UNIT 07

Thermal Properties of Matter

Q1. Describe the main points of particle theory of matter which differentiate solids, liquids and gases. 09107001

Ans: **Kinetic Molecular Theory of Matter:**

According to this theory, matter is composed of very small particles called molecules which are always in motion. Their motion may be vibrational, rotational or linear. There exists a mutual force of attraction between the molecules know as intermolecular force. This force depends upon the distance between the molecules. It decreases with increasing distance between them.

Energy of Molecules:

The molecules possess kinetic energy due to motion and potential energy due to force of attraction. When a substance is heated, its temperature rises and its molecular motion becomes more vigorous which increase the kinetic energy of the molecules. Thus, the temperature of the substance depends upon the average kinetic energy of its molecules. In general, matter exists in three states solids, liquids, and gases as shown in the figure 7.1.

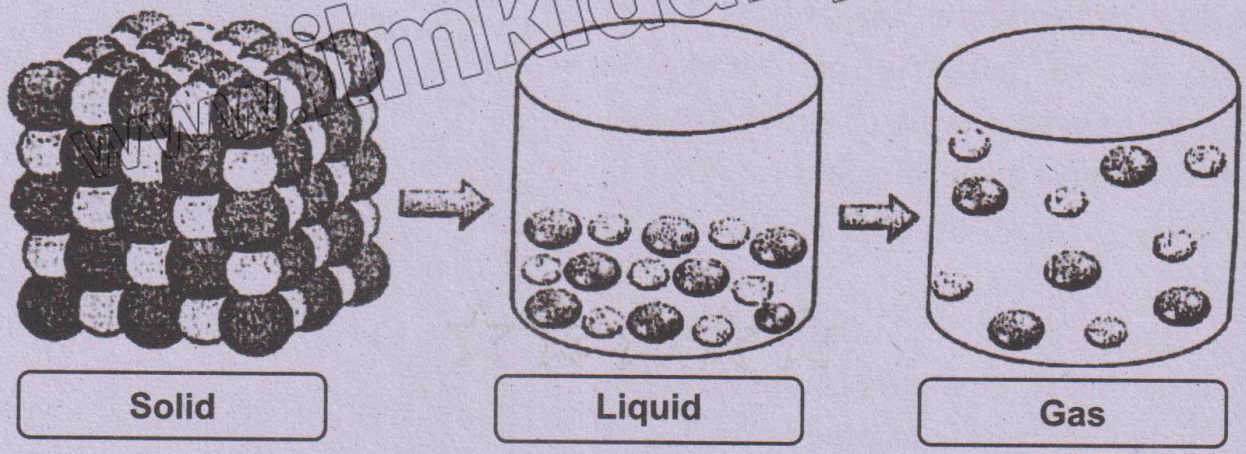


Fig. 7.1

States of Matter:

Most of the properties of the solids, liquids and gases can be explained on the basis of kinetic molecular theory of matter.

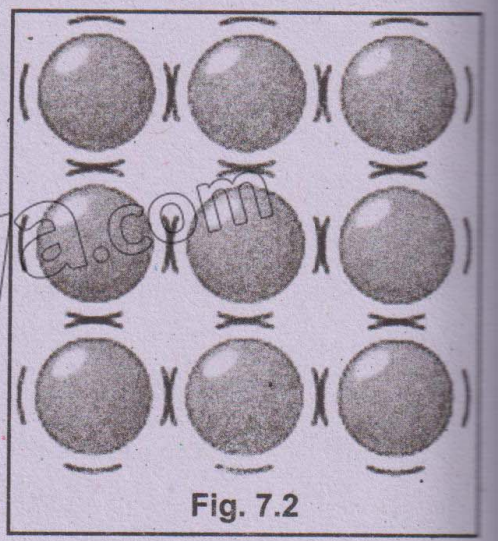


Fig. 7.2

(i) Solid: In case of solids, the intermolecular forces are so strong that they keep the molecules bound. So, the molecules are held at fixed position (Fig 7.2) but still they show vibrational motion about their fixed pints. This is why, the solids have a definite shape and a definite volume.

(ii) Liquid: In case of liquids, intermolecular forces so weak that it cannot hold the molecules at fixed positions and the molecules can slide over each other in random direction. A liquid, therefore, molecules it acquires the shape of the containing vessel.

(iii) Gas: Gas molecules are relatively far away from one and another. Due to which, gas neither posseses a definite volume nor a definite shape.

09107002

Q.2. Define and Explain Plasma.

Ans: Plasma:

The plasma is a gas in which most of the atoms are ionized containing positive ions and electrons. They are freely moving in the volume of the gas. Due to presence of positive ions and free electrons, plasma is the conduction state of matter. It allows electric current to pass through it. Since the gas in plasma state has properties which are quite different from ordinary gas, therefore, plasma is known as fourth state of matter. The Sun and the most of other stars are in plasma state. Plasma is also found in plasma TV and in gas discharge tubes when electric current passes through them. The plasma state also occurs during the early stages of lightning formation known as lightning streamers which are the conduction paths through the atmosphere due to ionized air molecules.

09107003

Q.3. Differentiate between Temperature and Heat.

Ans: Temperature and heat:

Temperature	Heat
Temperature of a body is defined as degree of its hotness or coldness.	*Heat is the form of energy which is transferred from one object to another due to difference of temperature between the two bodies.*
It is denoted by T.	Its quantity is denoted by Q.
Its SI unit is Kelvin.	Its unit is Joule.

