Name of the Student:_____
Max. Marks : 19 Marks **Time : 19 Minutes**

Mark Schemes

Q1.

(a) **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.**

Level	Criteria	QoWC
6 marks	A thorough and well communicated discussion using most of the statements in bullets 1 2 and 3	The student presents relevant information coherently, employing structure, style and SP&G to render meaning clear. The text is legible.
5 marks	A explanation that includes discussion using most of the statements in bullets 1 , 2 and 3 but may contain minor errors or omissions	
4	The response includes a well presented discussion of two from bullets 1 and two from bullet 3 and one from bullet 2	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	The response includes a discussion of one comment from each bullet	
2	The response makes comments about two bullet points (This is likely to be from bullets 2 and 3)	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	Makes relevant comment from the list	
0	No relevant coverage of the likely statements.	The student's presentation, SP&G seriously obstruct understanding.

The following statements are likely to be present:

Bullet point 1 in question

(Explanation of how shift expected)

1. PM_2 lies in the direction of the Earth's velocity

2. Speed of light different in the two directions

3. The time taken for light to travel from P to M_2 and back to P would be greater than the time taken from P to M_1 and back to P

4. If the speed of light depends on the Earth's velocity through the ether

5. Rotating the apparatus through 90° would cause the time difference

to reverse/change

6. When rotated there would be a change in the phase difference between the waves (at each point in the fringe pattern)

Bullet point 2 in the question

(Results compared with prediction)

7. The apparatus was capable of detecting shifts of 0.05 fringe

8. No shift was detected then or in later experiments when apparatus rotated

Bullet point 3 in the question (Conclusions)

9. The experiment showed that there is no absolute motion

10. Ether did not exist so light travels without the need for a material medium

11. The Earth was dragging the ether with it

Many responses fail to demonstrate an understanding that the shift pattern is there in the first place and the shift occurs due to rotation of the apparatus

They often imply that the shift is due to differences in the distance travelled

6

(b) Correct postulate

Invariance of the speed of light <u>in free space/vacuum</u>

Speed of light the same in free space

1

(c) Laws of physics have the same form in all inertial frames

Laws of physics unchanged from one inertial frame to another

The <u>same</u> laws of physics are obeyed/apply/hold in (all) inertial frames of reference/non accelerating frames of reference/frames moving at a constant velocity

Not Allowed

All laws of physics

Laws of physics are the same

Laws of physics are constant...

Mention of Newton's laws being obeyed

Allow 1 here if both (b) and (c) are correct but reversed

1

(d) Time of flight is found to be 4.41×10^{-6} s ✔

$t_o = t\sqrt{1-\frac{v^2}{c^2}}$ **OR** $t_0 = 4.41 \times 10^{-6}\ \sqrt{1-0.99^2}$ ✔

(Proper time t_0 is) 6.22×10^{-7} s ✔

Percentage remaining is (found from the graph) 82 +/– 1

OR

In muon reference frame

$L = 1310\ \sqrt{1-0.99^2}$ ✔

185 m✔

$t = \frac{185}{0.99 \times 3 \times 10^8} = 6.23 \times 10^{-7}$ s✔ allow ecf for incorrect length calculation

82 +/– 1%✔

May do
Number of half lives = $6.22 \times 10^{-7}/2.2 \times 10^{-6}$
fraction remaining = $0.5^{0.283} = 0.82$
185 m seen scores 2
Must see this stage with speed = $0.99 \times 3 \times 10^8$
Final answer in range can be awarded even if 0.99 omitted in MP3
Allow minor differences in time (3rd sf) due to rounding in processing

4

[12]

Q2.

(a) Cathode rays/electrons move from cathode toward anode

Accept move left to right.

1

The paddle wheel has gained energy from cathode rays/electrons. ✔

Accept as alternatives for energy kinetic,
energy/momentum/impulse ✔
Ignore references to force.
Ignore references to applying a magnetic field.

1

(b) Electrons are pulled out/escape from atoms OR gas atoms are ionised ✔

Condone molecules as alternative to atoms.

1

(Positive ions generated near the cathode are attracted to the cathode causing free) electrons emitted from the cathode.✔

1

Electrons are accelerated toward the anode (by the potential difference) ✔

Do not accept attraction as an alternative to acceleration.

1

(c) Reason: Idea of fewer electrons/cathode rays ✔

Effect: Paddle wheel rotates less ✔

Must score the reason mark to score the effect mark.
Ignore references to air resistance.

OR

Reason: Idea of electrons/cathode rays have higher energy/speed/momentum ✔

Effect: Paddle wheel rotates more ✔

If no mark is awarded, one mark can be awarded for the effect of the

paddle wheel rotating more where the reasoning is limited to less collisions of electrons with air molecules.

2

[7]