Mark schemes

1 (a) (i) Voltmeter across terminals with nothing else connected to battery / no additional load. ✓

1

(ii) This will give zero / virtually no current ✓

1

(b) (i) $\frac{VI}{\varepsilon I}$

Answer must clearly show power: εI and VI, with I cancelling out to give formula stated in the question ✓

1

(ii) Voltmeter connected across cell terminals ✓

Switch open, voltmeter records ε
Switch closed, voltmeter records *V*
Both statements required for mark ✓

Candidates who put the voltmeter in the wrong place can still achieve the second mark providing they give a detailed description which makes it clear that:

To measure emf, the voltmeter should be placed across the cell with the external resistor disconnected

And

To measure V, the voltmeter should be connected across the external resistor when a current is being supplied by the cell

2

(c) Vary external resistor and measure new value of *V*, for at least 7 different values of external resistor ✓

Precautions - switch off between readings / take repeat readings (to check that emf or internal resistance not changed significantly) ✓

2

(d) Efficiency increases as external resistance increases ✓

Explanation
Efficiency = Power in R / total power generated
$I^2R / I^2(R + r) = R / (R + r)$
So as *R* increases the ratio becomes larger or ratio of power in load to power in internal resistance increases ✓

Explanation in terms of V and ε is acceptable

2

[9]

2 (a) 2.9% ✓

Allow 3%

1

(b) $\frac{1}{3.5\times10^3}$ seen ✓

1

0.29 mm or 2.9 x 10^{-4} m✓ must see 2 sf **only**

1

(c) ± 0.01 mm ✓

1

(d) Clear indication that at least 10 spaces have been measured to give a spacing = 5.24 mm✓

spacing from at least 10 spaces
Allow answer within range ±0.05

1

(e) Substitution in $d\ sin\theta = n\lambda$✓

The 25 spaces could appear here as n with sin θ as 0.135 / 2.5

1

d = 0.300 x 10^{-3} m so
number of lines = 3.34 x10^3✓

Condone error in powers of 10 in substitution

Allow ecf from 1-4 value of spacing

1

(f) Calculates % difference (4.6%) ✓

1

and makes judgement concerning agreement ✓

Allow ecf from 1-5 value

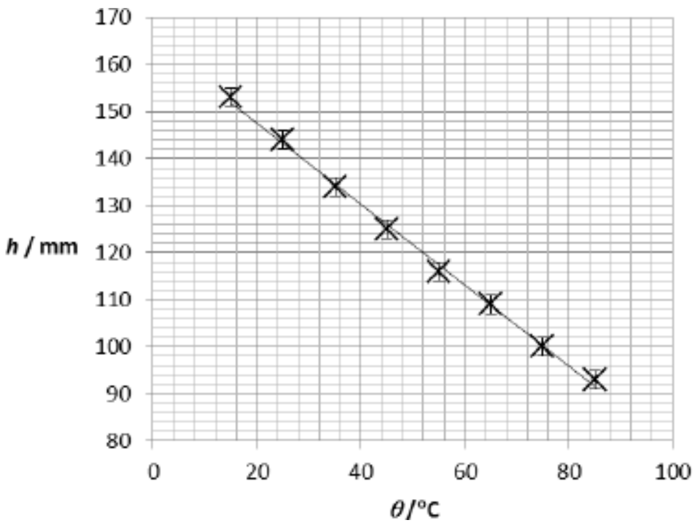
1

(g) care not to look directly into the laser beam✓
OR
care to avoid possibility of reflected laser beam ✓
OR
warning signs that laser is in use outside the laboratory✓
ANY ONE

1

[10]

3 (a) Straight line of best fit passing through all error bars ✓



Look for reasonable distribution of points on either side

1

(b) h_0 = 165 ± 2 mm✓

1

(c) Clear attempt to determine gradient ✓

1

Correct readoffs (within ½ square) for points **on line** more than 6 cm apart and correct substitution into gradient equation ✓

1

h_0k gradient =(-) 0.862 mm K^{-1} and negative sign quoted ✓

Condone negative sign
Accept range -0.95 to -0.85

1

(d) $k = \frac{\text{candidate value for } h_0 k}{\text{candidate value for } h_0}$

= 5.2 x 10^{-3} ✓

Allow ecf from candidate values

1

K^{-1} ✓

Accept range 0.0055 to 0.0049

1

(e) for h = 8000 mm, $d^{-1} = \frac{8000}{14.5}$ ✓

1

d = 1.8 x 10^{-3} mm ✓

1

(f) Little confidence in this answer because

One of

It is too far to take extrapolation ✓

OR

This is a very small diameter ✓

1

[10]

