

## 22.101 Applied Nuclear Physics

(Fall 2006)

### Problem Set No. 8

Due: December 6, 2006

#### Problem 1

Consider the problem of neutron elastic scattering in the notation as used in class.

- Find an expression for  $E_4$  involving  $E_1$  and angle  $\gamma$  (the angle between the recoil direction of  $M_4$  and the x-axis). Is there a one-to-one relation between  $E_4$  and  $\gamma$ ?
- Eliminate  $\gamma$  in favor of  $\theta_c$  in your result in (a), then use the fact that the scattering is isotropic in CMCS to find the distribution  $P(E_4)$ , the probability per unit energy that the recoil nucleus will have energy  $E_4$ .
- How would you obtain  $P(E_4)$  directly from the result for  $F(E' \rightarrow E)$  derived in class? How general is your relation between P and F?

#### Problem 2

Consider Compton scattering of a photon. Derive the four expressions stated in the Lecture Notes for (i) the Compton shift, (ii) energy of the scattered photon, (iii) energy of the recoiling electron, and (iv) the relation between the angles of the scattered photon and the recoiling electron.

#### Problem 3

Calculate the energy distribution of Compton electrons for an incident photon of energy 1.20 Mev. Give your results as the energy differential cross section,  $d\sigma/dT$ , in units of  $10^{-25} \text{ cm}^2/\text{Mev}$ , at electron energies 0.25, 0.5, 0.75, 0.9 and 0.99 Mev. Make a sketch of  $d\sigma/dT$  and compare with the corresponding figure in the Lecture Notes.

#### Problem 4

A sodium iodide detector in the shape of a 7 cm cube is bombarded by a beam of 2.8 Mev gamma radiation normal to one face of the cube.

- (a) What fraction of the gamma radiation is detected?
- (b) What fraction of the detected gamma appears in the photo peak, the Compton distribution, and the pair peaks, assuming no re-absorption of Compton gamma or annihilation quanta?
- (c) Make a rough estimate of the relative fraction of pair events that appear in the full-energy (photo) peak, in the one-escape peak, and in the two-escape peak. Compare your result with the figure given in the Lecture Notes.

(Note: The attenuation coefficients that you will need can be found in Evans, Chap. 25, Sec.1. For 0.51 Mev photons,  $\mu = 0.33 \text{ cm}^{-1}$ . For 2.8 Mev photons,  $\mu = 0.135 \text{ cm}^{-1}$ ,  $\mu_{\tau} = 2.5 \times 10^{-3} \text{ cm}^{-1}$ ,  $\mu_C = 0.113 \text{ cm}^{-1}$ ,  $\mu_{\kappa} = 0.020 \text{ cm}^{-1}$ .)