

Mark Scheme

Q1.

Question Number	Answer	Mark
	D is the correct answer as only transverse waves can be polarised A is not the correct answer as only transverse waves can be polarised B is not the correct answer as only transverse waves can be polarised C is not the correct answer as only transverse waves can be polarised	(1)

Q2.

Question Number	Answer	Mark
	C is the correct answer A is not the correct answer as light transmitted is unpolarised as this is unchanged B is not the correct answer as light reflected must be polarised as it is absorbed by the filter D is not the correct answer as light reflected must be polarised as it is absorbed by the filter	1

Q3.

Question Number	Answer	Mark
	D is the correct answer (Polarised waves have oscillations in one direction and perpendicular to the direction of wave travel) A is not the correct answer as the single plane of polarisation includes the direction of wave travel and is not perpendicular to it B is not the correct answer as polarised waves do not contain many planes C is not the correct answer as polarised waves do not contain many directions	(1)

Q4.

Question Number	Answer	Mark
	C is the correct answer A is not the correct answer as the intensity does not vary as the filter is rotated B is not the correct answer as the intensity does not vary as the filter is rotated D is not the correct answer as one filter will allow some oscillations to pass	(1)

Q5.

Question Number	Answer	Mark
	C is the correct answer A is not correct because $180^\circ - 90^\circ$ is 90° B is not correct because $270^\circ - 180^\circ$ is 90° D is not correct because $270^\circ - 360^\circ$ is -90°	1

Q6.

Question Number	Answer	Mark
	D is the correct answer as the intensity transmitted by a single polarising filter is independent of the angle of rotation of the filter. A is not the correct answer as the intensity transmitted by a single polarising filter is independent of the angle of rotation of the filter. B is not the correct answer as the intensity transmitted by a single polarising filter is independent of the angle of rotation of the filter. C is not the correct answer as the intensity transmitted by a single polarising filter is independent of the angle of rotation of the filter.	(1)

Q7.

Question Number	Answer	Mark
	A is the correct answer B is not the correct answer as the light reflected is polarised. C is not the correct answer as some of the light is reflected. D is not the correct answer as the rest of the light is refracted.	(1)

Q8.

Question Number	Answer	Mark
	Light emitted from the mobile phone screen is polarised (1)	
	When the phone is rotated, the plane of polarisation of the light and the plane of polarisation of the polarising (filter in the) sunglasses are perpendicular (1)	
	(when the phone is rotated) the sunglasses / polarising filter absorb the light (1)	3
	Total for question	3

Q9.

Question Number	Answer	Additional Guidance	Mark
(a)	Transmitted wave reflects from the metal plate (1) (Incident and reflected waves undergo) superposition / interference (1) Antinodes formed in regions of constructive interference (1) Or antinodes formed where waves meet in phase		3
(b)	Determine the wavelength (1) Use of $v = f\lambda$ (1) Speed of radio waves = $2.98 \times 10^8 \text{ m s}^{-1}$ (1)	<u>Example of calculation</u> $\lambda = \frac{4.75 \text{ m}}{2.5} = 1.90 \text{ m}$ $c = 157 \times 10^6 \text{ Hz} \times 1.90 \text{ m} = 2.98 \times 10^8 \text{ m s}^{-1}$	3
(c)	Oscillations are in one plane / one direction (1) So radio waves are polarised (1)	Accept vibrations Accept aerial acts as a polarising filter	2
Total for question			8

Q10.

Question Number	Answer	Mark
(a)	Angles as 43° and 65° ($\pm 1^\circ$) (1) Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ (allow use of $n = \frac{\sin i}{\sin r}$) (1) Refractive index in range 1.29 to 1.37 (1) (MP3 dependent on MP1) <u>Example of calculation</u> $n_1 \sin \theta_1 = n_2 \sin \theta_2$ $n_1 \times \sin (43^\circ) = 1.00 \times \sin (65^\circ)$ $n_1 = 1.33$	3
(b)(i)	Unpolarised light has vibrations/oscillations in many/all planes (1) Plane polarised light has vibrations/oscillations in one plane only (1) Including the direction of wave travel (1) OR Unpolarised light has vibrations/oscillations in many/all directions (1) Plane polarised light has vibrations/oscillations in one direction only (1) Perpendicular to the direction of wave travel (1) (MP3 dependent on either MP1 or MP2) (MP3 – for “direction of wave travel” allow “direction of energy transfer” or “direction of propagation”)	3
(b)(ii)	(Polarising) filter is rotated (1) Filter not aligned with plane of reflected light, so less light transmitted (1) OR (Polarising) filter positioned at 90° (1) to the plane of the reflected light, so no light transmitted (1) OR Place (polarising) filter so that its plane of polarisation is vertical (1) Horizontally polarised (reflected light) is not transmitted (1) (Maximum 1 mark if using two filters)	2
Total for question		8

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	Angle of incidence measured from the diagram in the range $53^\circ - 55^\circ$ (1)		1
(a)(ii)	Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ (1) $\theta_2 = 32-33^\circ$ (allow ecf from (a)(i)) (1)	Only penalise unit if not penalised in part ai <u>Example of calculation</u> $1 \times \sin 53^\circ = 1.5 \times \sin \theta_2$ $\theta_2 = \sin^{-1} \left(\frac{1 \times \sin 53^\circ}{1.5} \right) = 32^\circ$	2

