuss in terms of the nature of thermal expansion. 10110058

Ans. Bridges are long metal structures, so they expand significantly when heated. Small gaps (expansion joints) are placed in bridges to allow this expansion and contraction without damage. A glass jar with a metal lid is much shorter, so heating only causes a very small increase in length. In fact, warming the metal lid (for example by running it under warm water) makes it expand just enough to loosen the lid.

10.2 If two liquids are heated under same conditions, but one of them heats up faster, what does this indicate about specific heat capacity? 10110059

Ans. As heat capacity is given by $Q = mc\Delta T$ for same heat and mass 'm' $\Delta T \alpha \frac{1}{c}$, it means liquid which heats up faster has smaller specific heat capacity.

10.3 Why does a liquid evaporate faster when the air is dry? **10110060**

Ans. Evaporation depends on humidity. Low humidity increases evaporation, while high humidity reduces it.

Explanation

A liquid evaporates faster when the air is dry because dry air can hold more water vapor. When humidity is low, water molecules easily leave the liquid and mix with the air. Since the air is not saturated, evaporation continues quickly. If the air is humid, it already contains a lot of water vapor. In this case, the air cannot absorb much more vapor, so evaporation slows down.

10.4 When a piece of ice melts, the temperature does not increase even though heat is supplied. Where does the energy go, and why is this important in phase change? **10110061**

Ans. When ice melts, the heat supplied is used to break the bonds between water molecules. This energy is called latent heat of fusion. It helps change ice into water instead of raising the temperature. Therefore, the temperature remains at 0 °C until all the ice has melted. This is important in phase change because it allows a substance to change its state at a constant temperature.

10.5 Why do electric transmission wires sag in summer and tighten in winter? **10110062**

Ans. Electric transmission wires are made of metal and follow the formula

$$\Delta L = \alpha L_o \Delta T$$

Explanation

Electric transmission wires are made of metal. Metals expand when temperature increases and contract when temperature decreases. In summer, the high temperature makes the wires expand, so they become longer and sag. In winter, the low temperature causes the wires to contract, so they become shorter and tight.

Comprehensive Questions

10.1 How does thermal expansion differ between solids, liquids, and gases? Provide examples to illustrate these differences. **10110063**

Ans. Thermal expansion differs because the distance between particles and the strength of forces between them are different.

Solids: Particles are very close and strongly bonded, so expansion is very small.

Example: Railway tracks expand slightly in summer.

Liquids: Particles are less tightly packed, so expansion is more than solids.

Example: Mercury rises in a thermometer when heated.

Gases: Particles are far apart with very weak forces, so expansion is very large.

Example: A balloon expands when filled with hot air.

Conclusion

Gases expand most, liquids expand more than solids, and solids expand the least due to differences in particle spacing and bonding.

10.2 What are some practical consequences of thermal expansion in everyday life, such as in construction materials or household appliances?

Ans. See Q.#5 of theory. **10110064**

10.3 What is latent heat, and why is it important in phase transitions like melting and vaporization? **10110065**

Ans. See Q.#11 of theory.

10.4 Why do solids, liquids, and gases expand when heated? Explain with examples. **10110066**

Ans. See Q.#1 of theory.

10.5 If we have an equal amount of water in a wide, shallow dish and a tall, narrow container kept at the same temperature, in which container will evaporation occur faster? Explain the reason scientifically. **10110067**

Ans. Shallow dish has larger surface area compared to tall, narrow container, so more water molecules will evaporate in dish.

Numerical Problems

10.1 A metal rod of length 1 m expands by 0.02 m when heated from 20 °C to 120 °C. Calculate its coefficient of linear expansion. **10110068**

Solution

Initial length of rod = L_o = 1.00 m

Increase in length = ΔL = 0.02 m

Initial temperature, = T_o = 20°C

Final temperature, = T = 120°C

$\Delta T = T - T_o$ = 120 °C – 20 °C= 100 °C or 100 K

To Find:

Coefficient of linear expansion = α = ?

Using formula:

$$\alpha = \frac{\Delta L}{(L_o \times \Delta T)}$$

Putting the values, we have:

$$\alpha = \frac{0.02}{(1.00 \times 100)}$$

$$\alpha = 2.0 \times 10^{-4} K^{-1}$$

Result:

$$\alpha = 2.0 \times 10^{-4} K^{-1}$$

10.2 A container holds 1 litre of water at 20 °C. What will be its volume at 80 °C, assuming water's coefficient of volume expansion is 2.1×10^{-1} per °C?

Solution **10110069**

Initial volume of water = V_o = 1.00 L

= 1000 cm³ (1.00 L = 1000 cm³)

Coefficient of volume expansion

= β = 2.1×10^{-4} / °C

Initial temperature = T_o = 20 °C

Final temperature = T = 80 °C

$$\Delta T = T - T_o = 80°C - 20°C = 60°C$$

$$\Delta V = \beta \times V_o \times \Delta T$$

$$\Delta V = 2.1 \times 10^{-4} \times 1000 \times 60 = 12.6 cm^3$$

To Find:

Final volume = V = ?

