STUDY MATERIAL- BT ASSISTANT-PHYSICS-2022

Thermal Physics

No. of Sessions – 10

SESSION – 1 & 2

AIM

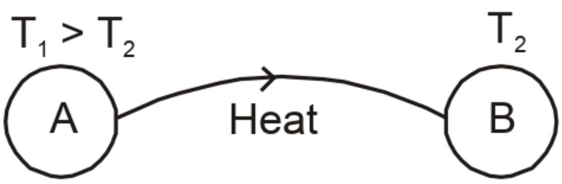
- ✓ To introduce the concept of Thermal capacity
- ✓ To introduce the Relation between Heat and Work
- ✓ To introduce the concept of change of state and latent heat

Heat:

- Heat is a form of energy.
- Heat produces the sensation of hotness or coldness in our body.

(Or)

- The energy that is being transferred between two bodies or between adjacent parts of a body as a result of temperature difference is called heat. Once it is transferred, it becomes the internal energy of the receiving body. so, "heat" is meaningful only as long as the energy is being transferred. Thus, expressions like "heat in a body" or "heat of a body" are meaningless.



There are two theories about heat

(1) Caloric theory of heat: This theory says that, heat is an invisible, weightless and odourless fluid called caloric. When some caloric is added to a body, its temperature rises and when some caloric is removed from a body, its temperature falls.

Drawbacks:

- This theory failed to explain the production of heat by friction.

(2) Dynamic theory of heat.: This theory says that, all substances (solids, liquids and) are made of molecules. These molecules are in a state of continuous random motion.

- Depending on temperature and nature of the substance ,the molecules may possess three types of motion namely translational, vibrational and rotational motions.

Different Units Of Heat

1. The CGS unit of heat is calorie

One calorie is defined as the heat energy required to raise the temperature of one gram of water through 1^0C (Say it from 4^0C to 5^0C)

2. The SI unit of heat is joule (J).

- 1 calorie = 4.186 joules

- **1 calorie :** The amount of heat needed to increase the temperature of 1 gm of water from 14.5 to 15.5 ºC at one atmospheric pressure is 1 calorie.

Mechanical Equivalent of Heat

According to Joule's Law, whenever heat is converted into mechanical work or mechanical work is converted into heat, then the ratio of work done to heat produced always remains constant.

$$W \propto Q$$
$$W = JQ$$

Where, W =Mechanical Work Done, Q=Heat produced, and J=Constant.

- In Joule's Law, J is known as the mechanical equivalent of heat.

if Q=1then J=W. Hence the amount of work done necessary to produce a unit amount of heat is defined as the mechanical equivalent of heat.
where J is called mechanical equivalent of heat.

- J is expressed in joule/calorie.
- The value of J gives how many joules of mechanical work is needed to raise the temperature of 1 g of water by 1°C.

TEMPERATURE:

- *Temperature is the degree of hotness or coldness of a body.*
- When two bodies are placed in Contact the heat flows from at higher temperature to the body at lower temperature. *Thus temperature may be define as the thermal state of a body which decide the direction of flow of heat energy from one body to another when they are placed in thermal contact with each other.*

Thermal Equilibrium

Heat energy flows from a body at higher temperature to that at lower temperature until their temperatures become equal. At this stage, the bodies are said to be in thermal equilibrium.

- According to Kinetic interpretation of temperature. The temperature of a body is the measure of average kinetic energy of its molecules. When a body is heated , its molecules moves faster . (or)
- The average K.E. increases of a body increases which will increases the temperature of the body

Comparison between heat and temperature:

Heat	Temperature
Heat is a form of energy. It is has the ability to do work	Temperature can be used to measure the degree of heat i.e it measures hotness or coldness of a body.
which produces in us the sensation of hotness or coldness	Temperature is the degree of hotness or coldness of a body
It is a cause, when some heat is supplied to a body, its temperature increases.	It is an effect
Heat of an object is the total energy of all the molecular motion inside that object.	Temperature represents the average kinetic energy possessed by the molecules of a body.

Heat flows from high temperature side to low temperature side irrespective of the amount of heat possessed by the bodies in contact	Temperature decides the direction of flow of heat from one body to another Temperature decides the direction of flow of heat from one body to another
It measured in cal , kcal or joule Its SI Unit is joule	It is measured in ^{0}C, °F or or K Its SI Unit is Kelvin
It's symbol is Q	It's symbol is T

Scales of Temperature:

- The Kelvin temperature scale is also known as thermodynamic scale.
- The *S.I.* unit of temperature is *kelvin* and is defined as (1/273.16) of the temperature of the triple point of water.

The triple point:

- The triple point of water is that point on a $P-T$ diagram where the three phases of water, the solid, the liquid and the gas, can coexist in equilibrium.

In addition to kelvin temperature scale, there are other temperature scales also like Celsius, Fahrenheit, Reaumer, Rankine *etc.*

To construct a scale of temperature, two fixed points are taken. First fixed point is the freezing point of water, it is called lower fixed point. The second fixed point is the boiling point of water, it is called upper fixed point.

Name of the scale	Symbol for each degree	Lower fixed point (LFP)	Upper fixed point (UFP)	Number of divisions on the scale
Celsius	$°C$	$0°C$	$100°C$	100
Fahrenheit	$°F$	$32°F$	$212°F$	180
Reaumer	$°R$	$0°R$	$80°R$	80
Rankine	$°Ra$	$460\ Ra$	$672\ Ra$	212
Kelvin	K	$273.15\ K$	$373.15\ K$	100

❖ Temperature on one scale can be converted into other scale by using the following identity.

$$\frac{Reading\ on\ any\ scale - Lower\ fixed\ point\ (LEP)}{upper\ fixed\ point(UFP) - lower\ fixed\ point\ (LEP)} = constant\ for\ all\ scales$$

$$\frac{C-0}{100} = \frac{F-32}{212-32} = \frac{K-273.15}{373.15-273.15} = \frac{R-0}{80-0} = \frac{Ra-460}{672-460}$$

$$(\text{Or})\ \frac{C}{5} = \frac{F-32}{9} = \frac{K-273}{5} = \frac{R}{4} = \frac{Ra-460}{10.6}$$

(or)

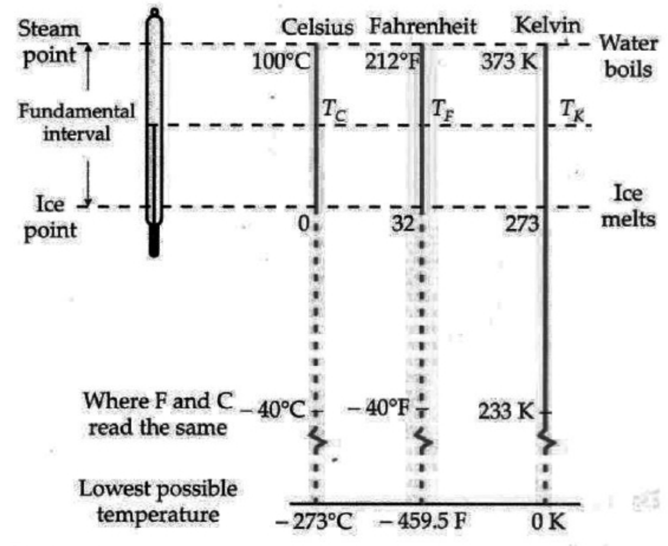
1. If T_C, T_F, T_R and T are the temperature of a body on Celsius, Fatrenheit, Reauner and Kelvin scales respectively then,

$$\frac{T_C-0}{100-0} = \frac{T_F-32}{212-32} = \frac{T_R-0}{80-0} = \frac{T-273.15}{100}$$

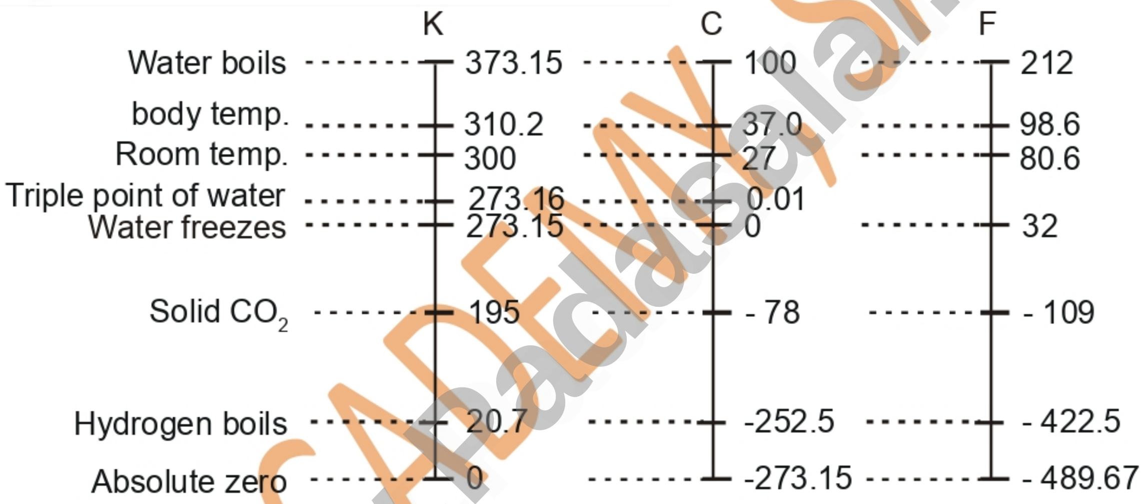
Or $\frac{T_C}{5} = \frac{T_F-32}{9} = \frac{T_R}{4} = \frac{T-273.15}{100}$

2. $T_C = \frac{5}{9}(T_F - 32)$, $T_F = \frac{9}{5}T_C + 32$),
3. $T = T_C + 273.15$, $T_C = T - 273.15$
4. $T_F = \frac{9}{5}(T_C - 32) + 32 = \frac{9}{5}T - 459.67$

Or $T = \frac{5}{9}T_F + 255.37$



Different temperature scales.



