UNIT 9 STRUCTURE QUESTIONS

HEAT AND TEMPERATURE

1. a) Define Heat and write its SI unit.

HEAT

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Heat is the transfer of energy across the boundary of a system due to the temperature difference between the system and its surrounding.
Heat is a macroscopic scalar quantity.

UNITS OF HEAT

i) The S.I. unit of heat is **Joule** which is denoted by J.

ii) Calorie (cal) is a old unit of heat **calorie** (cal) which is define as *the amount of energy transfer necessary to raise the temperature of* **1***g of water from 14.5* ^{0}C *to 15.5* ^{0}C

iii) The unit of heat energy in the British system is the **British thermal unit (Btu),** which is defined as *the amount of energy transfer required to raise the temperature of* 1 *lb of water from 63*^{0}F *to 64*^{0}F

b) Why does heat flows from hot body to cold body?

ANS:

Heat flows from a hot body to a cold body because of the natural behavior of particles and the laws of thermodynamics. The main reason is that energy always spreads from a region of higher temperature to a region of lower temperature until both bodies reach the same temperature

c) Convert 30 ^{o}C into Kelvin and Fahrenheit Scale.

Celsius to Kelvin Scale

$$T_k = T_c + 273$$

$$T_k = 30 + 273$$

$$T_k = 303\ K$$

Celsius to Fahrenheit Scale

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

$$T_F = \frac{9}{5} \times 30 + 32$$

$$T_F = 54 + 32$$

$$T_F = 86$$

2. a) Explain three different scales of temperature along with their main uses.
ANS

1. Celsius Scale (°C)

In this scale:

- The freezing point of water is **0°C**
- The boiling point of water is **100°C**
- The interval between them is divided into 100 equal parts called degrees Celsius.

Main Uses

- Used in most countries for daily temperature measurement
- Used in weather reports
- Used in schools and laboratories
- Common in scientific work

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2. Fahrenheit Scale (°F)

In this scale:

- Freezing point of water = **32°F**
- Boiling point of water = **212°F**
- The interval between them is divided into 180 equal parts.

Main Uses

- Commonly used in the United States for:
  - Weather forecasting
  - Household thermometers
  - Medical thermometers

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3. Kelvin Scale (K)

In this scale:

- **0 K** is called **absolute zero**
- At absolute zero, molecular motion is minimum.
- Freezing point of water = **273 K**
- Boiling point of water = **373 K**

Main Uses

- Used in scientific research
- Used in physics and chemistry
- Essential in gas laws and thermodynamics

b) **Differentiate between heat and temperature.**

HEAT	TEMPERATURE
Heat is a form of energy that flows from a hot body to a cold body.	Temperature is the degree of hotness or coldness of a body
It depends on the amount of substance present.	It does not depend on the amount of substance
Heat is transferred from one object to another.	Temperature only indicates the thermal condition of a body
SI unit of heat is **joule (J)**.	SI unit of temperature is **kelvin (K)**.
It is measured using a **calorimeter**.	It is measured using a **thermometer**
Example: Boiling water contains more heat energy than a cup of tea ≡	Example: A cup of boiling water and a bucket of boiling water may have the same temperature

c) Convert 212 °F into Celsius and Kelvin.
Fahrenheit to Celsius Scale

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

$$T_C = \frac{5}{9}(212 - 32)$$

$$T_C = \frac{5}{9} \times 180$$

$$T_C = 100\ ^\circ\mathrm{C}$$

Fahrenheit to kelvin Scale

$$212\ ^\circ\mathrm{F} = 100\ ^\circ\mathrm{C}$$

$$T_K = T_c + 273$$

$$T_K = 100 + 273$$

$$T_K = 373\ k$$

SPECIFIC HEAT CAPACITY

3. a) Explain specific heat capacity.

