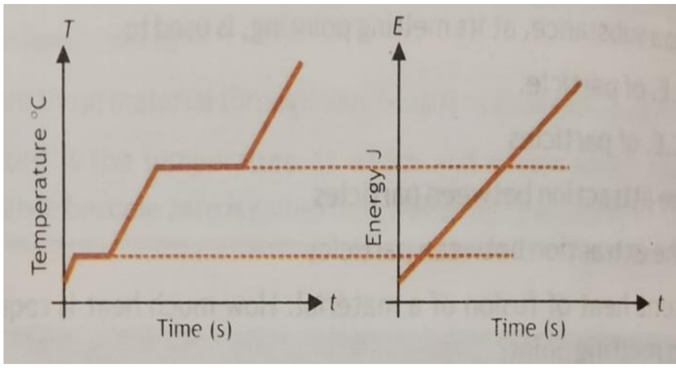
PHYSICS CLASS 10TH

CHAPTER NO 11 (THERMAL TRANSFORMATIONS)

CONSTRUCTED RESPONSE QUESTIONS

1. Look at these graphs for heating the ice, energy(E)-time(T) graph shows the energy is being supplied to the ice at constant rate to change it into liquid and finally into steam. While the temperature (T)-time(t) graph shows that change of temperature of ice and water during different stages.



a. There are two horizontal parts of this graph, where temperature is not changing but energy is being supplied to substance at constant rate. Explain why does temperature not change at these two stages?

Temperature is not changing at these two stages because energy is absorbed as latent heat in the substance during phase change from solid to liquid and liquid to gas. That's why energy is increasing but temperature is constant at these two-phase changing stages.

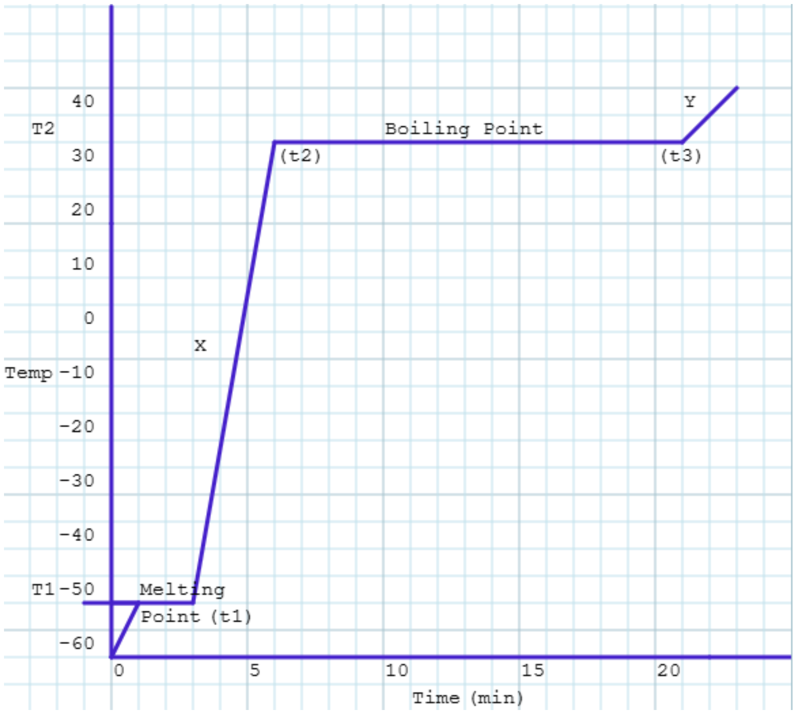
b. Explain why the temperature and energy trends are not same for the same time intervals?

Temperature is a measure of the average kinetic energy of the particles in a substance, while thermal energy (or heat) is the total kinetic energy of all the particles.

When a substance undergoes a phase change (like melting or boiling), energy is added or removed to break or form bonds between molecules, but this doesn't directly change the kinetic energy (and thus the temperature) of the particles.

When energy is added to a substance, it can be used for other processes besides increasing kinetic energy, like breaking bonds during a phase change, which causes temperature to remain constant.

2. A heater supplies energy at constant rate to 100g of substance. The variation with time of the temperature of substance is shown in figure. The substance is perfectly insulated from its surroundings. The power of heater is 250W. From the figure answer the following questions



a. What is the melting and boiling point of substance?

From graph melting point of substance is -50°C and its boiling point is 35°C

b. How long does it take to melt completely and how does it take to vaporize from liquid state?

Melting time: 2.5 minutes approximately from graph

Vaporizing time: $t_3 - t_2 = (21 - 6) = 15\ minutes$

c. How much temperature changes in its liquid state (x part of graph)?

Change in temperature from -50°C *to* 35°C:

$T_2 - T_1 = 35°C - (-50°C) = 85°C$

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d. Calculate latent heat of vaporization of substance?

Latent heat of vaporization will be calculated by formula when $P = 250\ W$ and $t = 15\ minutes$

$$P = \frac{Q}{t}$$
$$Q = P \times t$$
$$Q = 250 \times 15$$
$$\boldsymbol{Q = 3750\ J}$$

SHORT RESPONSE QUESTIONS

1. **Why do dew- drops form on leaves and grass in a spring morning?**

   Dew drops formation is due to process known as condensation, in which water vapor in the air will become liquid water.

   When water vapor in the air cools down and comes into contact with a cooler surface, it loses energy and changes from a gaseous state to a liquid state, forming visible water droplets. These droplets are the dew we see on leaves and grass in the morning.

2. **What is the effect of pressure and temperature variation on sublimation and deposition?**

   Effect of Pressure:

   Sublimation: Sublimation occurs at low pressure, as it allows solids to more easily transition to the gaseous state without first becoming a liquid.

   Deposition: Deposition occurs at high pressure, because gas molecules will collide and condense into a solid.

   Effect of Temperature:

   Sublimation: Sublimation occurs at high temperature, as it provides more energy for molecules to overcome the intermolecular forces that hold them in the solid state.

   Deposition: Deposition occurs at low temperature, as it slows down gas molecules and increases their tendency to condense and form a solid.

3. **Why do vapors form on the handle and cylinder of fire extinguisher when it is discharged?**

   This phenomenon is due to the process of vaporization, where a liquid like CO_2 absorbs heat and expands as it turns into a gas.

   When the handle is squeezed, the pressure inside the cylinder drops, causing the CO_2 to expand and rapidly vaporize.

   As the CO_2 vaporizes, it absorbs heat from its surroundings, including the handle and cylinder. This absorption of heat causes the cylinder and handle to feel cold.

