Name of the Student:_____
Max. Marks : 25 Marks **Time : 25 Minutes**

Mark Schemes

Q1.

(a) Lo = 2500 m

Length = 2500 x (1 -0.95^{2})^{½} ✔

length = 781 (780) m ✔

2

(b) Number of muons passing through detector per second measured at top of mountain/in upper atmosphere AND

Allow "intensity of muons"

Number of muons passing through detector per second measured on ground. ✔

Allow number decayed/difference in numbers at upper atmosphere and ground

Measurements show far fewer muons decay than expected in time taken (in observer's frame of reference) for muons to travel from upper atmosphere to ground (as the clock in muons frame of ref runs slower than observer so half-life appears longer). ✔

Allow more muons reach the ground than expected

2

(c) Lower velocity means

Take longer to travel to ground (in either frame of reference) ✔

And time dilation effect less (in Earth frame of reference)/length contraction effect less (in muon frame of reference) (as not so close to c) ✔

More muons decay before reaching ground so rate of detection reduced ✔

If there is no reference to frame of reference or relativistic effects award Max 1.

Answer needs to be consistent with the implicit frame of reference being discussed

3

[7]

Q2.

(a) Weight/gravitational force AND electric/electrostatic force ✔

Equal (magnitudes) and opposite directions,

AND one direction at least specified ✔

The second mark is conditional on the first.

First mark is for naming the two forces.

Condone 'electromagnetic' for 'electric'

Do not allow field or potential for force.

Allow "force due to electric field"; "force due to magnetic field"

Penalise additional forces in MP2.

The second mark is for the relationship between them. Must include idea of size and direction.

e.g. weight down equals E force up/towards positive plate/away from negative plate.

Do not allow 'balanced' or 'in equilibrium' for equals

The forces can be in the form of formulae for MP1 and MP2 (e.g. Eq, EV/d, mg)

2

(b) $m = 4\pi r^3\rho/3$ and $mg = 6\pi\eta rv$ seen ✔

$r^2 = 18\ \eta v / 4\ \rho g$ is seen in in some form, in symbols or through substituted data, ✔

Correct use of equations to obtain $r = 9.7 \times 10^{-7}$ m ✔

Do not allow backward calculation

Can be seen by substitution.

Can be seen in single equation:

$4\pi r^3\rho g/3 = 6\pi\eta rv$

Do not award if v and V confused

Do not condone 1sf answer.

Must be clear answer refers to r, not r^2 for example.

If no other mark given MP1 can be awarded if F used for mg,

and/or volume AND density equations seen separately

3

(c) The number of excess electrons on the droplet is 3 ✔

In order for each half to remain stationary, the charge would have to split equally
OR
Due to the quantisation of charge, the charge cannot split equally ✔

It is not possible for both droplets to remain stationary / the student is wrong ✔

May be seen in terms of values of charge or e

Award for idea that charge would have to be 1.5e

Evidence for MP1 and MP2 may be seen together. E.g. charge on drops are e and 2e, OR 1.6×10^{-19} and 3.2×10^{-19}

Ignore reference to particles repelling each other

3

[8]

Q3.

(a) Unchanged Changed

1

(b) **The mark scheme gives some guidance as to what statements are expected to be**

seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer.

Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria	QWC
6	All 3 areas A, B and C covered Only allow minor omissions	The student presents 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 other two OR Full descriptions of two areas with very little on third or nothing at all	The student presents relevant information and 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 discussion 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		

The following statements are likely to be present.

Area A

Description of corpuscular explanation of refraction

i) Light is made up of particles/corpuscles

ii) Force acts attracting them to the water.

iii) Attraction only affects motion at the interface/boundary.

iv) Only one component of velocity / momentum (vertical) changes at the interface.

v) The (vertical component of) velocity / momentum increases which causes the change in direction.

Partial answers may be missing idea of Force (ii) or component AND boundary (iv)(iii)

Area B

Description of wave explanation of refraction

i) Wave front is incident on interface

ii) Huygens secondary <u>wavelets</u> at wave fronts.

iii) Wavelets travel more slowly in the water.

iv) The slowing down of the waves / wavelets causes the change in direction.

A partial answer may have no reference to <u>wavelets</u>

Area C

Acceptance of wave theory

Discussion of speed:

(Newton's theory required light to travel faster in the water.

And

Huygens' theory required light to move more slowly in the water.)

When the speed of light was measured in water, the value found supported Huygens' prediction.

Discussion of wave properties

Light was observed to show interference effects that cannot be explained using corpuscular theory.)

Interference effects in Young's double slit experiment can be explained by Huygens' wave theory but not by Newton's corpuscular theory.

A partial answer will refer to only one piece of evidence.

6

(c) (vibrations of) the electric wave/field and magnetic wave/field are:
perpendicular to each other ✔
perpendicular to the labelled direction of motion ✔
in phase with each other ✔

Names of both waves needed for first mark

But condone missing labels (E and B) on diagram if mentioned in text

Condone single arrow unlabelled to represent direction of travel

But Reward unlabelled arrow on axis only if no arrows on other axes

Credit writing over poor diagram

3

[10]