09107004

Q.4. Define and Explain Internal Energy.

Ans: Temperature and internal Energy:

We know that matter is composed of molecules which are always in motion. Molecules of a solid are vibrating about their fixed positions. The molecules of a liquid are sliding one over the other and those of gases are randomly moving, The molecules possess kinetic energy on account of their motion. Potential energy is also associated with molecules because of their attractive forces.

"The sum of kinetic and potential energies of the molecules of an object is called its internal energy."

When we heat a substance, its molecular motion becomes more vigorous which means an increase in its internal energy. As a result, temperature of the substance rises.

The heat energy transferred to a body increases the internal energy of its molecules due to which its temperature rises.

Remember that, it is not true to say that a substance contains heat. The substance contains internal energy. The word heat is used only when referring to the energy actually in transit from hot to cold body.

Q.5. Define Thermometers and thermometric property. Write down some basic thermometric properties. 09107005

Ans: Thermometers:

"The instrument used for measurement of hotness or coldness of a substance is called thermometer." Our sense of touch can tell us whether an object is hot or cold. It gives an idea about the object's temperature but we cannot measure the actual temperature of the body just by touching it.

Thermometers use some property of a substance, which changes appreciably with the change of temperature.

Basic Thermometric Properties:

Some basic thermometric properties for a material suitable to construct a thermometer are the following:

i. It is a good conductor of heat.
ii. It gives quick response to temperature changes.
iii. It has uniform thermal expansion.
iv. It has high boiling pint.
v. It has low freezing point.
vi. It has large expansivity (low specific heat capacity).
vii. It does not wet glass.
viii. It does not vapourize.
ix. It is visible.

Q.6. What is temperature? How it is measured? Describe briefly construction of liquid-in-glass thermometer. 09107006

Ans: Temperature: It is degree of hotness or coldness.
Measuring instrument: Thermometer is used to measure temperature.

Liquid-in-Glass Thermometer:

We know that liquids expand on heating. So, expansion in the volume of a liquid can be used for the measurement of temperature. This is known as liquid-in-glass thermometer. One such liquid which is commonly used in thermometers is mercury. It is made of glass, It has a bulb at one end filled with mercury.

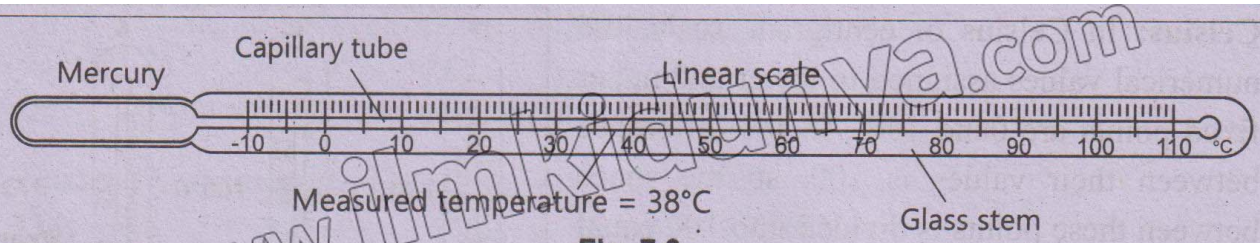


Fig. 7.3

When the temperature rises, the mercury expands and moves up through the arrow capillary tube in the form of a mercury thread. The position of the end of thread reads the temperature. Mercury is opaque and can be easily seen due to tis silvery colour. Alcohol is also a choice for the thermometric liquid, but it must be coloured to make it visible.

Construction:

A liquid-in-glass thermometer has a narrow and uniform capillary tube having a small bulb filled with mercury or alcohol at its lower end. The thin wall of the glass bulb allows quick conduction through glass to the liquid from a hot object whose temperature is to be measured. Mercury being metal is a good conductor and hence responds quickly to the change in temperature. The small quick response makes the device sensitive. Use of mercury is quite sensitive for normal measurements. For greater accuracy, alcohol can be used as its expansivity is six times more than mercury but it has range limitation to higher temperature measurements due to its low boiling point (78°C).

The uniformity of the narrow tube or bore ensures even expansion of the liquid required to make the linear measuring scale. The choice of mercury allows to use it over a long-range temperature due to its low freezing point and high boiling point. It provides a fairly long range of measurements of temperature.

Q.7. Compare three scales used for measuring temperature. Write down equation for conversion of temperature from one scale to another.

