

Name: _____

Optics

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: _____

Mark Scheme

Q1.

Question Number	Answer	Mark
	D	1

Q2.

Question Number	Answer	Mark
	C - 1.5	1
	Incorrect Answers: all select incorrect data from question Correct method: image distance \div object distance A – uses focal length \div object distance B – uses object distance \div image distance D – uses object distance \div focal length	

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	B	1

Q5.

Question Number	Acceptable Answers	Additional guidance	Mark
	<ul style="list-style-type: none"> increases the power (of the eye) Or to decrease the image distance Or to shorten the focal length (of the eye and lens) Or to the eye it makes the rays appear to come from an object further away (1)	If a candidate states that the image is formed at the focal point or that the retina is at the focal point do not award this mark	1

Q6.

Question Number	Answer	Mark
	A	1

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	<ul style="list-style-type: none"> Use of $P = \frac{1}{f}$ 1220 (mm) 	<p><u>Example of calculation</u></p> <p>0.82 D = 1/f</p> <p>f = 1 / 0.82 D = 1.22 m</p> <p>Accept 122 (cm)</p>	2

Q8.

Question Number	Acceptable Answers	Additional guidance	Mark
	<ul style="list-style-type: none"> Two straight lines drawn extrapolated from diverging rays meeting at a single point on the principal axis focal length = (-) 2.3 to 2.4 cm 	Accept dotted or solid lines	2

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	<ul style="list-style-type: none"> • difference in speed for air to cornea much greater than difference in speed from water to cornea Or lower refractive index for water to cornea (= 1.03) (1) • so less refraction Or so power of eye/cornea reduced (1) Or so focal length of eye/cornea increased • if goggles worn the interface is with air and refraction is as normal (1) Or if goggles worn the interface is with air and image focused on retina 	MP1: Seeing values of refractive index as 1.03 and 1.38 is not enough, a comparison is required.	3

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
	<ul style="list-style-type: none"> • Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with $u = 100$ and $v = (-)300$ (1) • $f = 150$ (mm) (1) • converging lens with focal length 150 mm (1) 	(MP3 dependent on MP2) <u>Example of calculation</u> $\frac{1}{f} = \frac{1}{100 \text{ mm}} - \frac{1}{300 \text{ mm}}$ $\frac{1}{f} = \frac{3 - 1}{300 \text{ mm}}$ $f = 150 \text{ mm}$ MP3 accept if annotated in question Accept convex for converging	3

Q11.

Question Number	Acceptable Answers	Additional guidance	Mark
	<ul style="list-style-type: none"> • Use of $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ (1) • Use of $P = \frac{1}{f}$ (1) • $P = 46 \text{ D} / \text{Dioptrre} / \text{dioptrre}$ (1) 	Accept MP2 if you see $\frac{1}{25}$ or $\frac{1}{2.4}$ for $\frac{1}{f}$ <u>Example of Calculation</u> $\frac{1}{0.25} + \frac{1}{0.024} = 46 \text{ D}$	3

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	Either <ul style="list-style-type: none"> • Rays from (a point) on the moon are <u>parallel</u> (1) • So the rays converge to the principal focus Or so the image is formed at the principal focus (1) Or <ul style="list-style-type: none"> • Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with $u = \infty$ or very large (1) • $f = v$ (1) 	Description of focal length as: the distance between the lens and point at which parallel rays will converge (after passing through lens), scores 2 Accept focal point for principal focus (MP2 dependent on MP1) (MP2 dependent on MP1)	2

Question Number	Acceptable answers	Additional guidance	Mark
(ii)	Real Diminished Inverted (2)	One/Two properties scores 1 mark Three properties score 2 marks Accept smaller Accept upside down	2

Q13.

Question Number	Acceptable answers	Additional guidance	Mark
	<ul style="list-style-type: none"> • use of $P = 1/f$ (1) • use of $P = P_1 + P_2$ etc (1) • total power = 63.8 (D) (1) • Comparative statement consistent with their values (1) 	<p>MP4 An attempt at a % must be made and a clear comparison with the 80% must be made</p> <p>e.g % for cornea from 44.8 / 63.8 is 71% which is not 80% so no</p> <p><u>Example of calculation</u></p> <p>$P_{\text{cornea}} = 1/0.0223 \text{ m} = 44.84 \text{ D}$</p> <p>$P_{\text{lens}} = 1/0.0527 \text{ m} = 18.98 \text{ D}$</p> <p>Total power = 63.82 D</p>	4

Q14.

