Chapter 1 (Black Body Radiation) Worksheet

MCQ (Multiple Choice Questions)

Q1. The thermal radiation emitted by a body is proportional to T^n where T is its absolute temperature. The value of n is exactly 4 for

(a) a blackbody (b) all bodies

(c) bodies painted black only (d) polished bodies only

Q2. Two bodies A and B having equal surface areas are maintained at temperatures $10^0 C$ and $20^0 C$. The thermal radiation emitted in a given time by A and B are in the ratio

(a) $1:1.15$ (b) $1:2$ (c) $1:4$ (d) $1:16$

Q3. Newton's law of cooling is a special case of

(a) Wien's displacement law (b) Kirchhoff's law

(c) Stefan's law (d) Planck's law

Q4. A wire of length $1m$ and radius $1mm$ is heated via an electric current to produce $1kW$ of radiant power. Treating the wire as a perfect blackbody and ignoring my end effects, the temperature of the wire is given by

(a) $694K$ (b) $1,294K$ (c) $2,494K$ (d) $4,894K$

Q5. The mass of the sun is $2\times10^{30}kg$, its radius $7\times10^8 m$ and its effective surface temperature $5,700K$. Calculate the mass of the sun lost per second by radiation.

(a) $4.1\times10^6 kg/\sec$ (b) $4.1\times10^9 kg/\sec$

(b) $4.1\times10^{10} kg/\sec$ (d) $4.1\times10^{12} kg/\sec$

Q6. Two solid spheres of the same material and similar surface, where the radius of one surface is four times of the other and when the Kelvin temperature of the large sphere is twice that of the small one (Assume that the temperature of the spheres is so high that absorption from the surroundings may be ignored). Ratio of power emitted from bigger to smaller sphere is given by

(a) 4 (b) 16 (c) 64 (d) 256

Q7. If the sun's radius $R_s = 7\times10^8 m$, earth sun distance $r = 1.5\times10^{-11} m$ and radius of earth is $R_E = 6.4\times10^6 m$ the sun's surface temperature, $T_s = 5,800K$ and Stefan-Boltzmann constant $\sigma = 5.7\times10^{-8}\frac{W}{m^2} - K^4$) then The solar constant, that is the radiation power received by $1m^2$ of earth's surface

(a) $700W/m^2$ (b) $1,400W/m^2$ (c) $2,100W/m^2$ (d) $2,800W/m^2$

Q8. If ε_0 is electric permittivity in free space and μ_0 is magnetic permeability then the value of $\frac{1}{\varepsilon_0\mu_0}$ in term of speed of light c

(a) c (b) $2c$ (c) c^2 (d) $2c^2$

Q9. Classical average energy of per standing wave at equilibrium temperature T is given by

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

Q10. According to Rayleigh-Jeans number of independent standing wave (mode) between frequency ν to $d\nu$ in three dimensional box is proportional to

(a) ν (b) ν^2 (c) ν^3 (d) ν^4

Q11. According to Rayleigh-Jeans number of independent standing wave (mode) between frequency λ to $d\lambda$ in three dimensional box is proportional to

(a) λ^{1} (b) λ^{2} (c) λ^{3} (d) λ^{4}

Q12. According to Rayleigh-Jeans total energy per unit volume in cavity in frequency ν to $d\nu$ is at equilibrium temperature T is given by

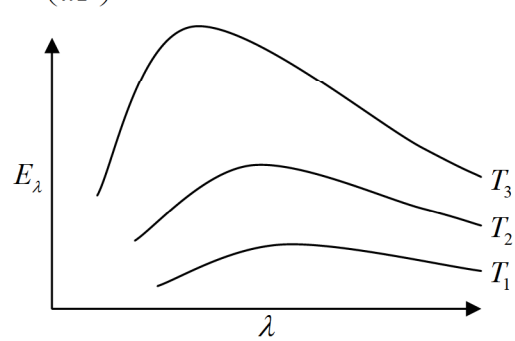
(a) $\frac{4\pi kT}{c^3}\nu d\nu$ (b) $\frac{4\pi kT}{c^3}\nu^2 d\nu$ (c) $\frac{8\pi kT}{c^3}\nu d\nu$ (d) $\frac{8\pi kT}{c^3}\nu^2 d\nu$

Q13. According to Planck total energy per unit volume in cavity in frequency ν to $d\nu$ is at equilibrium temperature T is given by

