COLLEGE OF ENGINEERING ROORKEE, ROORKEE
Autumn Semester 2014-2015

Subject: Physics **Subject Code: TPH101**
Compton Effect, Superconductivity& Radiation **Tutorial Sheet: 4**

1. X-ray of wavelength 1A are scattered from a block of carbon. The scattered rays are observed at 60^o. Find (i) the wavelength of scattered photon, (ii) energy lost by photon in this collision, (iii) direction of the recoiled electron. Ans. 1.012A, 147.4eV, 59.4^o
2. A gamma ray photon of 1.2 A suffers Compton scattering at $\pi/4$ radian. Find the % increase in its wavelength. Ans. 0.59%
3. γ rays of energy 0.8 MeV are made to fall on an aluminum sheet. Calculate (i) the maximum energy of recoiled electron, (ii) Compton Shift and (iii) wavelength of scattered photon. Ans. 0.604MeV, 0.0486A, 0.064A
4. An X-ray photon is found to have its wavelength doubled on being scattered through 90^o. Find the wavelength and energy of incident photon. Ans.$2.42x10^{-12}$m, 510.8KeV
5. In a Compton scattering experiment, the wavelength of scattered radiation through 120^o is 1.25A.Calculate the energy of the recoiled electron and the direction in which it is deflected. Ans. 29.83eV, 29.51^o
6. If an x-ray photon of energy 75keV is scattered at 30^o, then calculate the energy of scattered X-ray and that of recoiled electron. Ans. 73.55KeV, 1.45KeV
7. Show that the de-Broglie wavelength of the particle is equal to its Compton wavelength when its velocity is 0.707c.
8. Determine the penetration depth of mercury at 0K if the critical temperature of mercury is 4.2K and its penetration depth is 57 nm at 2.9nm. Also find the density of super conducting electrons. Ans. 50.1nm, $1.127x10^{28}m^{-3}$
9. The critical field of Nb is reduced to 1/3 of its value at 0K when its temperature is increased to 3K from 0K.Calculate the transition temperature of the element. Ans. 3.8K
10. For a specimen of V_3Ga, the critical fields are $4.2x10^5$and $1.4x10^6$ at 15K and 12K, respectively. Calculate its transition temperature and critical field at 0K. Ans. 16.12K, $3.142x10^6$A/m
11. Calculate the penetration depth at 0K for Pb. Its density is $1.13x\ 10^4kg/m^3$ and atomic weight is 207. Its transition temperature is 7.2K. Also calculate the % increase in the penetration depth at 3.6K from its value at 0K. Ans. 29.4nm, 3.28%
12. The critical fields at 6K and 8K for an alloy are 7.616T and 4.284T, respectively. Determine the critical field at 3K. Ans. 10.83T
13. Calculate the critical current density for a wire of Sn of radius 0.5 mm at 2K. Given that the critical temperature of Sn is 3.72K and H_c at 0K is $2.45x10^4$ A/m. Ans. $6.97x10^7A/m^2$
14. The critical temperature of a given superconducting sample is 1.19K with isotopic mass 26.91 a.m.u. Find the critical temperature if its isotopic mass is increased by 5.22 a.m.u. Ans. 1.089K
15. Calculate the energy gap in eV for Nb at 0K if T_c = 9.25K. Ans. 2.82meV
16. Estimate the temperature at which a body would appear red and blue. The corresponding wavelengths of maximum emission, λ_m=700nm and 500nm, respectively and Wien's constant =0.3cm-K. Ans. 6000K, 4285.7K
17. The operating temperature of a tungsten filament of a bulb is 3000K, having surface area 0.25 cm^2 and emissivity 0.35. Find the wattage of the bulb if the Stefan's constant is $5.67x10^{-5}erg\text{-}cm^{-2}sec^{-1}deg$. Ans. 40Watt
18. A black body radiates heat per unit area at a rate of 10^5 at 300^oC. If sun radiates heat per unit area at a rate 10^9watt, compute its temperature. Ans.5730K
19. Find the maximum amount of heat which may be lost in Cal/second by a sphere of radius of 10cm. diameter at temperature 227^oC when placed in an enclosure at 27^oC. Stefan's constant is $5.67x10^{-5}erg\text{-}cm^{-2}sec^{-1}deg$. Ans. 23.3Cal/s

Theoretical Questions:

1. What is Compton effect? Derive the expression for Compton shift. Hence define Compton wavelength.
2. Show that Compton effect is not observable for visible light.
3. Explain the presence of unmodified radiation in Compton scattering.
4. Derive the expression for the energy of the recoiled electron and show that the photon cannot transfer its whole energy to the recoiled electron.
5. Derive the London equations governing the motion of electrons in superconductors. Explain how these equations explain the superconducting behavior as well as Meissner effect and flux penetration.
6. What is superconductivity? What is the significance of critical temperature, critical magnetic field and critical current density for superconductors?
7. Give some important properties and applications of superconductors.
8. What are type I and type II superconductors. Discuss the usefulness of type II superconductors.
9. What is penetration depth? Derive an expression for it.
10. State Stefan-Boltzmann law of radiation. Show that Newton's law of cooling is an approximation of this law.
11. What is a black body? Plot black body spectrum and show how different radiation laws can be derived from it.
12. What is Planck's radiation formula? Prove that Wein's law and Rayleigh Jeans laws can be derived from it.
13. Derive Stefan's law from Planck's radiation formula
14. What do you mean by spontaneous and stimulated emissions? Deduce a relation between the transition probabilities of these processes.
15. Explain the following:
    a. critical field and critical current
    b. Isotope effect
    c. Coherence length