HSPTA MALAPPURAM

PHYSOL_*The solution for learning Physics*

Question Bank

11 Thermal properties of matter

Each question scores One

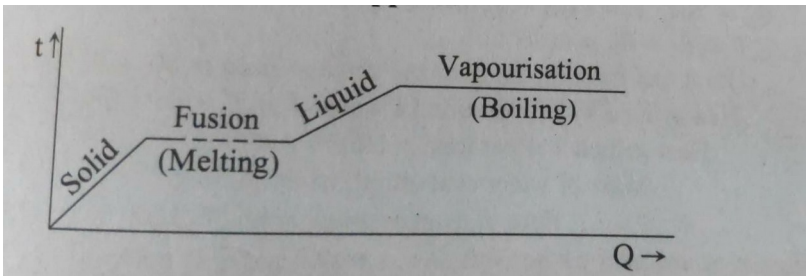
1	Which among the following possess the highest specific heat capacity? i. Water ii. Silver iii. Copper iv. Steel Ans: Water
2	Which is the only way of heat transfer through a solid? Ans: Conduction
3	How does the heat energy from the sun reach the earth ? Ans: By radiation
4	Out of the three modes of transmission of heat, which one is fastest ? Ans: Radiation
5	The temperature of a body is 0°C. Is it radiating ? Ans: Yes, a body radiates heat at 0°C.
6	At what temperature will a body stop radiating ? Ans: A body stops radiating at 0 K.
7	A brass tumbler feels much colder than a wooden tray on a chilly day. Why? Ans: This is because, brass tumbler is a heat conductor while the wooden tray is not.
8	What is the anomalous behaviour shown by water? Ans: Water contracts on melting where as all other substances expand on melting.
9	There are three distinct modes of heat transfer. The main mode of transmission of heat by which the sun heats the surface of the earth is: i) Conduction ii) Convection iii) Radiation iv) None of these Ans: Radiation.
10	Amount of heat required to increase the temperature of a substance by 1°C is called..... Ans: Heat capacity.
11	Amount of heat required to increase the temperature of 1Kg of the substance by 1°C is called..... Ans: Specific heat capacity.
12	Amount of heat required to change the state from solid to liquid without changing temperature is called..... Ans: Latent heat of fusion.
13	Amount of heat required to change the state from liquid to vapour without changing temperature is called..... Ans: Latent heat of vaporization.
14	The process of changing solid directly to vapour is called ..... Ans: Sublimation
15	When a solid metallic sphere is heated the largest percentage increase occurs in its_____ Ans: Volume
16	A metallic sphere has a cavity of diameter D at its centre. If the sphere is heated, the diameter of the

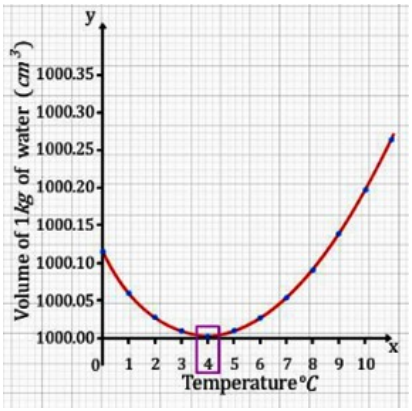
	cavity will _____ An. Increase
17	Why a small gap is left between the iron rails of railway tracks ? Ans: If no gap is left between the iron rails, the rails may bend due to expansion in summer and the train may get derailed.