(a) $\frac{8\pi h}{c^3}\frac{\nu^2 d\nu}{\exp\left(\frac{h\nu}{kT}\right)+1}$ (b) $\frac{8\pi h}{c^3}\frac{\nu^2 d\nu}{\exp\left(\frac{h\nu}{kT}\right)-1}$

(c) $\frac{8\pi h}{c^3}\frac{\nu^3 d\nu}{\exp\left(\frac{h\nu}{kT}\right)-1}$ (d) $\frac{8\pi h}{c^3}\frac{\nu^3 d\nu}{\exp\left(\frac{h\nu}{kT}\right)+1}$

Q14. Variation of radiant energy emitted by the sun, filament of tungsten lamp, and welding arc as a function of its wavelength is shown in figure. Which of the following option gives the correct match?



(a) Sun-T_1, tungsten filament-T_2, welding arc-T_3

(b) Sun-T_2, tungsten filament-T_1, welding arc-T_3

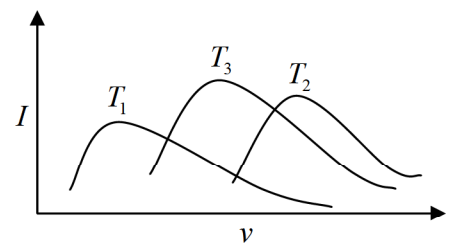
(c) Sun-T_3, tungsten filament-T_2, welding arc-T_1

(d) Sun-T_1, tungsten filament-T_1, welding arc-T_2

Q15. Three discs, A, B and C having radii $2m$, $4m$ and $6m$, respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are $300\,nm$, $400\,nm$ and $500\,nm$, respectively. The power radiated by them are Q_A, Q_B and Q_C. Then,

(a) Q_A is maximum (b) Q_B is maximum (c) Q_C is maximum (d) $Q_A = Q_B = Q_C$

Q16. The plots of intensity *versus* wavelength for three black bodies at temperatures T_1, T_2 and T_3, respectively are as shown in figure. Their temperatures are such that,



(a) $T_1 > T_2 > T_3$ (b) $T_1 > T_3 > T_2$

(c) $T_2 > T_3 > T_1$ (d) $T_3 > T_2 > T_1$

Q17. A black body is at a temperature of $2880\,K$. The energy of radiation emitted by this body with wavelength between $499\,nm$ and $500\,nm$ is U_1, between $999\,nm$ and $1000\,nm$ is U_2 and between $1499\,nm$ and $1500\,nm$ is U_3. The Wien constant, $b = 2.88 \times 10^6\ nmK$. Then,

(a) $U_1 = 0$ (b) $U_3 = 0$ (c) $U_1 > U_2$ (d) $U_2 > U_1$

MSQ (Multiple Select Questions)

Q18. A blackbody does not

(a) emit radiation (b) Absorb radiation (c) Reflect radiation (d) Refract radiation

Q19. A heated body emits radiation which has maximum intensity near the frequency v_0. The emissivity of the material is 0.5. If the absolute temperature of the body is doubled,

(a) The maximum intensity of radiation will be near the frequency $2v_0$

(b) The maximum intensity of radiation will be near the frequency $v_0/2$

(c) The total energy emitted will increase by a factor of 16

(d) The total energy emitted will increase by a factor of 8

Q20. A solid sphere and a hollow sphere of the same material and of equal radii are heated to the same temperature.

(a) Both will emit equal amount of radiation per unit time in the beginning.

(b) Both will absorb equal amount of radiation from the surrounding in the beginning.

(c) The initial rate of cooling (dT/dt) will be the same for the two spheres.

(d) The two spheres will have equal temperatures at any instant.

Q21. A cavity radiator has its maximum spectral radiance at a wavelength of $1.0\,\mu m$ in the infrared region of the spectrum. Then which one of the following is correct?