4. **How does sweating help to cool our body down during exercise?**

   Sweating help to cool our body down during exercise due to evaporation. During exercise, muscles generate heat as they contract, raising the body's temperature.

   During evaporation fast-moving high-energy molecules escape out from our body. Molecules that have lower kinetic energies are left behind. This lowers the average kinetic energy of the molecules and the temperature of the body.

   Since temperature of a substance depends on the average kinetic energy of its molecules. Evaporation of sweating reduces body temperature and helps to cool our bodies.

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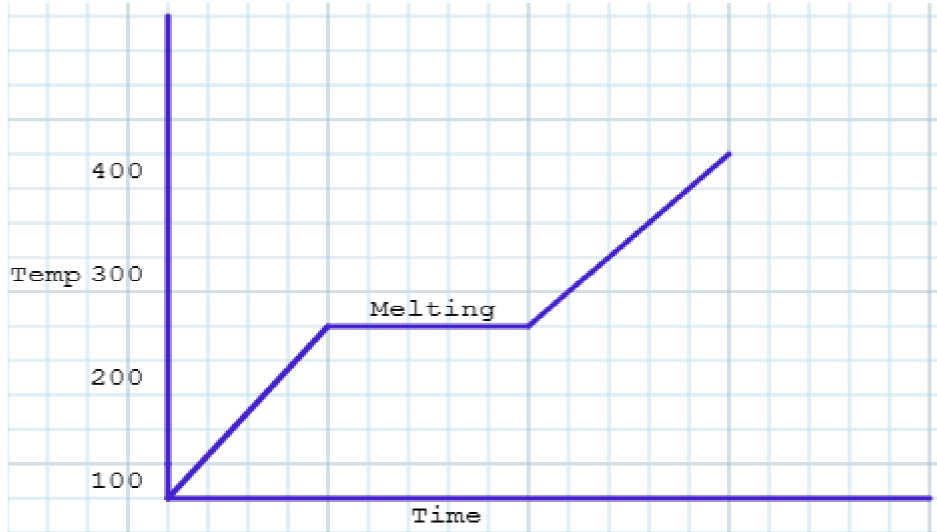
5. Consider a piece of metal X initially at temperature of 100^0C. It is placed on a heater (which is providing heat at constant rate) until it reaches a final temperature of 400^0C. the meatal has melting point of 250^0C.

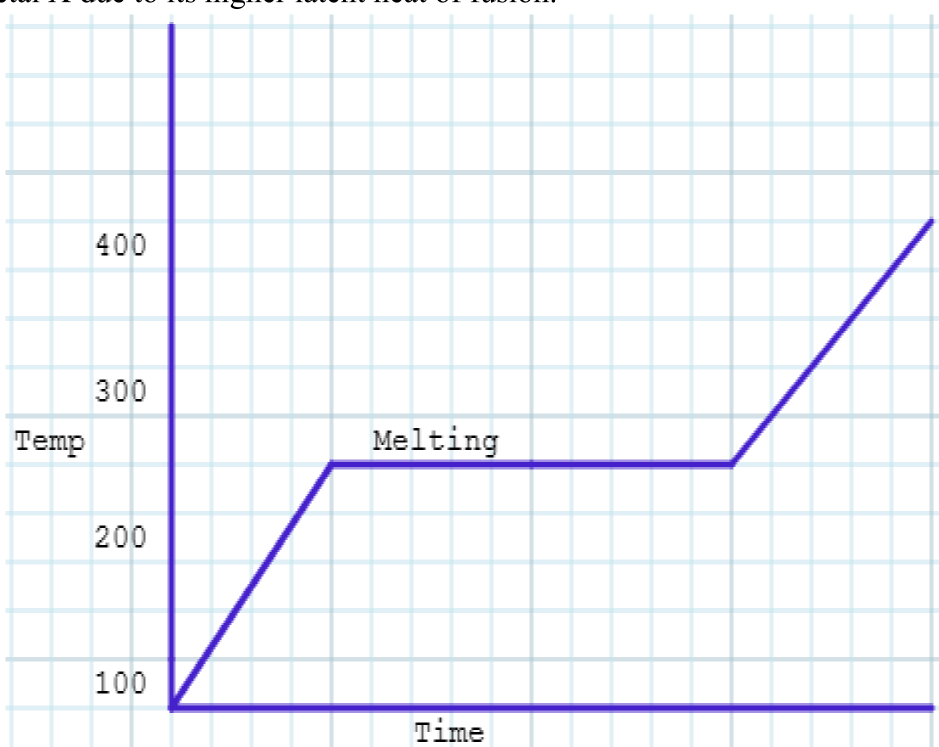
i. Draw a temperature -time graph illustrating the changes in temperature of metal X as it is heated



ii. Now, examine a different metal Y, which has higher latent heat of fusion compared to metal X. Both metals have identical melting points and heat capacities. The heating procedure for metal Y is conducted under the same energy supply rate as metal X. Describe how the temperature-time graph for metal Y will differ from that of metal X, considering the implications of its greater latent heat of fusion?

Since metal "Y" has a higher latent heat of fusion, it will require more energy to complete the phase change from solid to liquid at its melting point. This means the plateau on the temperature-time graph for metal "Y" will be longer than the plateau for metal "X".

Metal "Y" Phase transition for solid to liquid will absorb more energy and temperature remains constant for more time than metal X due to its higher latent heat of fusion.



