***1. Describe, qualitatively, the particle structure of solids, liquids and gases.**

*According to the kinetic molecular theory, matter is composed of very small particles called **molecules**, which are always in motion.*

Their motion may be **vibrational**, **rotational**, or **linear**. A mutual force of attraction called **intermolecular force** exists between the molecules. This force depends on the **distance between molecules** and **decreases** as the distance increases.

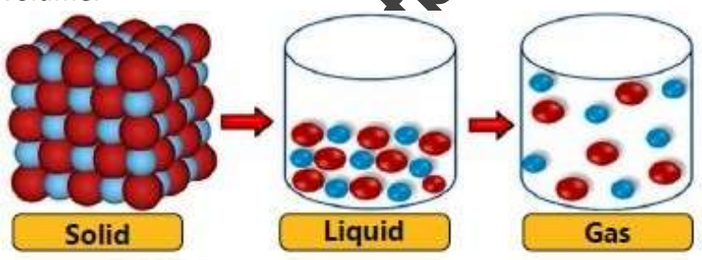
Molecules possess kinetic energy due to their motion and potential energy due to intermolecular forces. When a substance is heated, its temperature increases and the molecular motion becomes more vigorous, increasing the kinetic energy. Thus, the *temperature of a substance depends on the average kinetic energy of its molecules.*

**Properties of Kinetic Molecular Theory:** In general, matter exists in three states: solids, liquids, and gases.

**Solids:** In solids, the intermolecular forces are **very strong**, so molecules are held at fixed positions, showing only vibrational motion. That is why solids have a definite shape and volume.

**Liquids:** In liquids, the intermolecular forces are **weaker**, allowing molecules to slide over each other in random directions. Therefore, liquids have a definite volume but no definite shape, and take the shape of the container.

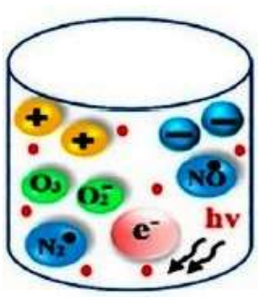
**Gases:** In gases, the molecules are **far apart** and the intermolecular forces are **v**ery weak. Gas molecules move freely in all directions, so a gas has no definite shape or volume.




***2. Describe plasma as a fourth state of matter.**

***Plasma** is a gas in which most of the atoms are **ionized**, containing **positive ions** and **electrons**.*

These particles move freely within the volume of the gas. Because of the presence of these charged particles, plasma is a **conducting state of matter**, allowing **electric current** to pass through it.




Since the gas in the **plasma state** shows properties **very different** from those of an ordinary gas, plasma is known as the **fourth state of matter**.

Examples of plasma include:

- The **Sun** and most **other stars**, which are in the plasma state.
- **Plasma TVs** and **gas discharge tubes**, which produce plasma when electric current passes through them.
- The **early stage of lightning formation**, known as **lightning streamers**, occurs due to ionized air molecules creating conducting paths through the atmosphere.

**** 3. What is meant by temperature of a body?**

*Temperature of a body is defined as the degree of its hotness or coldness.*

***4. How can temperature be defined in terms of thermal energy?**

*Temperature can be defined as a physical quantity which determines the direction of flow of thermal energy.*

**** 5. Define heat as 'energy in transit'.**

*Heat is the energy which is transferred from one object to another due to the **difference of temperature** between the two bodies.*

**6. Define internal energy.**

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

**** 7. What is a thermometer? State basic thermometric properties of a suitable material. OR What is meant by thermometric property of a substance? Describe some thermometric properties.**

*A **thermometer** is an instrument used for the exact measurement of the hotness or temperature of a substance.*

**OR**

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

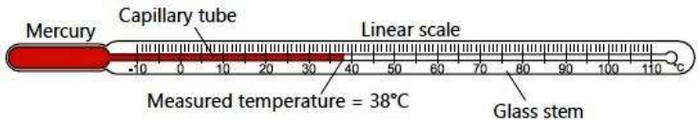
**Basic Thermometric Properties:** A thermometric property is a physical property of a substance that changes with temperature and is used in the construction of thermometers. Some thermometric properties are:

1. It is a good conductor of heat.
2. It gives quick response to temperature changes.
3. It has uniform thermal expansion.
4. It has high boiling point.
5. It has low freezing point.
6. It has large expansivity (low specific heat capacity).
7. It does not wet glass.
8. It does not vapourize.
9. It is visible.