Each question scores Two

1	Why do the metal utensils have wooden handles? Ans: Wood is a bad conductor of heat. Wooden handle does not allow heat to be conducted from the hot utensil to the hand. So we can easily hold the hot utensil with its help.
2	Why birds are often seen to swell their feathers in winter ? Ans: When the birds swell their feathers, they are able to enclose air in the feathers. Air, being a poor conductor of heat, prevents the loss of heat from the bodies of the birds to the surroundings as such they do not feel cold in winter.
3	Stainless steel cooking pans are preferred with extra copper bottom. Why? Ans: The thermal conductivity of copper is much larger than that of steel. The copper bottom allows more heat to flow into the pan and hence helps in cooking the food faster.
4	Can we boil water inside an earth satellite ? Ans: No. The process of transfer of heat by Convection is based on the fact that a liquid becomes lighter on becoming hot and rises up. In condition of weightlessness, this is not possible. So transfer of heat by convection is not possible in a satellite.
5	Water is heated from below. Why ? Ans: When water is heated, its density decreases and it rises up. Cooler liquid of the upper part takes its place and so convection currents are set up and water gets heated up. If heated from the top, it will conduct very small amount of heat to the bottom because water is poor conductor of heat.
6	What is the effect of pressure on melting point of a solid ? Ans: The melting point of a solid may increase or decrease depending on the nature of solid. For solids such as ice which contracts on melting, it is lowered while for solids such as sulphur and wax which expand on melting it increases.
7	How does the boiling point of water change with pressure ? Ans: The boiling point of water increases with the increase in pressure.
8	A spark is produced when two stones are struck against each other. Why ? Ans: The work done in striking the two stones against each other is converted into heat which produces spark.
9	Tea gets cooled, when sugar is added to it. Why ? Ans: When sugar is added to tea, its heat gets shared by sugar. So the temperature of the tea decreases.
10	Why do we pack ice in gunny bags? Ans: Gunny bags have a number of fine pores, which contain air in them. Air is a bad conductor of heat. Therefore, it does not allow the external heat to go in and melt the ice.
11	Distinguish between heat and temperature. Ans: Heat is a form of energy that flows from one body to another due to their temperature difference and temperature is the degree of hotness or coldness of a body.
12	Water kept in earthen pots gets cooled. Why?

	Ans. The water kept in an earthen pot seeps into the small pores in the pot and evaporates from the surface of the pot. The heat required for evaporation is taken from water inside the pot, thus cooling the water stored inside. This is why the water remains cool in earthen pot.
13	Why does a solid expand on heating ? Solution. The average distance between the positions of equilibrium of the atoms of a solid increases with an increase in temperature which results in the thermal expansion of a solid.
14	Is the temperature coefficient always positive ? Ans: No, Temperature coefficient is positive for metals and alloys and negative for semiconductors and insulators.
15	a) At what temperature, the value in Fahrenheit Scale is numerically equal to that in Celsius Scale? Ans : - 40^0C = - 40 ^{0}F b) Temperature of a body changes to 10^0c. What is the corresponding change in Fahrenheit Scale? Ans: 18 ^{0}F (Note: 1^0C change = 1.8^oF change)
16	A steel beam of length 5m is kept at a temperature of 20^0C. On a hot day, the temperature rises to 40^0C. What is the change in its length due to thermal expansion? (Coefficient to linear expansion of steel is 1.2 x 10^{-5}/0C) Ans: $l = l_0 (1 + \alpha t)$ $5 = l_0 (1 + 1.2 \times 10^{-5} \times 20) \Rightarrow l_0 = 4.999$ $l = 4.999 (1 + 1.2 \times 10^{-5} \times 40) = 4.999 \times 1.00048$ $= 5.0013995$ m
17	Distinguish between natural convection and forced convection. Give one example for each. Ans: In natural convection, gravity and buoyancy play important roles. When a fluid is heated up, the heat is transferred to all parts of the fluid by natural convection Examples for natural convection: Sea breeze and land breeze, Trade wind in forced convection, material is forced to move by a pump or by some other physical means. Examples: Forced air heating system in home, Air conditioner, Human blood circulatory system, the cooling system of auto-mobile engine.
18	A steel tape 1 m long is correctly calibrated at 27°C. The length of a rod measured by this tape is found to be 63 cm on a day when the temperature is 45°C. What is actual length of the rod? (coefficient of linear expansion of steel 1.2 x 10^{-5} /K) L_1=63 cm; Ans: L_2 =?; t_1 =27°C; t_2 = 45°C; t= t_2 -t_1 = 45-27= 18° C; $\alpha = 1.2 \times 10^{-5} K^{-1}$ $L_2=L_1(1+ \alpha t) = 63(1 +1.2 \times 10^{-5} \times 18) = 63.0136$ cm
19	A rod of length L having coefficient of Linear expansion a is lying freely on the floor. It is heated so that temperature changes by b. Find the longitudinal strain developed in the rod. Ans: There was no restriction for it expansion. So no tensile or compressive force developed. Longitudinal strains happens only when tensile or compressive force developed in the rod. So answer is Zero.
20	The top of a lake is frozen. Air in contact with it is at -15°C. What do you expect the maximum temperature of water in contact with the lower surface ice? What do you expect the maximum temperature of water at the bottom of the lake? An. 0°C, 4°C.
21	Why a thick glass tumbler cracks when boiling liquid is poured into it? An. Its inner and outer surfaces undergo uneven expansion due to the poor conductivity of glass, hence it cracks.
22	A steel rail road track has a length of 30 m when the temperature is 20°C. What is its length on a