ANS:

SPECIFIC HEAT CAPACITY

The **specific capacity**, c, of a material is defined as the amount of thermal energy required to raise the temperature of a unit mass of the material by 1 K or 1 ^{0}C.

$$C = \frac{\Delta Q}{m\,\Delta T}$$

UNIT

The SI unit of specific heat is $Jkg^{-1}k^{-1}$ or $J\ kg^{-1}\ {}^0C^{-1}$

Importance of Specific Heat Capacity

1. Climate Regulation
   Water absorbs a large amount of heat, helping coastal areas maintain moderate temperatures.
2. Cooking Utensils
   Metals with low specific heat capacity heat up quickly and are used in cooking pots.
3. Cooling Systems
   Water is used in car radiators because it can absorb large amounts of heat.

Conclusion

Specific heat capacity tells how much heat energy a substance needs to change its temperature. Substances with high specific heat capacity require more heat to warm up, while substances with low specific heat capacity heat up quickly.

b) How would you find the specific heat of a solid?

ANS: **APPARATUSE:**

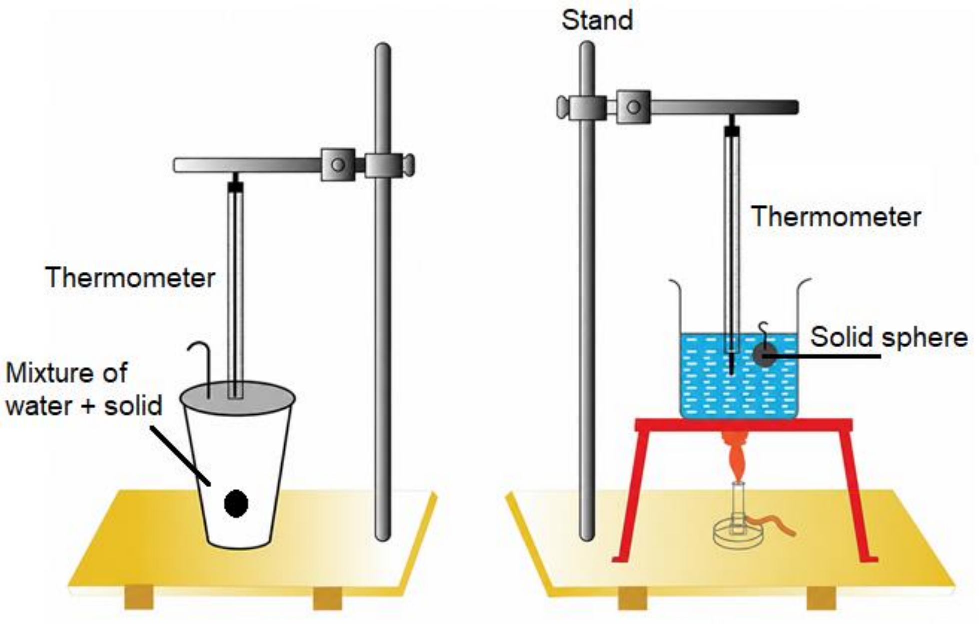
1) Calorimeter with stirrer placed in insulated box with lid
2) Given large solid bob
3) Vertical stand
4) Two half degree centigrade thermometers
5) Glass beaker containing some water
6) Tripod stand
7) Bunsen burner
8) Physical balance
9) Weight box

Theory:

The specific heat capacity C_b of a solid (bob) is given by

$$C_b = \frac{(m_c C_c + m_w C_w)(T_3 - T_2)}{m_b (T_1 - T_3)}$$

where m_c is the mass of calorimeter stirrer C_c the specific heat of the material of the calorimeter m_w the mass of water taken in calorimeter C_w the specific heat of water m_b the mass of solid bob T_1 the temperature of heated solid bob T_2 the initial temperature of water and T_3 the final temperature of water



c) How much heat is required to boil 3 kg water which is initially 10 ºC ?

Heating water from 10°C to 100°C

$$\Delta Q_1 = mc\,\Delta T$$

$$\Delta Q_1 = mc\,(T_2 - T_1)$$

$$\Delta Q_1 = (3)(4200)\,(100 - 10)$$

$$\Delta Q_1 = (3)(4200)\,(90)$$

$$\Delta Q_1 = 1134\,000\,J$$

4. a) Explain the effects of large specific heat of water with examples from our daily life.

ANS:

1) Moderates Earth's Climate

Because water heats and cools slowly, it helps control temperature on Earth.