***8. What is a liquid-in-glass thermometer and which liquids are used in it?**

*Liquids expand on heating. So, expansion in the volume of a liquid can be used for the measurement of temperature. This is known as a **liquid-in-glass thermometer**.*

**Mercury** is commonly used in thermometers. It is **opaque** and easily seen due to its **silvery colour**. The thermometer is made of **glass** with a **bulb at one end filled with mercury**.




When the temperature rises, the **mercury expands** and moves up through the narrow capillary tube in the form of a mercury thread. The position of the end of the thread reads the temperature.

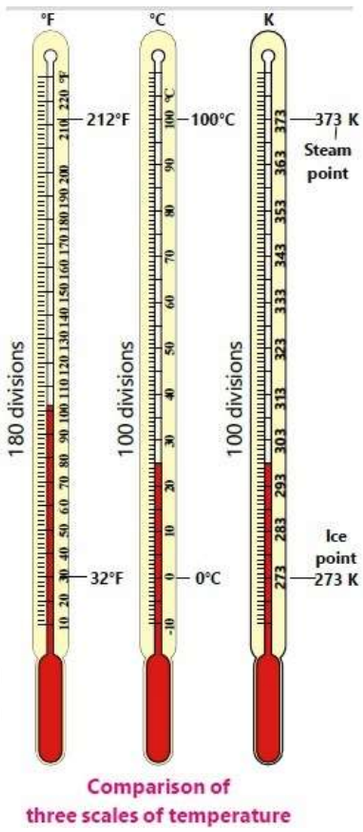
**Alcohol** can also be used, but it must be coloured to make it visible.

***9. What are the fixed points used in temperature measurement?**

For the measurement of temperature, two reference temperatures called **fixed points** are required.

**(i) Upper fixed point**: This is the **steam point**, slightly above the boiling point of water at standard atmospheric pressure.

**(ii) Lower fixed point**: This is the melting point of pure ice, also known as the **ice point**.



Comparison of three scales of temperature

**10. What are the three main types of temperature scales?**

The three types of temperature scales are:

**(i)** Celsius or centigrade scale

**(ii)** Fahrenheit scale

**(iii)** Kelvin scale

**Celsius (Centigrade) scale**:

- Lower fixed point: $0°C$
- Upper fixed point: $100°C$

The scale is divided into $100$ equal parts, each part representing $1°C$.

**Fahrenheit scale**:

- Lower fixed point: $32°F$
- Upper fixed point: $212°F$

The scale is divided into $180$ equal parts, each part representing $1°F$.

**Kelvin scale (Absolute temperature scale)**:

- Lower fixed point: $273\ K$
- Upper fixed point: $373\ K$

The scale is divided into $100$ equal parts, with each part representing $1\ K$, equivalent to $1°C$.

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

If the temperature of a body is $T_C$ on the **Celsius scale range** $(0°C\ to\ 100°C)$, $T_F$ on the **Fahrenheit scale** range $(32°F\ to\ 212°F)$, and $T_K$ on the **Kelvin scale** range $(273\ K\ to\ 373\ K)$, then these readings are related by the following formulae:

**Relationship between Celsius and Fahrenheit scale:**

$$T_F = \frac{9}{5} T_c + 32$$

$$T_F = 1.8\, T_c + 32$$

**Relationship between Fahrenheit and Celsius scale:**

$$T_c = \frac{5}{9} (T_F - 32)$$

**Relationship between Kelvin and Celsius scales:**

$$T_K = T_C + 273$$

***12. What is absolute zero and its significance in the Kelvin scale?**

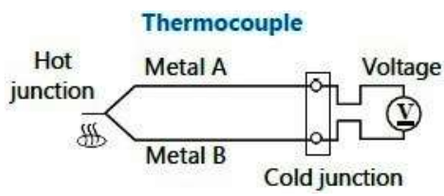
**Absolute zero** is the temperature at which molecular motion ceases, and the average kinetic energy of particles becomes zero. On the Kelvin scale, it is defined as $0\ K$, which is equivalent to $-273.15°C$ (rounded to $-273°C$ for calculations). It is the lowest possible temperature in the universe.

***13. What is a thermocouple thermometer and how does it work?**

*Thermocouple thermometer is based on the flow of electric current between two junctions of two wires of different materials due to difference of temperatures at the junctions.*

**Construction:** This type of thermometer consists of **two wires of different materials**, such as copper and iron. Their ends are joined together to form two junctions.

**Working Principle:** If the two junctions are at **d**ifferent temperatures, a small current flows across them. This current is due to the potential difference produced across the two junctions, as the wires have different resistance to the flow of current.