Question Number	Answer	Mark
(a)	Change in direction of wave (accept ray or any named wave) (do not accept bend) (1) (Due to) change in (optical) density / speed / medium (1)	2

Question Number	Answer	Mark
(b)	There is no change in direction for the light (passing between the water and the gel) Or There is no refraction (as the light passes between the water and the gel) (accept ... within the beaker) (1) The light must have the same/similar wave speed in the water and gel (1) (accept same/similar density for water and gel)	2

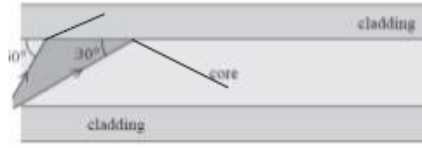
Q15.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> • use of $1/f = 1/u + 1/v$ (1) • $u = 4.8 \text{ cm}$ (1) 	<u>Example of calculation</u> $1/1.6 \text{ cm} = 1/u + 1/2.4 \text{ cm}$ $u = 4.8 \text{ cm}$	2

Question Number	Acceptable answers	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> • use of $n = c/v$ (1) • use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ Or $n = \sin i / \sin r$ with correct angles (1) • $\theta = 11^\circ$ (1) 	Accept use of $v_2 \sin \theta_1 = v_1 \sin \theta_2$ for MP1 and MP2 but $v_1 \sin \theta_1 = v_2 \sin \theta_2$ scores neither <u>Example of calculation</u> $n = 3 \times 10^8 \text{ m s}^{-1} / 2.18 \times 10^8 \text{ m s}^{-1}$ $= 1.376$ $1 \times \sin 15^\circ = 1.376 \times \sin \theta$ $\theta = 10.8^\circ$	3

Q16.

Question Number	Acceptable answers	Additional guidance	Mark
(a)	<ul style="list-style-type: none"> • Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ • Angle in cladding $\theta = 90^\circ$ • Critical angle = 50.3° 	<p>(1) Accept alternative method using $\sin c = \frac{1}{n}$ and $n = \frac{c}{v}$</p> <p>(1) to give $n = \frac{v_{cladding}}{v_{core}}$ Or $n = \frac{n_{core}}{n_{cladding}}$</p> <p>(1) Use of $\sin c = \frac{1}{n}$ with $n=1.2$ or 1.56 gains 1 mark</p> <p><u>Example of calculation</u> e.g. $1.56 \sin \theta_1 = 1.20 \sin \theta_2$</p> <p>$1.56 \sin c = 1.20 (\sin 90^\circ)$</p> <p>$\sin c = \frac{1.20}{1.56} \quad c = 50.3^\circ$</p>	3

Question Number	Acceptable answers	Additional guidance	Mark
(b)	<ul style="list-style-type: none"> • Left hand side of beam refracts away from normal • Right hand side of beam totally internally reflected • State Student C is correct 	<p>(1) Ignore any line continued beyond cladding Ignore any reflection</p> <p>(1) Reflection correct by eye Do not award if any line shown in cladding</p> <p>(1) (MP3 dependent on MP1 and MP2)</p>  <p>Arrows on rays not needed</p>	3

Q17.

Question Number	Acceptable Answers	Additional guidance	Mark
	<ul style="list-style-type: none"> Light is refracted as it passes into medium 2 (1) Angle of refraction may be calculated (1) using $n_1 \sin \theta_1 = n_2 \sin \theta_2$ Angle of refraction = 89.81° (1) Angle of <u>incidence</u> at layer 2-3 is greater than the critical angle (1) So <u>total internal reflection</u> occurs (at layer 2-3 interface) (1) So light/ rays appear to come from surface of road (so that observer sees mirage) (1) 	MP2 see use of the equation MP5 accept totally internally reflected and TIR MP6 is not just for saying there is a mirage. <u>Example of Calculation</u> $\sin^{-1} \left(\frac{1.00032 \times \sin 89.59^\circ}{1.00030} \right) = 89.81^\circ$	6

Q18.