	hot day, when the temperature is 45° C? $\alpha = 11 \times 10^{-6}/K$ $L_1 = 30$ cm ; t= 45-20 =25°C; L_2=? $L_2 = L_1(1 + \alpha t) = 30(1 + 11 \times 10^{-6} \times 25)$ $= 30 \times 1.000275 = 30.00825$ cm
23	A solid at 0°C is heated to convert it into its vapour. Draw a graph connecting temperature and the quantity of heat supplied. Ans: 
24	Explain why a brass tumbler feels much colder than a wooden tray on a chilly day. Ans: Both the brass tumbler and the wooden tray are at the same temperature. But brass is much better conductor of heat than wood. When we touch the brass tumbler, heat readily flows out from our hand to the tumbler and it feels colder. But this is not the case with the wooden tray.
25	Usually a good conductor of heat is a good conductor of electricity also. Give reason. Ans: Electrons contribute largely both towards the flow of electricity and the flow of heat. A good conductor contains a large number of free electrons. So it is both a good conductor of heat and electricity.
26	Why is water used as an effective coolant? Ans: The specific heat of water is very high. When it runs over hot parts of an engine or machinery, it absorbs a large amount of heat. This helps in maintaining the temperature of the engine low.
27	What kind of thermal conductivity and for specific heat requirements would you specify for cooking utensils? Ans: A cooking utensil should have (i) high conductivity so that it can conduct heat through itself and transfer it to the contents quickly. (i) low specific heat so that it immediately attains the temperature of the source.
28	Explain why a beaker filled with water at 4°C overflows if the temperature is decreased or increased Ans: It is because of the anomalous expansion of water. Water has a maximum density at 4°C. Therefore, water expands whether it is heated above 4° C or cooled below 4°C.
29	A block of wood is floating on water at 0°C with a certain volume V above the level of water. The temperature of water is gradually increased from 0°C to 8°C. How does the volume V change with the change of temperature? Ans: The density of water increases from 0° C to 4°C and decreases from 4°C to 8°C. So, V will increase till the temperature of water reaches 4°C and then it will go on decreasing.
30	Burns from steam are usually more serious than boiling water. Why? Latent heat of vaporization of water is $2.26 \times 10^6 JKg^{-1}$. ie, $2.26 \times 10^6 JKg^{-1}$of water is required to

	convert 1 kg of water into steam. So steam carries more heat than boiling water.
31	During winter aquatic animals are saved under water in cold countries. Justify? Ans:In cold countries during winter as the temperature of the atmosphere falls, the upper layer of water in the ponds, lakes etc cools and sinks to the bottom. This goes on until the whole water is cooled to 4^0C.When the top layer cools below 4^0C, it does not sink as its density is less than the water below it. Thus the top layer cools further and freezes but there is water at 4^0C below the ice. Thus aquatic animals and plants are saved.
32	What is sublimation? Write an example for sublime material. Ans: Some substances changes directly from solid state to vapour state on heating . This is called sublimation. Eg: solid CO_2 (dry ice)
33	Draw the graph showing the variation of volume of a given mass of water with temperature from 0^0C. Mark the temperature at which water has maximum density. 
34	Write an equation for coefficient of linear expansion? Show that coefficient of linear expansion is thrice its coefficient of volume expansion. $\alpha_l=\frac{\Delta l}{L\Delta T}$ Consider a cube of side 1m. Original volume = $1\times1\times1=1m^3$ Let it be heated so that its temperature increases by 1^0C New volume = $(1+\alpha_l)(1+\alpha_l)(1+\alpha_l) = (1+\alpha_l)^3$ Increase in volume = $(1+\alpha_l)^3-1 = 3\alpha_l+3\alpha_l^2+\alpha_l^3$ $\cong 3\alpha_l$(higher powers neglected) $\alpha_v=\frac{\Delta V}{V\Delta T}=\frac{3\alpha_l}{1\times1}=3\alpha_l$
35	Invar is used for making pendulum clocks. Why? Ans:The pendulum of the clock are made of invar. The coefficient of volume expansion of invar is low. $T=2\pi\sqrt{\frac{l}{g}}$. So even when temperature changes, there is no change in length of pendulum. So the clock keeps correct time in all seasons.

