CBSE

THERMAL PROPERTIES OF MATTER WS 9

Class 11 - Physics

Section A

1. The sun radiates energy in all directions. The average radiation received on the earth's surface from the sun per second is 1.4 kWm^{-2}. The average earth-sun distance is 1.5×10^{11} m. The mass lost by the sun per day (1 day = 86,400 s) is **[1]**

   a) 3.8×10^{14} kg
   b) 4.4×10^{9} kg
   c) 7.6×10^{14} kg
   d) 3.8×10^{12} kg

2. The surface temperature of the sun is T K and the solar constant for a planet is S. The sun subtends an angle θ at the planet. Then **[1]**

   a) $S \propto \theta$
   b) $S \propto T^2$
   c) $S \propto \theta^2$
   d) $S \propto T^4$

3. The sun emits a light with maximum wavelength 510 nm, while another star X emits a light with maximum wavelength of 350 nm. What is the ratio of surface temperature of the sun and the star X? **[1]**

   a) 1.45
   b) 2.1
   c) 0.68
   d) 0.46

4. During constant temperature, we feel colder on the day when the relative humidity is **[1]**

   a) 40%
   b) 25%
   c) 60%
   d) 85%

5. Earth orbiting satellite has solar energy collecting panel with total area $5m^2$. If solar radiations are perpendicular and completely absorbed, the average force associated with the radiation pressure is (solar constant = 1.4 kWm^{-2}) **[1]**

   a) 2.33×10^{-6} N
   b) 2.33×10^{-4} N
   c) 2.33×10^{-5} N
   d) 2.33×10^{-3} N

6. Heat travels through vacuum by **[1]**

   a) both conduction and convention
   b) convention
   c) conduction
   d) radiation

7. The amount of heat that a body can absorb by radiation **[1]**

   a) depends on temperature of body only
   b) depends on colour and temperature both of body
   c) depends on colour of body only
   d) depend on density of body

8. The wavelength of radiation emitted by a body depends upon **[1]**

a) all of these

b) the area of the surface

c) the nature of the surface

d) the temperature of the surface

9. If the earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now? **[1]**

a) Higher as the heating is better

b) Lower because the Greenhouse effect of the atmosphere would be absent

c) higher because the Greenhouse effect of the atmosphere would be present

d) Higher as earth has poor reflectivity

10. Assuming the sun to have a spherical outer surface of radius R, radiating like a black body at temperature t°C the power received by a unit surface (normal to the incident rays) at a distance r from the centre of the sun is: **[1]**

a) $\frac{16\pi R^2\sigma t^4}{r^2}$

b) $\frac{4\pi R^2\sigma t^4}{r^2}$

c) $\frac{R^2\sigma(t+273)^4}{r^2}$

d) $\frac{R^2\sigma(t+273)^4}{4\pi r^2}$

11. **Assertion:** A body that is a good radiator is also a good absorber of radiation at a given wavelength. **[1]**

Reason: According to Kirchhoff's law the absorptivity of a body is equal to its emissivity at a given wavelength.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

12. **Reason:** Blue star is at high temperature than red star. **[1]**

Assertion: According to Wien's displacement law $\lambda_m = \frac{b}{T}$, where symbols have their usual meanings.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

13. **Assertion:** Two stars A and B radiate maximum energy at 360 nm and 4800 $\mathring{A}$ respectively. Ratio Of their absolute temperature is 4 : 3. **[1]**

Reason: According to Wien's displacement law $\lambda_m T = b$ where symbols have their usual meaning.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

14. **Assertion:** Woolen cloth keep the body warm in winter. **[1]**

Reason: Air is a bad conductor of heat.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

15. **Assertion:** As temperature of a black body is raised, wavelength corresponding to maximum energy reduces. **[1]**

Reason: Higher temperature would mean higher energy and hence higher wavelength.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

16. **Assertion:** Perspiration from human body helps in cooling the body. **[1]**

Reason: A thin layer of water on the skin enhance, the emissivity.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

17. **Assertion:** The earth without its atmosphere would be inhospitably cold. **[1]**

Reason: All heat would escape in the absence of atmosphere.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

18. **Assertion:** A body with large reflectivity is a poor emitter of heat radiations. **[1]**