09107007

Ans: Temperature Scales:

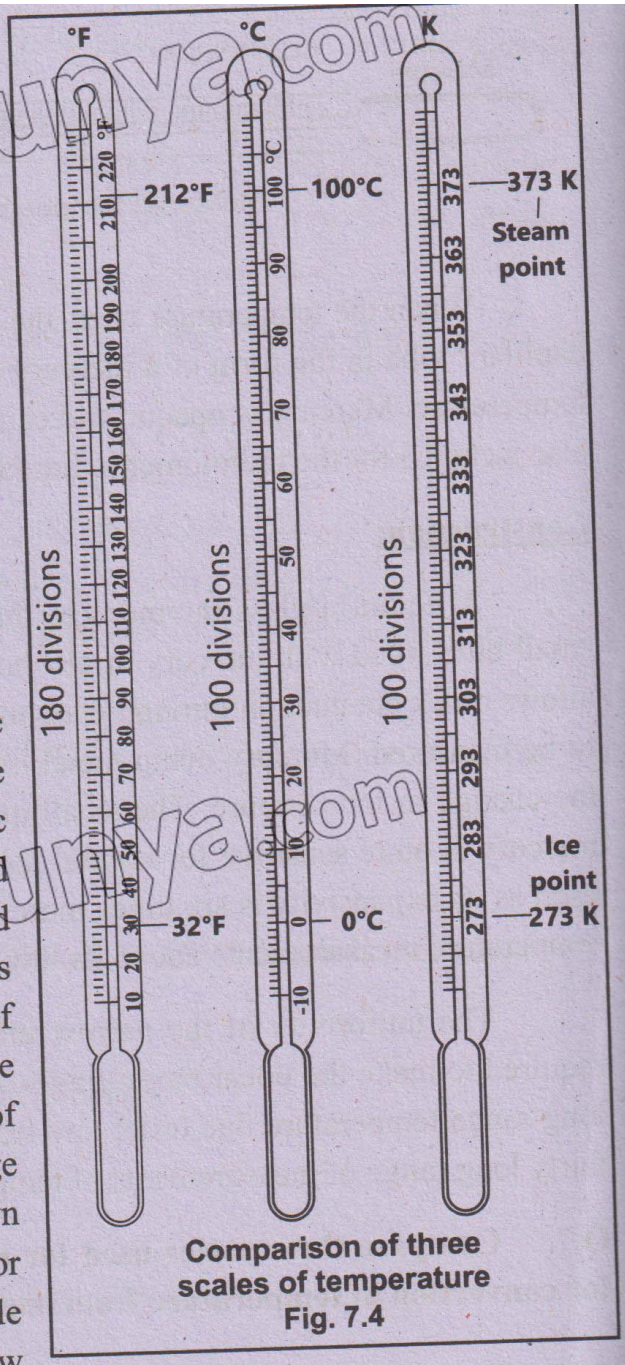
For the measurement of temperature, a scale is to be constructed which requires two reference temperature called two fixed points. One is the steam point slightly above the boiling of water at standard atmospheric pressure. This corresponds to upper fixed point of the scale. The second fixed point is the melting point of pure ice or simply ice point. It is called the lower fixed pint. Different scales of temperature have been constructed by assigning different numerical value to these fixed points. Three different scales are:

i. Celsius or Centigrade scale
ii. Fahrenheit scale
iii. Kelvin scale

i. **Celsius:** In Celsius or centigrade scale, the numerical values assigned to lower and upper fixed points are 0and 100. AS the difference between their values is 100, so the space between these points is divided into 100 equal parts. Each part is known as 1°C.

ii. **Fahrenheit:** In Fahrenheit scale, The lower fixed point is labelled as 32 and upper 212. As the difference between these two numbers in 180, so in this scale the space between these points is divided into 180 equal parts. Each part is known as 1°F. Celsius and Fahrenheit scales are generally used in ordinary life.

iii. **Kelvin:** There is a third scale of temperature known as kelvin scale or Absolute temperature scale. IT is used in scientific measurements. In Kelvin scale, the lower and upper fixed points are labelled as 273 and 373. As the difference between these values is 100, so the width of 1 k is the same as that of 1°C. The zero point of this scale is the temperature at which the molecules of substance cease to move. Their average kinetic energy becomes zero. This is known as absolute zero. Its value is -273.15^0C. For calculations, it is simply taken whole universe. The matter does not exist below absolute zero temperature.



Comparison of three scales of temperature
Fig. 7.4

Conversion of Temperature from One Scale to Another:

If the temperature of a body is T_c on Celsius scale, T_f on Fahrenheit scale and T_k on kelvin scale, then these reading are related by the following formulae:

(i) Conversion of Celsius (centigrade) to Fahrenheit scale

$$T_F = \frac{9}{5} \times T_C + 32 \quad \ldots\ldots(1)$$

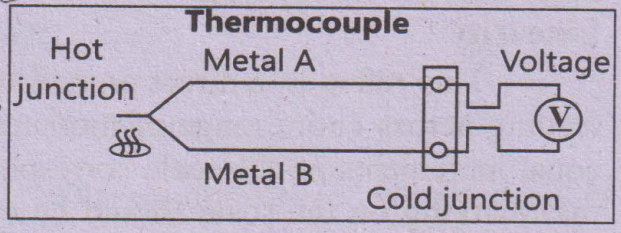
(ii) Conversion of Fahrenheit to Celsius scale:

$$T_C = \frac{5}{9}(T_F - 32) \quad \ldots\ldots(2)$$

(iii) Relationship between Kelvin and Celsius scales:

$$T_K = T_C + 273 \quad \ldots\ldots (3)$$

Q.8. Write a brief note on Thermocouple Thermometer. 09107008



Ans: Thermocouple Thermometer:

This type of thermometer consists of two wires of different materials such as copper and iron.

Construction:

The ends are joined together to form two junctions. If the two junctions are at different temperatures, a small current flows across them. This current is due to the potential difference produced across the two junctions as the two wires have different resistance to the flow of current. The greater is the difference of temperatures, the greater is the potential difference or voltage produced across the junctions. If one end of the junction is kept at a fixed lower temperature, say by placing it in an ice bath at 0°C for reference, the temperature of other junction at a higher temperature can measured using a millivolt meter by a calibrated scale on it.