36	What is meant by anomalous expansion of water? Ans: When water is cooled its volume will decrease and reaches a minimum at 4°C. Further cooling will results increase in volume. This expansion is called anomalous expansion of water.

Each question scores Three

1	Two accidents happen. The first one with water at 100° C and the second one with steam at 100°C. (a) Which is more dangerous; burn due to water at 100°C or burn due to steam at 100° C? Why? (b) Latent heat of vaporisation of water is 536 cal/g. Explain the idea of latent heat of vaporisation. (c) Find the heat required to convert 1 g of ice at 0°C to steam at 100°C [Latent Heat of ice = 80 cal/g: specific heat of water =1 cal/g°C] Ans: (a) Burn due to steam is more dangerous because heat content in steam at 100°C is very high compared to that in water at 100° C. b) Quantity of heat required to convert 1g of water at its boiling point into steam at the same temperature is 536 cal. (c) Q= mL + mcΔθ +mL, Q =1x 80 +1x 1 x 100 +1 x 536 = 716 cal =3007 J.
2	The coefficient of thermal expansion in solids are mainly i) Coefficient of Linear Expansion α ii) Coefficient of Area Expansion β iii) Coefficient of Volume Expansion γ a. What is the ratio of α, β and γ? b. Invar is used for making pendulum of clocks. Why? Ans.. a. 1:2:3 b. Invar has extremely small coefficient of linear expansion. Therefore the length of the clock pendulum doesn't change appreciably with the change of season so the clock keeps correct time.
3	Heat from the sun reaches earth through vacuum. a. Name the mode of heat transfer in the above case. b. Name the different modes of heat transfer in metals and in liquids? c. Aquatic animals are protected in cold countries as ice is formed on the surface of river. How? Ans: a. Radiation b. Conduction and convection c. It is due to the anomalous behaviour of water. This means that water has the maximum density at 4 °C. This property has an important environmental effect: bodies of water, such as lakes and ponds, freeze at the top first. As a lake cools toward 4 °C, water near the surface loses energy to the atmosphere, becomes denser, and sinks; the warmer, less dense water near the bottom rises. However, once the colder water on top reaches temperature below 4 °C, it becomes less dense and remains at the surface, where it freezes.
4	How does tea in a thermos flask remain hot for a long time? Ans: The air between the two walls of the thermos flask is evacuated. This prevents heat loss due to conduction and convection. The loss of heat due to the radiation is minimised by silvering the inside surface of the double wall. As the loss of heat due to the three processes is minimised, the tea remains hot for a long time.
5	Temperature is the degree of 'hotness 'of the body. a) Temperature of a normal human body is 98.6^0F. What is the corresponding temperature shown in the Celsius scale? Ans: $37\ ^0$C Note: $tc = \frac{t_f - 32}{1.8} = \frac{98.6 - 32}{1.8}$

b) Complete the table.