4 (a) path difference for two waves ✓

Allow 'waves travel different distances'

Condone out of phase

gives rise to a phase difference ✓

if phase and path confused only give 1 for first 2 marks

Destructive interference occurs ✓

allow explanation of interference

3

(b) (Path difference =) 0.056 m ✓

Path difference = 2λ or wavelength = 0.028 m ✓e

Use of $f = c/\lambda$ so f = 11(10.7) × 10^9 Hz ✓

Allow 2 max for 5.4 × 10^9 Hz or 2.7 × 10^9 Hz

Allow ecf

3

(c) Intensity decreases with distance ✓

One wave travels further than the other ✓

Amplitudes/intensities of the waves at the minimum points are not equal ✓

Or "do not cancel out"

max 2

(d) The signal decreases/becomes zero ✓

The waves transmitted are polarised ✓

zero when detector at 90° to the transmitting aerial/direction of polarisation of wave ✓

max 3

[11]

5 (a) Both t_m values correct: 0.404, 0.429

AND

Both t_m^2 values correct: 0.163, 0.184 ✓

Exact values required for the mark.

1

(b) Both plotted points to nearest mm ✓
Best line of fit to points ✓

The line should be a straight line with approximately an equal number of points on either side of the line.

2

(c) Large triangle drawn (at least 8 cm × 8 cm) ✓
Correct values read from graph ✓
Gradient value in range 0.190 to 0.222 ✓

Allow 2 or 3 sf for gradient

3

(d) g = 9.71 (ms^{-2}) or correct value from gradient value in **(c)** ✓.

(The answer must be in the range 9.0 to 10.5 (ms^{-2})).

Allow 2 or 3 sf.

Unit not required

1

(e) $\%\ difference = \frac{(9.81 - 9.71)}{9.81} \times 100 = 1.02$

OR correct computation using value from **(d)** ✓

If the candidate's value is exactly 9.81, then a statement that there is no (or zero) percentage difference is acceptable.

No sf penalty.

NB. Allow an answer from a calculation with either the candidate's value or the accepted value as the denominator in the equation.

1

(f) 0.001 s✓ (half the spread)
(Must have unit).

1

(g) $g = 2s/t_m^2$ ✓
= 2 × 0.300/0.245^2 ✓
= 10.0 (or 10.00) ms^{-2} ✓

Unit required and 3 or 4sf for the last mark.

3

(h) % uncertainty in s = 0.33 **and**
% uncertainty in t_m = 0.41 ✓

*Allow ecf from part **(f)**.*

% uncertainty in g
= 0.33 + (2 × 0.41) = 1.15 ✓

Allow ecf at each stage of calculation.

Uncertainty in g
= 10.0 × 1.15/100 = 0.12 m s^{-2} or 0.1 m s^{-2} ✓

*Allow ecf from part **(g)**.*

(allow 1 or 2 sf only)
(Must have unit for 3rd mark).

3

(i) (a) Use spherical objects of different mass **and** determine mass with balance ✓

Annotate the script with the appropriate letter at the point where the mark has been achieved.

(b) Would need **same diameter** spherical objects for fair comparison (same air resistance etc) ✓

(c) Time spherical object falling through same height **and** compare times

*Alternative for **(c)**:*
i.e. repeat whole of experiment, plot extracted values of g against mass. Horizontal line expected, concluding acceleration same for different masses.

3

[18]

6 (a) Capacitor must not lose charge through the meter ✓

1

(b) Position on scale can be marked / easier to read quickly etc ✓

1

(c) Initial current = $\frac{6}{100000}$ = 60.0 μA ✓

100 μA or 200 μA ✓ (250 probably gives too low a reading)