Kelvin scale or absolute scale:

- According to the kinetic theory of gases, All molecular motion stops at—273.15°C.
- Hence the lowest temperature of -273.15°C at which is a gas is supposed to have zero volume (and zero pressure) and at which entire molecular motion stop is called the absolute zero of temperature. In practice, all gases condense to liquids and solids before this temperature is reached.

The size of degree on Kelvin scale is same as that on Celsius scale. Therefore,

- **T(K)=t(°C)+273.15**
- Thus ice point (0°C) on absolute scale is 273.15 K and the steam point (100° C) is 373.15 K.

❖ The absolute scale of temperature is also called thermodynamic scale of temperature

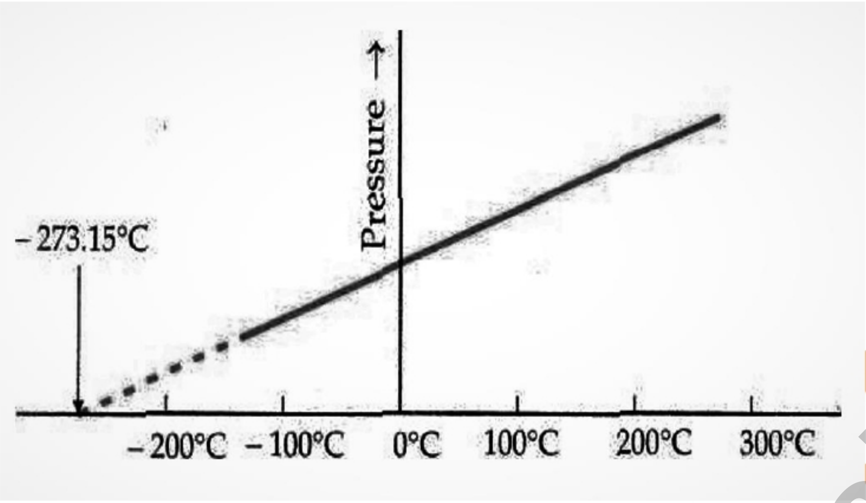


FIG. Pressure versus temperature of a low density gas kept at constant volume.

Triple point of water:

➢ The triple point of a substance is the temperature and pressure at which the three phases (gas, liquid, and solid) of that substance coexist in thermodynamic equilibrium.

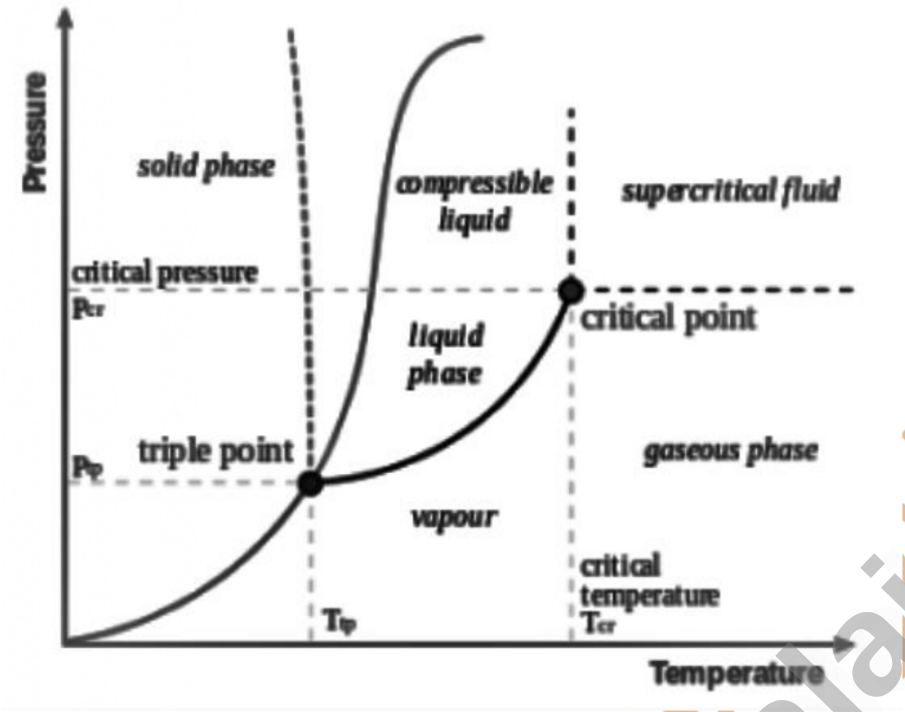
➢ It is unique because it occurs at a specific temperature of 273.16 K and a specific pressure of 0.46cm of Hg column. Thus for water,

P_{tr} =0.46 cm of Hg

T_{tr} = 273.16 K or 0.01° C

➢ The melting point of ice and boiling point of water both change with pressure. Moreover, the presence of impurities changes their values.

➢ The triple Point of water is independent of the external factors. So in Modern thermometry, the triple point of water is chosen to be one of the fixed points.



Objective Questions:

1. The change in potential energy of a 10 kg mass falls from 10 m height is (in calories)

(a) 1000 cal (b) 4187 cal
(c) 238.8 cal (d) 10 cal

Sol(c): Change in potential energy

$$U = mgh = 10 \times 10 \times 10 = 1000\text{ J} = \frac{1000}{4.186}\text{ cal}$$

2. The amount of heat required to convert 1 kg steam from 100ºC to 200ºC is

a) 50 cal b) 80 cal
c) 180 cal d) 4.187 cal

Sol(c): Heat required $Q = mc\Delta t = 1 \times \frac{1}{2} \times 100 = 50$ kcal

3. If 420 J of energy supplied to 10 g of water. The raise in temperature of water is

a) 420º C b) 120º C
c) 110º C d) 10º C

Sol(d):

4. Read the assertion and reason carefully to mark the correct option out of the options given below :

Assertion : Fahrenheit is the smallest unit measuring temperature.

Reason : Fahrenheit was the first temperature scale used for measuring temperature.

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

Sol: (c)

5. The ratio of the densities of the two bodies is 3 : 4 and the ratio of specific heats is 4 : 3 . The ratio of their thermal capacities for unit volume is

a) 2 : 3 b) 2 : 1
c) 3 : 2 d) 1 : 1

Sol(d): $\frac{\rho_1}{\rho_2} = \frac{3}{4}, \frac{s_1}{s_2} = \frac{4}{3}$

$$\text{ratio} = \frac{m \times s}{m/\rho} \frac{\theta_1}{\theta_2} = \frac{s_1}{s_2} \times \frac{\rho_1}{\rho_2} = 1 : 1.$$

6. Heat releases by 1 kg steam at 150ºC if it convert into 1 kg water at 50ºC.

a) 819 Kcal b) 615 Kcal
c) 520 Kcal d) 560 Kcal

Sol(b):

$$H = 1 \times \frac{1}{2} \times 50 + 1 \times 540 + 1 \times 1 \times 50 = 540 + 75 = 615 \text{ Kcal}$$

Heat release = 615 Kcal.

7. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : The temperature at which Centigrade and Fahrenheit thermometers read the same is – 40°.

Reason : There is no relation between Fahrenheit and Centigrade temperature.

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) *If assertion is false but reason is true.*

Sol: (c)

8. 200 gm water is filled in a calorimetry of negligible heat capacity. It is heated till its temperature is increase by 20ºC. Find the heat supplied to the water.

(a) 2 Kcal (b) 4 Kcal
(c) 5 Kcal (d) 20 Kcal

Sol: (b)

$$H = 200 \times 10^{-3} \times 1 \times 20 = 4 \text{ Kcal.}$$

Heat supplied = 4000 cal

9. A bullet of mass 5 gm is moving with speed 400 m/s. strike a target and energy. Then calculate rise of temperature of bullet. Assuming all the lose in kinetic energy is converted into heat energy of bullet if its specific heat is. 500J/kgºC.

a) 300 ºC b) 280 ºC
c) 180 ºC d) 160 ºC

Sol: (d)

$$\text{Kinetic energy} = \frac{1}{2} \times 5 \times 10^{-3} \times 400 \times 400$$

$$ms\,\Delta T = 5 \times 10^{-3} \times 500 \times \Delta T$$

$$\Delta T = 160^{\circ}\text{ C}$$

Rise in temperature is 160 ºC

10. The *SI* unit of mechanical equivalent of heat is

(a) *Joule* × *Calorie* (b) *Joule*/*Calorie*

(c) *Calorie* × *Erg* (d) *Erg*/*Calorie*

Sol: (b)

Change Of State:

- The state of a substance can be changed into another by heating or cooling it. *The transition of a substance from one state to another is called a change of state.*

The common changes of states are

1. Melting of a solid :

$$Solid \xrightarrow{\text{Heat}} Liquid$$

2. Vaporization of a liquid :

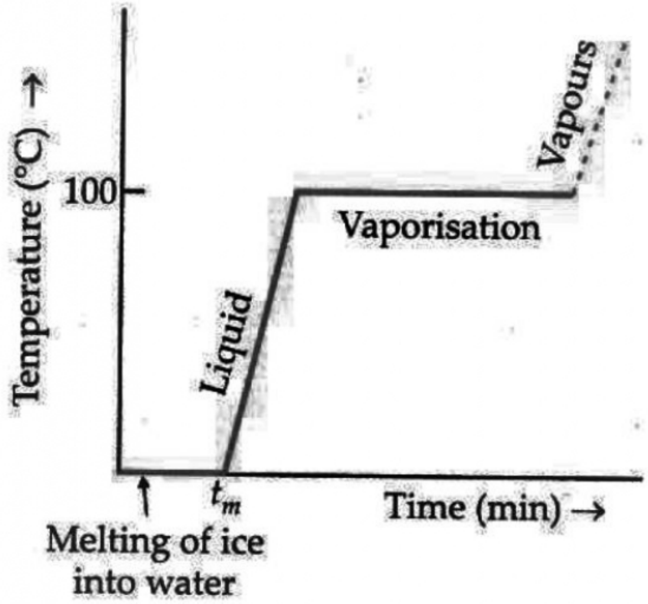
$$Liquid \xrightarrow{\text{Heat}} Vapour$$

3. Condensation of vapour

$$Vapour \xrightarrow{\text{Cool}} Liquid$$

3. Freezing of a liquid

$$Liquid \xrightarrow{\text{Cool}} Solid$$



❖ *The temperature of a substance remains constant during its change of state.*

➢ *The change of state from solid to liquid is called* melting and from liquid to solid is called fusion. It is seen that the temperature remains constant until the entire amount of the solid substance melts. Thus *both the solid and liquid states of the substance coexist in thermal equilibrium during the change of state from solid*

➢ *The change of state from liquid to vapour is called* **vaporisation**. It is noted that the temperature remains constant until the entire amount of the liquid is converted into vapour. Thus *both the liquid and the vapour states of the substance coexist in thermal equilibrium.*

❖ *The melting point of a substance at standard atmospheric pressure is called its* **normal melting point.**

❖ *The boiling point of a substance at standard atmospheric pressure is called its* **normal boiling point**.

