Name of the Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Mark Schemes

Q1.

(a) (Missing) energy carried off by third particle

Or

(A third particle must be produced) for conservation of energy✔

Accept energy is converted into mass of third particle.
Where third particle is named must be a neutrino or an antineutrino.

There is missing energy (When) a beta (particle) has less than 1.2 MeV (of kinetic energy).

Or

The law of conservation of energy appears to be violated when beta (particle) has less than 1.2 MeV ✔

Identify there is difference between 1.2 MeV and E_k.

2

(b) (It must be an electron antineutrino to) conserve lepton number✔

An electron and (electron) antineutrino have lepton numbers of opposite signs.

Or

An electron and (electron) antineutrino have a (total) lepton number of zero. ✔

Alternative for 2nd Marking point:
Appropriate particle equation seen annotated with correct lepton numbers.

Alternative:

Producing an (electron) neutrino wouldn't conserve lepton number✔

An electron and (electron) neutrino have lepton numbers of the same sign.

Or

An electron and (electron) neutrino have a (total) lepton number equal to 2. ✔

Alternative 2nd marking point:
Appropriate particle equation seen annotated with correct lepton

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numbers.

2

(c) (**X** =) W-minus (boson) / W^- (boson) ✔

(**Y** =) neutron / n ✔

2

(d) Lepton (in the water molecule) is an electron ✔

Must state that lepton (in the water) is an electron for all 3 marks

and

Max 2 from

annihilation ✔

gamma photon**s** are produced ✔

Two (gamma) photons are produced (that travel) in opposite directions. ✔

Penalise answers that list other products in MP3 and MP4

3

(e) **Max 3**

The positron because:

positron is charged and the (electron) antineutrino $(\bar{\nu}_{(e)})$ is neutral ✔

The antineutrino only interacts via the weak interaction / The positron interacts via the electromagnetic interaction (and weak interaction)✔

The antineutrino's (weak) interaction is shorter range / the antineutrino is less likely to get close enough to interact (with particles in the water so will travel further) / the antineutrino will interact with fewer particles✔

The positron's (electromagnetic) interaction has a longer range / the positron does not have to be so close to interact (with particles in the water so will travel a shorter distance) / the positron will interact with more particles✔

Must have the correct conclusion for 3 marks.

3

[12]

Q2.

(a) substitution into $E = hc/\lambda$ ✔

multiplies E by 3.0×10^{16} to give 0.0136 (W)✔

Condone POT error on MP1

2

(b) considers the effect of wavelength on power or emission rate ✔

Red photon energy calculated (3.0×10^{-19} J) and used with $P = E_{photon} \times$ rate of emission

Alternative for MP1: red photon energy is $\frac{440}{660}$ times smaller (than blue photon energy)

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considers the maximum possible, or required, emission rate ✔

<u>maximum</u> emission rate is 6.9 × 10^{16} s^{-1}

OR

evaluates required emission rate as 9.0 × 10^{16} s^{-1}

combining MP1 and MP2 with reference to graph to reach the conclusion that it is not possible ✔

not possible as:

max emission rate is 6.9 × 10^{16} s^{-1}, and required is 9.0 × 10^{16} s^{-1}

max power is 0.021 W, and required is 0.028 W

max current is 60 mA, and required is > 60 mA

3

(c) The mark scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.

Mark	**Criteria**	**QWC**
6	All 3 areas A, B and C covered Only allow minor omissions	The student presents the relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.
5	2 complete descriptions with one partial from A, B and C.	
4	Full description of one area, with partial description of two other. OR Full description of two areas with very little on third or nothing at all.	The student presents relevant information in a way which assists the communication of meaning. The text is legible. SP&G are sufficiently accurate not to obscure meaning.
3	A full description of one area and a partial description of one area. OR A partial discussion of all three areas.	
2	A full description of one area. OR A partial discussion of two areas.	The student presents some relevant information in a simple form. The text is usually legible. SP&G allow meaning to be derived although errors are sometimes obstructive.
1	Only one area covered, and that partially.	
0	No relevant information	

Area A - Wavelength comparison:

• Red LED will emit longer wavelengths than 660 nm (accept "longer than red light).

• Blue LED will emit wavelengths longer than 440 nm (accept "longer than blue light).

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• Blue LED will emit visible light. Accept named colours.

Area B - Excitation process:
• Excitation mentioned (as first step of fluoresence)
• Photons are absorbed by atoms in coating
• Atoms are excited/gain energy;
• Atomic electrons move to higher energy levels (than n = 2)
• Photons have sufficient energy to promote electrons to high enough levels

Area C - De-excitation process:
• De-excitation or relaxation mentioned (as subsequent step)
• Photons are emitted by atoms in coating
• Atoms de-excite/lose energy
• Atomic electrons move to lower energy levels
• Electrons move to ground state via other energy levels
• Emitted radiation consists of (a range of) lower photon energies/frequencies or longer wavelengths

6

[11]

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