Give max 1 mark if 65 μA (from 2.6) used and 100 μA meter chosen

2

(d) 0.05 V ✓

1

(e) Total charge = 6.0 x 680 x 10^{-6} (C) (= 4.08 mC) ✓

Time = 4.08 x 10^{-3} / 60.0 x 10^{-6} = 68 s ✓

Hence 6 readings ✓

3

(f) Recognition that total charge = 65 t μC and final pd = 0.098 t

so C = 65μ / 0.098✓

660 μF ✓

Allow 663 μF

2

(g) (yes) because it could lie within 646 – 714 to be in tolerance ✓

OR

it is 97.5 % of quoted value which is within 5% ✓

1

(h) Suitable circuit drawn ✓

Charge C then discharge through R and record V or I at 5 or 10 s intervals ✓

Plot ln V or ln I versus time ✓

gradient is 1 / RC ✓

OR

Suitable circuit drawn ✓

Charge C then discharge through R and record V or I at 5 or 10 s intervals✓

Use V or I versus time data to deduce half-time to discharge ✓

1 / RC = ln 2 / $t_{½}$ quoted ✓

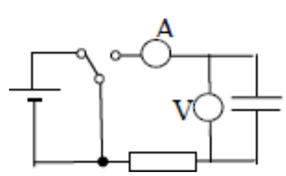
OR

Suitable circuit drawn ✓

Charge C then discharge through R and record V or I at 5 or 10 s intervals ✓

Plot V or I against t and find time T for V or I to fall to 0.37 of initial value ✓

$T = CR$ ✓



Either A or V required

For 2nd mark, credit use of datalogger for recording V or I.

4

[15]

Examiner reports

1

(a) (i) Students had to make it clear that the voltmeter 'alone' should be connected across the cell.

(ii) A correct explanation was given by a large proportion of students.

(b) (i) Answered well by the more able students.

(ii) A proportion of students seemed to understand how to use the voltmeter but failed to show the correct position on the circuit diagram.

(c) This question discriminated well. Many students failed to give sufficient detail as required by the mark scheme for the first marking point. The second marking point proved to be more accessible, with a greater proportion of students able to suggest an appropriate precaution.

(d) As anticipated this proved to be very demanding, with only the more able students successfully stating and explaining why efficiency would increase as external resistance increases.

4

This question placed the idea of double slit interference in the less familiar context of microwave transmission. Students who failed to make the link with interference found it difficult to make much headway in this question. There was evidence of students ignoring the context and writing in terms of sound or visible light.

(a) It was common to see answers referring to a simple line of sight issue related to the three metal plates, despite references to double slit interference in the stem. This may suggest that students fail to read the stem of a question with sufficient care, a problem that may be alleviated if students were in the habit of underlining key words as they read. Students who understood the context often lost marks by confusing path difference and phase difference. Being familiar with the difference, and relationship, between these two is fundamental to an understanding of interference in waves.

(b) This is a fairly demanding multi-step problem that many found difficult. In order to answer this question, students were required to relate the data in the diagram to the path difference of the waves, specifically 2 x the wavelength. They also had to apply the wave equation to the answer they obtained. Those who managed to make some attempt at an answer commonly missed the double wavelength, or made an arithmetical error in the use of speed = frequency x wavelength.

(c) Many students suggested that total destructive interference cannot occur, without relating it to the different amplitudes of the waves due to their different path lengths. This is probably due to the fact that students commonly picture waves of equal amplitude interfering, irrespective of path length. Incorrect answers included suggestions that other sources of microwaves, including the CMBR, were to blame.

(d) Most students were able to make an attempt to link the phenomenon described in this question to the polarisation of the waves. Some students interpreted the line AE as another sequence of slits and suggested that the microwaves were being blocked. Many had difficulties expressing their answer in terms of the orientation of the microwave and aerial, with some stating that the signal would increase as the aerial was aligned with the maxima.

5

(a) Correctly answered by almost all candidates.

(b) As usual in this question a small proportion of candidates failed to accurately plot both points and an even greater proportion were unable to draw an acceptable line of best fit.

(c) Less marks were lost on this question than in previous years, most likely because these were mostly A2 candidates re-sitting the paper. Most candidates were able to calculate a gradient value within the allowed range.

(d) This was straightforward for nearly all candidates.

(e) A familiar question, well answered by most candidates.

Parts **(f)**, **(g)** and **(h)** discriminated well, with only the most able candidates scoring five marks or more.

(f) The easiest part of the question, requiring use of 'uncertainty = 0.5 × range'

(g) Although this was considered to be straightforward, many candidates failed to score the full three marks. Common errors were incorrect substitution into the formula and missing the unit in the final answer.

(h) This was the most discriminating part of the question, with candidates often scoring no marks. The process of adding percentage uncertainties to calculate the percentage uncertainty in the calculated value of g, and then converting back to an absolute uncertainty with suitable significant figures and unit was beyond most candidates.

(i) This proved to be difficult, and only the most able candidates scored more than one mark. An easy mark was often lost by lack of reference to measuring the mass of the spheres with a balance. Many candidates failed to realise that for a fair comparison the spherical objects would need to have the same diameter so that air resistance was the same.