Temperature	Kelvin scale	Celsius scale	Fahrenheit scale
Steam point	373.15 K		212.00^{0}F
Ice point		0.00^{0}C	32^{0}F.
Absolute zero	0.00K		459.69^{0}F

Ans:

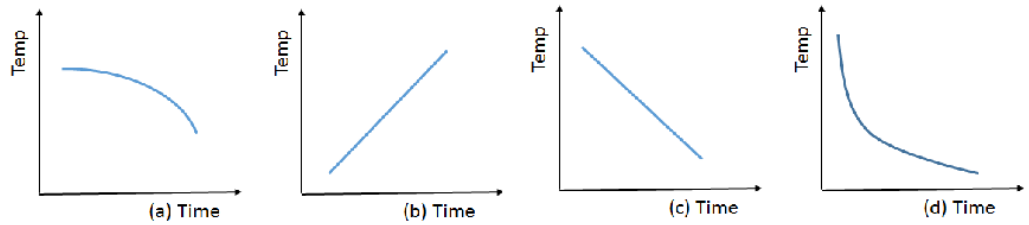
Temperature	Kelvin scale	Celsius scale	Fahrenheit scale
Steam point	373.15 K	...100^{0}c.....	212.00^{0}F
Ice point	273.15	0.00^{0}C	32^{0}F.
Absolute zero	0.00K	- 273.15 ^{0}C	459.69^{0}F

6 a. When you are about to make tea from hot tea and cold milk, your phone is ringing. Which of the following can be done to keep the cup of tea hotter when you return after attending the phone call?

1) Pour hot tea and cold milk in your cup and leave it to attend phone call.
2) Mix the two after attending the call

Ans: Pour hot tea and cold milk in your cup and leave it to attend phone call.

b. Also indicate which among the curves below represents a cooling curve.



Ans: curve (d)

7 The time taken by a hot body to cool from 70^{0}c to 60^{0}c is 6 minutes. The surrounding temperature is 25^{0}c. What will be the time taken by the body to cool from 60^{0}c to 50^{0}c?

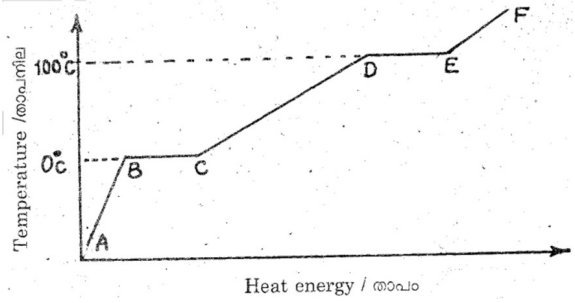
According to Newton's law of cooling $\frac{T_1-T_2}{t} = K \left\{ \frac{T_1+T_2}{2} - T_0 \right\}$

$\frac{70-60}{6} = K \left\{ \frac{70+60}{2} - 25 \right\}$ ------- (1)

$\frac{60-50}{t} = K \left\{ \frac{60+50}{2} - 25 \right\}$ --------(2)

$\frac{eq(1)}{eq(2)}$ --> $t = 6 \times \frac{40}{30} =$ <u>8 minutes</u>

8 The below graph represents temperature versus heat for water at 1 atm. pressure.



(a) Match the following using the above graph.

Graph	Process	State
i) BC	b) Sublimation	p) Water
ii) DE	a) Melting	q) Ice
	c) Regelation	r)Partially Solid and liquid
	d) Vaporisation	s) Partially liquid and vapour

Ans:

Graph	Process	State
i) BC	a) Melting	r)Partially Solid and liquid
ii) DE	d) Vaporisation	s) Partially liquid and vapour

b) The slopes of AB and CD are different. Why?

Ans: Specific heat capacity of ice and water are different (specific heat of ice < specific heat of water)

9 A circular hole of diameter 2.00 cm is made in an aluminium plate at 0 ^{0} C .what will be the diameter at 100^0 C?

Linear expansion for aluminium = $2.3 * 10^{-3}$ / 0 C

Diameter of circular hole in aluminium plate at 0^0 C=2.0 cm

With increase in temperature from 0^0 C to 100^0 C diameter of ring increases

using $L=L_0(1+\alpha\Delta T)$

where L_0=2.0 cm

$\alpha = 2.3 * 10^{-3}$ / ^{0} C

$\Delta T=(100 -0)=100\ ^0$ C

we can find diameter at 100^0 C

$L=2(1+2.3*10^{-3}*100)=2.46$ cm

10 A blacksmith fixes iron ring on the rim of a wooden wheel. The diameter of the rim and iron ring are 5.243m and 5.231m at 27^0C. To what temperature should the ring be heated so as to fit the rim of the wheel? $\alpha_l(iron)=1.2\times10^{-5}K^{-1}$

