



A-Level Physics
Newton's Corpuscular
Theory of Light
Mark Scheme

Time available: 52 minutes
Marks available: 38 marks

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Mark schemes

1. (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 wavelets 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 wavelets

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.

- (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]

2.

- (a) (i) Appreciation that one component changes speed while the other component at right angles does not ✓

When entering a denser medium a corpuscle / light accelerates or its velocity / momentum increases perpendicular to the interface ✓

There is a (short range) attractive force between light corpuscle and the (denser) material ✓

Not allowed:

Attraction due to opposite charges

Force making them move faster is not enough

Accelerate in medium

Not gains energy

3

- (ii) Light (was shown by experiment to) travel slower in (optically) denser medium OWTTE ✓

Condone 'waves..' instead of 'light'

OWTTE e.g. speed in vacuum higher than speed in other medium

Newton's theory required light to travel faster, wave theory suggested slower speed ✓

or

Newton's theory could not explain the slower speed

or

Huygens theory could explain the slower speed

Not allowed:

Reference to Young's two slit- question asks them about refraction

2

- (iii) A corpuscular theory predicts only two (bright) lines / high intensity patches of light whereas a wave theory predicts many fringes ✓

Corpuscles can only travel in straight lines

or

waves can produce fringes because (diffract and) interfere / superpose / arrive in and out of phase / have different path differences ✓

Need to describe the patterns ie not just interference fringes are seen for the first mark

2

- (b) Substitutes data in photon wavelength = hc / E ; Allow for substitution with no conversion to J ✓

$$2.48 \times 10^{-10} \text{ m } \checkmark$$

For electron: Substitution in $\lambda = \frac{h}{\sqrt{2mE}}$

$$2.48 \times 10^{-10} \text{ (or their } \lambda \text{)}$$

$$= 6.6 \times 10^{-34} / (2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \text{ V})^{1/2} \checkmark$$

No conversion to J gives $\lambda \approx 4 \times 10^{-29}$ and $V \approx 9 \times 10^{38}$ V)

$$V = 24(.4) \text{ V } \checkmark = 1.49 \times 10^{-18} / (\text{their } \lambda)^2 \checkmark$$

Allow small rounding errors in dp

May calculate v using $v = h / m\lambda$ then substitution in

$$V = \frac{1}{2} mv^2 / e \checkmark \text{ (for third mark)}$$

4

[11]

3.

- (a) Light consists of corpuscles that travel in straight lines ✓

Condone 'particles' for 'corpuscles'

Accept description of travelling in straight lines.

(which means that) shadows are formed with sharp edges ✓

*In MP2 accept: no diffraction, **only/just** 2 lines/fringes seen, sharp shadows, lines are distinct*

Treat references to interference as neutral.

2

- (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
6	All three areas covered well. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to cover all 3 areas, but one area may only be covered partially.
4	Two areas successfully covered, or one covered and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
3	One area covered and one covered partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	One area covered, or two covered partially
1	Only one area partially covered.
0	No relevant analysis.

Accept information seen in an appropriate diagram.
The following statements are likely to be present.

A alterations to experiment

Slits separation / width should be closer to wavelength of wave.
Make slits narrower and closer together.
Use monochromatic (red) light.
Use a single slit (to make the light coherent).
Use a laser as it is coherent/ monochromatic.

B description of Huygens' theory

Light is a wave.
The theory uses the idea of (secondary) wavelets.
Every point on wavefront acts as source of secondary wavelets.

C explanation in terms of Huygens

(When wave reaches slit) each point at slit produces secondary wavelets.
Wavelets overlap on screen.
Path difference due to different distances between a point on the screen and the two slits.
Path difference introduces phase differences.
Bright fringes form where path difference is whole number of wavelengths/waves arrive in phase.
Dark fringes where path difference is odd number of half wavelengths/waves arrive in antiphase. Do not accept 'out of phase'.

The mention of destructive/constructive interference or diffraction on its own does not gain credit.

6

- (c) (Most of the screen dark)

Newton's theory predicts:

(bright) central spot surrounded by partial shadow ✓

Credit labelled additions to diagram

Condone MP1 for any suggestion of gradual decrease in brightness moving out from central region, e.g. suggestion it resembles a central maximum with no other maxima. Do not accept fringe.

Huygens' theory predicts:

(bright region with) fringes around the edge ✓

edge of bright region / fringes coloured ✓

3

[11]

4.

- (a) particles of light/corpuscles **(1)**
attracted towards glass surface (on entry into glass) **(1)**
velocity/momentum normal to surface increased **(1)**
velocity/momentum parallel to surface unchanged **(1)**

max 3

- (b) (i) Newton predicted $\text{speed}_{\text{glass}} > \text{speed}_{\text{air}}$
and Huygens predicted $\text{speed}_{\text{glass}} < \text{speed}_{\text{air}}$ **(1)**
- (ii) named experiment **(1)**
relevance explained **(1)**
(e.g. Young's double slit **(1)** give rise to fringes/interference
which is a wave property **(1)**
or diffraction of light **(1)** which is a wave property **(1))**

3

[6]