

Name of the Student: _____

Max. Marks : 23 Marks

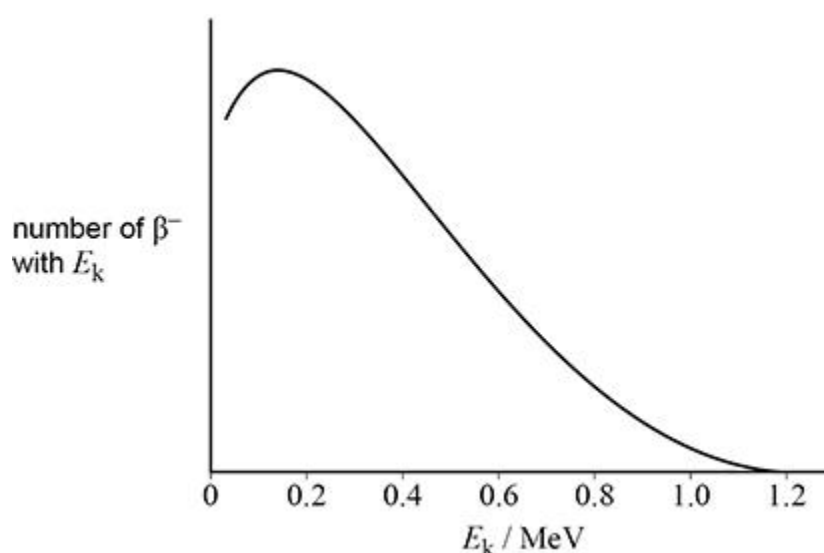
Time : 23 Minutes

Q1.

The kinetic energies of β^- particles emitted from a sample of bismuth-210 are analysed. These β^- particles have a range of kinetic energies.

The total energy released when each nucleus of bismuth-210 decays to a nucleus of polonium-210 is 1.2 MeV.

Figure 1 shows the variation with E_k of the number of β^- particles that have the kinetic energy E_k .

Figure 1

- (a) Explain how the data in **Figure 1** support the hypothesis that a third particle is produced during β^- decay.

(2)

- (b) This third particle is an electron antineutrino.

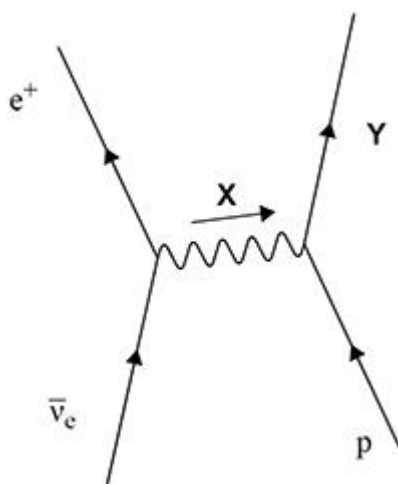
Explain why an electron antineutrino, rather than an electron neutrino, is produced during β^- decay.

(2)

- (c) A large tank of water is used as part of an electron antineutrino detector. An electron antineutrino $\bar{\nu}_e$ enters the tank and interacts with a proton (p).

Figure 2 represents this interaction.

Figure 2



Identify **X** and **Y**.

X = _____

Y = _____

(2)

- (d) The positron produced in the interaction in **Figure 2** slows down and collides with a lepton in a molecule of water.

Describe the process that occurs when the positron collides with this lepton. In your answer you should identify the lepton in the molecule of water.

(3)

- (e) The range of the electromagnetic interaction is infinite.
The table below gives the range of the strong nuclear interaction and the range of the weak nuclear interaction.

Interaction	Range / m
strong nuclear	10^{-15}
weak nuclear	10^{-18}

Deduce whether the positron or the electron antineutrino is likely to travel the shorter distance in the tank of water before interacting.

(3)

(Total 12 marks)

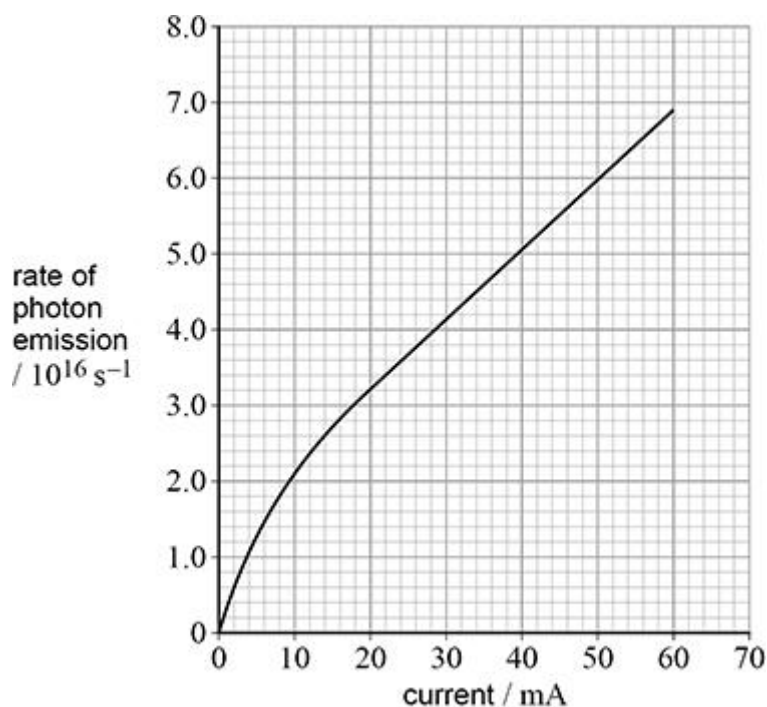
Q2.

- (a) A light emitting diode (LED) emits blue light with a wavelength of 440 nm. The rate of photon emission is $3.0 \times 10^{16} \text{ s}^{-1}$.

Show that the power output of the LED is approximately 0.014 W.

(2)

- (b) A different LED emits red light with a wavelength of 660 nm.
The graph below shows how the rate of photon emission varies with current up to the maximum operating current of this LED.



A student claims that the red LED can have twice the power output of the blue LED.

Deduce whether the student's claim is correct.

(3)

- (c) The student has paint that fluoresces when light of any wavelength is incident on it. She coats the blue LED and the red LED with the paint.

Compare the wavelengths of light emitted by the paint on each LED.

In your answer you should also explain the processes that cause the paint to fluoresce.

(6)
(Total 11 marks)