PHYSICS CLASS XI
CHAPTER – 11 THERMAL PROPERTIES OF MATTER

Q.1. White clothes are more comfortable in summer while colourful clothes are more comfortable in winter. Why?

Ans. White clothes absorb very little heat radiation and hence they are comfortable in summer. Coloured clothes absorb almost whole of the incident radiation and keep the body warm in winter.

Q.2. Can we boil water inside in the 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 rise up. In condition of weightlessness, this is not possible. So, transfer of heat by convention is not possible in the earth satellite.

Q.3. A tightened glass stopper can be taken out easily by pouring hot water around the neck of the bottle. Why?

Ans. The neck expands but not the stopper due to poor conductivity of glass. Thus, the stopper can be taken out easily.

Q.4. Why water is preferred to any other liquid in the hot water bottles?

Ans. Water is preferred to any other liquid in the hot water bottles because due to high specific heat it does not cool fast. Also for the given mass of water, the

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amount of heat contained is higher and it can provide more warmth as compared to any other liquid.

Q.5. Two bodies at different temperatures T_1 and T_2, if brought in thermal contact do not necessarily settle at the mean temperature $\frac{(T_1+T_2)}{2}$. Why?

Ans. The two bodies may have different masses and different materials i.e., they may have different thermal capacities.

In case the two bodies have equal thermal capacities, they would settle at the mean temperature $\frac{T_1+T_2}{2}$.

Q.6. Place a safety pin on a sheet of paper. Hold the sheet over a burning candle, until the paper becomes yellow and charr. On removing the pin, its white trace is observed on the paper. Why?

Ans. The safety pin is made of steel which is good conductor of heat. So, the safety pin takes heat from the paper under it and transfer it away to the surroundings. The portion of the paper under the safety pin remains comparatively colder than the remaining part.

Q.7. 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.

Q.8. What is the difference between the specific heat and the molar specific heat?

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Ans. The specific heat is the heat capacity per unit mass whereas the molar specific heat is the heat capacity per mole.

Q.9. 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, so it prevents the loss of heat from the bodies of the birds to the surroundings and as such they do not feel cold in winter.

Q.10. Which object will cool faster when kept in open air, the one at 300° C or the one of 100° C? Why?

Ans. The object at 300° C will cool faster than the object at 100° C. This is in accordance with Newton's law of cooling.

As we know, rate cooling of an object ∝ temperature between the object and its surroundings.

Q.11. If all the objects radiate electromagnetic energy, why do not the objects around us in everyday life become colder and colder?

Ans. According to the Prevost theory of heat exchanges, all the objects (above 0 k) not only radiate electromagnetic energy but also absorb at the same rate from their surroundings. Thus, they do not become colder.

Q.12. Black body radiation is white. Comment.

Ans. The statement is true. A black body absorbs radiations of all wavelengths. When heated to a suitable temperature, it emits radiations of all wavelengths. Hence, a black body radiations is white.

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Q.13. 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.

Q.14. Calorimeters are made of metals not glass. Why?

Ans. This is because metals are good conductors of heat and have low specific heat capacity.

Q.15. Why an ice is constructed with a double wall?

Ans. An ice box is made of double wall and the space in between the walls is filled with some non-conducting material to provide heat insulation, so that the loss of heat can be minimized.

Q.16. Why juice bottles are placed under water in the cold countries?

Ans. This is done so to prevent the freezing of juice. Water has to release comparatively large amount of heat to lower its temperature to the same extent than juice and hence the chances of freezing are reduced.

Q.17. When we step barefoot into an office with a marble floor, we feel cold. Why?

Ans. This is because marble is a better conductor of heat than concrete. When we walk barefooted on a marble floor, heat flows our body through the feet and we feel cold.

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Q.18. In a coal fire, the pockets formed by coals appear brighter than the coals themselves. Is the temperature of such a pocket higher than the surface temperature of a glowing coal?

Ans. The temperature of pockets formed by coals are not appreciably different from the surface temperature of glowing coals.

However, the pockets formed by coals act as cavities. The radiations from these cavities are black body radiations and so have maximum intensity. Hence, the pockets appear brighter than the glowing coals.

