

Answer **all** questions in the spaces provided.

0 1 . 1 Identify the number of neutrons in a nucleus of polonium-210 (${}_{84}^{210}\text{Po}$).

Tick (✓) **one** box.

[1 mark]

84

126

210

294

0 1 . 2 A polonium-210 nucleus is formed when a stationary nucleus of bismuth-210 decays. A beta-minus (β^-) particle is emitted in this decay.

Outline, with reference to β^- decay, why bismuth-210 and polonium-210 have different proton numbers.

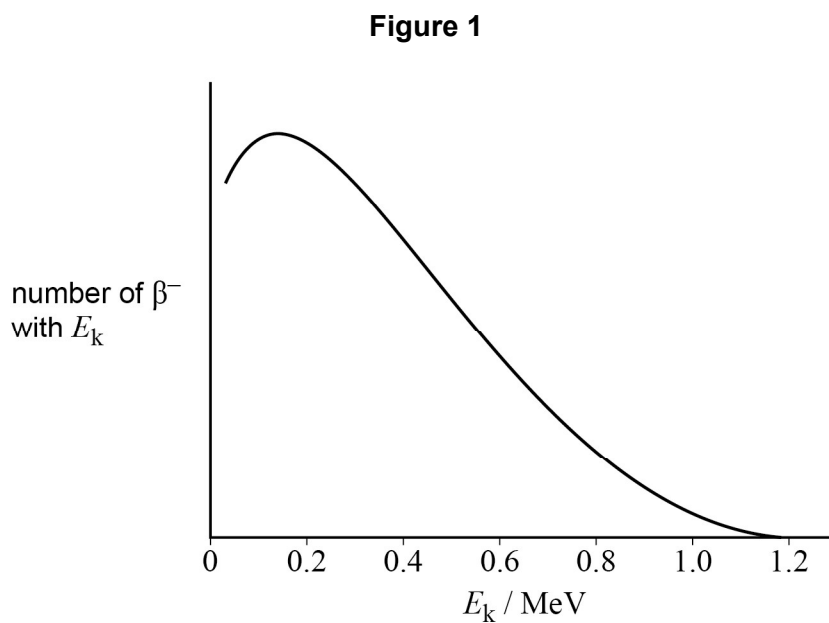
[2 marks]



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 .



0 1 3

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

[2 marks]

Question 1 continues on the next page

Turn over ►



0 1 . 4 This third particle is an electron antineutrino.

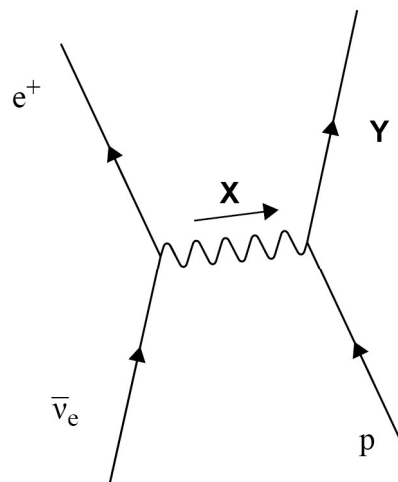
Explain why an electron antineutrino, rather than an electron neutrino, is produced during β^- decay.

[2 marks]

0 1 . 5 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**.

[2 marks]

X = _____

Y = _____



0 1 . 6 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 marks]

0 1 . 7 The range of the electromagnetic interaction is infinite.
Table 1 gives the range of the strong nuclear interaction and the range of the weak nuclear interaction.