Sublimation:

Some substances, on being heated, pass from the solid state to liquid state directly. The *process of transition of a substance from the solid state to the vapour state without passing through the liquid state is Called sublimation*, and the substance is said to sublime.

Ex: Dryice (solid CO_2), iodine, naphthalene and camphor undergo sublimation when heated. During the sublimation process, the solid and vapour states of a substance coexist in thermal equilibrium with each other

P-T diagram of water

Fig shows Pressure-temperature phase diagram for water. It consists of the following three curves

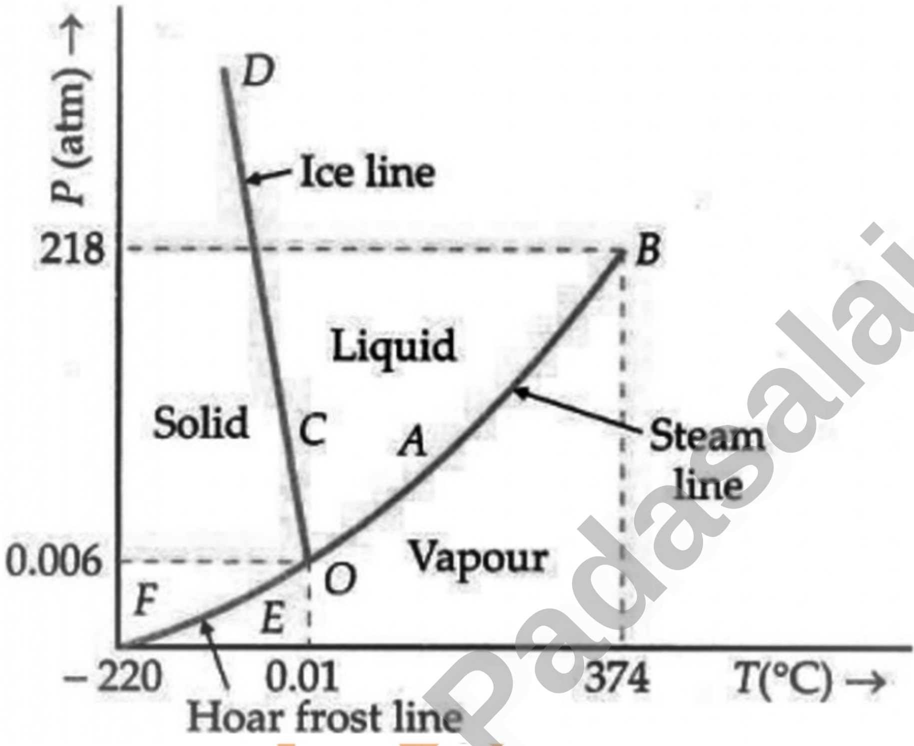


Fig. Pressure temperature phase diagram for water

(i) Vaporisation curve (Steam line AB).

- It is a graph between pressure and the boiling point of the substance in the liquid state.
- Each point on this curve fixes a set of pressure and temperature at which the liquid and gaseous phases can co-exist.
- If the pressure is increased, the vapour will at once condense into liquid but if the pressure is decreased, the liquid will evaporate. So, all points above the vaporisation curve correspond to liquid phase and below it to vapour phase.

Critical temperature:

- Critical temperatures is the maximum temperature at which a gas can be liquefied by increasing the pressure alone

(The critical temperature is **the temperature above which the gas cannot become** liquefied by increasing the pressure)

(ii) **Fusion curve (Ice line CD).**

- It is a graph between the pressure and the melting point of the substance in the solid state.
- Each point on this curve gives the value of pressure and the temperature at which the solid and liquid phases can co-exist.
- If pressure is increased, the solid would melt into liquid but if the pressure is isotherm decreased liquid will turn into solid. So all the points above the fusion curve correspond to liquid phase and means those below it to solid phase.

(iii) **Sublimation curve (Hoar frost line EF).**

- It is a graph between pressure and temperature at which a solid directly changes to vapour state.
- Each point on this curve gives the values of pressure and temperature at which the solid and vapour phases can co-exist.
- If pressure is increased, the vapour changes to solid phase and if the pressure is decreased, the solid changes to vapour state. So all the points above this curve correspond to solid phase while those below it correspond to vapour state.

Conclusions.

(i) In the space above the steam line and on the right of ice-line, water exists in liquid phase as water

(ii)In the space below the steam line and on the right of hoar frost line, water exists in gaseous phase as steam.

(iii) In the space above the hoar-frost line and on the left of ice-line, water exists in solid phase as ice.

Triple point.

It is a unique point on P-T diagram at which all the three phases of a substance can co-exist in equilibrium with each other. i.e three curves AB, CD and EF on being extended meet at point O which represents the triple point.

The values of pressure and temperature for triple point water are 0.46 cm of Hg and 273.16 K.

- The negative slope of ice line for water indicates that melting point of ice decreases with the increase in pressure. The triple point of such substances is above its melting point at normal pressure.
-

Pressure-temperature phase diagram for CO_2 :

It consists of the following three curves :

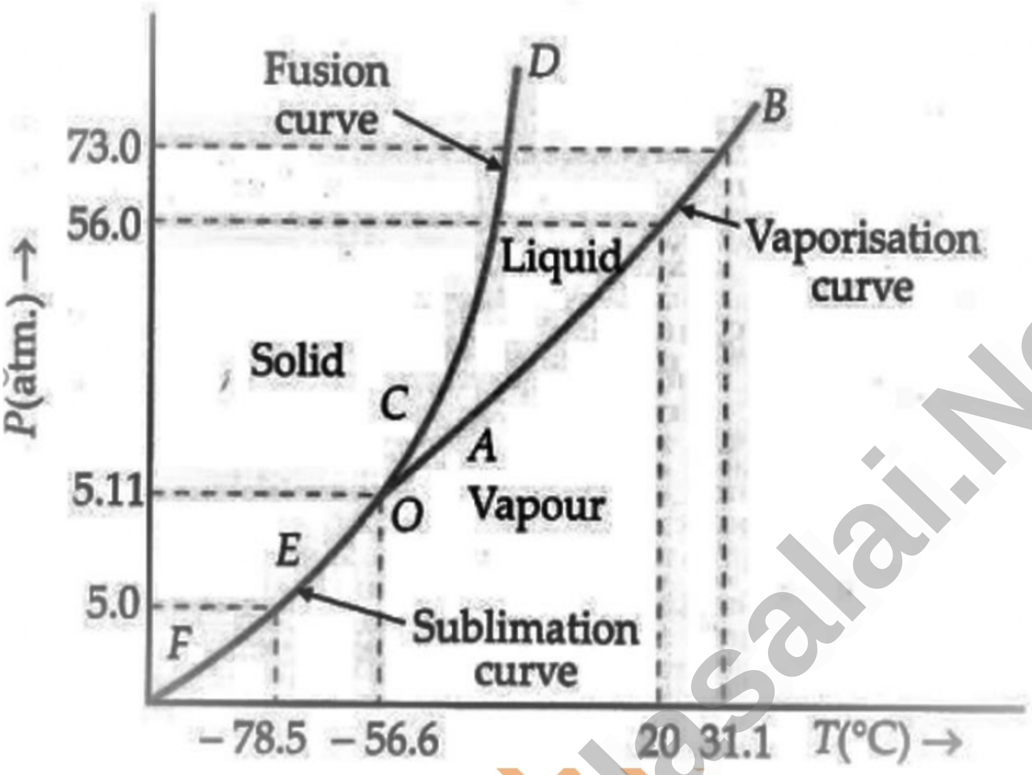


Fig : Pressure temperature diagram for CO_2

(i) Vaporisation curve (AB).

- The curve AB in which the liquid and the vapour phase co-exist.
- This graph shows the variation of boiling point with pressure.
- For all substances boiling point increases with pressure.

(ii) Fusion curve (CD).

- The curve CD in which solid and liquid co-exist i.e. the substance melts and the temperature is called melting point.
- The graph shows that the melting point of the substance increases with increase in pressure.

(iii) Sublimation curve (ED).

- The curve EF, in which the solid and the vapour co-exist. Here the solid changes directly to vapour state and process is called sublimation
- The three curves meet at O. This is called the triple point of CO_2 . The values of pressure and temperature corresponding to triple point for CO_2 are 5.11 atm and 216.4 K.

- Here all the three curves have positive slopes. So the triple point of CO_2 is below its melting point at the normal pressure.