Reason: A body with large reflectivity is a poor absorber of heat.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

19. **Assertion (A):** The SI unit of Stefan's constant is $Wm^{-2} K^{-4}$. **[1]**

Reason (R): This follows from Stefan's law $E = \sigma T^4$

$\therefore \sigma = \frac{E}{T^4} = \frac{Wm^{-2}}{K^4}$

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

20. **Assertion:** Two thin blankets put together are warmer than a single blanket of double the thickness. **[1]**
Reason: Thickness of blanket increases because of air layer enclosed between the two blankets.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

21. Which of the following statement is true about the radiation emitted by human body? **[1]**

a) the radiation is emitted during the summers and absorbed during the winters.

b) the radiation is emitted only during the day.

c) the radiation emitted lies in the ultraviolet region and hence is not visible.

d) the radiation emitted is in the infrared region.

22. In which methods of heat transfer, mass of the substance heated does not play any part? **[1]**

23. What is the nature of heat radiations? **[1]**

24. Why are clear nights colder than cloudy nights? **[1]**

25. Do the thermal radiations obey the laws of reflection and refraction? **[1]**

26. Can thermal radiations pass through vacuum? **[1]**

27. Gasoline tanks are generally painted with aluminium paint. Why? **[1]**

28. Out of the three modes of transmission of heat, which one is fastest? **[1]**

29. On a hot day, a car is left in sunlight with all windows closed. Explain why it is considerably warmer than outside, after some time? **[1]**

30. If all the objects radiate electromagnetic energy, why do not the objects around us in everyday life become colder and colder? **[1]**

31. White clothes are more comfortable in summer while colourful clothes are more comfortable in winter. Why? **[1]**

Section B

32. A sphere of radius 10 cm is hung inside an oven whose walls are at a temperature of 1000 K. Calculate total heat energy incident per second (in Js^{-1}) on the sphere. Given $\sigma = 5.67 \times 10^{-8}$ SI units. **[2]**

33. Luminosity of Rigel star in Orion constellation is 17,000 times that of our sun. If the surface temperature of the sun is 6000 K, calculate the temperature of the star. **[2]**

34. On a hot day, a car is left in sunlight with all the windows closed. After some time, it is found that the inside of the car is considerably warmer than the air outside. Explain, why? **[2]**

35. A body re-emits all the radiation it receives. Find surface temperature of the body. Energy received per unit area per unit time is 2.835 Watt/m^2 and $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}. **[2]**

36. An iron ball having a surface area of 200 cm^2 and at a temperature of 527 ^oC is placed in an enclosure at 27 ^oC. If the surface emissivity of iron be 0.4, at what rate is heat being lost by radiation by the ball? **[2]**

37. An electric bulb with tungsten filament having an area of 0.25 cm^2 is raised to a temperature of 3000 K, when a current passes through it. Calculate the electrical energy being consumed in watt, if the emissivity of the filament is 0.35. Stefan's constant, $\sigma = 5.67 \times 10^{-5}$erg s^{-1}A m^{-2} K^{-4}. If due to fall in main voltage the filament temperature falls to 2500 K, what will be wattage of the bulb? **[2]**

38. A furnace is at a temperature of 2000 K. At what wavelength will it radiate maximum intensity? Is it in the visible region? **[2]**

39. The thermal conductivity of copper is four times that of brass. Two rods of copper and brass of same length and cross-section are joined end to end. The free end of copper rod is at 0°C and that of brass rod at 100°C. Calculate the temperature of the junction at equilibrium. Neglect radiation losses. **[2]**

40. Two stars radiate maximum energies at wavelengths $3.6 \times 10^{-7}\ m$ and $4.8 \times 10^{-7}\ m$ respectively. What is the ratio of their temperatures? **[2]**

41. How much energy is radiated per minute from the filament of an incandescent lamp at 3000 K, if the surface area is 10^{-4} m^2 and its emissivity is 0.4? Stefan's constant $\sigma = 5.67 \times 10^{-8}$ Wm^{-2} K^{-4}. **[2]**

42. Write the main features of Prevost theory of heat exchange. How does this theory lead to the fact that good absorbers are good radiators? **[2]**

43. A full radiator at 0°C radiates energy at the rate of 3.2×10^4 erg cm^{-2} s^{-1}. Find **[2]**

    i. Stefan's constant and

    ii. the amount of heat radiated per second by a sphere of radius 4 cm and at a temperature of 1000°C.