**Temperature Measurement:** The **greater** the temperature difference, the **greater** the potential

difference. If one junction is kept at a fixed lower temperature (e.g., in an ice bath at 0℃), the temperature of the other junction can be measured using a millivolt meter with a calibrated scale as shown in figure.

**Uses:** It is useful for very high temperatures and rapidly changing temperatures, as there is only a small mass of metal (the junction) to heat up.

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

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.*

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

***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 $\mathbf{35}$℃ to $\mathbf{45}$℃. A long-range thermometer is usually used for science experiments in the laboratory with markings from $-\mathbf{10}$℃ to $\mathbf{110}$℃.

The **choice of liquid** for thermometers puts a lower and upper limit for the range of a thermometer.

- Mercury freezes at $-\mathbf{39}$℃ and boils at $\mathbf{357}$℃. Hence, we can construct mercury-in-glass thermometers within this range.
- For extremely low temperatures, alcohol is used. Alcohol has a much lower freezing point, about $-\mathbf{112}$℃, which increases its lower limit for the range, but it has a **lower upper limit** as it boils at $\mathbf{78}$℃.

***Linearity****: This refers to a* ***direct proportional relationship*** *between the temperature and scale reading across the* ***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.

**** 15. Explain how the parameters sensitivity, range and linearity are improved in the structure of a liquid-in-glass thermometer.**

**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.

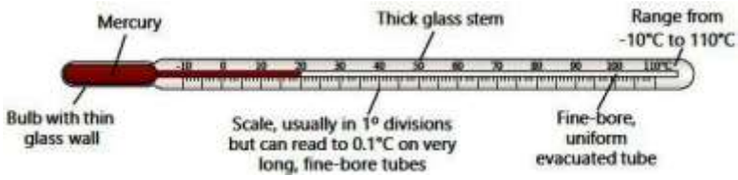
**Sensitivity:** Mercury being **metal** is a good conductor and hence responds quickly to the change in temperature. The small amount of liquid also responds more quickly to a change in temperature. The quick response makes the device sensitive. Use of mercury is quite sensitive for normal measurements.

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℃).

**Linearity:** The uniformity of the narrow tube or bore ensures even expansion of the liquid required to make the linear measuring scale.

**Range:** 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.




**** 16. Why do solids have a fixed volume and shape according to the particle theory of matter?**

Solids have a fixed volume and shape because their molecules are held at fixed positions by very strong intermolecular forces and can only vibrate about their mean positions.

**** 17. What are the reasons that gases have neither a fixed volume nor a fixed shape?**

In gases, intermolecular forces are very weak and molecules are far apart, moving freely in all directions. That is why gases have neither a fixed volume nor a fixed shape.

**** 18. Compare the spacing of molecules in the solid, liquid, and gaseous state.**

**Solids:** Molecules are tightly packed with very little space between them.

**Liquids:** Molecules are less tightly packed and can slide over each other.

**Gases:** Molecules are far apart with large spaces between them.

**** 19. What is the effect of raising the temperature of a liquid?**
Raising the temperature of a liquid increases the kinetic energy of its molecules, making them move more vigorously and reducing the intermolecular forces.

**** 20. What makes the scale reading of a thermometer accurate?**
Accurate scale readings depend on uniform thermal expansion, fine scale markings, good thermal conductivity, and proper calibration using fixed reference points like ice and steam points.

**** 21. What determines the direction of heat flow?**
**Temperature difference** determines the direction of heat flow. Heat always flows from a body at higher temperature to one at lower temperature.

**** 22. Distinguish between heat and internal energy.**
**Heat:** Heat is the energy which is transferred from one object to another due to the difference of temperature between the two bodies.

**Internal Energy:** The sum of kinetic and potential energies of the molecules of an object is called its internal energy.

**** 23. 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?**
Energy travels from your hand to the cold surface. Heat always flows from the warmer object (your hand) to the cooler one (the surface).

**** 24. Can you feel your fever by touching your own forehead? Explain.**
No, you cannot feel your own fever accurately because your hand and forehead are at the same temperature, so no heat flow occurs that you can sense.

**** 25. Which is greater: an increase in temperature 1°C or one 1°F?**
An increase of temperature $1℃$ is greater than $1℉$, because $1℃ = 1.8℉$.

**** 26. Why are there no negative numbers on the Kelvin scale?**
The Kelvin scale starts from absolute zero ($0\ K$), the point where molecular motion stops. Negative values are not possible as temperature cannot be lower than absolute zero.

**** 27. Why is mercury usually preferred to alcohol as a thermometric liquid?**
Mercury is preferred because it has a uniform expansion, is **opaque and shiny** (making it easy to read), does not stick to glass, and remains in liquid state over a wide temperature range.