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6. **How does the pressure in a car tire change during a long drive on a hot day?**
   When you drive a car, the friction between the tire and the road surface, as well as the heat from the surrounding environment, causes the tire to heat up, which causes their pressure to rise. High summer temperatures cause the air within the tire to expand more rapidly.
   At higher temperature molecules gain maximum kinetic energy and expand fastly. The expanding air molecules cannot escape in closed tire and instead cause the pressure inside the tire to increase.
7. **How does understanding thermal expansion help prevent cracks in sidewalks during hot weather?**
   Materials expand or contract when subjected to changes in temperature. Most materials expand when they are heated, and contract when they are cooled.
   Concrete also expands slightly as temperature rises and contracts as temperature falls. If the expansion is not allowed to occur freely, the pressure can become too great, and cracks will form.
   To accommodate this expansion and prevent cracks, expansion joints are created. These joints allow for a small space between sections of concrete, enabling them to expand and contract without causing cracks.
8. **Imagine you are stuck in the snow with your car. Which would be more effective for melting the snow trapped underneath, a pot of hot water or a high-powered heat lamp?**
   A high-powered heat lamp would be more effective for melting the snow trapped underneath a car than a pot of hot water because of continuous and effective heat source.
   Hot water will initially melt some snow, but it will quickly cool and freeze again, especially in sub-zero temperatures.
   The heat lamp provides a continuous source of heat, directly melting the snow without relying on the water's temperature to remain high. The lamp also heats a larger area more efficiently.
9. **How does the evaporation of water from a plant's leaves help to transport water and nutrients through plants?**
   The evaporation of water from a plant's leaves, a process called transpiration, creates a negative pressure (suction) that pulls water and dissolved nutrients up the plant from the roots.
   The transpiration process is the primary driving force behind water and nutrient transport in plants, allowing them to obtain water from the soil and distribute it to all parts of the plant.
10. **Why does adding ice to a drink cool it down more effectively than adding cold water?**
   It is due to latent heat of fusion that Ice absorbs more heat than water from the substance and thus providing a more effective cooling effect. When ice melts, it absorbs a significant amount of energy without changing its temperature.
   While water at 0°C can cool a drink by transferring heat, it doesn't absorb the extra heat. Thus, ice is more effective in cooling than water.
11. **What are the challenges associated with maintaining the extremely low temperatures required for superconductivity to occur?**
   Superconductors have many advantages that make them attractive for use in various practical applications. However, there are also some challenges and limitations associated with their use.
   Limited operating temperatures: Superconductors only exhibit zero resistance below a certain critical temperature, which varies depending on the material. Many superconductors require extremely low temperatures, typically below -200°C, to achieve superconductivity. This can make them impractical for many applications.

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Complexity of cooling systems: Achieving and maintaining the necessary low temperatures required for superconductivity often requires complex cooling systems, such as cryogenic liquids or refrigeration systems. These systems can be expensive, bulky, and require a lot of energy to operate.

LONG RESPONSE QUESTIONS

1. Define latent heat. Differentiate between latent heat and specific latent heat of fusion. Write their formula.

Latent Heat: The energy absorbed or released by a substance during a change in its physical state (phase) that occurs without changing its temperature.

	Latent heat of fusion	Specific Latent heat of fusion
1.	Heat energy required to change substance from solid to liquid state at its melting point without change in its temperature is called its latent heat of fusion.	Heat energy required to change unit mass of a substance from solid to liquid state at its melting point without change in its temperature is called its latent heat of fusion.
2.	Latent heat of fusion depends on mass of substance	Specific Latent heat of fusion does not depend on mass of substance
3.	Latent heat of fusion is extensive property of matter.	Specific latent heat is measured per unit mass, it is an intensive property of matter.
4.	Latent heat is the energy required to change a materials state.	Specific latent heat of fusion is the energy required to change the state of 1 kg of a material
5.	It is given by: $\Delta Q = mL_f$	It is given by: $L_f = \frac{\Delta Q}{m}$
6.	SI unit: Joule (J)	SI unit: $J\ kg^{-1}$

2. Differentiate between latent heat of vaporization and specific latent heat of vaporization. Give their formula and units.

	Latent heat of Vaporization	Specific Latent heat of Vaporization
1.	Heat energy required to change substance from liquid to gas state at its melting point without change in its temperature is called its latent heat of fusion.	Heat energy required to change unit mass of a substance from liquid to gas state at its melting point without change in its temperature is called its latent heat of fusion.
2.	Latent heat of vaporization depends on mass of substance	Specific Latent heat of vaporization does not depend on mass of substance
3.	Latent heat of vaporization is extensive property of matter.	Specific latent heat of vaporization is measured per unit mass, it is an intensive property of matter.
4.	Latent heat is the energy required to change a materials state.	Specific latent heat is the energy required to change the state of 1 kg of a material
5.	It is given by $\Delta Q = mL_v$	It is given by $L_v = \frac{\Delta Q}{m}$
6.	SI unit: Joule (J)	SI unit: $J\ kg^{-1}$

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3. What is evaporation? Differentiate between boiling and evaporation. On what factors evaporation depends?

Evaporation: Evaporation is the changing of a liquid into vapours (gaseous state) from the surface of the liquid without heating it. Evaporation is escaping out of fast-moving water molecule from the surface of a liquid without heating.

	Evaporation	Boiling
1.	It involves the change of liquid into a gaseous state.	During boiling, the vapour pressure of liquid is increased to atmospheric pressure so that it changes into vapour.
2.	It is a natural process.	Boiling is an unnatural process.
3.	It occurs only on the surface of the liquid. Thus, it is called as surface-phenomenon.	The boiling takes place within the entire mass.
4.	It is a slow process.	It is rapid, depending upon the heat provided.
5.	No bubbles are formed in the liquid being evaporated.	One can see the bubbles formed when a liquid is heated up.
6.	The evaporation can take place at any temperature.	The boiling of liquid occurs at the boiling point. Every liquid has a specific boiling point.
7.	It can take place below the boiling point temperature.	It takes place at a higher temperature than the evaporation.
8.	It does not require extra heat from outside.	It requires a high amount of energy from the outside.
9.	Example - The clouds are formed from evaporation of water of sea	Example - When we heat up the water in a container, we boil it.

Factors affecting evaporation:

1. **Temperature:** Rate of evaporation is directly proportional to temperature. When the temperature is high, the kinetic energy of the water particles increases, leading to the quicker conversion of liquid water into its gaseous state.
   This explains why hot water evaporates more quickly than cold water. The wet clothes dry faster on a hot sunny day because of the high temperature.

$$\boldsymbol{Evaporation \propto temperature}$$

2. **Surface Area;** Evaporation is influenced by surface area because increased surface area exposed to air allows water molecules to absorb more heat energy from the environment.
   The water in the bowl will evaporate much faster than in the glass because the larger surface area gives more space for the water particles to evaporate.

$$\boldsymbol{Evaporation \propto Surface\ area}$$

3. **Humidity:** Humidity is a measure of the amount of water vapor in the air. Evaporation is also affected by humidity, or the amount of water vapor in the air. The lower the relative humidity, the dryer the air is and the faster it evaporates. The higher the humidity, the closer the air is to saturation, and less evaporation is possible. Room air cooler function most effectively in the dry month of June and less efficiently in humid month of august.

$$\boldsymbol{Evaporation \propto \frac{1}{Humidity}}$$

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4. **Wind speed:** With rising wind speeds, the rate of evaporation of liquid increases. When the wind speed increases, the water vapor particles travel away with the wind, reducing the amount of water vapor in the environment. This increases the rate of water evaporation.

$$\boldsymbol{Evaporation \propto Wind\ speed}$$

5. **Nature of Liquid:** Less dense liquid evaporates more as compare to dense liquids. Spirit evaporates more than water because spirit has less density as compare to water

$$\boldsymbol{Evaporation \propto \frac{1}{Density}}$$

4. **What are linear and volume thermal expansion of solids? Discuss qualitatively the factors upon which this thermal expansion depends?**

Linear thermal expansion in solids (ΔL): The change in length of solid on heating. Change in one dimension of solid object on heating is called linear thermal expansion.