Uses:

This type of thermometer is particularly useful for very high temperatures and also rapidly changing temperature as there is only a small mass of metal (the junction) to heat up.

Q.9. What is mean by the sensitive, range and linearity of thermometers? Explain with example. 09107009

Ans: A thermometer is evaluated by its three key characteristics that are sensitivity, range and linearity. They help determine the suitability of the thermometer for specific use ensuring accurate and reliable measurement of temperature.

Sensitivity

Sensitivity of a thermometer refers to its ability to detect small changes in the temperature of an object.

Example: The minimum division on the scale of a thermometer is 1^0C. The accuracy of its temperature measurement will be 1^0C. On another thermometer the marks are 0.1^0C. apart. Hence, its accuracy will be up to 0.1^0C and said to be more sensitive. Its measurement will be more precise than the measurement by a thermometer with an accuracy of 1^0C.

Range

This refers to the span of temperature, from low to high, over which the thermometer can measure accurately. For example, a clinical thermometer designed for human body temperature has a narrow or short range, say from 35^0C to 45^0C. A long-range thermometer is usually used for science experiments in the laboratory with markings from -10^0C to 110^0C. The choice of liquid for thermometers put a lower and upper limit for the range of a thermometer. For example, Mercury freezes at $-39°C$ and boils at $357°C$. Hence, we can construct mercury in glass thermometers within this range. The

marking scale depends on desired range of measurement. For extremely low temperatures, alcohol is used. Alcohol has a much lower freezing point about $-112°C$ which increases its lower limit for the range but it has lower upper limit as it boils at 78°C.

Linearity

This refers to a direct proportional relationship between the temperature and scale reading across entire range of measurement. A good linear thermometer should measure equal increments on the scale corresponding to equal change in the temperature. It means that marking on the scale should be evenly spaced over the whole range. High linearity means more consistent and proportional scale readings over the entire range to ensure accuracy of measurement.

Q.10. Describe structure of a liquid-in-gas thermometer. 09107010

Ans: Structure of a Liquid-in-Glass Thermometer

A liquid-in-glass thermometer has a narrow and uniform capillary tube having a small bulb filled with mercury or alcohol at its lower end. The thin wall of the glass bulb allows quick conduction through glass to the liquid from a hot object whose temperature is to be measured. Mercury being metal is a good conductor and hence responds quickly to the change in temperature. The small amount of liquid also responds more quickly to a change in temperature. The quick response makes the device sensitive. Use of mercury is quite sensitive for normal measurements. For greater accuracy, alcohol can be used as its expansivity is six times more than mercury but it has range limitation to higher temperature measurements due to its low boiling point (78°C).

The uniformity of the narrow tube or bore ensures even expansion of the liquid required to make the linear measuring scale. The choice of mercury allows to use it over a long-range temperature due to its low freezing point and high boiling point. It provides a fairly long range of measurement of temperature.

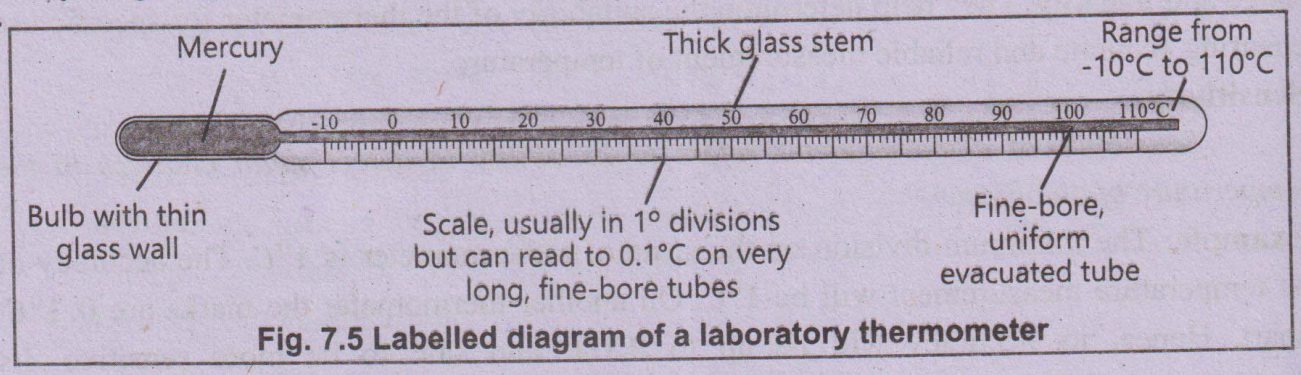


Fig. 7.5 Labelled diagram of a laboratory thermometer

Examples

Example 7.1 09107011

How much 30^0C temperature would be on Fahrenheit and Kelvin scales?

