

Name of the Student: _____

Max. Marks : 25 Marks

Time : 25 Minutes

Mark Schemes

Q1.

- (a) Experiments suggested cathode rays were negatively charged particles ✓

Particle has mass much smaller than mass of an atom / hydrogen ion

OR

Compares Specific charge with that of hydrogen ion / atom ✓

Particles were part of the substructure of matter / atoms ✓

Particles emitted in each case were the same

OR

Particles emitted were the same for different gases / for photoelectrons and particles from thermionic emission ✓

MAX 2

Specific charge defined = 0

Millikan / Rutherford deductions = 0

Do not allow small mass alone

Allow proton

Allow two correct deductions in 1 or 2 provided that the other comment is not relevant but does not contradict,

2

- (b) (i) electrons collide with atoms of gas ✓ (condone molecules)

Reference to collisions with nucleus = 0 for the question

atoms / electrons are excited

or atoms / electrons change to higher energy states ✓

light / photon emitted when relaxation / de-excitation occurs or as electrons move / fall back to lower energy level ✓

Do not allow

- *collide with gas unless atoms mentioned later*
- *particles*
- *electrons absorbed by atoms*

Allow move from ground state

Allow return to ground state

3

(ii) $eV = \frac{1}{2}mv^2$ and $\frac{mv^2}{r} = Bev$ or $\frac{e}{m} = \frac{v}{Br}$ in any form ✓
 or $\frac{e}{m} = \frac{2V}{Br^2}$

Correct substitution of data in the question allowing errors in powers of 10 ✓

1.9×10^{11} ✓

C kg⁻¹ ✓

Do not allow

Must be seen

Substitution of values of e and m_e can gain 1st and last marks only

4

[9]

Q2.

- (a) (i) Only Box Ticked: Mesons

1

- (ii) (Muon) anti-neutrino symbol

Not electron anti-neutrino

Penalise incorrect subscript

1

- (b) (i) Use of Speed = distance / time by rearrangement and 3.75×10^{-5} (s) seen
 Or

$10.7 \times 10^3 \div 2.85 \times 10^8 = 3.75 \times 10^{-5}$ (s) seen

Or substitution **and** 3.75×10^{-5} (s) seen

No. of half-lives = $3.75 \times 10^{-5} \div 2.2 \times 10^{-6} = 17.065$ or 17.07

not 17.05 not 17.06

At least 3 sf for answer 17.1

$3.75 \times 10^{-5} \div 17 = 2.208$ or $2.21 \mu\text{s}$

At least 3 sf

Or

$17 \times 2.2 \times 10^{-6} = 37.4 \times 10^{-6}$ **with comparison**

2

- (ii) $2.5 \times 10^8 \times (1/2)^{17}$ or equivalent

1900 to 1910 (1910 maximum to 4 sf)

Answer consistent with any working seen

Use of $N = N_0 e^{-\lambda t}$ and $\lambda = \frac{\ln 2}{2.2 \times 10^{-6}}$ correct sub

Answer in range 1.8×10^3 to 1.91×10^3

(1820 minimum and 1910 maximum to 4 sf)

2

- (iii) (Theory of special) relativity

Time dilation / length contraction treat as neutral

Not general relativity

1

- (iv) • Travelling close to speed of light less time passes in muon's reference frame for the journey (so fewer decay)

- Travelling close to speed of light so journey is shorter in length for the muon's frame of reference (so fewer decay)
- Travelling close to speed of light so muons are observed to travel further in a half-life (on Earth) than expected (so fewer decay during journey)
- Travelling close to speed of light so muon's half-life is observed to be longer (on Earth) (so fewer decay)

Allow:

- travelling close to speed of light so time is slower (for muons) so fewer decay
- travelling close to speed of light so time dilates so fewer decay

1

- (v) Attempted use of $L = L_0 (1-v^2/c^2)^{1/2}$ or $t = t_0 / (1-v^2/c^2)^{1/2}$
 Correct use of $L = L_0 (1-v^2/c^2)^{1/2}$ **and** $(t_0 = L/v) = 3341/2.85 \times 10^8$

or correctly makes t_0 subject of $t = t_0 / (1-v^2/c^2)^{1/2}$

$(t_0 =) 1.17 \times 10^{-5}$ or 1.2×10^{-5} (s)

Condone mix up on L / L_0 or t / t_0

1.2×10^{-4} s gets 1 mark

Sub for L_0 as 10.7×10^3

Or sub for $t = 3.75 \times 10^{-5}$

3

- (vi) Use of $T_{1/2} = \ln 2 / \lambda$ seen with sub for $T_{1/2}$
 allow if seen in partial sub in $N = N_0 e^{-\lambda t}$

Use of $N = N_0 e^{-\lambda t}$ with $\lambda = 3.15 \times 10^5$ (or equivalent) and $t =$ answer from b(v)

5.7×10^6 to 6.3×10^6

no ecf on answer

Or use of no half-lives = $\frac{b(v)}{2.2 \times 10^{-6}}$

$$\text{And } \frac{2.5 \times 10^8}{\frac{b(v)}{2.2 \times 10^{-6}}}$$

Only accept answers in this range

No ecf on answer

3

[16]