Factors affecting linear thermal expansion: linear thermal expansion depends on following factors**:**

A. **Increase in temperature of solid:** When object is heated its molecules gain kinetic energy. The kinetic energy of the molecules of an object depends on its temperature. The molecules of a solid vibrate with larger amplitude at high temperature than at low temperature. Thus, on heating, the amplitude of vibration of the atoms or molecules of an object increases.

Therefore, linear thermal expansion is directly proportional to increase in temperature.

$$\Delta L \propto \Delta T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

B. **Original length of rod (L_o):** A longer rod will expand or contract more than a shorter rod for the same temperature change. Therefore, linear thermal expansion is also directly proportional to original length

$$\Delta L \propto L_o \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (ii)$$

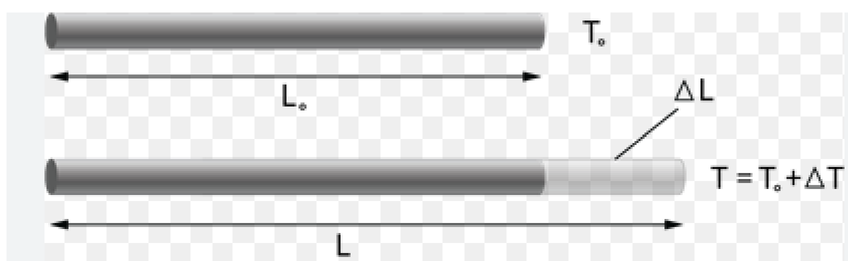
C. **Nature of material of rod:** The type of material (e.g., metal, plastic, glass) and its bonding nature significantly influence its thermal expansion behavior. E.g. aluminum rod expands more than steel rod.

Mathematically:

Consider a metal rod of length L_o at certain temperature T_o. Let its length on heating to a temperature T becomes L, thus from above discussed factors

$Combining\ equ\ (i)\ and\ (ii)$

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



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

Where α is the constant of proportionality and is called coefficient of linear thermal expansion.

$$\alpha = \frac{\Delta L}{L_o \Delta T}$$

Coefficient of linear expansion $\boldsymbol{\alpha}$ is defined as the fractional change in length per kelvin change in temperature. Its SI unit is per kelvin K^{-1}.

$$\alpha = \frac{\Delta L/L}{\Delta T} = \frac{Fractional\ change\ in\ length}{Change\ in\ temperature}$$

Material with greater coefficient of linear expansion expands more than material with less coefficient of linear expansion.

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Volumetric thermal expansion in solids (ΔV): The change in volume of solid on heating. Change in three dimensions of solid (length, width, height) on heating is called linear thermal expansion.

Factors affecting volumetric thermal expansion: Volumetric thermal expansion depends on following factors**:**

A. Increase in temperature of object: When object is heated its molecules gain kinetic energy. The kinetic energy of the molecules of an object depends on its temperature. The molecules of object vibrate with larger amplitude at high temperature than at low temperature. Thus, on heating, the amplitude of vibration of the atoms or molecules of an object increases.

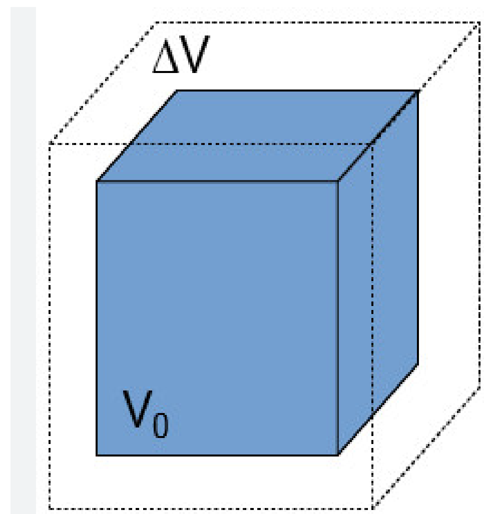
Therefore, volumetric thermal expansion is directly proportional to increase in temperature.

$$\Delta V \propto \Delta T \dots\dots\dots\dots\dots\dots\dots\dots\dots (i)$$

B. Original length of rod (V_o): A larger original volume will generally result in a larger change in volume for the same temperature change. Therefore, volumetric thermal expansion is also directly proportional to original volume.

$$\Delta V \propto V_o \dots\dots\dots\dots\dots\dots\dots\dots.. (ii)$$

C. Nature of material of object: The type of material (e.g., metal, plastic, glass) and its bonding nature significantly influence its thermal expansion behavior.



Mathematically: Consider a solid of volume V_o at certain temperature T_o. Let its volume on heating to a temperature T becomes V, thus from above discussed factors

Combining equ (i) *and* (ii)

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

Where β is the constant of proportionality and is called coefficient of volumetric thermal expansion.

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

Coefficient of Volumetric expansion $\boldsymbol{\beta}$ is defined as the fractional change in volume per kelvin change in temperature. Its SI unit is per kelvin K^{-1}.

$$\beta = \frac{\Delta V / V_o}{\Delta T} = \frac{Fractional\ change\ in\ length}{Change\ in\ temperature}$$

Material with greater coefficient of volumetric expansion expands more than material with less coefficient of volumetric expansion.