44. A body which has surface area of 5.0 cm^2 and a temperature of 727°C radiates 300 J of energy each minute. What is its emissivity? Stefan's constant $\sigma = 5.67 \times 10^{-8}$ Wm^{-2} K^{-4}. **[2]**

45. To what temperature must a black body be raised in order to double total radiation, if original temperature is 727^oC? **[2]**

46. Why it is much hotter above a fire than by its side? **[2]**

47. A thin brass rectangular sheet of sides 15.0 cm and 12.0 cm is heated in a furnace to 600°C, and taken out. How much electric power is needed to maintain the sheet at this temperature, given that its emissivity is 0.0250? Neglect heat loss due to convection. (Stefan Boltzmann constant, a = 5.67×10^{-8} W m^{-2} K^{-4}). **[2]**

48. 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? **[2]**

49. The earth constantly receives heat radiation from the sun and gets warmed up. Why does the earth not get as hot as the sun? **[2]**

50. A small hole is made in a hollow sphere whose walls are at 273^o C. Find the total energy radiated per second per cm^2. Given Stefan's constant = 5.7×10^{-5} erg cm^{-2} s^{-1} K^{-4}. **[2]**

51. Consider the sun to be a perfect sphere of radius 6.8×10^8 m. Calculate the energy radiated by the sun in one minute. Surface temperature of the sun = 6200 K. Stefan's constant = $5.67 \times 10^{-8} Jm^{-2}\ s^{-1}\ K^{-4}$. **[2]**

Section C

52. **Fill in the blanks:** **[3]**

    (a) Thermal radiations are electromagnetic waves having wavelength range from _____ μm to _____ μm. **[1]**

    (b) The downward flux, of long wave radiations by the green house gases, is called _____ flux. **[1]**

    (c) A cloudy night is _____ than a clear night. **[1]**

53. The sun is a black body of surface temperature about 6000 K. If the sun's radius is 7×10^8 m, calculate the energy per second radiated from its surface. Given that Stefan's constant $\sigma = 5.67 \times 10^{-8} Wm^{-2} K^{-4}$. **[3]**

54. State and prove Kirchoff's law of radiation. Hence show that a good absorber is also a good emitter of radiation. **[3]**

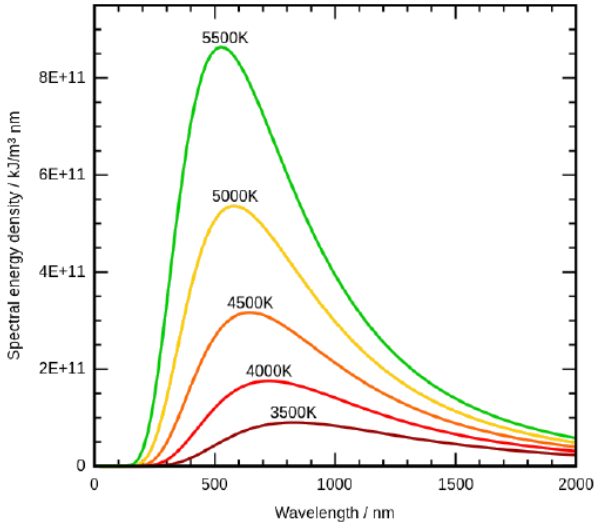
55. What are thermal radiation? State their important properties. **[3]**

56. What do you mean by absorptive power and reflecting power of a surface? What are their units? How are the two related to each other? **[3]**

Section D

Question No. 57 to 61 are based on the given text. Read the text carefully and answer the questions: **[5]**

Blackbody radiation is a term used to describe the relationship between an object's temperature, and the wavelength of electromagnetic radiation it emits. A black body is an idealized object that absorbs all electromagnetic radiation it comes in contact with. It then emits thermal radiation in a continuous spectrum according to its temperature.



