

Name of the Student: _____

Max. Marks : 24 Marks

Time : 24 Minutes

Mark Schemes

Q1.

- (a) The laws of physics are the same in all inertial frames of reference OWTTE
Allow specified laws eg Newton's laws applies in all inertial frames of reference
*Do not allow laws of physics are **obeyed or apply***
Allow any / every inertial frame of reference

1

- (b) (i) Converts 24 GeV to J $24 \times 10^9 \times 1.6 \times 10^{-19}$ or 3.84×10^{-9} (J) seen ✓

$$3.84 \times 10^{-9} \text{ or } 24 \times 10^9 = \frac{9.11 \times 10^{-31} \times (3 \times 10^8)^2}{\gamma} (-9.11 \times 10^{-31} \times (3 \times 10^8)^2) \quad \checkmark$$

2.14 or 2.13×10^{-5} ✓ from correct working
 at least 3 sf needed

Many convert to equivalent mass
 4.27×10^{-26} and then work in masses throughout
May include the bracketed term. Depending on whether they assume 24 GeV to be the total energy or the kinetic energy
Allow incorrect powers of 10
May use given γ and find energy and compare with 24 GeV

3

- (ii) $3000 \times 2.1 \times 10^{-5} = 0.063$ or 0.064 m ✓

1

- (c) Starts at m_0 ✓

Shallow increase to

- no more than $2m_0$ at $0.7c$
- curves (sharply) upwards becoming greater than $0.9c$ at $6m_0$
- never greater than $1.0c$
- within $\frac{1}{2}$ square of $1.0c$ at $12m_0$ ✓

Never greater than $1.0c$ *Allow statement of asymptote*

2

[7]

Q2.

- (a) electric field strength **and** magnetic flux density / magnetic field strength ✓

They are in phase with each other ✓

OR Phase difference = 0 (not 2π)

Allow E and B (not E field and B field)

Not electric field and magnetic field

Not allowed if quantities are mentioned are not related to electric and magnetic fields (e.g. frequency & wavelength) or no quantities given

2

- (b) (i) Direct and reflected waves superpose
Waves arriving directly interfere with reflected waves.
Or Direct and reflected wave produce a stationary wave ✓

When a maximum constructive interference or explanation of condition and minimum destructive interference or explanation of condition Or maximum / constructive interference at antinode and minimum / destructive interference at a node ✓

Explains maximums / antinodes and minimums / nodes in terms of wavelengths, relative phase or path difference ✓

i.e.

there is constructive interference / antinode

- reflected wave travels whole number of wavelengths further
- path difference is whole number of wavelengths
- waves are in phase

destructive interference minimum/node when

- the direct and reflected waves interfere destructively
- the waves become antiphase / 180° out of phase
- path difference is $\lambda / 2$ or $(n+1/2) \lambda$

Do not allow superimpose

Do not allow out of phase

3

- (ii) Wavelength = $\frac{3 \times 10^8}{2.2 \times 10^9}$ or 0.136 m (0.14) seen
or appreciates that the reflector has to move $\lambda/4$ ✓

0.034 or 0.035 (m) ✓

Penalise 1 sf answer

2

(c)

Light is diffracted when it falls on a slit	
Light travels as $3 \times 10^8 \text{ m s}^{-1}$ in free space	✓
Light changes speed when it enters a medium of different optical density	
Light can be polarised when it is passes through polaroid	

1

[8]

Q3.

- (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)

$$eV = \frac{1}{2}mv^2 \text{ and } \frac{mv^2}{r} = Bev \text{ or } \frac{e}{m} = \frac{v}{Br} \text{ in any form } \checkmark$$
$$\text{Or } \frac{e}{m} = \frac{2V}{B^2r^2}$$

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

$$1.9 \times 10^{11} \checkmark$$

$$\text{C kg}^{-1} \checkmark$$

Do not allow

Must be seen

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

4

[9]