Relation between coefficients of linear and volume thermal expansion: The coefficient of volume thermal expansion is three times greater than linear thermal expansion. They are related by:

$$\boldsymbol{\beta = 3\alpha}$$

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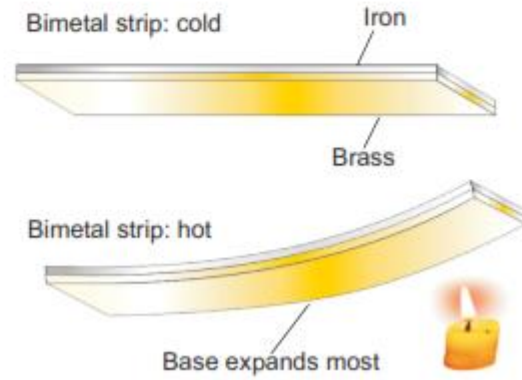
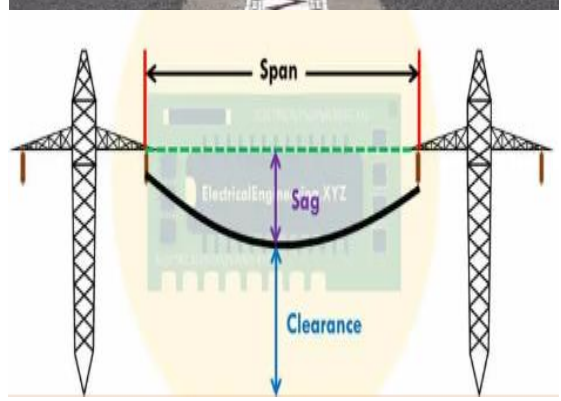
5. **What are uses of thermal expansion in our daily life? Give examples.**
There are many applications of thermal expansions in daily life:
Thermometers: In thermometers, thermal expansion is used in temperature measurements. Liquid mercury which is used in thermometer also expand on heating. As temperature rises, the liquids expand and rises in calibrated capillary tube. From which we read temperature.



Bimetallic strips: A bimetal strip consists of two thin strips of different metals such as brass and iron joined together. On heating the strip, brass expands more than iron. This unequal expansion causes bending of the strip.
Bimetal thermometers are used to measure temperatures especially in furnaces and ovens.
Bimetal strips are also used in thermostats. Bimetal thermostat switch is used to control the temperature of heater coil in an electric iron.

Expansion Joints: Expansion joints are gaps or spaces designed into structures to accommodate movement caused by thermal expansion and contraction of materials, like concrete or brick.
Opening a cap of bottle: To open the cap of a bottle that is tight enough, immerse it in hot water for a minute or so. Metal cap expands and becomes loose. It would now be easy to turn it to open.



Power Lines: Overhead transmission lines are also given a certain amount of sag so that they can contract in winter without snapping.
Designing Instruments and machinery: Different materials expand at different rates. Engineers use the coefficient of thermal expansion to predict how much a material will expand or contract with a given temperature change. gaps are strategically placed in structures like bridges and pipelines to accommodate thermal expansion without causing damage.

6. **Explain thermal expansion of liquids in detail.**
Liquids thermal expansion
The molecules of liquids are free to move in all directions within the liquid. On heating a liquid, the average amplitude of vibration of its molecules increases.
The molecules push each other and need more space to occupy. This accounts for the expansion of the liquid when heated.
The thermal expansion in liquids is greater than solids due to the weak forces between their molecules. Therefore, the coefficient of volume expansion of liquids is greater than solids.
Volume thermal expansion in liquids: Liquids have no definite shape of their own. A liquid always attains shape of the container in which it is poured.
Therefore, when a liquid is heated, both liquid and the container undergo a change in their volume. Thus, there are two types of thermal volume expansion for liquid.
Real volume Expansion: The actual change in volume of a liquid when heated, considering both the liquid and the container's expansion.

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Coefficient of real volume expansion: It is defined as fractional change in real volume for the liquid for one kelvin rise in temperature. It is represented by γ_r. Its SI unit is per kelvin K^{-1}

$$\gamma_r = \frac{\Delta V_{real}}{V_o \Delta T}$$

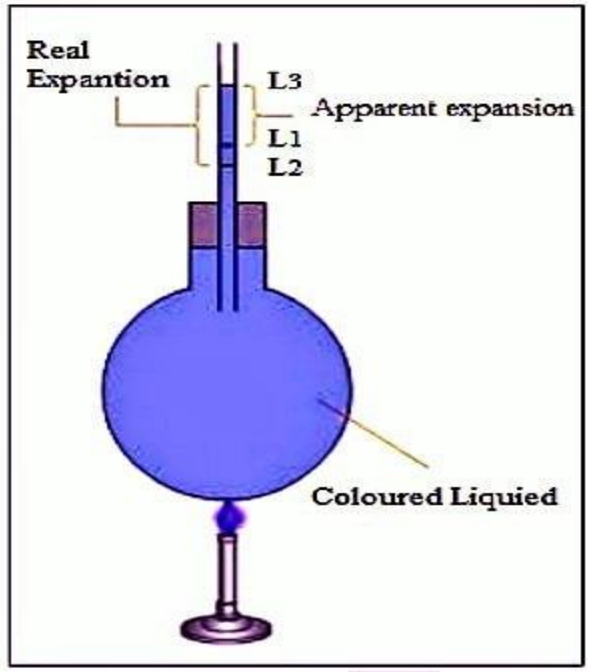
Apparent Volume expansion: The expansion of liquid apparently observed without considering the expansion of the container.

Coefficient of Apparent volume expansion: It is defined as fractional change in apparent volume for the liquid for one kelvin rise in temperature. It is represented by γ_a. Its SI unit is per kelvin K^{-1}

$$\gamma_a = \frac{\Delta V_{appaent}}{V_o \Delta T}$$

Explanation:

i. Take a long-necked flask. Fill it with some colored liquid up to the mark V_1 .
ii. Now start heating the flask from bottom. The liquid level first falls to V_2 and then rises to V_3.
iii. The heat first reaches the flask which expands and its volume increases. As a result, liquid descends in
iv. the flask and its level falls to V_2.
v. After sometime, the liquid begins to rise above V_2 on getting hot. At certain temperature it reaches at V_3.
vi. The rise in level from $V_1$to V_3 is due to the apparent expansion in the volume of the liquid.
vii. Real or actual expansion of the liquid is from V_2 to V_3 greater than apparent expansion.
viii. Thus, real expansion of the liquid is equal to the expansion of liquid and expansion of flask



$$Real\ expansion\ of\ liquid = Apparent\ expansionof\ liquid + expansion\ of\ flask$$

$$V_2V_3 = V_1V_3 + V_1V_2$$

$$\gamma_r = \gamma_a + \gamma_g$$

7. Discuss the applications of bimetallic strips in temperature control devices like thermostats. Explain the principle of thermal expansion that allows the bimetallic strip to function, and illustrate how the differing expansion rates of the two metals are utilized in practical?

Construction: A bimetallic strip consists of two thin strips of metal that are typically brass, copper, or steel. The strips are layered on top of each other, with one end joined and the other end free.

Working principle: A bimetallic strip works on the principle of thermal expansion, which is defined as the change in volume of metal with the change in temperature. The bimetallic strip works on two basic fundamentals of metals.

- The first fundamental is the thermal expansion, which states that the metals expand or contract based on variation in temperature
- The second fundamental is the expansion coefficient, where each metal (having its own expansion coefficient) expands or contracts differently at a constant temperature.

