Paper 2 Mark scheme

Question Number	Acceptable Answers	Additional Guidance	Mark
1	D		**1**
2	B		**1**
3	C		**1**
4	A		**1**
5	B		**1**
6	A		**1**
7	C		**1**
8	C		**1**

(Total for Multiple Choice Questions = 8 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
9	Analyses data by: • use of $v = f\lambda$ **(1)** • $\lambda = 6 \times 10^{-4}$ m **(1)** • stone about 4 mm from photo **(1)** **AND** • concludes this would give sufficient resolution at this frequency because the wavelength is less than half the size of the kidney stone **(1)**	Example of calculation: 1500 m s^{-1} = 2.5 $\times 10^{6}$ Hz $\times \lambda$ $\lambda = 6 \times 10^{-4}$ m	**4**

(Total for Question 9 = 4 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
10 (a)	A description that makes reference to: • for unpolarised waves – oscillations/vibrations in many directions **(1)** • after undergoing polarisation – oscillations/vibrations in a single direction **(1)** • which is perpendicular to direction of propagation **(1)** **OR** • for unpolarised waves – oscillations/vibrations in many planes **(1)** • after undergoing polarisation – oscillations/vibrations in a single plane **(1)** • and this plane includes direction of propagation **(1)**	Marks should be awarded from one sequence only.	**3**
10 (b)	An explanation that makes reference to: • microwaves from source are polarised **(1)** • plane of polarisation of filter and the plane of polarisation of the waves are parallel at first, therefore microwaves pass through **(1)** • plane of polarisation of filter and the plane of polarisation of the waves are perpendicular to each other after rotation, therefore microwaves are absorbed **(1)**		**3**

(Total for Question 10 = 6 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
11 (a)	• use of mass = density × volume **(1)** • use of upthrust = weight of fluid displaced = $m \times g$ **(1)** • upthrust = 8.3×10^{-4} N **(1)**	Example of calculation: mass of liquid displaced = 1300 kg $m^{-3} \times 6.5 \times 10^{-8}$ m^3 mass of liquid displaced = 8.45×10^{-5} kg upthrust = 8.45×10^{-5} kg × 9.81 m s^{-1}	**3**
11 (b)	• viscous force = weight – upthrust **(1)** • use of $F = 6\pi\eta rv$ **(1)** • viscosity = 18 (kg m^{-1} s^{-1}) **(1)**	Example of calculation: viscous force = W - U = 4.8×10^{-3} N - 8.3×10^{-4} N = 3.97×10^{-3} N $\eta = 3.97 \times 10^{-3}$ N / ($6 \times 3.14 \times 4.6 \times 10^{-3}$ m $s^{-1} \times 2.5 \times 10^{-3}$) η = 18 kg m^{-1} s^{-1}	**3**

(Total for Question 11 = 6 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
12 (a)	An explanation that makes reference to: • waves/light passing through a narrow gap spread/s out **(1)** • light reaches the wall from each part of the slit with differing phase relationships **(1) OR** light reaches the wall from each part of the slit with differing path lengths **(1)** • when the waves meet superposition takes place and if the waves are in antiphase it results in destructive interference so a dark spot is seen **(1) OR** when the waves meet superposition takes place and if the waves are in phase it results in constructive interference so a bright(er) region is seen **(1)**	Accept relevant reference to Huygen's construction for first mark.	**3**
12 (b)	An explanation that makes reference to: • green light has a shorter wavelength than red light **(1)** **OR** red light has a longer wavelength that green light **(1)** • so green light diffracts less than red light **or** red light diffracts more than green light **(1)** • so the dark points would be closer to the centre or more dark points would be seen in the same space on the wall or central fringe narrower **(1)**	Accept a diagram clearly to the same scale and showing a narrowed pattern. MP2 and MP3 may be awarded if reference is made to frequency difference rather than wavelength.	**3**

Question Number	Acceptable Answers	Additional Guidance	Mark
12 (c)	• use of trigonometrical functions to calculate θ **(1)** • calculate diffraction grating spacing **(1)** • wavelength = 5.1×10^{-7} m **(1)**	Example of calculation: $\theta = \tan^{-1}$ (0.23 m/1.5 m) = 8.7° $d = 10^{-3}/300 = 3.3 \times 10^{-6}$ m $\lambda = 3.3 \times 10^{-6}$ m × sin 8.7° $= 5.1 \times 10^{-7}$ m	**3**

(Total for Question 12 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
13 (a)(i)	• measure angle of incidence at edge (53°) **(1)** • use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ **(1)** • value of angle in glass = 32° **(1)**	±1° tolerance Allow ecf for candidate's value Example of calculation: $1 \times \sin 53° = 1.5 \times \sin\theta_2$ $\theta_2 = 32°$	**3**
13 (a)(ii)	• show refraction towards normal entering glass and how refraction away from normal exiting glass **(1)**		**1**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>13 (b)*</td>
<td>This question assesses a student’s ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded fo indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>13 (b)*

Continued</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.