(a) Temperature corresponding to $1.0\,\mu m$ is $2,896\,K$

(b) If the radiant intensity of the body is doubled then the temperature of the body is now increased to $3,445\,K$

(c) When radiant intensity is doubled the wave length correspondence to maximum intensity will more than $1\,\mu m$

(d) When radiant intensity is doubled the wave length correspondence to maximum intensity will less than $1\,\mu m$

Q22. Which of the following is correct the form of the Planck radiation formula in the limit for energy density $\rho(\lambda)$ for wave length λ at absolute temperature T

(a) $\rho(\lambda,T)=\frac{8\pi hc}{\lambda^5}\frac{1}{\exp(hc/\lambda k_B T)-1}$

(b) $\rho(\lambda,T)=\frac{8\pi hc}{\lambda^5}\frac{1}{\exp(hc/\lambda k_B T)+1}$

(c) For large wave length $hc/\lambda k_B T \ll 1$ $\rho(\lambda,T)=\frac{8\pi}{\lambda^4}k_B T$

(d) For short wavelength $hc/\lambda k_B T \gg 1$ $\rho(\lambda)=\frac{8\pi hc}{\lambda^5}\exp(-hc/\lambda k_B T)$

Q23. Which of the following is correct about theory related about black body radiation?

(a) Rayleigh-Jeans theory for intensity of radiation is correct for small wavelength .

(b) Rayleigh-Jeans theory for intensity of radiation is correct for greater wavelength.

(c) Wien's Distribution Law for intensity of radiation is correct for small wavelength.

(d) Wien's Distribution Law for intensity of radiation is correct for greater wavelength.

Q24. Which of the following is correct about Plank's theory related about intensity of radiation?

(a) Plank's theory is correct for both smaller and bigger wavelength.

(b) Plank's theory of radiation has basic assumption that Energy of radiation is discrete

(c) Derivation Plank's theory of radiation has same method as Rayleigh-Jeans to calculate number of mode between frequency ν to $\nu+d\nu$

(d)) Energy density $\rho(\nu)d\nu$ between frequency ν to $\nu+d\nu$ is $\frac{8\pi\nu^2}{c^3}.\frac{h\nu}{\exp\left(\frac{h\nu}{k_B T}\right)-1}$

Q25. Consider the following statements:

The maximum kinetic energy of a photoelectron depends on:

(a) frequency of incident radiation

(b) nature of photo emitter

(c) intensity of incident radiation

(d) on plate potential

Which of these statements are correct?

NAT (Numerical Answer Type)

Q26. An electric heater emits $1000W$ of thermal radiation. The coil has a surface area of $0.020\,m^2$. Assuming that the coil radiates like a blackbody, its temperature is_____ K, where $\sigma = 6.00\times10^{-8}Wm^{-2}K^{-1}$.

Q27. A spherical tungsten piece of radius $1.0\,cm$ is suspended in an evacuated chamber maintained at $300\,K$. The piece is maintained at $1000K$ by heating is electrically. The rate at which the electrical energy must be supplied is αW then value α is _____ If The emissivity of tungsten is 0.30 and the Stefan constant σ is $6.0\times10^{-8}Wm^{-2}K^{-4}$.

Q28. The pressure inside the sun is estimated to be of the order of 400 million atmospheres. The temperature corresponding to such a pressure assuming it to result from the radiation is $\alpha\times10^{7}K$ then value of α is _____

Q29. The mass of the sun is $2\times10^{30}\,kg$, its radius $7\times10^{8}\,m$ and its effective surface temperature $5,700\,K$. Time taken for the mass of sun (M) to decrease by 1% is $\alpha\times10^{11}\,years$ the value of α is _____

Q30. Two solid spheres of the same material and similar surface, where the radius of one surface is four times of the other and when the Kelvin temperature of the large sphere is twice that of the small one (Assume that the temperature of the spheres is so high that absorption from the surroundings may be ignored). Ratio of rate of change of temperature emitted from bigger to smaller sphere is given by _____

Q31. For a tungsten lamp, for example, emissivity e is about 0.4. A tungsten lamp at a temperature of $3000K$ and a surface area of $0.3cm^2$ then power radiates at the rate $\alpha.Watt$ the value of α is_____

Q32. The wavelength λ_m for which energy is the maximum and T is temperature in kelvin. The relation $\lambda_m T = \alpha\times10^{-3}mK$, then the value of α is_____

Q33. The temperature of the human body is $37^0 C$ C. The intensity of radiation emitted by the human body is maximum at a wavelength is $\alpha \times 10^{-6} m$ the value of α is_____

Q34. The intensity of radiation emitted by the sun has its maximum value at a wavelength of $510\,nm$ and that emitted by the north star has the maximum value at $350\,nm$. If these stars behaves like black bodies, then the ratio of the surface temperature of the sun and the north star is ___