Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Mark Schemes

Q1.

(a) (i) electrons pulled out of (gas) atoms so (gas) atoms become (+) ions
OR
ionisation by collision (also) occurs
OR
(+) ions (that) hit cathode causing it to release electrons ✓
conduction due to electrons and positive ions ✓

; Allow 'electrons ionise atoms' as compensation mark (if no marks elsewhere)

2

(ii) ions and electrons (moving in opposite directions) collide (with each other) and recombine and emit photons ✓

Owtte

electrons excite gas atoms (by collision)
and photons are emitted when de-excitation occurs ✓

If light not photons given in 1st 2 mark points, 1 max for 1st two mark points

gas needs to be at sufficiently low pressure in order that the particles (or uncharged gas atoms / ions / electrons) in the gas are widely spaced ✓

Owtte

otherwise (+) ions and / or electrons / particles would be stopped by gas atoms OR so that ions / electrons are accelerated (or gain enough ke) to cause excitation ✓

3max

(b) Specific charge = charge / mass (and
charge(s) of ion does not depend on the type of gas) ✓

Mass of ion depends on the type of gas ✓

Accept Q / m in symbols Q / m but not e / m if e / m is specifically stated as specific charge

2

[7]

Q2.

(a) (i) Distance travelled in muons' frame of reference
$= 10700(1-0.996^2)^{1/2} = 956$ m ✓
Time taken in muons' frame of reference = 3.2 μs ✓
This is 2 half-lives so number reaching Earth = 250 ✓

Downloaded from www.merit-minds.com

OR

Time in Earth frame of reference

$= 10700 / (0.996 \times 3 \times 10^8) = 3.581 \times 10^{-5}$ s ✓

Time taken in muons' frame of reference = 3.2 μs ✓

This is 2 half-lives so number reaching Earth = 250 ✓

OR

Half-life in Earth frame of reference

$=1.6 \times 10^{-6} / (1-0.996^2)^{1/2} = 17.9\times 10^{-6}$ s ✓

Time taken = 35.8×10^{-6} s ✓

This is 2 half lives so number reaching Earth = 250 ✓

OR

Distance travelled in muons' frame of reference

$= 10700(1-0.996^2)^{1/2} =956$ m ✓

Distance the muon travels in one half-life in muons reference frame

$= 0.996 \times 3 \times 10^8 \times 1.6 \times 10^{-6} = 478$ m ✓

Therefore 2 half-lives elapse to travel 956 m so number = 250 ✓

OR

Decay constant in muon frame of reference

Or decay constant in the Earth frame of reference ✓

Uses the corresponding elapsed time and decay constant in

$N = N_0 e^{-\lambda t}$ ✓

Arrives at 250 ✓

All steps in the working must be seen

Award marks according to which route they appear to be taking

The number left must be deduced from the correct time that has elapsed in the frame of reference they are using

3

(ii)

	✓ if correct
For an observer in a laboratory on Earth the distance travelled by a muon is greater than the distance travelled by the muon in its frame of reference	✓
For an observer in a laboratory on Earth time passes more slowly than for a muon in its frame of reference	
For an observer in a laboratory on Earth, the probability of a muon decaying each second is lower than it is for a muon in its frame of reference	

1

(b) (i) Total energy $= 9.11 \times 10^{-31} \times (3 \times 10^8)^2 / (1-0.98^2)^{1/2}$ ✓

4.12×10^{-13} J seen to 2 or more sf ✓

Show that so working must be seen

2

(ii) Change $= 7.5 \times 10^{-14}$ J

V = 469 (470) kV allow ecf using their answer to (i) ✓

ecf is their ((i) −3.37) × 10^{-13}) / 1.6 × 10^{-19}

Downloaded from www.merit-minds.com

Using 4 × 10^{-13} gives 394 (390) kV
Using 3.9 × 10^{-13} gives 331(330) kV
Do not allow 1 sf answer

1

[7]

Q3.

(a) emitted electrons have a range of speeds ✓

(electrostatic) force acting on electrons emitted from surface increases OR pull / attraction on electrons from surface increases ✓

microammeter reading due to electrons reaching T (moving round circuit) ✓

(microammeter reading decreases because) electrons unable to reach T due to increasing force(or insufficient ke or too much work needed) ✓

Alternative for last point ; (microammeter reading decreases because) fewer electrons can reach T as pd increases,

3 max

(b) (i) Graph ; straight line with a positive gradient ✓
intercept on + x-axis (or on – y-axis if drawn) ✓

Need to see 1st point to get the 2nd point

2

(ii) $E_{K(max)} = eV_S$ (or $E_{K(max)}$ proportional to V_S) ✓

gives $eV_S = hf - \varphi$

where hf = photon energy
and φ = work function of metal ✓

Alt for 2nd mark; recognition that

$V_S = \frac{hf}{e} - \frac{\varphi}{e}$

where φ = work function of metal so this is equation for st line (or y = mx + c)

Graph of V_S against f is a straight line with gradient h / e ✓

and x-intercept = φ / h
(or y-intercept = $-\varphi / e$) ✓

Accept either of last 2 marks if shown on the graph clearly

3 max

(c) $hf = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{418\times10^{-9}} = 4.76 \times 10^{-19}$ J ✓

Accept sub or ans for marks1 and 2

$E_{K(max)} = eV_S = 1.6\times 10^{-19} \times 1.92 = 3.07 \times 10^{-19}$J ✓

(Ans in J; allow 1.7 or 1.66 or 1.70 in place of 1.69)*

$\varphi = hf - E_{K(max)}$ (or $4.76 \times 10^{-19} – 3.07 \times 10^{-19}$)

Downloaded from www.merit-minds.com

= 1.69×10^{-19} ✓ J ✓ (or 1.06 eV)

(Ans in eV ; allow 1.1 or 1.04)*
**arises from rounding 3.07 to 3.1)*

4

[12]

Downloaded from www.merit-minds.com