Example:

Oceans and seas absorb heat during the day and release it slowly at night.
Coastal areas (like Karachi) have **less extreme temperatures** than inland deserts.

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2) Protects Living Organisms

Bodies of plants and animals contain a lot of water, which keeps temperature stable.

Example:

Human body temperature does not change quickly even in hot or cold surroundings.
Water in our cells prevents sudden overheating or cooling.

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3) Used in Cooling Systems

Water is used as a coolant because it absorbs a lot of heat without a big rise in temperature.

Example:

Car radiators use water to absorb engine heat.

Factories use water to cool machines.

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4) Sea Breeze and Land Breeze

Water and land heat at different rates due to water's high specific heat.

Example:

During the day, land heats faster → cool air from sea (sea breeze).

At night, land cools faster → breeze moves from land to sea.

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5) Slow Heating in Cooking and Daily Use

Water takes time to heat up and cool down.

Example:

Large pots of water take longer to boil.

Hot water stays warm for a long time in thermos bottles.

b) 2kg of copper requires 2050J of heat to raise its temperature through 10 °C. Calculate the heat capacity of the sample.

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

$$\frac{\Delta Q}{m\ \Delta T} = c$$

$$c = \frac{\Delta Q}{m\ \Delta T}$$

$$c = \frac{2050}{(2)\ (10)}$$

$$c = 102.5\ \mathrm{J\,kg^{-1}\ {}^{\circ}C^{-1}}$$

HEAT OF FUSION AND HEAT OF VAPORIZATION

5. Define heat of fusion with the help of an experiment.

<u>LATENT HEAT OF FUSION</u>

The quantity of heat required to convert unit mass of a substance from the solid to liquid state at its melting point is called latent heat of fusion.

EXPERIMENT

Apparatus: Ice, beaker, thermometer, burner (or heater)

PROCEDURE:

1. Take a beaker and fill it with **crushed ice**.
2. Insert a thermometer into the ice.
3. Record the initial temperature (usually **0°C**).
4. Start heating the beaker gently using a burner or heater.
5. Observe the temperature as the ice starts melting.
6. Continue heating until all the ice changes into water.

CONCLUSION:

- The experiment proves that during melting, heat is absorbed but temperature remains constant.
- This absorbed heat is called **latent heat of fusion**.

6. Differentiate between heat of fusion and heat of vaporization

FEATURE	HEAT OF FUSION	HEAT OF VAPORIZATION
Definition	The amount of heat required to convert **1 kg of a solid into liquid** at its melting point without temperature change.	The amount of heat required to convert **1 kg of a solid into liquid** at its boiling point without temperature change.
Change of state	solid into liquid	solid into liquid
Temperature condition	Occurs at **melting point** (e.g., 0°C for ice)	Occurs at **boiling point** (e.g., 100°C for water)
Energy required	Relatively **less energy** is needed	**More energy** is needed compared to fusion
Reason	Energy breaks **intermolecular forces in solid state**	Energy completely overcomes **intermolecular forces in liquid state**
Fixed value of ice and water	The latent heat of fusion of ice is 336000 $J\ kg^{-1}$ or $3.36 \times 10^5\ J\ kg^{-1}$	Latent heat of vaporization of water 2,26,000 J / kg or 2.26×10^6 J / kg

7. Demonstrate heat of fusion and heat of vaporization by the help of heating ice graph.
ANS:

When heating ice from below 0 ℃ to steam, the energy added goes into breaking intermolecular bonds rather than increasing temperature, resulting in two flat regions on a temperature vs. time graph

Slope 1 (Ice Heating):

Temperature increases from below 0 ℃ to 0 ℃

Heat of Fusion:

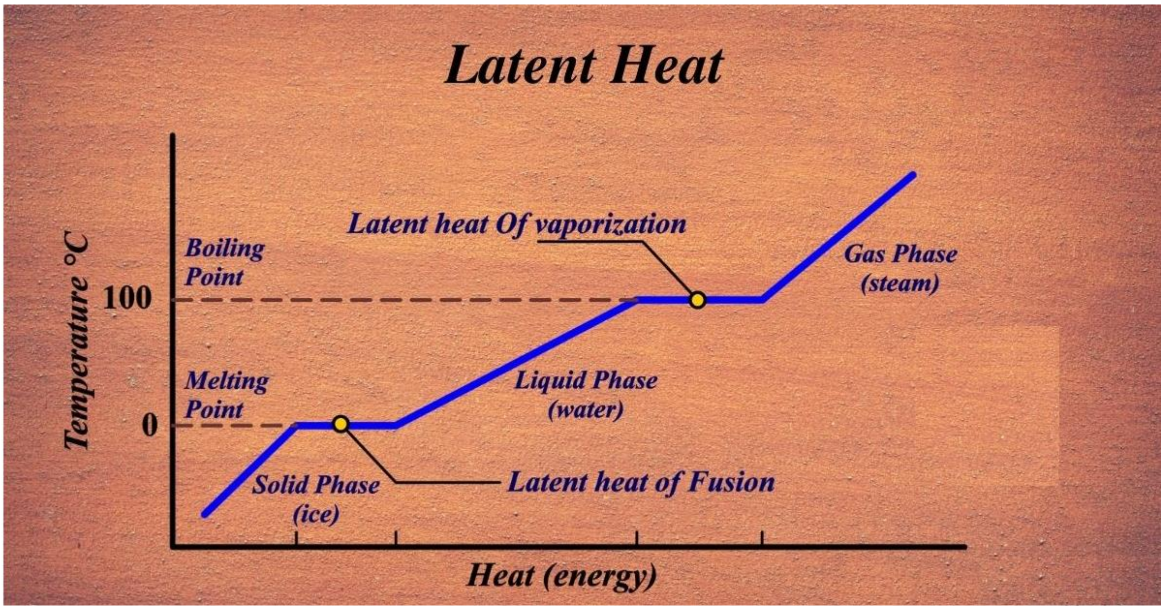
The temperature stays constant at 0 ℃. Heat energy added is entirely used to change ice to liquid water at the same temperature . The energy required is the *Latent Heat of Fusion*

Slope 2 (Water Heating):

Temperature increases from 0 ℃ to100 ℃

Heat of Vaporization:

The temperature stays constant at 100 ℃. Heat energy added is entirely used to change liquid water into steam. The energy required is the *Latent Heat of Vaporization*, which is greater than the heat of fusion



EVAPORATION PROCESS

8. Explain in detail, why evaporation causes cooling?

ANS

Evaporation is the process in which molecules of a liquid escape from its surface and change into vapour below the boiling point. This process causes a cooling effect.
When high-energy molecules leave:
The average kinetic energy of remaining liquid decreases, Since temperature depends on average kinetic energy, the temperature of the liquid drops. So, the liquid becomes cooler.

9. Differentiate between evaporation and boiling.

Evaporation	Boiling
1· It takes place without supply having external heat source.	1· It only takes place without on supply external heat source.
2· It occurs at any temperature below boiling point.	2· It occurs only at certain temperature called "Boiling point".
3· It causes cooling.	3· It do not causes cooling.
4· It is relatively slow.	4· It is relatively fast.
5· It takes place only at the liquid surface.	5· It takes place throughout the liquid.
6· No formation of bubbles.	6· Bubbles are formed.

10. Write any four factors that influence the surface evaporation.

1. Temperature: With the increase in temperature the rate of evaporation also increases.
2. Wind Speed: Rate of evaporation also increases with the increase in wind speed.
3. Surface area of liquid: Rate of evaporation increases with the increase in surface area of liquid.
4. Humidity: The rate of evaporation decreases with increase in humidity.

11. Write down the freezing and boiling points of following

i) Acetic acid ii) Benzene iii) Chloroform iv) Water

Acetic Acid

Freezing point: 16.6°C

Boiling point: 118.1°C

Benzene

Freezing point: 5.5°C

Boiling point: 80.1°C

Chloroform

Freezing point: −63.5°C

Boiling point: 61.2°C

Water

Freezing point: 0°C

Boiling point: 100°C

THERMAL EXPANSION

12. Why solids increases in size on heating ? Explain.

ANS:

When a solid is heated, it **expands (increases in size)** because its particles gain energy and vibrate more vigorously.