<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td><td></td><td>6</td></tr>
</table>

Question Number	Acceptable Answers	Additional Guidance	Mark
13 (b)* **Continued**	**Indicative content** • a narrow ray should be used • because it reduces uncertainty in the position (angle) of the ray (accept allows position to be determined with greater precision) • a range of large angles should be used • because the precision of the measurement will be determined by the protractor • for larger angles the percentage uncertainty will be smaller • a smaller uncertainty in the final answer from sin *i*/sin *r* (and thus greater accuracy) **OR** graph		**6**

(Total for Question 13 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
14 (a)	• use of difference in energy levels in eV and use of $W = QV$ for conversion to Joule **(1)** • use of $E = hf$ **(1)** • frequency = 7.2×10^{13} Hz **(1)**	Example of calculation: difference in energy levels = –0.55 eV – (–0.85 eV) = 0.3 eV = 0.3 V × 1.6×10^{-19} C = 4.8×10^{-20} J $f = 4.8 \times 10^{-20}$ J ÷ 6.63×10^{-34} Js = 7.2×10^{13} Hz	**3**
14 (b)	An explanation that makes reference to: • if photon energy equal to an energy level difference in the elements present **(1)** • then the photon can be absorbed by an electron and the electron is excited/moves to higher level **(1)** • so the absorption spectrum is created because the frequencies of the absorbed photons are missing from the continuous spectrum produced by the star **(1)**	Accept references to re-emission in all directions.	**3**

(Total for Question 14 = 6 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
15 (a)(i)	An explanation that makes reference to: **EITHER** • holding the lens steady in your hand would be difficult and would make the distance measurement inaccurate **(1)** • so the lens should be in a holder on a stable surface to make the measurement accurate **(1)** **OR** • holding the ruler steady parallel to the principal axis would be difficult and make the distance measurement inaccurate **(1)** • so the ruler should be on a stable surface to make the measurement accurate **(1)** **OR** • focal length is image distance when object distance is infinite **(1)** • this is not at infinity so lens formula should be used **(1)**	These marks can be awarded only for answers in the context of the method described in the question. Reference to use of an optical bench is acceptable. Reference to use of a clamp is acceptable.	**2**

Question Number	Acceptable Answers	Additional Guidance	Mark
15 (a)(ii)	• use of power = 1/focal length **(1)** • calculates at least two powers correctly **(1)** • analyses data to compare powers or focal lengths **(1)** • draws a conclusion that is consistent with calculated values about how well the relationship is supported **(1)**	This is a comparison, so use of cm not penalised if used for all and unit D is not required. MP3 calculates combined power and uses it to calculate focal length for the combination and compares this with the measured value of focal length. Example of calculation: $P = 1/f$ power $_{lid} = 1/0.12 = 8.3$ D power $_{optional} = 1/0.175 = 5.7$ D power $_{combined} = 1/0.07 = 14$ D 8.3 + 5.7 = 14 D	**4**
15 (b)	• use of $1/v + 1/u = 1/f$ **(1)** • use of magnification = v/u **(1)** • magnification = 3.5 **(1)**	Example of calculation $1/v = 1/7.0 – 1/5.0$ $v = 17.5$ cm $M = 17.5 / 5.0 = 3.5$	**3**

(Total for Question 15 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
16 (a)	An explanation that makes reference to: • coherent means there is a constant phase relationship **(1)** • for some parts of the beam the phase difference could be 180°/in antiphase **(1)** • causing destructive interference and therefore zero amplitude **(1)**		**3**
16 (b)(i)	• state or use of $\mathcal{E} = V + Ir$ **(1)** • $r = 28.6\ \Omega$ **(1)**	Example of calculation: $4.1\ \text{V} = 3.7\ \text{V} + 0.014\ \text{A} \times r$ $r = 28.6\ \Omega$	**2**
16 (b)(ii)	• use of $I = P/A$ **(1)** • use of $P = IV$ **(1)** • calculation of efficiency of pointer **(1)** • analysis of data in passage to give efficiency of laser as approximately 40% **(1)** • comparing data analysed to draw a conclusion that the claim is not justified. **(1)**		**5**

(Total for Question 16 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
17 (a)	An explanation that makes reference to: • balance measures to 1 g **(1)** • more rubber bands should have been placed on the balance to obtain a reading of at least 10 g **(1)** • so that a more precise reading is obtained **(1)**		**3**
17 (b)	• use of area under graph to represent work done **(1)** • uses area accurately between line and distance axis to determine work done **(1)** • 0.97 J (range from printed graph) **(1)**	Do not award first mark for use of E=1/2Fx	**3**
17 (c)	• use of ke = ½ mv^2 **(1)** • v = 70 m s^{-1} **(1)**	Example of calculation: 0.97 J = ½ mv^2 = ½ 0.0004 kg × v^2 v = 70 m s^{-1}	**2**
17 (d)	An explanation that makes reference to: • video the band over a short distance so it determines the initial speed **(1)** **OR** because its speed will rapidly reduce because of air resistance **(1)** • include a scale or object of known length in the area filmed **(1)** • analyse the video to determine the time taken to travel the known distance **AND** calculate the speed using the measured time in speed = distance/time **(1)** • (light gates would not be suitable because) the band is not sufficient in size to interrupt the light gate beam **(1)**		**4**

(Total for Question 17 = 12 marks)

PMT

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