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Working: The bimetallic strip consists of two metal strips with different coefficients of thermal expansion, such as iron and brass. The iron strip has a lower coefficient of thermal expansion than the brass strip, which means it expands or contracts less than the brass strip for the same temperature change.

When heated, the brass strip expands more than the iron strip, bending the strip with the brass on the outside. When cooled, the brass contracts more than the steel, bending the strip with the brass on the inside.

Applications of bimetallic strips:

- **Temperature control devices**: Bimetallic strip thermometers can be used to activate or deactivate a cooling or heating system when the temperature reaches a preset value. For example, a bimetallic strip can be used to switch off an electric kettle when the water boils or to turn on a fan when the room temperature is too high.
- **Air conditioning and refrigeration**: Bimetallic strip thermometers can be used to measure and regulate the temperature in air ducts, refrigerators, freezers, and other cooling or heating devices. For example, a spiral-type bimetallic thermometer can be used in an air conditioning thermostat to adjust the airflow according to the desired temperature.
- **Temperature measurement and indication**: Bimetallic strip thermometers can be used to measure and display the temperature of various media, such as liquids, gases, solids, and surfaces. For example, a bimetallic strip thermometer can be used to measure the water temperature in a heating pipe or the surface temperature of an engine.

8. **What is superconductivity? Explain the phenomenon in detail. What is their scope in future world?**

Superconductivity: Superconductivity is a phenomenon where materials exhibit zero electrical resistance below a critical temperature, enabling current flow without energy loss.

Explanation: In 1911, Heike Kamerlingh Onnes, a Dutch physicist, discovered the superconductivity phenomenon. He found that the electrical resistance of mercury abruptly disappeared when cooled below a temperature of 4.2 Kelvin (around -269°C).

Superconductivity simply states that there is no resistance or almost zero resistance in the material or any object. A material or an object that shows such properties is known as a superconductor. The conductivity referred to here is the electrical conductivity of a material.

Effect of temperature on Superconductivity: If the temperature of the material is increased the resistance increases whereas if the temperature of the material is decreased the resistance decreases. This phenomenon is exploited for achieving the highest conductivity of the superconductor.

The zero resistance is achieved by lowering the temperature of the material which leads to a decrease in the resistance of the material and an increase in the conductivity.

Critical temperature (T_c): The temperature at which and below which the resistance and resistivity of substance become zero is called critical temperature or superconducting transition temperature

This transition occurs at a specific temperature for each material, with values typically ranging from fractions of a Kelvin to over 100 Kelvin.

Different materials have different critical temperatures once the temperature drops down from the critical temperatures the resistance falls to absolute zero.

Thus, it indicates that superconductivity in a superconductor is a thermal property and hence after having reached a superconducting state the phenomenon is independent of the physical properties of the material. All the superconducting materials behave in the same manner.

Applications of Superconductors:

i. Superconducting magnets are essential in MRI machines, creating the strong magnetic fields needed for detailed medical imaging.

ii. Maglev trains utilize superconductors to levitate and propel vehicles, enabling high-speed travel without friction.

iii. Superconductors are used in memory devices and other electronic components, offering faster and more efficient processing.

Future Considerations: Future possible applications involve high-performance smart grids, electric power transmission, transformers, electric motors (in vehicles like maglev trains), magnetic levitation devices, superconducting magnetic refrigerators, etc.

SLO QUESTIONS

1. **Write down postulates of Kinetic molecular theory.**
    - Matter is made up of particles called molecules.
    - The molecules remain in continuous motion.
    - Molecules attract each other.
2. **How kinetic molecular model of matter is helpful differentiating various states of matter?**

Solids	Liquids	Gases
Solids have fixed shapes and volume.	The distances between the molecules of a liquid are more than in solids.	In gases, molecules are much farther apart than solids or liquids
Their molecules are held close together.	Attractive forces between them are weaker as compare to solids	Gases such as air have no fixed shape or volume.
Solids have strong forces of attraction.	Molecules of a liquid also vibrate about their mean position but are not rigidly held with each other.	They can be filled in any container of any shape.
They vibrate about their mean positions but do not move from place to place.	Liquids have no specific shape.	Agas exerts pressure on the walls of the container due to less attractive forces.
Solids have maximum density and minimum Kinetic energy.	Liquids have greater Kinetic energy than solids	Gases have less density and maximum Kinetic energy.

3. **Why water vapours form on cold bottle?**

Water vapor condenses on a cold bottle due to the process of condensation. When a cold bottle is brought into a room with moisture in the air, the surrounding air is cooled down as it comes into contact with the bottle. This cooling reduces the air's capacity to hold water vapor, causing the excess water vapor to change from a gaseous state to a liquid state and deposit on the cold surface of the bottle.

4. **Why wind screen of car becomes foggy? How fog is formed?**
   Fog forms when water vapor in the air condenses into tiny liquid water droplets, which then hang in the air near the ground. This condensation happens when the air cools to its dew point, the temperature at which it becomes saturated with water vapor.
   A car windshield fogs up due to condensation. When the warm, moist air comes into contact with the cold windshield, the water vapor in the air condenses into tiny water droplets, which then form a mist on the glass, creating the foggy appearance.
5. **Why do we see dew drops on leaves during spring and autumn season?**
   Spring and autumn are transitional seasons where there is a shift from warmer weather to cooler weather. These temperature changes are more pronounced at night, leading to more frequent dew formation.
   When the air cools down at night, it can no longer hold as much water vapor, causing the water vapor to condense and form tiny water droplets on the cooler surfaces of leaves**.**
6. **How frost is formed on leaves and window panes?**
   It is due to the process of deposition in which gas is directly converted into solid state without passing through liquid sats at low temperature and high pressure.
   On a cold night, water vapours in the air comes in contact with surfaces like leaves or windowpanes that are much cooler than the surrounding air. The water vapors lose heat to the cold surfaces, condenses directly into ice crystals forming the frost.
7. **How food is preserved using deposition and sublimation?**
   Foods are first frozen to a very low temperature, then subjected to a vacuum, which allows the ice to sublimate directly into water vapor. This removes moisture, preventing microbial growth and spoilage.
   Deposition can occur in food storage, especially when there are temperature fluctuations or high humidity. Water vapor in the air can deposit directly onto the surface of frozen foods as ice crystals.
8. **On what factors thermal expansion of matter depends? Compare expansion of solids liquids and gases.**
   Thermal expansion of matter depends on
   a. Nature of its material
   b. Increase in temperature
   c. Original Size of material before heating

State	**Expansion**
Solid	Expand slightly because the low energy molecules cannot overcome intermolecular forces of attraction holding them together
Liquid	Expands more than solids because the molecules have enough energy to partially overcome the intermolecular forces of attraction holding them together
Gas	Expands significantly because the molecules have enough energy to overcome the intermolecular forces of attraction holding them together

9. **Why volumetric thermal expansion of solid sis greater than linear thermal expansion?**
   Volumetric thermal expansion is greater than linear thermal expansion because it occurs in three dimensions, resulting in a volume change that is approximately three times the linear change.
10. **Why liquids expand more than solids?**
    In liquids, intermolecular forces are weaker than in solids, so molecules are not held in fixed positions. When heated, the molecules gain more kinetic energy and can move around more freely, spreading out further. This allows for a larger increase in volume compared to solids.