Solution:

Temperature $T_C = 30^0C$

Using $T_F = \frac{9}{5} \times T_C + 32^0$

$= \frac{9}{5} \times 30^0C + 32^0 = 86^0F$

Using $T_K = T_C + 273$

$= 30^0C + 273 = 303\ K$

Exercise

(A) Multiple Choice Questions

1. **How do the molecules in a solid behave?** 09107012
   (a) Move randomly
   (b) Vibrate about their mean position
   (c) Rotate and vibrate randomly at their own positions
   (d) Move in a straight line from hot to cold ends

2. **What type of motion is of the molecules in a gas?** 09107013
   (a) Linear motion
   (b) Random motion
   (c) Vibratory motion
   (d) Rotatory motion

3. **Temperature of substance is:** 09107014
   (a) the total amount of heat contained in it
   (b) the total number of molecules in it
   (c) degree of hotness of coldness
   (d) dependent upon the intermolecular distance

4. **Heat is the:** 09107015
   (a) total kinetic energy of the molecules
   (b) the internal energy
   (c) work done by the molecules
   (d)the energy in transit

5. **In Kelvin scale, the temperature corresponding to melting point of ice is:** 09107016
   (a) zero
   (b) 32
   (c) -273
   (d) $+273$

6. **The temperature which has the same value on Celcius and Fahrenheit scale is:** 09107017
   (a) -40 (b) $+40$
   (c) $+45$ (d) -45

7. **Which one is a better choice for a liquid-in-glass thermometer is that:** 09107018
   (a) Is colourless
   (b) Is a bad conductor
   (c) Expand linearly
   (d) Wets glass

8. **One disadvantage of using alcohol in a liquid-in-glass thermometer:** 09107019
   (a) it has large expansivity
   (b) it has low freezing point (-112^0C)
   (c) it wets the glass tube
   (d) its expansion is linear

9. **Water is not a used as a thermometric liquid mainly due to:** 09107020
   (a) clourless
   (b) a bad conductor of heat
   (c) non-linear expansion
   (d)a low boiling point (100^0C)

10. **A thermometer has a narrow capillary tube so that it:** 09107021
    (a) quickly responds to temperature changes
    (b) can read the maximum temperature
    (c)gives a large change for a given temperature rise
    (d)can measure a large range of temperature

11. **Which thermometer is most suitable for recording rapidly varying temperature?** 09107022
(a) Thermocouple thermometer
(b) Mercury-in-glass laboratory thermometer
(c) Alcohol-in-glass thermometer
(d) Mercury-in-glass clinical thermometer

Answer Key

1.	(b)	2.	(b)	3.	(c)	4.	(d)	5.	(d)	6.	(a)
7.	(c)	8.	(c)	9.	(c)	10.	(a)	11.	(a)		

SLO based Additional MCQs

State of matter

1. **How many phases of mater are there?** 09107023
(a) 1 (b) 2
(c) 3 (d) 4

2. **In which of the materials, particles have only vibrational motion?** 09107024
(a) Solid
(b) Liquids
(c) Gas
(d) Plasma

3. **Which state of matter has particles that are highly compressible and can fill any container?** 09107025
(a) Solid
(b) Liquid
(c) Gas
(d) Plasma

4. **What happens to the arrangement of particles when a solid is heated and turns into a liquid?** 09107026
(a) Particles become more closely packed
(b) Particles move farther apart
(c) particles start vibrating in fixed positions
(d) Particles change their state from solid to gas

Fluids

5. **Gases and liquids are categorized as:** 09107027
(a) Liquids
(b) Gases
(c) Fluids
(d) Solids

Kinematic Theory of Matter

6. **Which Statement describes the particles structure of gases?** 09107028
(a) particles are tightly packed and have strong bonds
(b) particles have moderate kinetic energy and move randomly
(c) particles are arranged in a repeating pattern
(d) Particles have fixed positions and low kinetic energy

Internal Energy

7. **Which of the following is not a form of internal energy?** 09107029
(a) A Kinetic energy of the particles
(b) Potential energy of the particles
(c) Chemical energy of the bonds between the particles
(d) Light energy

8. **When an ideal gas is expanded keeping its temperature constant, its internal energy:** 09107030
(a) Increases
(b) Decreases
(c) Remains the same
(d) Cannot be determined

Sensitivity of Thermometer

9. Which of the following can increase the sensitivity of liquid in glass thermometer? 09107031

(a) Use a bigger bulb which contains more amount of liquids

(b) Use a longer capillary tube

(c) Using long specific its

(d) Changes colour on temperature.

Thermocouple

10. Thermometer, which is most suitable for measuring rapid changing temperatures, is: 09107032

(a) Constant volume gas thermometer

(b) Resistance thermometer

(c) Liquid in glass thermometer

(d)thermocouple

Mercury Thermometer

11. Mercury has uniform linear expansion in liquid in glass thermometers. A liquid in glass thermometer has a mercury level of 2cm at melting point of ice and a mercury level of 6cm at boiling point of water. What is the distance between every 1^0C division on Celsius scale of thermometer? 09107033

(a) 0.04 cm (b) 0.06 cm

(c) 0.08 (d) 1.00 cm

Types of Thermometer

12. Which thermometer uses voltage to measure temperature of a hot body? 09107034

(a) Thermocouple

(b) Resistance thermometer

(c) Liquid in glass thermometer

(d) Gas thermometer

Answer Key

1.	(d)	2.	(a)	3.	(c)	4.	(b)	5.	(c)
6.	(b)	7.	(d)	8.	(c)	9.	(b)	10.	(d)
11.	(a)	12.	(a)						

(B) Short Answer Questions

7.1 Why solids have a fixed volume and shape according to particle theory of matter? 09107035

Ans: Solids have fixed volume and shape because their particles are closely packed and have a fixed position in space, with strong forces holding them together.