Clausius Clapeyron equation

$$\frac{dP}{dT} = \frac{L}{T(V_2 - V_1)}$$

Where, L-Latent heat

T-absolute temperature

V_2-volume of vapour

V_1-volume of liquid

If $V_2 > V_1$, then $V_2 - V_1 = +ve$

So, $\frac{dP}{dT} = +ve$

For such a substance pressure increases the boiling point also increases

Melting Point of Ice:

i.e The transformation from ice to water

V_1-volume of ice

V_2-volume of water

If $V_2 < V_1$, then $V_2 - V_1 = -ve$

So, $\frac{dP}{dT} = -ve$

Which means as pressure increases the boiling point decreases

The substances which contract on melting :

The melting point of the substances decreases by the increase in pressure. Ex: ice , polythene

Melting Point of Wax:

Now $V_2 > V_1$, then $V_2 - V_1 = +ve$

So, $\frac{dP}{dT} = +ve$

Which means as pressure increases the boiling point also increases.

The substances which expand on melting:

The melting point of the substances , increases by the increase in pressure. Ex: wax, lead

Thermal capacity:

➢ It is defined as the amount of heat required to raise the temperature of the whole body (mass m) through $1°C$ or $1K$.

Thermal capacity= $mc = \mu C = \frac{Q}{\Delta T}$

❖ The value of thermal capacity of a body depends upon the nature of the body and its mass.

❖ SI unit of heat capacity is J/K

❖ Unit: $cal/°C$ (practical { $kgm^2s^{-2}K^{-1}$ }

❖ Dimension: $[ML^2T^{-2}\theta^{-1}]$.

Specific Heat:

(1) Gram specific heat(small c):

We know that When heat is given to a body and its temperature increases

The heat required to raise the temperature of unit mass of a body through $1°C$ (or K) is called specific heat of the material of the body.

If an amount of heat ΔQ is needed to raise the temperature of M mass of a substance through ΔT, then specific heat is given by

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

Units: $Calorie/gm \times °C$ (practical Unit),
$S.I.Unit : J/kg \times K$
Dimension: $[L^2T^{-2}\theta^{-1}]$

Specific heat of water : S = 4200 J/kgºC = 1000 cal/kgºC = 1 Kcal/kgºC = 1 cal/gmºC

So , the amount of heat required to raise the temperature of M mass of a substance through ΔT is $\Delta Q = Mc\Delta T$

(2) Molar specific heat (capital C):

Molar specific heat of a substance is defined as the amount of heat required to raise the temperature of one mole of the substance through a unit degree it is represented by (capital) C.

By definition, one mole of any substance is a quantity of the substance, whose mass M grams is numerically equal to the molecular mass M.

{Note: The mass of one mole of a substance in gram is called its molar mass
$No\ of\ moles\ \mu = \frac{molar\ mass}{mass\ in\ gram}$}

$\therefore$ Molar specific heat $= M \times Gram\ specific\ heat$

or $C = Mc; \quad C = M\frac{\Delta Q}{m\Delta T} = \frac{1}{\mu}\frac{\Delta Q}{\Delta T} \qquad \left[As\ c = \frac{\Delta Q}{m\Delta T}\ and\ \mu = \frac{m}{M}\right]$

$$\therefore \quad C = \frac{\Delta Q}{\mu \Delta T}$$

Units: $\frac{calorie}{mole} \times {}^\circ C$ (practical);
S.I. Units: $J/mole \times kelvin$ (S.I.)
Dimension: $[ML^2T^{-2}\theta^{-1}\mu^{-1}]$

Therefore, the amount of heat required to raise the temperature of n moles of a substance through ΔT is $\Delta Q = \mu C \Delta T$ or $\Delta Q = nC\Delta T$

{Note: The amount of heat required to raise the temperature of unit mass of a body is equal to specific heat c.

$\therefore$Heat capacity = Mass × Specific heat

Or S = mc }

Important points:

(1) $C = Mc = \frac{M}{m}\frac{\Delta Q}{\Delta T} = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}\left[As\ \mu = \frac{m}{M}\right]$

i.e. molar specific heat of the substance is M times the gram specific heat, where M is the molecular weight of that substance.

(2) Specific heat for hydrogen is maximum $c = 3.5\frac{cal}{gm \times {}^\circ C}$.

(3) In liquids, water has maximum specific heat $c = 1\frac{cal}{gm \times {}^\circ C}$.

(4) Specific heat of a substance also depends on the state of substance *i.e.* solid, liquid or gas.

Example: $C_{ice} = 0.5\frac{cal}{gm \times {}^\circ C}, C_{water} = 1\frac{cal}{gm \times {}^\circ C}, C_{steam} = 0.47\frac{cal}{gm \times {}^\circ C}$

Important points:

❖ Specific heat for hydrogen is maximum($3.5 cal/gm \times {}^\circ C$) and for water, it is $\frac{1cal}{gm} \times {}^\circ C$. For all other substances, the specific heat is less than $1 cal/gm \times {}^\circ C$.

- ❖ Specific heat is minimum for radon and actinium ($\simeq 0.022\ cal/gm \times {}^\circ C$).
- ❖ Specific heat of a substance also depends on the state of the substance *i.e.* solid, liquid or gas.

{Note: Specific heat of steam = half of specific heat of water = specific heat of ice}

(5) Specific heat also depends on the conditions of the experiment. That is the experiments are made either at constant volume or at constant pressure.
So there are two specific heat

In case of solids and liquids, due to small thermal expansion, so for solids and liquids the two specific heats are almost same. However, in case of gases, specific heat at constant volume is quite different from that at constant pressure.

Specific Heat of Gases:

In case of gases, heat energy supplied to a gas is spent not only in raising the temperature of the gas but also in expansion of gas against atmospheric pressure.

Hence specific heat of a gas, which is the amount of heat energy required to raise the temperature of one gram of gas through a unit degree not have a single (not unique value.)

(i) Adiabatic compression:

If the gas is compressed suddenly and no heat is supplied from outside *i.e.* $\Delta Q = 0$, but the temperature of the gas raises on the account of compression.

$\therefore C = \frac{\Delta Q}{m(\Delta T)} = 0 \qquad i.e.\ C = 0$

(or) The specific heat of a substance when it undergoes adiabatic changes is zero.

As $C = \frac{Q}{m\Delta T} = \frac{0}{m\Delta T} = 0 \qquad [\text{As } Q = 0]$

Thus when liquid in the thermos flask is shaken, its temperature increases without the transfer of heat and hence the specific heat of liquid in the thermos flask is zero.

(ii) Isothermal compression:

If the gas is heated and allowed to expand at such a rate that rise in temperature due to heat supplied is exactly equal to fall in temperature due to expansion of the gas. *i.e.* $\Delta T = 0$

$\therefore C = \frac{\Delta Q}{m(\Delta T)} = \frac{\Delta Q}{0} = \infty \qquad i.e.\ C = \infty$

(or) The specific heat of a substance when it melts or boils at constant temperature is infinite.

As $C = \frac{Q}{m\Delta T} = \frac{Q}{m \times 0} = \infty$ [As $\Delta T = 0$]

Thus the specific heat of a substance when it melts or boils at constant temperature is infinite.

(iii) If rate of expansion of the gas were slow, the fall in temperature of the gas due to expansion would be smaller than the rise in temperature of the gas due to heat supplied. Therefore, there will be some net rise in temperature of the gas *i.e.* ΔT will be positive.

$\therefore C = \frac{\Delta Q}{m(\Delta T)}$ = positive *i.e* C = positive

(iv) If the gas were to expand very fast, fall of temperature of gas due to expansion would be greater than rise in temperature due to heat supplied. Therefore, there will be some net fall in temperature of the gas *i.e.* ΔT will be negative.

$C = \frac{\Delta Q}{m(-\Delta T)}$ = negative *i.e.* C = negative

Hence the specific heat of gas can have any positive value ranging from zero to infinity. Further it can even be negative. The exact value depends upon the mode of heating the gas.

Note: Negative specific heat means that in order to raise the temperature, a certain quantity of heat is to be withdrawn from the body.

Example : To raise the temperature of saturated water vapours, heat (Q) is withdrawn. Hence, specific heat of saturated water vapours is negative.

Two main specific heats are

(1) Specific heat of a gas at constant volume (c_v):

The specific heat of a gas at constant volume is defined as the quantity of heat required to raise the temperature of unit mass of gas through 1 K when its volume is kept constant, *i.e.,* $c_v = \frac{(\Delta Q)_v}{m\Delta T}$

If instead of unit mass, 1 mole of gas is considered, the specific heat is called molar specific heat at constant volume and is represented by capital C_v.

$C_v = Mc_v = \frac{M(\Delta q)}{m\Delta T} = \frac{1}{\mu}\frac{(\Delta Q)_v}{\Delta T}$ $\left[As\ \mu = \frac{m}{M}\right]$

(2) Specific heat of a gas at constant pressure (c_p):

The specific heat of a gas at constant pressure is defined as the quantity of heat required to raise the temperature of unit mass of gas through 1 K when its pressure is kept constant, $i.e., c_P = \frac{(\Delta Q)_p}{m\Delta T}$

If instead of unit mass, 1 mole of gas is considered, the specific heat is called molar specific heat at constant pressure and is represented by C_p.

$$C_p = MC_p = \frac{M(\Delta Q)_p}{m\Delta T} = \frac{1}{\mu}\frac{(\Delta Q)_p}{\Delta T}\left[As \ \ \mu = \frac{m}{M}\right]$$

Mayer's Formula:

$$\Rightarrow C_p - C_v = R$$

This relation is called Mayer's formula and shows that $C_p > C_v$ *i.e.* molar specific heat at constant pressure is greater than that at constant volume.