57. As the wavelength of the radiation decreases, the intensity of the black body radiations:

a) decrease
b) first increase then decrease
c) first decrease then increase
d) increase

58. The radiations emitted by hot bodies are called as:

a) gamma-ray
b) visible ray
c) X-ray
d) black body radiation

59. For a prescribed wavelength a black body radiates how much energy at the temperature of the body?

a) 20%
b) 50%
c) Maximum
d) Minimum

60. Three black bodies A, B and C in the form of cubes of sides in the ratio of 3:4:5 are kept at the same high temperature. The ratio of the quantity of heat lost per second by A, B and C will be

a) 5:4:3
b) 9:16:25
c) 3:4:5
d) 25:16:9

61. The emissive of a perfectly black body is

a) 0.75
b) 0
c) 1
d) 0.5

62. **State True or False:** **[5]**

(a) In summer, the pendulum clock will be faster as due to more temperatures in summer, their time period will increase. **[1]**

(b) If a hot body is kept in surroundings that are cooler than the body, only the hot body radiates heat, while the cooler surroundings do not. **[1]**

(c) Black body radiation is white. **[1]**

(d) Stefan-Boltzmann law states that the total energy emitted per second by a unit area of a body is proportional to the fourth power of its absolute temperature. **[1]**

(e) A perfect body absorbs 100% of radiations falling on it. **[1]**

63. State: **[5]**

i. Stefan's law and

ii. Wein's displacement law.

How you will derive Newton's law of cooling from Stefan's law?

64. According to Stefan's law of radiation, a black body radiates energy σT^4 from its unit surface area every second where T is the surface temperature of the black body and $\sigma = 5.67 \times 10^{-8}$ W/m^2 / K^4 is known as Stefan's constant. A nuclear weapon may be thought of as a ball of radius 0.5 m. When detonated, it reaches temperature of 10^6K and can be treated as a black body. **[5]**

a. Estimate the power it radiates.

b. If surrounding has water at 30°C , how much water can 10% of the energy produced evaporate in 1 s?

[S_w = 4186.0 J / kgK, $L_v = 22.6 \times 10^5$ J / kg]

c. If all this energy U is in the form of radiation, corresponding momentum is $P = \frac{U}{c}$.How much momentum per unit time does it impart on unit area at a distance of 1 km?

65. Thermal expansion is a consequence of atomic vibrations and asymmetry of potential energy function. Explain. **[5]**

66. Explain why: **[5]**

a. a body with large reflectivity is a poor emitter.

b. a brass tumbler feels much colder than a wooden tray on a chilly day.

c. an optical pyrometer (for measuring high temperatures) calibrated for ideal black body radiation gives too low a value for the temperature of a red hot iron piece in the open but gives a correct value for the temperature when the same piece is in the furnace.

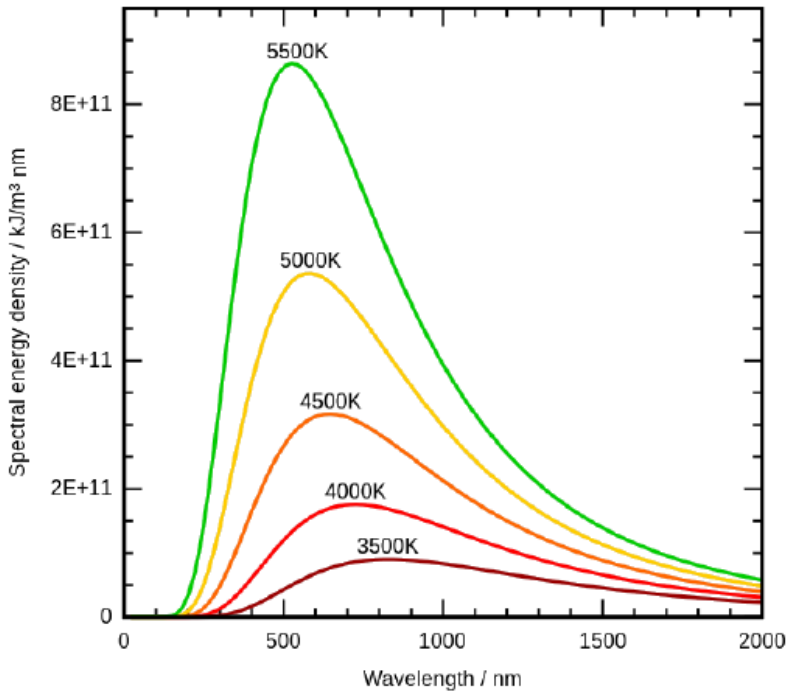
d. the earth without its atmosphere would be inhospitably cold.

e. heating systems based on the circulation of steam are more efficient in warming a building than those based on the circulation of hot water.