7.2 What are the reasons that gases have neither a fixed volume nor a fixed shape? 09107036

Ans: Gases have neither fixed volume nor a fixed shape because:

i. Molecules are widely spaced.

ii. Molecules are free to move.

iii. Weak intermolecular forces.

7.3 Molecules can be compressed or expanded. Compare the spacing of molecules in the solid, liquid and gaseous state. 09107037

Ans: In solids the particles are closely spaced due to strong interatomic forces but in case of liquids the spacing is greater than solids because of moderate intermolecular forces. The spacing in case of gases is much greater than solids and liquids due to weak forces.

7.4 What is the effect of raising the temperature of a liquid? 09107038

Ans: Raising the temperature of a liquid increases the kinetic energy of its particles, causing them to move faster and spread out, eventually turning into vapours form.

7.5 What is meant by temperature of a body? 09107039

Ans: The degree of hotness or coldness is called temperature of a body. It can also be defined as a physical quantity which determines the direction of flow of thermal energy.

7.6 Define heat as 'energy in transit'. 09107040

Ans: Heat can be defined as "The energy that is transferred from one body to another due to a temperature difference between the two bodies."

7.7 What is meant by thermometric property of a substance? Describe some thermometric properties. 09107041

Ans: A thermometric property in a physical property that changes with temperature some common thermometric properties include:

i. Volume expansion (e.g. Hg in a thermometer)
ii. Colour change (liquid crystal thermometer)
iii. Electrical resistance (e.g. thermistors)
iv. Pressure change (e.g. gas thermometer)

7.8 Describe the main scales used for the measurement of temperature. How are they related with each other? 09107042

Ans: See answer from comprehensive Q.No.7.

7.9 What is meant by sensitivity of a thermometer? 09107043

Ans: Sensitivity of thermometer refers to how small change in temperature it can detect and measure.

7.10 What do you mean by the linearity of a thermometer? 09107044

Ans: Linearity of a thermometer refers to how directly its readings correspond to the actual temperature i.e. whether the temperature scale is evenly spaced and consistent.

7.11 What makes the scale reading of a thermometer accurate? 09107045

Ans: The scale reading of a thermometer is accurate due to:

i. **Calibration:** The thermometer is calibrated against a known temperature standard.
ii. **Linear expansion:** The thermometric property (e.g., mercury expansion) changes linearly with temperature.
iii. **Accurate markings:** The temperature scale is accurately marked and evenly spaced.
iv. **Proper construction:** The thermometer is constructed to minimize errors and ensure consistent readings.

7.12 What does determines the direction of heat flow? 09107046

Ans: Temperature difference determines the direction of heat flow. Heat always flows from a body at a higher temperature to a body at a lower temperature.

7.13 Distinguish between the heat and internal energy. 09107047

Ans: Heat:

- Energy transferred between systems due to temperature difference.
- Can be gained or lost

- Measured in joules (J)

Internal Energy:

- Total energy of particles in a system
- Includes kinetic energy and potential energy of bonds
- Also measured in joules (J)

7.14 When you touch a cold surface, does cold travel from the surface to your hand or does energy travel from your hand to cold surface? 09107048

Ans: The heat flows from your hand to the cold surface because of fundamental nature of heat flow and laws of thermodynamics.

7.15 Can you feel your fever by touching your own forehead? Explain. 09107049

Ans: No, you can't feel fever by touching your own forehead. This is because your hand is at the same temperature as your forehead, so you won't be able to detect the heat.

SLO Based Additional Short Questions

Thermometer

7.1 (i) Why the walls of the thermometer bulb are thin? 09107050

(ii) Why the inner bore must be narrow?

Ans. (i) The walls of thermometer are made thin for:

- Reducing thermal mass.
- Increasing heat transfer
- Improving sensitivity.

(ii) The narrow inner bore in thermometer made to:

- Increase capillary action
- Improves sensitivity
- Reduces thermal lag

7.2 Why pressure and resistance are thermodynamic properties. 09107051

Ans. The pressure of a given mass of gas increases with temperature. So, pressure of a gas is also a thermometric property which is used in gas thermometers. The resistance of a given length of wire also depends upon temperature. It increases with the increase in temperature. So, the resistance of a wire is also a thermometric substance and is used in plantinum resistance thermometer.

7.3 What are thermometric properties? 09107052

Ans. Thermometers use some property of a substance, which changes appreciably with the change of temperature are called thermometric properties.

7.4 What is thermistors? 09107053

Ans. The device which converts the heat energy into electrical energy is called thermistors.

7.5 Define absolute zero? What is its values? 09107054

Ans. The temperature of matter of which particles of stop their motion is called absolute zero temperature. Its value is 0K or -273.15^0C.

Molecular Theory of Matter

7.6 Write a brief note Define Molecular Theory of matter. 09107055

Ans. According to this theory, matter is composed of very small particles called molecules which are always in motion. Their motion may be vibrational, rotational or linear. There exists a mutual force of attraction between the molecules

know as intermolecular force. Tis force depends upon the distance between the molecules. It decreases with increasing distance between them.