Specific Heat in Terms of Degree of Freedom

We know that kinetic energy of one mole of the gas, having f degrees of freedom can be given by

$E = \frac{f}{2}RT$ .....(i)

where T is the temperature of the gas but from the definition of C_v, if dE is a small amount of heat energy required to raise the temperature of 1 gmmole of the gas at constant volume, through a temperature dT then

$dE = \mu C_v dT = C_v\, dT \ \ or\ C_v = \frac{dE}{dt}$ $[As\ \mu = 1]$ .....(ii)

Putting the value of E from equation (i) we get$C_v = \frac{d}{dT}\left(\frac{f}{2}RT\right) = \frac{f}{2}R$

$\therefore C_v = \frac{f}{2}R$

From the Mayer's formula$C_p - C_v = R \Rightarrow C_p = C_v + R = \frac{f}{2}R + R = \left(\frac{f}{2} + 1\right)R$

$\therefore C_p = \left(\frac{f}{2} + 1\right)R$

Ratio of C_p and C_v:

$$\gamma = \frac{C_p}{C_v} = \frac{\left(\frac{f}{2}+1\right)R}{\frac{f}{2}R} = 1 + \frac{2}{f}$$

$$\therefore \gamma = 1 + \frac{2}{f}$$

Important points:

(i) Value of γ is always more than 1. So we can say that always $C_p > C_v$.

(ii) Value of γ is different for monoatomic, diatomic and triatomic gases.

(iii) As$\gamma = 1 + \frac{2}{f} \Rightarrow \frac{2}{f} = \gamma - 1 \Rightarrow \frac{f}{2} = \frac{1}{\gamma - 1}$

So, $\therefore C_v = \frac{f}{2}R = \frac{R}{\gamma-1}$

and $C_p = \left(\frac{f}{2}+1\right)R = \left(\frac{1}{\gamma-1}+1\right)R = \left(\frac{\gamma}{\gamma-1}\right)R$

Specific heat and kinetic energy for different gases

		Monoatomic	Diatomic	Triatomic non-linear	Triatomic linear
Atomicity	A	1	2	3	3
Restriction	B	0	1	3	2
Degree of freedom	$f = 3A - B$	3	5	6	7
Molar specific heat at constant volume	$C_v = \frac{f}{2}R = \frac{R}{\gamma - 1}$	$\frac{3}{2}R$	$\frac{5}{2}R$	$3R$	$\frac{7}{2}R$
Molar specific heat at constant pressure	$C_p = \left(\frac{f}{2}+1\right)R = \left(\frac{\gamma}{\gamma-1}\right)$	$\frac{5}{2}R$	$\frac{7}{2}R$	$4R$	$\frac{9}{2}R$
Ratio of C_p and C_v	$\gamma = \frac{C_p}{C_v} = 1 + \frac{2}{f}$	$\frac{5}{3} \simeq 1.66$	$\frac{7}{5} \simeq 1.4$	$\frac{4}{3} \simeq 1.33$	$\frac{9}{7} \simeq 1.28$
Kinetic energy of 1 mole	$E_{mole} = \frac{f}{2}RT$	$\frac{3}{2}RT$	$\frac{5}{2}RT$	$3RT$	$\frac{7}{2}RT$
Kinetic energy of 1 molecule	$E_{molecule} = \frac{f}{2}kT$	$\frac{3}{2}kT$	$\frac{5}{2}kT$	$3kT$	$\frac{7}{2}kT$
Kinetic energy of 1 gm	$E_{gram} = \frac{f}{2}rT$	$\frac{3}{2}rT$	$\frac{5}{2}rT$	$3rT$	$\frac{7}{2}rT$

****

Objective questions on Specific heat

1. At constant volume the specific heat of a gas is $\frac{3R}{2}$, then the value of γ will be

a) $\frac{3}{2}$ b) $\frac{5}{2}$ c) $\frac{5}{3}$ d) None of the above

Sol: (c)Specific heat at constant volume $C_v = \frac{R}{\gamma-1} = \frac{3R}{2}(given)$

$\therefore \gamma - 1 = \frac{2}{3} \Rightarrow \gamma = \frac{5}{3}$.

2. The amount of Heat required to increases the temperate of 1 kg water by 20ºC is

a) 20 KJ b) 20 Kcal c) 1 Kcal d) 4.187 Kcal

Sol: (c) heat required = $\Delta Q = ms\Delta T$

S = 1 cal/gmºC = 1 Kcal/kgºC = 1 × 20 = 20 Kcal.

3. If specific heat of a substance is infinite, it means

(a) Heat is given out

(b) Heat is taken in

(c) No change in temperature takes place whether heat is taken in or given out

(d) All of the above

Sol: (c) $Q = m.c.\Delta\theta \Rightarrow c = \frac{Q}{m.\Delta\theta}$; when $\Delta\theta = 0 \Rightarrow c = \infty$

4. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : Specific heat of a body is always greater than its thermal capacity.

Reason : Thermal capacity is the required for raising temperature of unit mass of the body through unit degree.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (d)

5. The amount of Heat required to increases the temperate of 1 kg water by 20ºC is

a) 20 KJ b) 20 Kcal

c) 1 Kcal d) 4.187 Kcal

Sol: (c) heat required $= \Delta Q = ms\Delta\theta$

$S = 1$ cal/gmºC $= 1$ Kcal/kgºC $= 1 \times 20 = 20$ Kcal.

6. For a gas the difference between the two specific heats is 4150 $J/kg\ K$. What is the specific heats at constant volume of gas if the ratio of specific heat is 1.4

(a)8475 $J/kg - K$ (b)5186 $J/kg - K$

(c)1660 $J/kg - K$ (d)10375 $J/kg - K$

Sol: (d)

Given $C_p - C_v = 4150$ .....(i)

And $\frac{C_p}{C_v} = 1.4 \Rightarrow c_p = 1.4\ c_v$ .....(ii)

By substituting the value of c_p in equation (i) we get $1.4\ c_v - c_v = 4150 \Rightarrow 0.4c_v = 4150$

$\therefore c_v = \frac{4150}{0.4} = 10375\ J/kg - K$

7. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : Specific heat capacity is the cause of formation of land and sea breeze.

Reason : The specific heat of water is more than land.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (a)

8. When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas is

(a)2/5 (b)3/5 (c)3/7 (d)5/7

Sol: (d)When a gas is heated at constant pressure then its one part goes to increase the internal energy and another part for work done against external pressure *i.e.*

$(\Delta Q)_p = \Delta U + \Delta W$

$\Rightarrow \mu C_p \Delta T = \mu C_v \Delta T + P\Delta V$

So fraction of energy that goes to increase the internal energy

$\frac{\Delta U}{(\Delta Q)_p} = \frac{C_v}{C_p} = \frac{1}{\gamma} = \frac{5}{7}$[As γ=7/5 for diatomic gas]

9. The factor not needed to calculate heat lost or gained when there is no change of state is

(a) Weight (b)Specific heat

(c) Relative density (d)Temperature change

Sol:(c) $\Delta Q = mc\Delta\theta$.

10. Supposing the distance between the atoms of a diatomic gas to be constant, its specific heat at constant volume per mole (gram mole) is

(a) $\frac{5}{2}R$ (b) $\frac{3}{2}R$ (c) R (d) $\frac{7}{2}R$

Sol:(a) degrees of freedom f = 5

$C_V = \frac{fR}{2}$ $C_V = \frac{5R}{2}$

11. A gas has

(a) one specific heat only (b)two specific heats only

(c) infinite number of specific heats (d) no specific heat

Sol: (C) Gas has different specific heat for different processes gas has infinite number of specific heats

12. If temperature scale is changed from °C to °F, the numerical value of specific heat will

(a) Increases (b)Decreased

(c) Remains unchanged (d)None of the above

Sol: (b) $Q = m.c.\Delta\theta \Rightarrow c = \frac{Q}{m.\Delta\theta}$

In temperature measurement scale $\Delta\theta°F > \Delta\theta°C$ so $(c)_{°F} < (c)_{°C}$.

13. By exerting a certain amountof pressure on an ice block, you

(a) Lower its melting point

(b) Make it melt at 0°C only

(c) Make it melt at a faster rate

(d) Raise its melting point

Sol: (a) Increasing pressure lowers melting point of ice.

14. A gas, is heated at constant pressure. The fraction of heat supplied used for external work is

(a) $\frac{1}{\gamma}$ (b) $\left(1-\frac{1}{\gamma}\right)$ (c) $\gamma - 1$ (d) $\left(1-\frac{1}{\gamma^2}\right)$

Sol: (b)We know fraction of given energy that goes to increase the internal energy= $\frac{1}{\gamma}$

So we can say the fraction of given energy that supplied for external work= $1-\frac{1}{\gamma}$.

15. Which of the following is the unit of specific heat

(a) $J\,kg\,°C^{-1}$ (b) $J/kg\,°C$

(c) $kg\,°C/J$ (d) $J/kg\,°C^{-2}$

Sol: (a) $c = \frac{Q}{m.\Delta\theta} \rightarrow \frac{J}{kg \times °C}$

Water equivalent:

The water equivalent of a body is defined as the mass of water which requires the same amount heat as is required by the given body for the same rise of temperature

(Simply the mass of water)

Water equivalent = Mass x Specific heat

Or w = mc

- The CGS unit of water equivalent is g and the SI unit is kg.

Note: ❑Unit of thermal capacity is J/kg while unit of water equivalent is kg.
❑ Thermal capacity of the body and its water equivalent are numerically equal.
❑If thermal capacity of a body is expressed in terms of mass of water it is called water-equivalent of the body.

- Dimension: $[ML^0T^0]$

Latent Heat:

- When a solid changes into liquid or a liquid changes into gas, it absorbs heat. This heat does not show up as an increase in temperature. This heat, used to change the state, is hidden or latent (lying hidden), and is therefore called latent heat

(or)

The heat supplied to a substance which changes its state at constant temperature is called latent heat of the body.

(or)

The amount of heat required to change the state of unit mass of a substance at constant temperature and pressure is called latent heat of the substance

(1) No change in temperature is involved when the substance changes its state. That is, phase transformation is an isothermal change.

Ex:

- Ice at $0°C$ melts into water at $0°C$.
- Water at $100°C$ boils to form steam at $100°C$.

(2) The amount of heat required to change the state of the mass m of the substance is written as:

$$\Delta Q = mL$$

where L is the latent heat of the substance and is a characteristic of the substance.

- Latent heat is also called as Heat of Transformation.