Using formula:

$$\Delta V = V - V_o$$

$$V = \Delta V + V_o$$

Putting the values, we have:

So, $= 12.6 + 1000 = 1012.6 cm^3$

Result

$$V = 1012.6\ cm^3$$

Note: The problem can also be solved by applying equation $V = V_o(1 + \beta \Delta T)$

10.3 A steel rod initially measures 2 m at 20 °C. If its coefficient of linear expansion is 1.2×10^{-5} °C^{-1}, what will be its length at 100 °C? **10110070**

Solution

Initial length of rod = L_o = 2.00 m

Coefficient of linear expansion

= α = $1.2 \times 10^{-5} K^{-1}$

Initial temperature, = T_o = 20 °C

Final temperature = T = 100 °C

$$\Delta T = T - T_o = 100°C - 20°C = 80°C$$

To Find:

Final length = L = ?

Using formula:

$L = L_o \times (1 + \alpha \times \Delta T)$

Putting the values, we have:

$L = 2.00 \times (1 + 1.2 \times 10^{-5} \times 80)$

$L = 2.00 \times (1 + 0.00096) = 2.00 \times 1.00096$

$= 2.00192$ m

Result: $L = 2.00192$ m

10.4 A steel bridge expands by 5 cm on a hot summer day. If the bridge originally spanned 100 m, what is the temperature change? 10110071

Solution

Original length of bridge = $L_o = 100.0$ m

Expansion in length = $\Delta L = 5$ cm = 0.050 m

Coefficient of linear expansion

$= \alpha = 1.2 \times 10^{-5}\ K^{-1}$

To Find:

Temperature change = ΔT = ?

Using formula:

$\Delta L = \alpha \times L_o \times \Delta T$

or $\Delta T = \dfrac{\Delta L}{(\alpha \times L_o)}$

Putting the values, we have:

$$\Delta T = \frac{0.050}{(1.2 \times 10^{-5} \times 100.0)} = 41.67\ °C$$

Result

$\Delta T = 41.67$ °C

10.5 How much heat is required to raise the temperature of a 2 kg iron bar from 20 °C to 100 °C, given that the specific heat capacity of iron is 450 J kg^{-1} k^{-1}? 10110072

Solution

Mass of iron bar = m = 2.00 kg

Specific heat capacity of iron

$= c = 450\ J\ kg^{-1}\ K^{-1}$

Initial temperature = T_o = 20 °C

Final temperature, = T = 100 °C

$\Delta T = T - T_o = 100°\ C - (20°\ C) = 80°\ C$ or 80k

To Find:

Heat required, Q = ?

Using formula:

$Q = m \times c \times \Delta T$

Putting the values, we have:

$Q = 2 \times 450 \times 80 = 72000$ J

= 72000 J

= 72 kJ

Result: Q = 72 kJ

10.6 How much heat is required to melt 500 g of ice at 0°C into water at 0 °C? 10110073

(Latent heat of fusion of ice = 3.36×10^5 J kg^{-1} = 0.5kg)

Solution

Mass of ice = m = 500 g = $\dfrac{500\,kg}{1000} = 0.5\,kg$

Latent heat of fusion of ice

$= L_f = 3.36 \times 10^5\ J\ kg^{-1}$

To Find:

Heat required to melt ice = Q = ?

Using formula:

$Q = m \times L_f$

Putting the values, we have:

$Q = 0.5 \times 3.36 \times 10^5 = 168$ kJ

Result

Q = 168 kJ

10.7 Calculate the heat required to completely vaporize 1 kg of water at 100 °C. (Latent heat of vaporization of water =2.2610^6 J kg^{-1}) 10110074

Solution

Mass of water = m = 1.00 kg

Latent heat of vaporization of water

$= L_V = 2.26 \times 10^6\ J\ kg^{-1}$

To Find:

Heat required to vaporize water = Q = ?

Using formula:

$Q = m \times L_V$

Putting the values, we have:

$Q = 1 \times 2.26 \times 10^6 = 2.26 \times 10^6$ J

Result

$Q = 2.26 \times 10^6$ J

= 2.26 MJ

Important Questions of Board Examination

(i) Define co-efficient of linear thermal expansion and derive an expression for same.
(ii) Define specific heat. Explain effects of large specific heat of water.
(iii) Define evaporation. Explain different factors affecting evaporation.
(iv) Differentiate between latent heat of fusion and vaporization.

Important Short Questions of Board Examination

(i). Define thermal expansion.
(ii). Define specific heat capacity of a substance. Write down its formula and SI units.
(iii). Define evaporation. Name different factors affecting evaporation.
(iv). Differentiate between latent heat of fusion and latent heat of vaporization. Write their SI units.
(v). Define
  (i) Superconductor
  (ii) Critical temperature
(vi). Write down uses of superconductors in advanced technology.
(vii). Define
  (i) Melting
  (ii) Boiling
(viii). Define
  (i) Condensation
  (ii) Solidification
(ix). Define linear thermal and volume thermal expansion of a solid. Write their formulas.
(x). Define co-efficient of linear thermal expansion. Write down its SI units.
(xi). Why temperature-time graph for heating ice remains flat during melting and boiling but rises when substance is not changing.
(xii). Explain why gases expand more than solids and liquids when heated, based on kinetic theory.
(xiii). Why are bridges and railway tracks designed with expansion gap?
(xiv). Differentiate between real and apparent expansion of liquids.
(xv). Differentiate between boiling and evaporation.
(xvi). Why does sand and beach heat up faster during day compared to water in sea?
(xvii). How hot air balloon rise in air?
(xviii). Explain and compare the thermal expansion for solids, liquids and gases.