Q.19. What kind of thermal conductivity and specific heat requirement 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. (ii) low specific heat so that it immediately attains the temperature of the source.

Q.20. Two vessels of different materials are identical in size and wall thickness. They are filled with equal quantities of ice at 0°C.

If the ice melts completely in 10 and 25 min respectively, compare the coefficients of thermal conductivity of the materials of the vessels.

Ans. Let, K_1 and K_2 be the coefficients of thermal conductivity of the materials and t_1 and t_2 be the times in which ice melts in the two vessels.

As the same quantity of ice melts in the two vessels the quantity of heat flowed into the vessels must be same.

$\therefore Q = \frac{K_1 A(T_1 - T_2)t_1}{x} = \frac{K_2 A(T_1 - T_2)t_2}{x}$

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or $K_1 t_1 = K_2 t_2$

$\therefore \quad \frac{K_1}{K_2} = \frac{t_2}{t_1} = \frac{25\ min}{10\ min} = 5 : 2$

Q.21. Two thermos flasks are of the same height and same capacity. One has a circular cross-section while the other has a square cross-section. Which of the two is better?

Ans. As both flasks have same height and capacity, the area of the cylindrical wall will be less than that of the square wall. Hence, the thermos flask of circular cross-section will transmit less hear as compared to the thermos flask of square cross-section and will be better.

Q.22. Why rooms are provided with the ventilators near the roof?

Ans. It is done so to remove the harmful impure air and to replace it by the cool fresh air. The air we breath out is warm and so it is lighter. It rises upwards and can go out through the ventilator provided near the roof. The cold fresh air from outside enters the room through the doors and windows. Thus, the convention current is set up in the air.

Q.23. Why it is much hotter above a fire than by its side?

Ans. Heat carried away from a fire sideways mainly by radiation. Above the fire, heat is carried by both radiation and convention of air. But convection carries much more heat than radiation. So, it is much hotter above a fire than by its sides.

Q.24. If a drop of water falls on a very hot iron, it does not evaporate for a long time. Give reason.

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Ans. When a drop of water falls on a very hot iron, it gets insulated from the iron by a layer of poor conducting water vapour. As the heat is conducted very slowly through this layer, it takes quite long for the drop to evaporate. But if the drop of water falls on iron which is not very hot, then it comes in direct contact with iron and evaporates immediately.

Q.25. The coolant used in a nuclear reactor should have high specific heat. Why?

Ans. The purpose of a coolant is to obsorb maximum heat with least rise in its own temperature. This is possible only if specific heat is high because $Q = mc \Delta T$. For a given value of m and Q, the rise in temperature ΔT will be small if c is large. This will prevent different parts of the nuclear reactor from getting too hot.

Q.26. How does tea in a thermo flask remain hot for a long time?

Ans. The air between the two walls of the thermo flask is evacuated. This prevents heat loss due to conduction and convention.

The loss of heat due to radiation is minimized by silvering the inside surface of the double wall. As the loss of heat due to the three processes is minimized the tea remains hot for a long time.

Q.27. The earth constantly receives heat radiation from the sun and gets warmed up. Why does the earth not get as hot as the sun?

Ans. Because the earth is located at a very large distance from the sun, hence it receives only a small fraction of the heat radiation emitted by the sun. Further, due to loss of heat from the surface of the earth due to convection and radiation also, the earth does not become as hot as the sun.

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Q.28. Woolen clothes are warm in winter. Why?

Ans. Woolen fibres enclose a large amount of air in them. Both wool and air are bad conductors of heat. The small coefficient of thermal conductivity prevents the loss of heat from our body due to conduction. So, we feel warm in woolen clothes.

Q.29. A piece of paper wrapped tightly on a wooden rod is observed to get charred quickly when held over a flame as compared to a similar piece of paper when wrapped on a brass rod. Explain why?

Ans. Brass is a good conductor of heat. It quickly conducts away the heat. So, the paper does not alter its ignition point easily. On the other hand, wood is a bad conductor of heat and is unable to conduct away the heat. So, the paper quickly reaches its ignition point and is charred.

