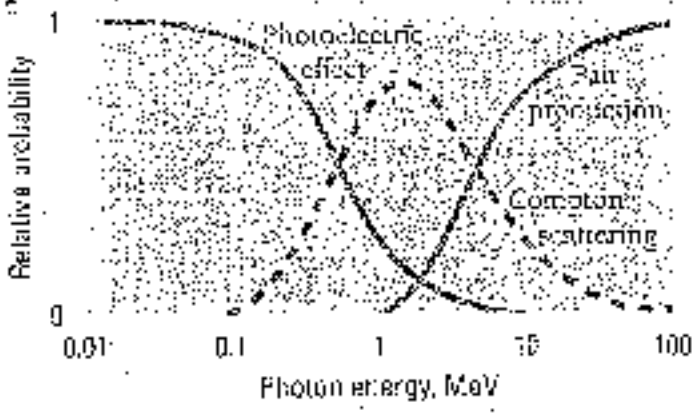
八十四學年度材料科學工程研究所 所 乙 組碩士班研究生入學考試

科目 近代物理(I) 科號 130 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. Figure 1 shows the relative probabilities of the photoelectric effect, Compton scattering, and pair production as functions of energy in lead. (a) Please explain the reason why the Compton scattering and pair production are not observed at a photon energy of 0.01 MeV. (8 points) (b) The Compton wavelength of an electron is 2.426×10^{-12} m. Please find out the maximum wavelength change in the Compton scattering. (7 points)

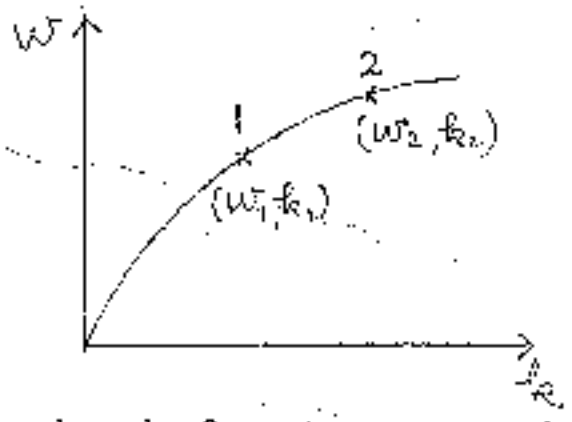
FIG. 1



2. The smallest angle of Bragg diffraction is determined to be θ_1 when X-ray of a wavelength λ_1 is incident on a polycrystal of gold. Find out the magnitude of the second smallest angle of Bragg diffraction. The result should be expressed in terms of θ_1 or λ_1 only. (10 points)

3. The w-k diagram in figure 2 shows the angular frequency w as a function of wave number k for a wave propagating in a material. Two points labeled 1 and 2 correspond to (w_1, k_1) and (w_2, k_2) respectively. (a) Find out which point, 1 or 2, has higher group velocity. (7 points) (b) Draw a new w-k diagram which has twice the magnitude of the phase velocity at each wave number in figure 2. (8 points)

FIG. 2



4. The de Broglie wavelength of an electron, moving with a speed of 10^6 m/s, is λ_1. Find out the de Broglie wavelength of the electron if its speed is raised to 10^8 m/s. Express the result in terms of λ_1. (10 points)

5. Please explain the "Corresponding Principle" and state the author. (5 points)

6. a) Can we derive (導証) the "Schrödinger Equation"? If yes, derive it. If not, please explain why. (5 points)
b) Is the Schrödinger equation universally applicable? If yes, try to prove it. If not, please give one example where the Schrödinger equation breaks down. (5 points)

7. We normally use wave packet to describe a particle. The wave packet can be constructed mathematically by a Fourier integral

$$y(x,t) = \int A(k) \sin(kx-wt)dk$$

a) show that if we use

$$A(k) = \exp\{-(k-k_0)^2/[2(\Delta k)^2]\}$$

y becomes

$$y(x,t) = (2\pi)^{1/2}\,\Delta k\{\exp[-(\Delta kx)^2/2]\sin k_0x\}$$

which is a Gausslan wave packet. (5 points)

b) Sketch y(x,t) versus x. (5 points)
c) Obtain the phase and group velocity of a light and a particle respectively using this representation. (10 points)

8. Obtain the energy eigenvalues E_n for a one-dimensional infinite square well of width a in terms of the mass m and the integer n. Please be concise and neat. (5 points)

9. What are "tunneling phenomena"? (5 points) They are well predicted by the Quantum Mechanics of particle physics, but are they observable realities or just wishful theoretical results? Please explain in detail and, if you think they are observable, cite an example. (5 points)