(3) Unit: cal/gm or J/kg and

(4) Dimension: $[L^2T^{-2}]$

(5) Any material has two types of latent heats

(i) Latent heat of fusion:

Latent heat of fusion. The amount of heat required to change the state of unit mass of a substance from solid to liquid at its melting point is called latent heat offusion or latent heat of melting. It is denoted by L

Latent heat of ice

$$L_F = L_{ice} \approx 80\frac{cal}{g} \approx 80\ \text{Kcal/kg} \approx \frac{60kJ}{mol} \approx 336\frac{kilo\ \ joule}{kg}.$$

(ii) Latent heat of vaporisation:

Latent heat of vaporisation. The amount of heat required to change the state of unit mass of a substance from liquid to vapour at its boiling point is called latent heat of vaporisation or latent heat of boiling.

Latent heat of steam

$$L_V = L_{steam} \approx 540\frac{cal}{g} \approx 540\frac{\text{Kcal}}{\text{kg}} \approx \ \ 40.8\ kJ\ /mol \approx 2260\ \ kilo\ joule/kg$$

(6) In the process of melting or boiling, heat supplied is used to increase the internal potential energy of the substance and also in doing work against external pressure while internal kinetic energy remains constant. This is the reason that internal energy of steam at $100°C$ is more than that of water at $100°C$.

Process	solid-liquid	liquid-gas
latent heat	fusion	vaporization
endothermic phase changes	melting, liquefaction	boiling, evaporation, vaporization
exothermic phase changes	crystallization, freezing, fusion, solidification	condensation, liquefaction
temperature	melting point, freezing point	boiling point, dew point

Important Formulas:

Formulae used

1. Heat gained or lost, $Q = mc\ \Delta T$
2. According to the principle of calorimetry

   Heat gain = Heat lost

3. Water equivalent, $w = mc$ (gram)

4 . Heat capacity mc (cal°C^{-1} or cal/°C)

5. Latent heat of vaporisation or fusion, Q = mL

Sample problems based on Latent heat

1. The amount of heat releases if 1 kg steam at 200ºC is converted into –20ºC ice is

a) 780 Kcal

b) 1000 Kcal

c) 1200 Kcal

d) 1400 Kcal

Sol:(a)

$Q = 1 \times \frac{1}{2} \times 100 + 540 \times 1 + 1 \times 1 \times 100 + 1 \times 80 + 1 \times \frac{1}{2} \times 20 = 780$ Kcal.

Read the assertion and reason carefully to mark the correct option out of the options given

2. Assertion :Melting of solid causes no change in internal energy.

Reason : Latent heat is the heat required to melt a unit mass of solid.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (d)

3. Work done in converting one gram of ice at $-\ 10°C$ into steam at $100°C$ is

a)3045 J b) 6056 J c)721 J d)616 J

Sol: (a)Work done in converting 1gm of ice at $-\ 10°C$ to steam at $100°C$

= Heat supplied to raise temperature of 1gm of ice from $-\ 10°C$ to $0°C$ $[m \times c_{ice} \times \Delta T]$

+ Heat supplied to convert 1 gm ice into water at $0°C [m \times L_{ice}]$

+ Heat supplied to raise temperature of $1gm$ of water from $0°C$ to $100°C$ $[m \times c_{water} \times \Delta T]$

+ Heat supplied to convert 1 gm water into steam at $100°C$ $[m \times L_{vapour}]$

$= [m \times c_{ice} \times \Delta T] + [m \times L_{ice}] + [m \times c_{water} \times \Delta T] + [m \times L_{vapour}]$

$= [1 \times 0.5 \times 10] + [1 \times 80] + [1 \times 1 \times 100] + [1 \times 540] = 725 + calorie = 725 \times 4.2 = 3045J$

4. 2 kg of ice at $-20°C$ is mixed with 5 kg of water at $20°C$ in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 $kcal/kg$ per $°C$ and 0.5 $kcal/kg/°C$ while the latent heat of fusion of ice is 80 $kcal/kg$

a) 7 kg b) 6 kg c) 4 kg d) 2 kg

Sol.: (b)Initially ice will absorb heat to raise it's temperature to $0°C$ then it's melting takes place

If m = Initial mass of ice, m' = Mass of ice that melts and m_w = Initial mass of water

By Law of mixtureHeat gain by ice = Heat loss by water

$\Rightarrow m \times C \times (20) + m' \times L = m_W c_W [20]$

$\Rightarrow 2 \times 0.5(20) + m' \times 80 = 5 \times 1 \times 20 \Rightarrow m' = 1kg$

Practice Questions:

1. The standard fixed point for temperature measurement is used these days is:

(a) melting point of ice at S.T.P.

(b) that temperature at which ice, water and water vapour coexist

(c) that temperature at which pure ice and pure water coexist

(d) none of the above

Sol: (b)

2. When the pressure on water is increased, the boiling temperature of water as compared to 100°C will be:

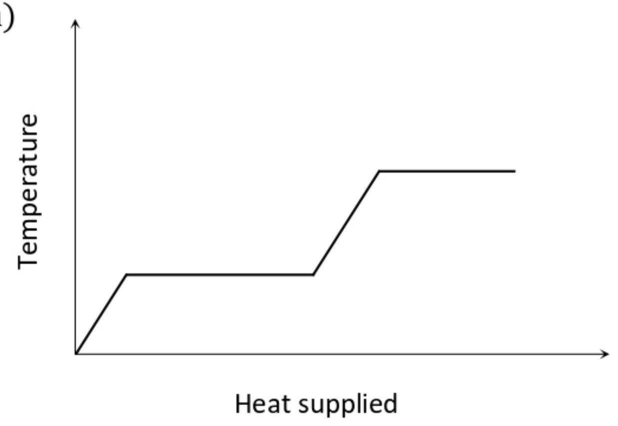
(a) lower (b) the same

(c) higher (d) on the critical temperature

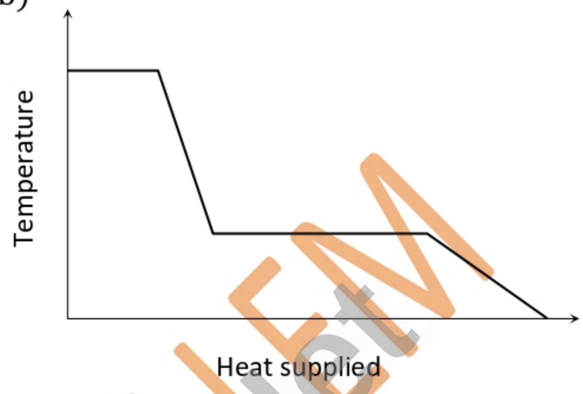
Sol: (c)

3. A block of ice at $-10°C$ is slowly heated and converted to steam at $100°C$. Which of the following curves represents the phenomenon qualitatively

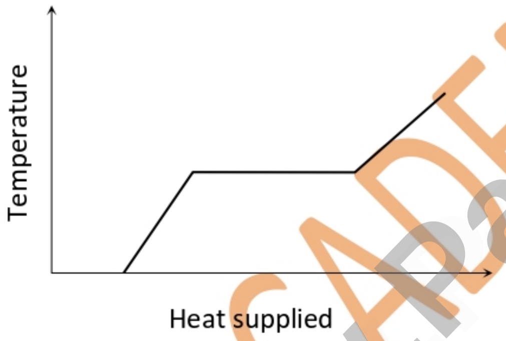
(a)



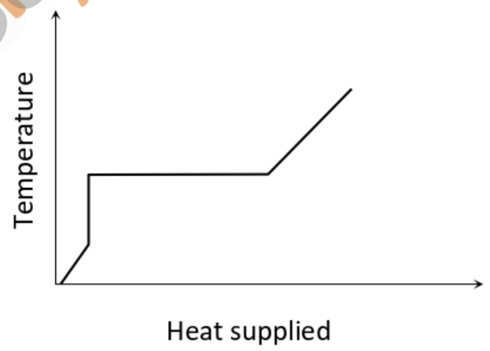
(b)



(c)



(d)



Sol: (a)

4. The specific heat of gas in an isothermal process is:

(a) zero (b) infinite (c) negative (d) remains constant

Sol: (a)

5.Two spheres made of same substance have diameters in the ratio 1: 2, their thermal capacities are in the ratio of:

(a) 1:2 (b) 1:8 (c) 1 : 4 (d) 2: 1

Sol: (b)

6. As the pressure on the gas is increased from 1 to 2 atmosphere, its heat capacity:

(a) decreases linearly (b) increases linearly
(c) increases logarithmically (d) is practically constant

Sol: (d)

7. The temperature at which Centigrade thermometer and Kelvin thermometer gives the same reading, is:

(a) 4° (b) 273° (c) not possible (d) 0°

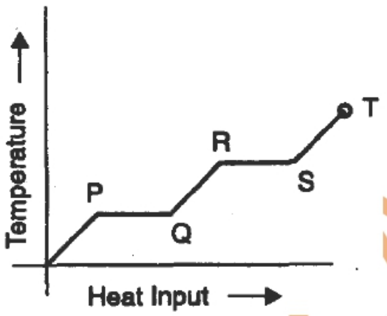
Sol: (c)

8. What is the change the temperature on Fahrenheit scale and on Kelvin scale, if a iron piece is heated from 30° to 90°C ?

(a) 108°F, 60K (b) 100°F, 55K (c) 100°F, 65K (d) 60°F, 108K

Sol: (a)

9. A source of heat supplies heat at a constant rate to a solid cube. The variation of the temperature of the cube with the heat supplied is shown in the fig. The slope of the part ST of the graph represents :



(a) the latent heat of the vapour
(b) the specific heat of the vapour
(c) the thermal capacity of the vapour
(d) the reciprocal of the thermal capacity

Sol: (d)

10. When an ideal diatomic gas is heated at constant pressure , the fraction of the heat energy supplied which increases the internal energy of the gas is .