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11. What is meant by anomalous expansion of water?

Water shows irregular expansion and contraction between 0ºC to 4ºC. Water on cooling below 4°C begins to expand until it reaches 0°C. On further cooling its volume increases suddenly as it changes into ice at 0°C. When ice is cooled below 0°C, it contracts i.e. its volume decreases like solids. This unusual expansion of water is called the anomalous expansion of water.

12. What is relation between coefficient of linear and volume expansion of solids? Show that $\boldsymbol{\beta = 3\alpha}$

The coefficient of linear and volume expansion is related by:

$$\boldsymbol{\beta = 3\alpha}$$

Proof:

$\Delta V = \Delta(L)^3$

$\Delta V = 3L^2 \Delta L$

$\Delta V = 3L^2 \times \alpha L \Delta T \qquad \therefore \; (\Delta L = \alpha L \Delta T)$

$\Delta V = 3\alpha L^3 \Delta T$

$\Delta V = 3\alpha V \Delta T \; \dots\dots\dots\dots\dots\dots \; equ\ (i)$

As we Know $\Delta V = \beta V \Delta T$, put in $equ\ (i)$

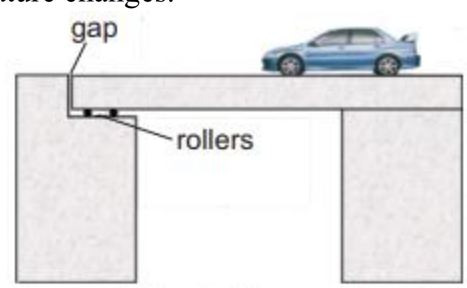
$\beta \cancel{V \Delta T} = 3\alpha \cancel{V \Delta T}$

$\boldsymbol{\beta = 3\alpha}$

13. Why gaps are left in railway tracks?

Gaps are left in railway tracks to allow for thermal expansion and contraction of the steel rails, preventing them from buckling and causing deformation. As steel expands when heated and contracts when cooled, these gaps provide space for the rails to move without bending or deforming under temperature changes.

14. Why rollers are used in construction of bridges made up of steel girders?



Bridges made of steel girders also expand during the day and contract during night. They will bend if their ends are fixed. To allow thermal expansion, one end is fixed while the other end of the girder rests on rollers in the gap left for expansion.

15. How evaporation causes cooling?

During evaporation fast moving molecules escape out from the surface of the liquid. Molecules that have lower kinetic energies are left behind. This lowers the average kinetic energy of the liquid molecules and the temperature of the liquid. Since temperature of a substance depends on the average kinetic energy of its molecules. The reduced temperature produces cooling sensation in material.

16. How cooling is produced in refrigerator by evaporation?

Cooling is produced in refrigerators by evaporation of a liquified gas. This evaporation process is part of a larger refrigeration cycle that involves compression, condensation, and expansion of the refrigerant.

A liquid refrigerant, like Ammonia, is circulated through the refrigeration system. When the pressure of this liquid is lowered, it evaporates, meaning it changes from a liquid to a gas.

As the refrigerant evaporates, it absorbs heat from the surrounding environment, such as the inside of the refrigerator.

The process of absorbing heat causes the refrigerant to cool down as it evaporates. This cooling effect is what leads to the desired reduction in temperature inside the refrigerator.

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17. Why desert room coolers are not efficient in humid month of august?

Desert room coolers cause cooling by process of evaporation. Evaporation decreases in humid month of august. Desert room coolers cool by drawing air through a wet pad or wick, where the water evaporates, absorbing heat and lowering the air temperature.

High humidity means the air already contains a lot of moisture. Water vapor molecules are already abundant, making it difficult for more water to evaporate from the cooler's wet surfaces.

18. Explain why burns caused by steam at 100 °C on the skin are often more severe than burns caused by water at 100 ° C?

When water turns into steam, it absorbs a significant amount of energy called the latent heat of vaporization. This energy is stored within the steam.

When steam comes into contact with the skin, it condenses back into water. As it condenses, it releases the stored latent heat of vaporization.

The additional heat released during condensation, along with the initial heat of the steam itself, causes a more intense and severe burn compared to the heat of boiling water alone.

19. Why latent heat of vaporization is greater than latent heat of fusion?

Latent heat of vaporization is greater than fusion because turning a liquid into a gas requires much more energy than converting a solid into a liquid.

Latent heat is the energy required to change the phase of a substance at a constant temperature. For melting (fusion), the energy input is used to break some of the intermolecular forces, allowing the solid to become a liquid. For vaporization, the energy input is used to overcome all of the intermolecular forces, completely separating the molecules and converting the liquid to a gas.

MULTIPLE CHOICE QUESTIONS

1	B	**2**	C	**3**	A	**4**	B
5	A	**6**	A	**7**	C	**8**	D
9	B	**10**	C	**11**	A	**12**	D
13	D	**14**	C				

NUMERICAL RESPONSE QUESTIONS

1. Consider a steel ball of length 1.5m at 10^{0}C. It is heated to raise its temperature to 100^{0}C. Calculate (a)increase in length (b)final length at 100^{0}C. (Coefficient of linear thermal expansion of steel is $1.2 \times 10^{-5} K^{-1}$).