Plasma

7.7 Define plasma. 09107056

Ans. The plasma is a gas in which most of the atoms are ionized containing positive ions and electrons. They are freely moving in the volume of the gas. Due to presence of positive ions and free electrons, plasma is the conduction state of matter. It allows electric current to pass through it.

(C) Constructed Response Questions

7.1 Is kinetic molecular theory of matter applicable to the plasma state of matter? Describe briefly. 09107057

Ans: Kinetic theory applies to plasma. It explains the random motion of ions and electrons, but additional complexities like coulomb interaction and collective behavior also need to be considered.

7.2 Why is mercury usually preferred to alcohol as a thermometric liquid? 09107058

Ans: Mercury is preferred to alcohol as a thermometric liquid because:

iii. High boiling point (357^0C)

iv. Lower freezing point (-39^0C)

Mercury remains liquid at low temperature while alcohol solidifies at lower temperature.

v. Uniform expansion

vi. High density (Allows for more compact thermometer)

vii. Chemically stable does not wet the surface of glass tube.

7.3 Why is water not suitable for use in thermometers? Without calculations, guess what is equivalent temperature of 373 K on Celcius and Fahrenheit scales? 09107059

Ans: Water is not suitable for use in thermometer because:

i. Freezing point: Water freezes at 0^0C, making it unsuitable for measuring temperature below 0^0C.

ii. Boiling water: Water boils at 100^0C, limiting its range for measuring higher temperature.

iii. Expansion properties: Water expands when it freezes, which can cause the glass tube to burst. Its expansion properties also make it less sensitive to temperature change.

iv. The equivalent temperature of 373 K on Celsius scale is 100^0C and 212^0F on Fahrenheit scale (without calculation).

7.4 Mention two ways in which the design of a liquid-in-glass thermometer may altered to increase its sensitivity. 09107060

Ans: Following are two ways to increase the sensitivity of a liquid-in-glass thermometer.

i. Narrow bore: By reducing the diameter of glas tube (bore), the thermometer becomes more sensitive. This is because a smaller bore requires less liquid expansion to register a temperature change, allowing for more precise measurement.

ii. Increasing liquid expansion co-efficient: Using a liquid with a higher

expansion co-efficient (such as ethanol or pentane) instead of mercury or water, increases the sensitivity of thermometer. This is because liquids with higher expansion co-efficient expand more for a given temperature.

7.5 One litre of water is heated by a stove and its temperature rises by 2^0C. If two litres of water is heated on the same stove for the same time, what will be then rise in temperature? 09107061

Ans: Specific heat capacity of water remains constant, the temperature rise will become half of original value, since the same amount of heat energy is spread over twice the mass of water. So, the temperature for 2 liters of water will approximately 1^0C (half of the original 2^0C rise).

7.6 Why are there no negative numbers on the Kelvin scale? 09107062

Ans: There are no negative numbers on the Kelvins scale because it starts at absolute zero (0k), the lowest possible temperature where all molecular motion stops. Since temperature measures the thermal energy of a system, and energy cannot be less than zero, negative values are not possible on Kelvin scale.

7.7 Comment on the statement, "A thermometer measures its own temperature." 09107063

Ans: A thermometer measures the temperature of substance not its own temperature. It measure the temperature of an external object or environment.

7.8 There are various objects made of cotton, wood, plastic, metals etc. in a winter night. Compare their temperatures with the air temperature by touching them with your hand. 09107064

Ans: Metal objects feel colder than air temperature:

- Wooden objects feel closer to temperature.
- Cotton and plastic objects feel slightly warmer than air temperature.

This is because metals are good conductors of heat, quickly transferring heat away from your skin, making them feel colder. Wood and plastic are poorer conductors, while cotton is a poor conductor and a good insulator.

7.9 Which is greater: increase in temperature 1^0C or 1^0F? 09107065

Ans: An increase in temperature of 1^0C is greater than 1^0F.

Reason: $1^0C = 1.8^0F$

7.10 Why would not you expect all the molecules in a gas to have the same speed? 09107066

Ans: Gas molecules do not have same speed due to random motion and collisions, resulting in a distribution of speeds.

7.11 Does it make sense to talk about the temperature of a vacuum? 09107067

Ans: In an ideal vacuum, where no particles exist, temperature does not have any sense. However, in practical or at so physical contexts, we might refer to the effective temperature associated with radiations present in vacuum. Thus, it may make sense in specific contexts.

7.12 Comment on the statement: "A hot body does not contain heat". 09107068

Ans: A hot body does not contain heat, instead, it has internal energy due to the

motion of its particles. Heat only describes the energy transferred between systems due to a temperature difference.

7.13 Discuss whether the Sun is matter. 09107069

Ans: The sun is matter because it is composed of physical substances (hydrogen, Helium, and other elements) in a plasma state, which have mass and occupy space. However, it also emits energy, which is not matter but a byproduct of the nuclear reaction taking place at sun.

(D) Comprehensive Questions

7.1 Describe the main points of particle theory of matter which differentiate solids, liquids and gases. 09107070

Ans: See QNo.1.

7.2 What is temperature? How is it measured? Describe briefly the construction of a mercury-in-glass thermometer. 09107071

Ans: See QNo.6.

7.3 Compare the three scales used for measuring temperature. 09107072

Ans: See QNo.7.

7.4 What is meant by sensitive, range and linearity of thermometers? Explain with examples. 09107073

Ans: See QNo.9.