Question Number	Answer	Mark
(a)	Measure angles of incidence and refraction (clear variants accepted or correct angles shown on a diagram)('i' and 'r' accepted) (1) Plots $\sin i$ vs $\sin r$ (1) Correct gradient identified for their graph (assume $\sin i$ on y axis unless stated otherwise, assume statements using 'vs' or 'against' state y axis first) (1) [If angle of reflection referred to instead of refraction, only allow 2 nd mark] (Allow 3 rd but not 2 nd mark if i vs r and point from line used in $\mu = \sin i / \sin r$)	3
(b)(i)	angle of incidence (for light travelling from denser medium) (1) has angle of refraction of 90° (may refer to leaving along surface/boundary) (1)	2
(b)(ii)	Use of $\mu = \sin i / \sin r$ (accept stating $\sin c = 1 / \mu$) (1) $c = 49^\circ$ (n.b. ue applies) (1)	2
	<u>Example of calculation</u> $\sin c = 1 / \mu = 1 / 1.33$ $c = 49^\circ$	
	Total for question	5

Question Number	Answer	Mark
(a)	(When light strikes a boundary with) angle of incidence greater than the critical angle Or When light within a denser medium strikes a boundary with a less dense medium All of the light is reflected Or none of the light is transmitted Or none of the light is refracted	(1) (1) 2

Question Number	Answer	Mark
(b)(i)	Use of $\mu = \sin i / \sin r$ $x = 41(^{\circ})$ <u>Example of calculation</u> $\sin x = \sin 60^{\circ} / 1.33$ $x = 40.6^{\circ}$	(1) (1) 2
(b)(ii)	Use of $\mu = \sin i / \sin r$ with $i = 90^{\circ}$ (accept stating $\sin c = 1 / \mu$) $c = 49(^{\circ})$ <u>Example of calculation</u> $\mu = \sin 90^{\circ} / \sin c$ $\sin c = 1 / \mu = 1 / 1.33$ $c = 49^{\circ}$	(1) (1) 2
(b)(iii)	Angle in gel < critical angle Or angle y < critical angle Or (If angle $x =$ angle y , then this corresponds to an) angle in air of 60° Not total internal reflection so some light reaches screen Or Light will be refracted/transmitted so some light reaches screen	(1) (1) 2

Q20.

Question Number	Answer	Mark	
(a)	Credit any sensible limitation Examples include: <ul style="list-style-type: none"> • blunt pencil, • protractor divisions only to one degree, • protractor of limited radius • method requires rays to be marked and then drawn on Limited precision – linked to limitation	(1) (1) (1) (1) (1) (1) (1)	2
(b)	Use of refractive index = ratio of speeds Speed = $2.0 \times 10^8 \text{ m s}^{-1}$ <u>Example of calculation</u> speed in plastic = $3.0 \times 10^8 \text{ m s}^{-1} \div 1.52$ = $1.97 \times 10^8 \text{ m s}^{-1}$	(1) (1)	2
(b)(ii)	Use of $\sin c = 1/\mu$, $\sin c = 1/n$ (or equivalent, but must allow full solution if used correctly without further equations) critical angle = 41° <u>Example of calculation</u> $\sin c = 1/1.52$ $c = 41^\circ$	(1) (1)	2
* (c)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The light strikes the sides at an angle greater than the critical angle It undergoes <u>total internal reflection</u> It is reflected again It strikes the other end at less than the critical angle Or It is transmitted at the final boundary Or the ray has zero angle of incidence at the first end and is transmitted undeviated	(1) (1) (1) (1)	4
	Total for question		10

Q21.

Question Number	Answer	Mark	
(a)	change in direction / wavelength (of wave/ray/light) (when entering a medium where) the wave has a different velocity OR (when entering a medium where) the density is different the light travels at a lower speed in the air than in a vacuum	(1) (1) (1)	3
(b)	identify angle of incidence = 64° use of $\sin i / \sin r = \text{refractive index}$ $r = 63.9^\circ$ to at least 3 sf calculation of difference = 0.12° <u>Example of calculation</u> $\sin r = \sin i \div \mu$ = $\sin 64^\circ \div 1.001$ $r = 63.88^\circ$ difference = 0.12°	(1) (1) (1) (1)	4
	Total for question		7