Q.30. Two vessels A and B of different materials but having identical shape, size and wall thickness are filled with ice and kept at the same place. Ice melts at the rate of 100 g min^{-1} and 150 $gmin^{-1}$ in A and B respectively. Assuming that heat enters the vessels through the walls only, calculate the ratio of thermal conductivities of their materials.

Ans. Let m_1 and m_2 be the masses of ice melted in same time (t = 1 min) in vessels A and B respectively.

Then, the amounts of heat flowed into the two vessels will be

$Q_1 = \frac{K_1 A(T_1 - T_2)t}{x} = m_1 L$

$Q_1 = \frac{K_2 A(T_1 - T_2)t}{x} = m_2 L$

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Where, L is latent heat of ice. Dividing Eq. (i) by Eq. (ii) we get,

$\frac{K_1}{K_2} = \frac{m_1}{m_2} = \frac{100g}{150g} = \frac{2}{3} = 2:3$

Q.31. Explain the following

(i) Hot tea cool rapidly when poured into the saucer from the cup.

(ii) Temperature of a hot liquid falls rapidly in the beginning but slowly afterwards.

(iii) A hot liquid cools faster if outer surface of the container is blackened.

Ans. (i) As surface area increases on pouring hot tea in saucer from the cup and the rate of loss of heat is directly proportional to surface area of the radiating surface, so the tea will cool faster in the saucer.

(ii) Temperature of a hot liquid falls exponentially in accordance with Newton's law of cooling. In other words, rate of cooling is directly proportional to the temperature difference between hot liquid and the surroundings**.** It is due to this reason that a hot liquid cools rapidly in the beginning but slowly afterwards.

(iii) When outer surface of container is blackend, the surface becomes good emitter of heat and so the hot liquid in it cools faster.

Q.32. A thermocole cubical icebox of side 30 cm has a thickness of 5.0 cm. If 4.0 kg of ice are put in the box, estimate the amount of ice remaining after 6 h. The outside temperature is 45°C and coefficient of thermal conductivity of thermocole = 0.01 Js^{-1} $m^{-1}{}^{\circ}C^{-1}$.

Given, heat of fusion of water = 335 $\times$ 10^3J kg^{-1}

Ans. Here, A = 6 $\times side^2$ = 6 × 30 × 30

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$= 5400\ cm^2 = 0.54\ m^2$

$x = 5\ cm = 0.05\ m$

$t = 6h = 6 \times 3600s$

$T_1 - T_2 = 45 - 0 = 45°C,$

$K = 0.01\ Js^{-1}m^{-1}°C^{-1}$

$L = 335 \times 10^3\ Jkg^{-1}$

Total heat entering the box through all the six faces,

$$Q = \frac{KA(T_1 - T_2)t}{x}$$

$$= \frac{0.01 \times 0.54 \times 45 \times 6 \times 3600}{0.05}$$

$= 104976\ J$

Let m kg of ice melt due to this heat. Then,

$Q = mL$

or $m = \frac{Q}{L} = \frac{104976J}{336 \times 10^3 Jkg^{-1}} = 0.313\ kg$

Mass of ice left after six hours = 4 – 0.313 = 3.687 kg

Q.33. A fat man is used to consuming about 3000 kcal worth of food everyday. His food contains 50 g of butter plus a plate of sweets everyday, besides items which provide him with other nutrients (proteins, vitamins, minerals, etc.) in addition to fats and carbohydrates. The caloric value of 10 g of butter is 60 kcal and that of a plate of sweets is of average 700 kcal. What dietary strategy should be adopt to cut down his calories to about 2100 kcal per day? Assume the man cannot resist eating the full plate of sweets once it is offered to him.

Ans. The man intends to cut down 3000 – 2100 = 900 kcal.

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But avoiding sweets completely, he will cut down 700 kcal. To cut down another 200 kcal, he should cut down butter by $\frac{10}{60} \times 200 \backsimeq 33$ g per day.

He should not cut down consumption of food, that provides him with vitamins and other vital nutrients.

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