7.5 Explain, how the parameters mentioned in question 7.4 are improved in the structure of glass-in-thermometer. 09107074

Ans: The structure of glass in a thermometer is improved to enhance its sensitivity, range, and linearity. Here's how:

Sensitivity:

(i) Thin-walled glass: Using thin-walled glass reduces the thermal mass of the thermometer, allowing it to respond more quickly to temperature changes.

(ii) Uniform bore: A uniform bore (inner diameter) ensures that the mercury or alcohol column rises or falls uniformly, providing a more sensitive response to temperature changes.

Range:

(i) Long, narrow tube: A longer, narrower tube allows for a greater expansion and contraction of the mercury or alcohol column, increasing the thermometer's range.

(ii) Gradations: Careful gradations (markings) on the thermometer enable accurate readings over a wider temperature range.

Linearity

(i) Constant internal diameter: Maintaining a constant internal diameter along the length of the thermometer ensures that the mercury or alcohol column expands and contracts linearly with temperature changes.

(ii) Accurate calibration: Accurate calibration of the thermometer ensures that the gradations are evenly spaced and correspond to a linear temperature scale.

By improving the structure of the glass in a thermometer, manufacturers can create more sensitive, accurate, and reliable thermometers with a wider range and better linearity.

(E) Numerical Problems

7.1 The temperature of normal human body on Fahrenheit scale is 98.6^0F. Convert it into Celsius scale and Kelvin scale. 09107075

Solution:

Give Data: $T_F = 98.6^0F$

To Find: $T_C = ?$ $T_K = ?$

To convert 98.6°F to Celsius and Kelvin:

Here are the formulas:

$T_F = (°C \times 9/5) + 32$

$T_C = (°F - 32) \times 5/9$

$T_K = °C + 273.15$

$T_C = K - 273.15$

$T_C = (°F - 32) \times 5/9$

Celsius: $(98.6 - 32) \times 5/9 = 37°C$

$T_K = °C + 273.15$

Kelvin: $37°C + 273.15 = 310.15\ K$

7.2 At what temperature Celsius and Fahrenheit thermometer reading would be the same? 09107076

Solution: Let's call the temperature where Celsius and Fahrenheit are equal "x".

We can set up the equation:

$°C = °F = x$

Using the conversion formula:

$x = (x \times 9/5) + 32$

Solving for x, we get:

$x = -40$

So, at $-40°C$ and $-40°F$, the Celsius and Fahrenheit thermometer readings would be the same.

7.3 Convert 5^0F to Celcius and Kelvin scale. 09107077

Solution:

Give Data: $T_F = 5^0F$

To Find: $T_C = ?$ $T_K = ?$

Here are the conversions:

$T_C = (°F - 32) \times 5/9$

$T_C = (5 - 32) \times 5/9$

$T_C = -15°C$

$T_K = °C + 273.15$

$T_K = -15 + 273.15$

$T_K = 258.15\ K$

7.4 What is equivalent temperature of 25^0C on Fahrenheit and Kelvin scales? 09107078

Solution:

Give Data: $T_C = 25^0F$

To Find: $T_F = ?$ $T_K = ?$

Here are the conversions:

$T_F = (°C \times 9/5) + 32$

$T_F = (25 \times 9/5) + 32$

$T_F = 77°F$

$T_K = °C + 273.15$

$T_K = 25 + 273.15$

$T_K = 298.15\ K$

7.5 The ice and steam points on an ungraduated thermometer are found to be 192 mm apart. What temperature will be on Celsius scale if the length of mercury thread is at 67.2 mm above the ice point mark? 09107079

Solution:

Given Data:

Ice and steam points apart = L = 192 mm

Mercury thread above ice point = ℓ = 67.2 mm

Temperature on Celsius scale corresponding to length 'ℓ'=?

To Find:

We can set up a proportion to find the temperature "t" corresponding to the length "ℓ".

$T_C = ?$

To find the temperature, we need to calculate the ratio of the length of the mercury thread above the ice point to the

total length between the ice and steam points.

Let's call the total length "L" and the length above the ice point "ℓ".

Now, we know that the temperature range between ice and steam points is 100°C (0°C to 100°C).

$T_C / 100 = \ell / L$

$T_C = (\ell / L) \times 100$

$T_C = (67.2 / 192) \times 100$

$T_C \approx 35°C$

So, the temperature on the Celsius scale is approximately 35°C.

7.6 The length between the fixed point of liquid-in-glass thermometer is 20 cm. If the mercury level is 4.5 cm above the lower mark, what is the temperature on the Fahrenheit scale?

09107080

Solution:

Given Data:

Total length between fixed points L = 20 cm

mercury thread above lower mark=ℓ=4.5 cm

mercury thread above lower mark

Temperature on Fahrenheit scale = T_F = ?

To find the temperature, we need to calculate the ratio of the length of the mercury thread above the lower mark to the total length between the fixed points.

Let's call the total length "L" and the length above the lower mark "ℓ".

$T_F = (\ell / L) \times 180 + 32$

Now, we know that the temperature range between the fixed points (ice and steam points) is 180°F (32°F to 212°F).

$T_F = (4.5 / 20) \times 180 + 32$

$T_F \approx 41 + 32$

$T_F \approx 73°F$

So, the temperature on the Fahrenheit scale is approximately 73°F.