Table 1

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 marks]

15

Turn over ►



0 5 . 1

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 marks]

Question 5 continues on the next page

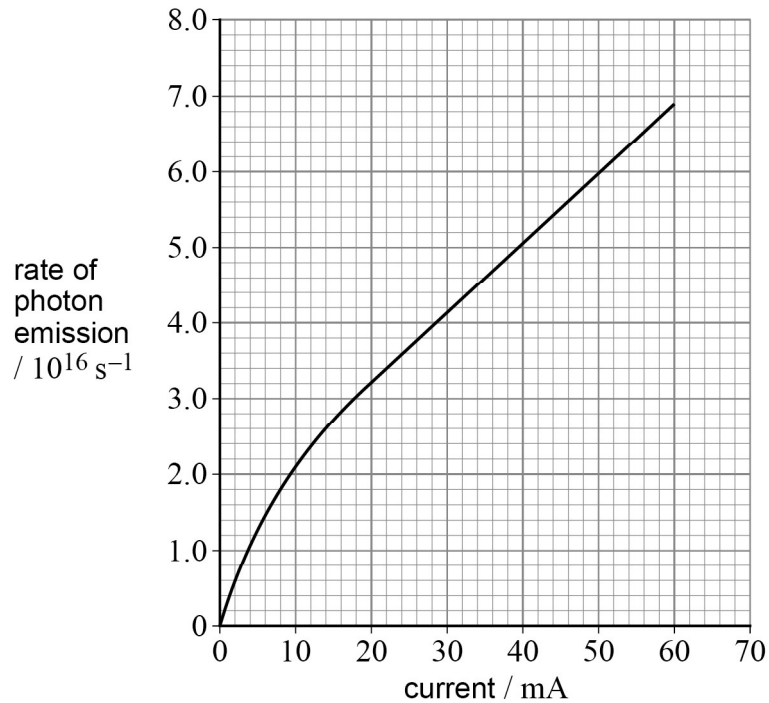
Turn over ►

0 5 . 2

A different LED emits red light with a wavelength of 660 nm.

Figure 12 shows how the rate of photon emission varies with current up to the maximum operating current of this LED.

Figure 12



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 marks]



Section C

Each of Questions **06** to **35** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.

For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD

WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

0 6 An atom of oxygen-15 ($^{15}_8\text{O}$) gains two electrons to form an ion.

What is the specific charge of the ion?

[1 mark]

A $-1.3 \times 10^7 \text{ C kg}^{-1}$

B $-2.4 \times 10^7 \text{ C kg}^{-1}$

C $-5.1 \times 10^7 \text{ C kg}^{-1}$

D $-6.4 \times 10^7 \text{ C kg}^{-1}$

0 7 Which is an exchange particle for the weak interaction?

[1 mark]

A lepton

B photon

C pion

D W^+



0 8 A particular baryon has a quark structure dss and decays by the weak interaction.

What are possible decay products of this baryon?

The quark structure of Λ^0 is uds .

[1 mark]

A $\Lambda^0 + \pi^-$

B $n + \pi^-$

C $\Lambda^0 + e^-$

D $K^+ + K^0$

0 9 A muon and an antimuon annihilate to produce the minimum number of photons.

What is the maximum wavelength of the photons?

[1 mark]

A $5.9 \times 10^{-15} \text{ m}$

B $1.2 \times 10^{-14} \text{ m}$

C $5.9 \times 10^{-9} \text{ m}$

D $1.2 \times 10^{-8} \text{ m}$

1 0 An electron has speed v . The electron's kinetic energy is doubled.

What is the new speed of the electron?

[1 mark]

A $\frac{v}{\sqrt{2}}$

B $\sqrt{2}v$

C $2v$

D $4v$

Turn over ►



1 1 An object of mass m is accelerated from rest to a velocity v by a constant resultant force F .

What is the work done on the object during this acceleration?

[1 mark]

A $\frac{Fv}{2}$

B Fv

C mv^2

D $\frac{mv^2}{2}$

1 2 Which row describes the nature of the strong nuclear force between two nucleons at separations of 0.25 fm, 2.0 fm and 8.0 fm?

[1 mark]

	At a separation of 0.25 fm	At a separation of 2.0 fm	At a separation of 8.0 fm	
A	attractive	repulsive	negligible	<input type="checkbox"/>
B	repulsive	attractive	attractive	<input type="checkbox"/>
C	negligible	repulsive	attractive	<input type="checkbox"/>
D	repulsive	attractive	negligible	<input type="checkbox"/>

