

## A-Level Physics · Unit 24 Medical physics

Part 1 · Vocabulary review (9 items). The terms this unit is examined on most. Mark it yourself from the answer key.

*Write the English word.*

- Part 2 · Exam questions (37 marks, 4 questions) begins on the next page. They are ordered easy to difficult and none of them has been set before.*

..... [1]

- (b)** Outline the principles of CT scanning.

..... [5]

[Total: 6]

**11** Positron emission tomography (PET scanning) obtains diagnostic information from a person. The information is used to form an image.

**(a)** PET scanning uses a tracer.

Explain what is meant by a tracer.

.....  
..... [1]

**(b)** PET scanning involves annihilation.

**(i)** Explain what is meant by annihilation.

.....  
..... [1]

**(ii)** State the names of the particles involved in the annihilation process.

..... [1]

**(c) (i)** Calculate the total energy released in one annihilation event in **(b)**.

energy = ..... J [1]

**(ii)** Calculate the wavelength of each gamma photon released.

wavelength = ..... m [2]

**(d)** Explain how the gamma photons are used to produce an image.

.....  
.....  
.....  
.....  
..... [3]

[Total: 9]

**12 (a)** Electrons are accelerated through a potential difference of 15 kV. The electrons collide with a metal target and a spectrum of X-rays is produced.

**(i)** Explain why a continuous spectrum of energies of X-ray photons is produced.

.....  
.....  
.....  
..... [3]

**(ii)** Calculate the wavelength of the highest energy X-ray photon produced.

wavelength = ..... m [3]

- (b) A beam of X-rays has an initial intensity  $I_0$ . The beam is directed into some body tissue. After passing through a thickness  $x$  of tissue the intensity is  $I$ . The graph in Fig. 11.1 shows the variation with  $x$  of  $\ln(I/I_0)$ .

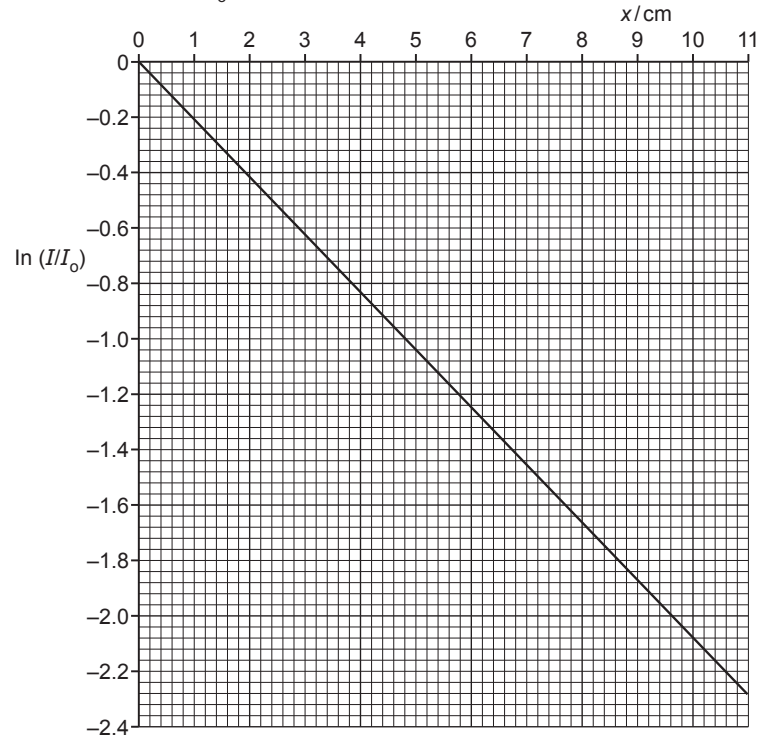


Fig. 11.1

- (i) Determine the linear attenuation (absorption) coefficient  $\mu$  for this beam of X-rays in the tissue.

$$\mu = \dots \text{ cm}^{-1} \quad [2]$$

- (ii) Determine the thickness of tissue that the X-ray beam must pass through so that the intensity of the beam is reduced to 5.0% of its initial value.

$$\text{thickness} = \dots \text{ cm} \quad [2]$$

[Total: 10]

- 13 Fluorine-18 ( $^{18}\text{F}$ ) is a radioactive nuclide that is used as a tracer in positron emission tomography (PET scanning). Fluorine-18 decays to a nuclide of oxygen (O) according to



- (a) (i) State what is meant by a tracer.

.....  
 ..... [1]

- (ii) State the symbol of the particle that is represented by X and the values of  $P$ ,  $Q$  and  $R$ .

X: ..... P: .....

Q: ..... R: .....

[2]

- (b) (i) Explain how the radioactive decay of fluorine-18 results in the emission from the body of the gamma-ray photons that are detected during a PET scan.

.....  
 .....  
 .....  
 ..... [2]

- (ii) Explain how the detection of the gamma-ray photons is used to produce an image of the tissue being examined.

.....  
 .....  
 .....  
 ..... [2]

- (c) The half-life of fluorine-18 is  $T$ .  
 A patient is injected with amount of substance  $n$  of fluorine-18.

- (i) Determine an expression for the initial value  $R_0$  of the rate  $R$  of production of gamma-ray photons by the tracer, in terms of  $n$ ,  $T$  and the Avogadro constant  $N_A$ .

$$R_0 = \dots [3]$$

(ii) On Fig. 9.1, sketch the variation with time  $t$  of  $R$ .

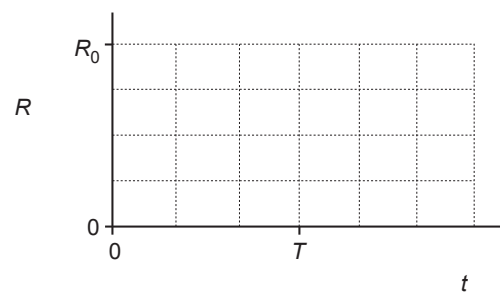


Fig. 9.1

[2]

[Total: 12]