$\alpha_l=1.2\times10^{-5}K^{-1}, T_2=218^0C, T_1=27^0C, T_2=?\ l_1=5.231\,m, l_2=5.243\,m$

$l_2=l_1[1+\alpha_l(T_2-T_1)]$

$5.243=5.231\left[1+1.2\times10^{-5}(T_2-27)\right]$

$T_2=218^0C$

11 A steel rail of length 5m and area of cross section $40c\,m^2$ is prevented from expanding while the temperature rises by 10^0C. The coefficient of linear expansion of steel is $1.2\times10^{-5}K^{-1}$. Young's

	modulus of steel is $2\times10^{11}\,N\,m^{2}$.Calculate the thermal stress and external force? $l=5\,m\,,A=40\times10^{-4}m^{2}\,,\Delta T=10^{0}C\,,\alpha_{l}=1.2\times10^{-5}K^{-1}\,,\,Y=2\times10^{11}\,N\,m^{2}$ $\alpha_{l}=\frac{\Delta l}{L\Delta T}\qquad Y=\frac{\Delta F/A}{\Delta l/L}$ *Compressive strain* $=\frac{\Delta l}{l}=\alpha_{l}\Delta T=1.2\times10^{-5}\times10=1.2\times10^{-4}$ *Thermal stress* $=\frac{\Delta F}{A}=Y\times\frac{\Delta l}{l}=2\times10^{11}\times1.2\times10^{-4}=2.4\times10^{7}\,N\,m^{-2}$ *External force* $\Delta F=A\times2.4\times10^{7}=40\times10^{-4}\times2.4\times10^{7}\cong10^{5}\,N$
12	Derive the relation between coefficient of linear expansion and coefficient of area expansion Consider a thin square plate of side 1m. Original Area = $1\times1=1\,m^{2}$ Let the plate be heated so that its temperature increases by $1^{0}C$ New area $=(1+\alpha_{l})(1+\alpha_{l})=(1+\alpha_{l})^{2}$ Increase in area $=(1+\alpha_{l})^{2}-1$ $=\alpha_{l}^{2}+2\alpha_{l}$ $\cong2\alpha_{l}$ (higher powers neglected) $\alpha_{a}=\frac{\Delta A}{A\Delta T}=\frac{2\alpha_{l}}{1\times1}=2\alpha_{l}$
13	When 0.15kg of ice at $0^{0}C$ mixed with water of mass 0.30kg at $50^{0}C$ in a container, the resulting temperature is $6.7^{0}C$. Calculate the heat of fusion of ice? Specific heat capacity of water is $4186\,Jkg^{-1}K^{-1}$. Ans: Heat lost by water = heat gained by ice $m_{w}s_{w}(T_{w}-T)=m_{ice}s_{w}(T-T_{ice})+m_{ice}L$ $0.30\times4186(50-6.7)=0.15\times4186\times(6.7-0)+0.15\times L$ $L=3.354\times10^{5}\,Jkg^{-1}$
14	Derive the relation connecting α_l and α_v. Ans: $V=l^{3}$ $V_1=l_1^{3}$ $V_1=V(1+\alpha_v\Delta T)$.....(1) $V_1=[\,l\,((1+\alpha_l\Delta T)\,]^{3}$ $V_1=[\,l^{3}\,(1+\alpha_l\Delta T)^{3}]$ $V_1\approx[\,V\,(1+3\alpha_l\Delta T]$.....(2) From (1) and (2) $V(1+\alpha_v\Delta T)=V(1+3\alpha_l\Delta T)$ $\alpha_v=3\alpha_l$
15	Derive the relation connecting α_v. and α_a Ans: $\alpha_a=2\alpha_l$ $\alpha_v=3\alpha_l$ $\alpha_l=\alpha_a/2$ $\alpha_l=\alpha_v/3$ $\alpha_v/3=\alpha_a/2$ or $\alpha_v=3\,\alpha_a/2$