67. State and prove the Kirchhoff's law of heat radiation. Why does a glass heated in a furnace when taken out in dark glow with red light? **[5]**

68. **Read the case study given below and answer any four subparts:** **[5]**

Blackbody radiation is a term used to describe the relationship between an object's temperature, and the wavelength of electromagnetic radiation it emits. A black body is an idealized object that absorbs all electromagnetic radiation it comes in contact with. It then emits thermal radiation in a continuous spectrum according to its temperature.



i. If a black body is heated from 27°C to 927°C, then the ratio of the radiation emitted by the body at the two temperatures will be:

a. 1:4
b. 1:16
c. 1:256
d. 1: 64

ii. The temperature of a black body is gradually increased. The color of the body will change from:

a. White-green-red
b. Red-yellow-blue
c. Red-violet-yellow
d. none of these

iii. Radiation emitted by a surface is directly proportional to

a. Third power of its temperature
b. Equal to its temperature
c. Twice power of its temperature
d. Fourth power of its temperature

iv. An ideal black body is represented by:

a. A metal coated with a black dye
b. A glass surface coated with coal tar
c. A hollow enclosure blackened from inside and having a small hole
d. none of these

v. Energy released by a radiating surface is not continuous but is in the form of successive and separate packets of energy called:

a. photon
b. phonon
c. electron
d. neutron

69. **Read the case study given below and answer any four subparts:** **[5]**

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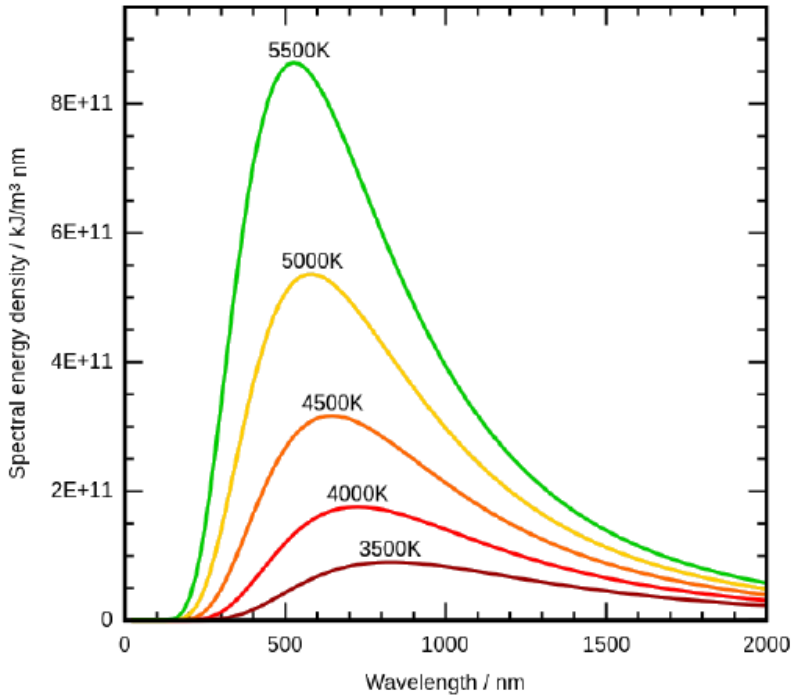

i. As the wavelength of the radiation decreases, the intensity of the black body radiations:

a. increase

b. decrease

c. first increase then decrease

d. first decrease then increase

ii. The radiations emitted by hot bodies are called as:

a. X- ray

b. gamma-ray

c. black body radiation

d. visible ray

iii. For a prescribed wavelength a black body radiates how much energy at the temperature of the body?

a. maximum

b. minimum

c. 50%

d. 20%

iv. Three black bodies A, B and C in the form of cubes of sides in the ratio of 3: 4: 5 are kept at the same high temperature. The ratio of the quantity of heat lost per second by A, B and C will be

a. 9:16:25

b. 5:4:3

c. 25:16:9

d. none of these

v. The emissive of a perfectly black body is

a. 0

b. 0.5

c. 0.75

d. 1