Given Data:

$L_o = 1.5\ m$

$T_1 = 10°C = 10 + 273 = 283\ K$

$T_2 = 100°C = 100 + 273 = 373\ K$

$\Delta T = 373 - 283 = 90\ K$

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

$\Delta L = ?$

$L = ?$

Formula:

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

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

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Solution:

i) Increase in length

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

$\Delta L = (\,1.2 \times 10^{-5} K^{-1})(1.5)(90)$

$\boldsymbol{\Delta L = 1.62 \times 10^{-3}\, m}$

ii) Final length at 100^0C

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

$L = \lfloor (1.5)(1 + (1.2 \times 10^{-5})(90) \rfloor$

$\boldsymbol{L = 1.50162\, m}$

2. **A solid cube of side length 10 cm at 25^0C is heated. What will be increase in its volume at 125^0C if its coefficient of linear thermal expansion is $\boldsymbol{9 \times 10^{-6} K^{-1}}$?**

Given Data:

$V_0 = (10\, cm)^3 = 1000\, cm^3 = 1 \times 10^{-3}\, m$

$T_1 = 25℃ = 25 + 273 = 298\, K$

$T_2 = 125℃ = 125 + 273 = 398\, K$

$\Delta T = 398 - 298 = 100\, K$

$\alpha = \ 9 \times 10^{-6} K^{-1}$

$\Delta V = ?$

Formula:

$\beta = 3\alpha$

$\Delta V = \beta V_0 \Delta T$

Solution:

To find β we use

$\beta = 3\alpha$

$\beta = 3(9 \times 10^{-6})$

$\boldsymbol{\beta = 27 \times 10^{-6}\, K^{-1}}$

To find increase in volume

$\Delta V = \beta V_0 \Delta T$

$\Delta V = (\,27 \times 10^{-6})(\,1 \times 10^{-3})(100)$

$\boldsymbol{\Delta V = 2.7 \times 10^{-6}\, m^3}$

3. **A steel railroad track segment is 10 meters long at a cool morning temperature of 15^0C. The coefficient of linear expansion for steel is $\boldsymbol{1.2 \times 10^{-5} K^{-1}}$. Later in day, the temperature is raised to 30^0C. how much will the steel track segment expand in length?**

Given Data:

$L_o = 10\, m$

$T_1 = 15℃ = 15 + 273 = 288\, K$

$T_2 = 30℃ = 30 + 273 = 303\, K$

$\Delta T = 303 - 288 = 15\, K$

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

$\Delta L = ?$

Formula:

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

Solution:

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

$\Delta L = (\,1.2 \times 10^{-5} K^{-1})(10)(15)$

$\boldsymbol{\Delta L = 1.8 \times 10^{-3}\, m}$

4. **A 2-liter (2000 cm^3) glass bottle is filled completely with orange juice at room temperature 0f 20^0C. the coefficient of volumetric thermal expansion for orange juice is $\boldsymbol{5 \times 10^{-5} K^{-1}}$. If the bottle is left in a hot car where the temperature reaches 40^0C, what volume of orange juice will overflow?**

Given Data:

$V_0 = 2000\, cm^3 = \ 2 \times 10^{-3}\, m$

$T_1 = 20℃ = 20 + 273 = 293\, K$

$T_2 = 40℃ = 40 + 273 = 313\, K$

$\Delta T = 313 - 293 = 20\, K$

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

$\Delta V = ?$

Formula:

$\Delta V = \beta V_0 \Delta T$

Solution:

$\Delta V = \beta V_0 \Delta T$

$\Delta V = (\,5 \times 10^{-5})(\,2 \times 10^{-3})(20)$

$\boldsymbol{\Delta V = 2 \times 10^{-6}\, m^3}$

5. **How much heat is required to change 15 kg of ice into water at its melting point?**

Given Data:

$m = 15\, kg$

$L_f(Water) = 3.33 \times 10^5\, Jkg^{-1}$

$\Delta Q = ?$

Formula:

$\Delta Q = mL_f$

Solution:

$\Delta Q = (15)(\,3.33 \times 10^5)$

$\boldsymbol{\Delta Q = 4.9 \times 10^6\, J}$

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6. **How much heat is required to change 7 kg of water into steam at its boiling point?**

Given Data:

$m = 7\ kg$

$L_v(Water) = 2.26 \times 10^6\ Jkg^{-1}$

$\Delta Q = ?$

Formula:

$\Delta Q = mL_v$

Solution:

$\Delta Q = (7)(\ 2.26 \times 10^6)$

$\boldsymbol{\Delta Q = 1.58 \times 10^7\ J}$

7. **4 kg of ice has temperature of -20^{0}C. it is heated to convert into steam. Its final temperature is 120^{0}C. calculate the total amount of heat energy involve for this conversion of ice into steam? (Specific heat of ice=2100 J/kg K, specific heat of water= 4200 J/kg K, specific heat of steam= 2000 J/kg K, latent heat of fusion of ice= $\boldsymbol{3.3 \times 10^5 J\ kg^{-1}}$ and latent heat of vaporization of water= $\boldsymbol{2.26 \times 10^6 J\ kg^{-1}}$).**

Given Data:

$m = 4\ kg$

$T_1 = -20°C = -20 + 273 = 253\ K$

$T_2 = 120°C = 120 + 273 = 393\ K$

$\Delta T = 393 - 253 = 140\ K$

$c_{ice} = 2100$ J/kg K

$c_{water} = 4200$ J/kg K

$c_{steam} = 2000$ J/kg K

$L_f(ice) = 3.33 \times 10^5\ Jkg^{-1}$

$L_v(water) = 2.26 \times 10^6 J\ kg^{-1}$

$Q_{total} = ?$

Formula:

$Q = mc\Delta T$

$Q = mL_f$

$Q = mL_v$

Solution:

Heat of ice from -20^{0}C to 0^{0}C

$Q_1 = mc_{ice}\Delta T$

$Q_1 = (4)(2100)(20)$

$\boldsymbol{Q_1 = 168000\ J}$

Heat absorbed by the ice at its melting point 0^{0}C

$Q_2 = mL_f$

$Q_2 = (4)(\ 3.33 \times 10^5)$

$\boldsymbol{Q_2 = 1320000\ J}$

Heat of water from 0^{0}C to 100^{0}C

$Q_3 = mc_w\Delta T$

$Q_3 = (4)(4200)(100)$

$Q_3 = mc_w\Delta T$

$\boldsymbol{Q_3 = 1680000\ J}$

Heat absorbed by the water at its melting point 100^{0}C

$Q_4 = mL_v$

$Q_4 = (4)(\ 2.26 \times 10^6)$

$\boldsymbol{Q_4 = 9040000\ J}$

Heat of steam from 100^{0}C to 120^{0}C

$Q_5 = mc_{steam}\Delta T$

$Q_5 = (4)(2000)(20)$

$\boldsymbol{Q_5 = 160000\ J}$

Total energy required to heat ice from -20^{0}C to 120^{0}C

$Q = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$

$$Q = 168000 + 1320000 + 1680000 + 9040000 + 160000$$

$\boldsymbol{Q = 1.236 \times 10^7\ J}$

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