When heat is supplied:

Particles gain **kinetic energy**

They start vibrating **more strongly**

The **average distance between particles increases slightly**

So, the solid expands in:

Length (linear expansion)

Area (area expansion)

Volume (volume expansion)

13. An iron block of volume 3 m^3 is heated, so that its temperature changes from 25 ^oC to 100 ^oC. If the coefficient of linear expansion of iron is $11 \times 10^{-6}\ ^oC^{-1}$. What will be the new volume of the iron block after heating ?

DATA

$V_1 = 3\ m^3$

$T_1 = 25\ ^oC$

$T_2 = 100\ ^oC$

$\Delta T = 100 - 25 = 75\ ^oC$

$\alpha = 11 \times 10^{-6}\ ^oC^{-1}$

$V_2 = ?$

SOLUTION

$$\beta = 3\alpha$$

$$\beta = 3(11 \times 10^{-6}) = 33 \times 10^{-6}\ C^{-1}$$

$$\Delta V = V_1 \beta \Delta T$$

$$\Delta V = (3)(33 \times 10^{-6})(75)$$

$$\Delta V = 7425 \times 10^{-6}\ m^3$$

$$\Delta V = 0.00\,7425\ m^3$$

$$V_2 - V_1 = 0.00\,7425\ m^3$$

$$V_2 - 3 = 0.00\,7425\ m^3$$

$$V_2 = 3.00\,7425\ m^3$$

14. a) Draw the diagram, showing real and apparent expansion of liquid. Label the diagram properly.

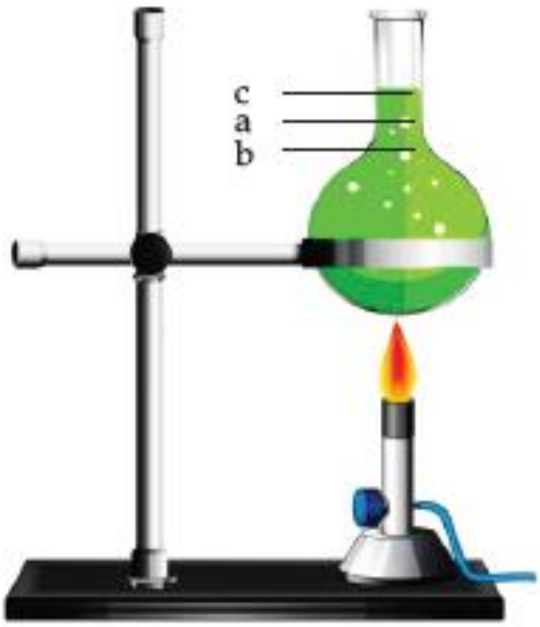
REAL AND APPARENT EXPANSION OF LIQUIDS

Consider a flask, filled with water up to level "a". The flask is placed on a burner, as shown below in; Fig

Heat starts to flow through the flask to water. So, the flask expands first. Due to expansion of flask, the level of water falls from point "a", level L_1 to point "b", level L_2

So, when water get heated, it starts to expand from a point "b" beyond its original level.

Thus expansion of water appear from level "L_1 " point "a" to level "L_3 " point "c" is called "apparent expansion of water". But in real sense, the water on heating has expanded from level "L_2 " point "b" to level 2 "L_3 " point "c" which is the "real expansion of water". Real expansion = L_2 to L_3 i.e from point "b" to "c", as shown in, Fig



b) Why small gaps are left at the joints of sections of railway tracks? Explain the phenomenon involved in it.

ANS

Small gaps are left between adjacent rails sections to allow **thermal expansion and contraction** of the metal.

Railway rails are usually steel. When temperature rises (hot weather), steel **expands** ; when temperature falls (cold weather), it **contracts** .

If the rails were laid with no gaps, then in summer the expanding rails would have **no space to expand** , creating large compressive forces. This can cause the track to **bend/buckle** (kink) or damage the joints.

The gaps provide room for expansion, keeping the track aligned and safe.