(a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{3}{7}$ (d) $\frac{5}{7}$

Sol: (d)

11. Boiling water is changing into steam. Under this condition, the specific heat of water is

(a) zero (b) one (c) Infinite (d) less than one

Sol: (c)

12. The temperature at which phase transition depends on:

(a) pressure (b) volume (c) density (d) mass

Sol: (a)

13. The boiling water is changing into steam. Under this condition, the specific heat of water is

(a) zero (b) one (c) infinite (d) less than one

Sol: (c)

14. The thermal capacity of 40 g of aluminium (specific heat = 0.2 cal/gmºC)

(a) 40 cal/ºC (b) 160 cal/ºC

(c) 200 cal/ºC (d) 8 cal/ºC

Sol: (d)

15. The amount of heat required to change the state of 1 kg of substance at constant temperature is called

(a) kilocal (b) calorie (c) specific heat (d) latent heat

Sol: (d)

16. Heat required to convert 1 g of ice at 0ºC into steam at 100ºC is

(a) 100 cal (b) 0.01 cal/ºC (c) 720 cal (d) 1 kilocal

Sol: (c)

17. One kg of ice at 0ºC is mixed with 1 kg of water at 10ºC. The resulting temperature will be

(a) between 0ºC and 10ºC (b) 0ºC

(c) less than 0ºC (d) greater than 0ºC

Sol: (b)

18. If 10g of ice at 0ºC is mixed with 10g of water at 40ºC, the final mass of water in the mixture is

(a) 10 g (b) 15 g (c) 18 g (d) 20 g

Sol: (b)

19. 40 g of ice at 0ºC is mixed with 540 g of water at 80ºC. The final temperature of the mixure is

(a) 0ºC (b) 40ºC (c) 80ºC (d) less than 0ºC

Sol: (a)

20. If mass – energy equivalence is taken into account, when water is cooled to form ice, the mass of water should:

(a) increase (b) remain unchanged

(c) decrease (d) first increase then decrease

Sol: (a)

21. On the Celsius scale the absolute zero of temperature is at

(a) $0°C$ (b) $-32°C$

(c) $100°C$ (d) $-273.15°C$

Sol: (d)

22. Oxygen boils at $-183°C$. This temperature is approximately

(a) $215°F$ (b) $-297°F$

(c) $329°F$ (d) $361°F$

Sol: (b)

23. Recently, the phenomenon of superconductivity has been observed at 95 K. This temperature is nearly equal to

(a) $-288°F$ (b) $-146°F$

(c) $-368°F$ (d) $+178°F$

Sol: (a)

24. The temperature of a substance increases by $27°C$. On the Kelvin scale this increase is equal to

(a) 300 K (b) 2.46 K

(c) 27 K (d) 7 K

Sol: (c)

25. The resistance of a resistance thermometer has values 2.71 and 3.70 ohm at $10°C$ and $100°C$. The temperature at which the resistance is 3.26 ohm is

(a) $40°C$ (b) $50°C$

(c) $60°C$ (d) $70°C$

Sol: (b)

26. No other thermometer is as suitable as a platinum resistance thermometer to measure temperature in the entire range of

(a) $0°C$ to $100°C$ (b) $100°C$ to $1500°C$

(c) $-50°C$ to $+350°C$ (d) $-200°C$ to $600°C$

Sol: (d)

27. The absolute zero is the temperature at which

(a) Water freezes
(b) All substances exist in solid state
(c) Molecular motion ceases
(d) None of the above

Sol: (c)

28. Absolute zero (0 K) is that temperature at which
(a) Matter ceases to exist
(b) Ice melts and water freezes
(c) Volume and pressure of a gas becomes zero
(d) None of these

Sol: (c)

29. On which of the following scales of temperature, the temperature is never negative
(a) Celsius (b)Fahrenheit
(c) Reaumur (d)Kelvin

Sol: (d)

30. The temperature on Celsius scale is 25°C. What is the corresponding temperature on the Fahrenheit scale
(a) 40°F (b)77°F
(c) 50°F (d)45°F

Sol: (b)

31. The temperature of a body on Kelvin scale is found to be x K. When it is measured by Fahrenheit thermometer, it is found to be x° F, then the value of x is
(a) 40 (b)313
(c) 574.25 (d)301.25

Sol: (c)

32. A centigrade and a Fahrenheit thermometer are dipped in boiling water. The water temperature is lowered until the Fahrenheit thermometer registers 140°. What is the fall in temperature as registered by the Centigrade thermometer
(a) 30° (b)40°
(c) 60° (d)80°

Sol: (c)

33. At what temperature the centigrade (Celsius) and Fahrenheit, readings are the same
(a) – 40° (b) + 40°
(c) 36.6° (d) – 37°

Sol: (a)

34. The absolute zero temperature in Fahrenheit scale is

(a) $-273°F$ (b) $-32°F$

(c) $-460°F$ (d) $-132°F$

Sol: (c)

35. If temperature of an object is $140°F$, then its temperature in centigrade is

(a) $105°C$ (b) $32°C$

(c) $140°C$ (d) $60°C$

Sol: (d)

36. On centigrade scale the temperature of a body increases by 30 degrees. The increase in temperature on Fahrenheit scale is

(a) 50° (b) 40°

(c) 30° (d) 54°

Sol: (d)

37. The correct value of $0°C$ on Kelvin scale will be

(a) $273.15\ K$ (b) $273.00\ K$

(c) $273.05\ K$ (d) $273.63\ K$

Sol: (a)

38. When vapour condenses into liquid

(a) It absorbs heat (b) It liberates heat

(c) Its temperature increases (d) Its temperature decreases

Sol: (b)

39. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : A beaker is completely filled with water at $4°C$. It will overflow, both when heated or cooled.

Reason : There is expansion of water below and above $4°C$.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (a)

40. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : Latent heat of fusion of ice is 336000 $J\,kg^{-1}$.

Reason : Latent heat refers to change of state without any change in temperature

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (b)

41. At NTP water boils at $100°C$. Deep down the mine, water will boil at a temperature

(a) $100°C$ (b) $> 100°C$

(c) $< 100°C$ (d) Will not boil at all

Sol: (b)

42. If specific heat of a substance is infinite, it means

(a)Heat is given out

(b)Heat is taken in

(c)No change in temperature takes place whether heat is taken in or given out

(d) All of the above

Sol: (c)

43. A quantity of heat required to change the unit mass of a solid substance, from solid state to liquid state, while the temperature remains constant, is known as

(a) Latent heat (b)Sublimation

(c) Hoar frost (d) Latent heat of fusion ?

Sol: (d)

44. The latent heat of vaporization of a substance is always

(a) Greater than its latent heat of fusion

(b) Greater than its latent heat of sublimation

(c) Equal to its latent heat of sublimation

(d) Less than its latent heat of fusion

Sol: (a)

45. The factor not needed to calculate heat lost or gained when there is no change of state is

(a)Weight (b)Specific heat

(c) Relative density (d)Temperature change

Sol: (c)

46. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is

(a) 0°C (b)40°C

(c) 80°C (d)Less than 0°C

Sol: (a)

47. Supposing the distance between the atoms of a diatomic gas to be constant, its specific heat at constant volume per mole (gram mole) is

(a) $\frac{5}{2}$R (b) $\frac{3}{2}$R (c) R (d) $\frac{7}{2}$R

Sol: (a)

48. A gas has :

(a)one specific heat only (b) two specific heats only

(c)infinite number of specific heats (d) no specific heat

Sol: (c)

49. Water is used to cool radiators of engines, because

(a) Of its lower density (b)It is easily available

(c) It is cheap (d)It has high specific heat

Sol: (d)

50. How much heat energy is gained when 5 kg of water at 20°C is brought to its boiling point

(Specific heat of water = 4.2 $kJ\ kg^{-1} c^{-1}$)

(a) 1680 kJ (b)1700 kJ

(c) 1720 kJ (d)1740 kJ

Sol: (a)

51.Melting point of ice

(a) Increases with increasing pressure

(b) Decreases with increasing pressure

(c) Is independent of pressure

(d) Is proportional to pressure

Sol: (b)

52.For an ideal gas, the heat capacity at constant pressure is larger than than that at constant volume because

(a)positive work is done during expansion of the gas by the external pressure

(b) positive work is done during expasion by the gas against external pressure

(c) positive work is done during expansion by the gas against intermolecular forces of attraction

(d) more collisions occur per unit time when volume is kept constant.

Sol: (b)

53. 80 gm of water at $30° C$ are poured on a large block of ice at $0° C$. The mass of ice that melts is

(a) 30 gm (b)80 gm

(c) 1600 gm (d)150 gm

Sol: (a)

54. A bullet of mass 10 gm in moving with speed 400m/s. its kinetic energy in calorie?

a) 100 cal b) 191 cal

c) 258 cal d) 500 cal

Sol: (b)

55. The saturation vapour pressure of water at $100° C$ is

(a) 739 mm of mercury (b) 750 mm of mercury

(c) 760 mm of mercury (d) 712 mm of mercury

Sol: (c)

56. Two spheres made of same substance have diameters in the ratio 1 : 2. Their thermal capacities are in the ratio of

(a) 1 : 2 (b)1 : 8

(c) 1 : 4 (d)2 : 1

Sol: (b)

57. Work done in converting one gram of ice at $-10° C$ into steam at $100° C$ is

(a) 3045 J (b)6056 J

(c) 721 J (d)616 J

Sol: (a)

58. Compared to a burn due to water at $100° C$, a burn due to steam at $100° C$ is

(a) More dangerous (b)Less dangerous

(c) Equally dangerous (d) None of these

Sol: (a)

59. 50 *gm* of copper is heated to increase its temperature by 10°*C*. If the same quantity of heat is given to 10 *gm* of water, the rise in its temperature is (Specific heat of copper = 420 $Joule\text{-}kg^{-1}\,{}^{\circ}C^{-1}$)

(a) 5°*C* (b) 6°*C*

(c) 7°*C* (d) 8°*C*

Sol: (a)

