ELT-61406 RADIATION PHYSICS

Tentti 30.11.2016 Hannu Eskola

Ei-ohjelmoitavien laskinten käyttö sallittu

1. a. Luonnostele tyypillinen röntgenputkesta saatavan röntgensäteilykeilan energiapektri.
   b. Mihin vuorovaikutusmekanismeihin spektrin muoto perustuu?
   c. Mikä putken parametri määrää spektrin maksimienergian?
   d. Miten spektrin muotoa matalilla energioilla voidaan säädellä?

2. Selosta kapean ja leveän fotonisäteilykeilan vaimenemismekanismit ilmassa ja kudoksessa.

3. a. Neutronin ja materian vuorovaikutusmekanismit.
   b. Mikä on niiden merkitys lääketieteessä?

4. Montako alfahajoamista ja beta-miinus-hajoamista tarvitaan, jotta $_{92}$U -238 hajoaa isotoopiksi $_{82}$Pb-206?

5. Määritä de Broglie-aallonpituudet (a) elektronille, (b) protonille, ja (c) α-hiukkaselle, jolla on 880 eV liike-energia.

ELT-61406 RADIATION PHYSICS

Examination, November 30th, 2016 Hannu Eskola

Use of non-programmable calculators allowed

1. a. Sketch the energy spectrum of a typical X-ray beam obtained from an X-ray tube.
   b. Which interaction mechanisms are responsible for the shape?
   c. Which tube parameter defines the maximum energy of the X-rays?
   d. In which way the shape of the spectrum at low energies is modified?

2. Explain the attenuation mechanisms of narrow and broad photon beam in air and tissue.

3. a. Interaction mechanisms of neutron and matter.
   b. What is the relevance of those in medicine?

4. How many alpha and beta minus decays are needed for the disintegration of $_{92}$U -238 to $_{82}$Pb-206?

5. Calculate the de Broglie wavelengths of (a) an electron, (b) a proton, and (c) an α particle of 880-eV kinetic energy.

⇒

COLLECTION OF FORMULAE FOR EXAMINATIONS OF RADIATION PHYSICS

$$E_{kin} = \frac{p^2}{2m} = \frac{1}{2}mv^2$$, v = velocity

$$p = mv$$, v = velocity

$$\lambda = \frac{h}{p}$$

$$E = h\nu = \frac{hc}{\lambda}$$,ν = frequency

$$E_B = Zm_pc^2 + (A-Z)m_nc^2 - Mc^2 = (Zm_p + (A-Z)m_n - M)c^2$$

$$h\nu' = h\nu \frac{1}{1 + \frac{h\nu}{m_ec^2}(1-\cos\theta)}$$

$$\frac{1}{h\nu'} - \frac{1}{h\nu} = \frac{1}{m_ec^2}(1-\cos\theta)$$,ν = frequency

$$\Delta\lambda = \lambda' - \lambda = \lambda_c(1-\cos\theta)$$, λ_c = 0.0243 Å (1Å=10^{-10} m)

$$m(v) = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$, v = velocity

$$E_{tot,rel} = \sqrt{p^2c^2 + m_0^2c^4}$$

$$D = \frac{d\bar{\varepsilon}}{dm}$$

$$N = \frac{m \cdot N_A}{M}$$

$$A = \lambda N$$

$$E = \frac{dQ}{e}W$$

$$D_m = X\frac{W_{ilma}}{e} = Xf$$

$$N_B(t) = \frac{N_{0A}\lambda_A}{\lambda_B - \lambda_A}\left(e^{-\lambda_A t} - e^{-\lambda_B t}\right)$$

W_{ilma} = 34 eV

$h = 6.626076*10^{-34}$ Js = $4.135669*10^{-15}$ eVs

$c = 3*10^8$ m/s

$e = 1.6021773*10^{-19}$ C

$R\infty = 1.097373 \cdot 10^7$ 1/m

$m_e = 9.1093897*10^{-31}$ kg = $5.4857990*10^{-4}$ u

$m_p = 1.6726231*10^{-27}$ kg = 1.0072765 u

$m_n = 1.6749286*10^{-27}$ kg = 1.0086650 u

m_H = 1.007825 u

m_D = 2.014102 u

m_{He} = 4.002603 u

$u = 1.6605402*10^{-27}$ kg

$N_A = 6.0221367*10^{23}$ mol^{-1}

$$I = I_0e^{-\mu \cdot x} = I_0e^{-\frac{\mu}{\rho}\cdot\rho\cdot x}$$

$$E_D = -E_R Z^2(1/n_i^2 - 1/n_f^2)$$

$$A_{(t)} = A_0e^{-\lambda t}$$

$$\lambda = \frac{ln2}{T_{\frac{1}{2}}}$$

$$Q = [(m_1+m_2)-(m_3+m_4)]c^2$$

$$E_{k,thr} \approx -Q(1+ m_1/m_2)$$

$$N = \frac{m \cdot N_A}{M}$$

$$A = \lambda N$$

$$X = \frac{dQ}{dm}$$