60. Two liquids *A* and *B* are at 32°*C* and 24°*C*. When mixed in equal masses the temperature of the mixture is found to be 28°*C*. Their specific heats are in the ratio of

(a) 3 : 2 (b)2 : 3

(c) 1 : 1 (d)4 : 3

Sol: (c)

61. Amount of heat required to raise the temperature of a body through 1*K* is called its

(a) Water equivalent (b)Thermal capacity

(c) Entropy (d)Specific heat

Sol: (b)

62. A metallic ball and highly stretched spring are made of the same material and have the same mass. They are heated so that they melt, the latent heat required

(a) Are the same for both

(b) Is greater for the ball

(c) Is greater for the spring

(d) For the two may or may not be the same depending upon the metal

63. A liquid of mass *m* and specific heat *c* is heated to a temperature 2*T*. Another liquid of mass $m/2$ and specific heat 2*c* is heated to a temperature *T*. If these two liquids are mixed, the resulting temperature of the mixture is

(a) (2/3)*T* (b)(8/5)*T*

(c) (3/5)*T* (d)(3/2)*T*

Sol: (d)

64. Calorie is defined as the amount of heat required to raise temperature of 1*g* of water by 1°*C* and it is defined under which of the following conditions

(a) From 14.5°*C* to 15.5°*C* at 760 *mm* of *Hg*

(b) From 98.5°C to 99.5°C at 760 mm of Hg

(c) From 13.5°C to 14.5°C at 76 mm of Hg

(d) From 3.5°C to 4.5°C at 76 mm of Hg

Sol: (a)

65.100 gm of ice at 0°C is mixed with 100 g of water at 100°C. What will be the final temperature of the mixture

(a) 10°C (b)20°C

(c) 30°C (d)40°C

Sol: (a)

66. At atmospheric pressure, the water boils at 100°C. If pressure is reduced, it will boil at

(a) Higher temperature (b)Lower temperature

(c) At the same temperature (d)At critical temperature

Sol: (b)

67. A closed bottle containing water at 30°C is carried to the moon in a space-ship. If it is placed on the surface of the moon, what will happen to the water as soon as the lid is opened

(a) Water will boil

(b) Water will freeze

(c) Nothing will happen on it

(d) It will decompose into H_2 and O_2

Sol: (a)

68.The thermal capacity of 40 gm of aluminium (specific heat = 0.2 $cal/gm/°C$) is

(a) 40 $cal/°C$ (b) 160 $cal/°C$

(c) 200 $cal/°C$ (d) 8 $cal/°C$

Sol: (d)

69.If temperature scale is changed from °C to °F, the numerical value of specific heat will

(a) Increases (b)Decreased

(c) Remains unchanged (d)None of the above

Sol: (b)

70.By exerting a certain amountof pressure on an ice block, you

(a) Lower its melting point

(b) Make it melt at $0° C$ only

(c) Make it melt at a faster rate

(d) Raise its melting point

Sol: (a)

71.When we rub our palms they gets heated but to a maximum temperature because

(a) Heat is absorbed by our palm

(b) Heat is lost in the environment

(c) Produced of heat is stopped

(d) None of the above

Sol: (b)

72.The mechanical equivalent of heat J is

(a) A constant (b)A physical quantity

(c) A conversion factor (d)None of the above

Sol: (c)

73.4200 J of work is required for

(a) Increasing the temperature of 10 gm of water through $10° C$

(b) Increasing the temperature of 100 gm of water through $10° C$

(c) Increasing the temperature of 1 kg of water through $10° C$

(d) Increasing the temperature of 10 kg of water through $10° C$

Sol: (b)

74.At $100° C$, the substance that causes the most severe burn, is

(a) Oil(b) Steam

(c) Water (d)Hot air

Sol: (b)

75.The temperature at which the vapour pressure of a liquid becomes equals to the external (atmospheric) pressure is its

(a) Melting point (b)Sublimation point

(c) Critical temperature (d)Boiling point

Sol: (d)

76.When the pressure on water is increased the boiling temperature of water as compared to $100°C$ will be

(a) Lower

(b) The same

(c) Higher

(d) On the critical temperature

Sol: (c)

77.Calorimeters are made of which of the following

(a) Glass (b)Metal

(c) Wood (d)Either (a) or (c)

Sol: (b)

78.Triple point of water is

(a) $273.16°F$ (b)$273.16\ K$

(c) $273.16°C$ (d)$273.16\ R$Sol: (b)

79.A liquid boils when its vapour pressure equals

(a) The atmospheric pressure

(b) Pressure of 76.0 cm column of mercury

(c) The critical pressure

(d) The dew point of the surroundings

Sol: (a)

80.Which of the following is the unit of specific heat

(a) $J\,kg\,°C^{-1}$ (b) $J/kg\,°C$

(c) $kg\,°C/J$ (d) $J/kg\,°C^{-2}$

Sol: (a)

81.50 gm of ice at $0°C$ is mixed with 50 gm of water at $80°C$, final temperature of mixture will be

(a) $0°C$ (b)$40°C$

(c) $40°C$ (d)$4°C$

Sol: (a)

82.Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : The molecules at 0º*C* ice and 0º*C* water will have same potential energy.

Reason : Potential energy depends only on temperature of the system.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (d)

83.The freezing point of the liquid decreases when pressure is increased, if the liquid(a) Expands while freezing

(b) Contracts while freezing

(c) Does not change in volume while freezing

(d) None of these

Sol: (a)

84.Latent heat of 1*gm* of steam is 536 *cal*/*gm*, then its value in *joule*/*kg* is

(a) 2.25×10^6 (b) 2.25×10^3

(c) 2.25 (d) None

Sol: (a)

85.Boiling water is changing into steam. At this stage the specific heat of water is

(a) < 1 (b) ∞

(c) 1 (d) 0

Sol: (b)

86. The thermal capacity of a body is 80 *cal*, then its water equivalent is

(a) 80 *cal* / *gm* (b)8 *gm*

(c) 80 *gm* (d)80 *kg*

Sol: (c)

87.A liquid of mass M and specific heat S is at a temperature $2t$. If another liquid of thermal capacity 1.5 times, at a temperature of $\frac{t}{3}$ is added to it, the resultant temperature will be

(a) $\frac{4}{3}t$
(b) t
(c) $\frac{t}{2}$
(d) $\frac{2}{3}t$

Sol: (b)

88.Dry ice is

(a) Ice cube
(b)Sodium chloride
(c) Liquid nitrogen
(d)Solid carbon dioxide

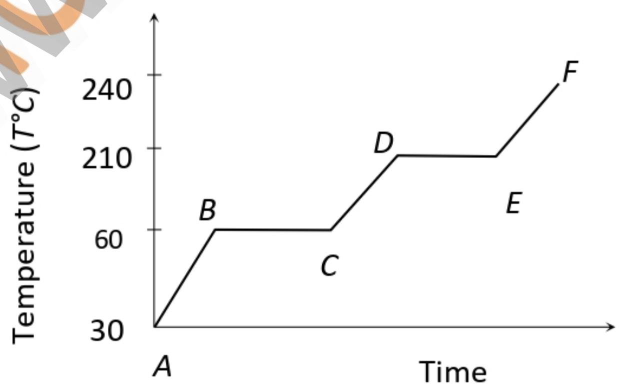
Sol: (d)

89.Solids expand on heating because

(a) Kinetic energy of the atoms increases
(b) Potential energy of the atoms increases
(c) Total energy of the atoms increases
(d) The potential energy curve is asymmetric about the equilibrium distance between neighbouring atoms

Sol: (d)

90.A solid substance is at 30°C. To this substance heat energy is supplied at a constant rate. Then temperature versus time graph is as shown in the figure. The substance is in liquid state for the portion (of the graph)

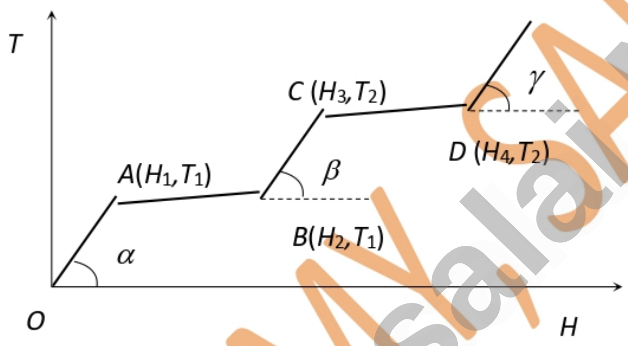


(a) BC (b) CD

(c) ED (d) EF

Sol: (b)

91. The graph shows the variation of temperature (T) of one *kilogram* of a material with the heat (H) supplied to it. At O, the substance is in the solid state. From the graph, we can conclude that



(a) T_2 is the melting point of the solid

(b) BC represents the change of state from solid to liquid

(c) $(H_2 - H_1)$ represents the latent heat of fusion of the substance

(d) $(H_3 - H_1)$ represents the latent heat of vaporization of the liquid

Sol: (c)

92. Read the assertion and reason carefully to mark the correct option out of the options given

below :

Assertion : The melting point of ice decreases with increase of pressure.

Reason : Ice contracts on melting.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)If the assertion and reason both are false.

Sol: (a)

93. Which of the following has maximum specific heat

(a) Water (b)Alcohol (c)Glycerine (d)Oil

Sol: (a)

94. The point on the pressure temperature phase diagram where all the phases co-exist is called

(a) Sublimation (b)Fusion point

(c) Triple point (d)Vaporisation point

Sol: (c)

95. Read the assertion and reason carefully to mark the correct option out of the options given

Assertion : Water kept in an open vessel will quickly evaporate on the surface of the moon.

Reason : The temperature at the surface of the moon is much higher than boiling point of the water.

(a)If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c)If assertion is true but reason is false.

(d)*If assertion is false but reason is true.*

Sol: (a)

96. The heat required to raise the temperature of 1 g of water through 1ºC is

a) 4.187 cal b) 62.4 cal c) 180 cal d) 1cal

Sol: (d)