(b)(i)	Either Unpolarised light has oscillations / vibrations in all / many planes (1) polarised light has oscillations / vibrations in one plane (1) which includes the <u>direction</u> of (wave) travel (1) Or Unpolarised light has oscillations / vibrations in all / many directions (1) Polarised light has oscillations / vibrations in one direction (1) which is perpendicular to the <u>direction</u> of (wave) travel (1) (MP3 dependent on MP2 being awarded)	(MP3 dependent on MP2 being awarded) (MP3 dependent on MP2 being awarded)	3
(b)(ii)	Intensity of light varies (1) from a maximum to a minimum every 90 degree rotation (1) The maximum intensity occurs when the (plane of) the polarising filter is in the same direction as the (plane of) oscillation of the light (1) Or The minimum intensity occurs when the (plane of) the polarising filter is perpendicular to the (plane of) oscillation of the light	Allow amount of light / brightness for intensity	3

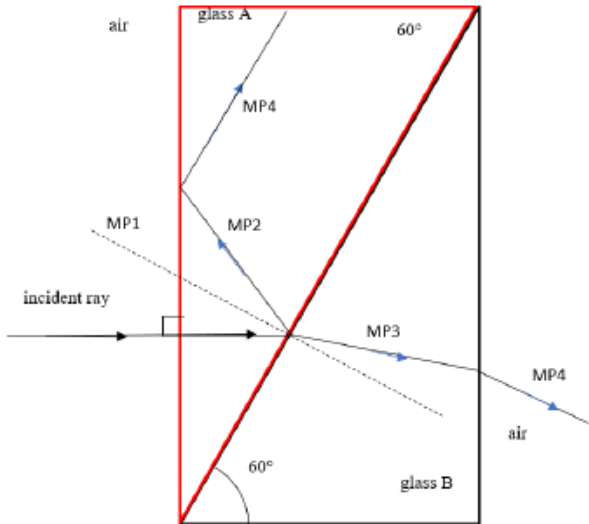
Question Number	Answer	Mark
(a)	Unpolarised light vibrates/oscillates in all planes (1) Plane polarised light vibrates/oscillates in one plane (1) Including the direction of wave travel (1) OR Unpolarised light vibrates/oscillates in all directions (1) Plane polarised light vibrates/oscillates in one direction (1) Perpendicular to the direction of wave travel (1)	3
(b)	Number(s) added to both axes (1) Single maximum at 0° and single minimum at 90° (1) Intensity at $0^\circ \leq 0.5 \text{ W m}^{-2}$ (but not 0) (1) (MP3 cannot be awarded if the graph has a positive gradient) <u>Examples of graphs</u> (These appear at the end of the mark scheme)	3
(c)	(Polarising) filters at 90° to each other do not allow light to pass through (1) Rotation of plane of polarisation (due to stress) allows light to pass (1) Darker areas represent less stress Or brighter areas represent greater stress (1)	3
Total for question		9

Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	Unpolarised has oscillations / vibrations in all / many planes (1) Plane polarised has oscillations / vibrations in one plane (1) Which includes the <u>direction</u> of (wave) travel (MP3 dependent on MP1 and MP2 being awarded) (1) Or Unpolarised has oscillations / vibrations in all / many directions (1) Plane polarised has oscillations / vibrations in one direction (1) Which is perpendicular to the <u>direction</u> of (wave) travel (MP3 dependent on MP1 and MP2 being awarded) (1)		3
(a)(ii)	The polarising filter only transmits light in one plane / direction (1) (as the filter is rotated) a different single plane / direction of oscillation passes through, so the intensity stays the same (1)		2

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	<u>Initial orientation:</u> Filter 1 is aligned with filter 2 so light is transmitted through filter 2 (1) Or filter 2 transmits the light transmitted by filter 1 Filter 3 is perpendicular to filter 2 (1) so no light passes through filter 3 (1) <u>After rotation:</u> some light transmitted through filter 2 is also transmitted through filter 3 (1) So intensity of light transmitted through filter 3 increase (1)		5
	Total for question		10

Q14.

Question Number	Answer	Mark
a	Transverse: vibrations/oscillations are perpendicular to the direction of (wave) travel (1)	2
	Longitudinal: vibrations/oscillations are parallel to the direction of (wave) travel (1)	
bi	The light is (incident on the boundary) along the normal Or The angle of incidence is 0° Or The light hits (prism A) at right angles (1)	1
bii	Normal line correctly drawn at right angles to boundary (by eye) (1) Reflected ray in correct direction from boundary (by eye) (1) Refracted ray in correct direction from boundary (by eye) (1) Correct refraction at the right hand side of the glass block (by eye) and either TIR or correct direction refraction at the left hand side (by eye) (1)	4
		
biii	Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ (1) with 30° , 1.40 and 1.55 substituted correctly (1) Angle of refraction = 27° (1)	3
	<u>Example of calculation</u> $n_1 \sin \theta_1 = n_2 \sin \theta_2$, so $1.40 (\sin 30^\circ) = 1.55 (\sin r)$, $r = 26.8^\circ$	
c	Light (emerging) is polarised (1) Only transverse waves can be polarised (1)	2
Total for question		12

Question Number	Answer	Mark
ai	Use of area = $1.20 \text{ (m)} \times 0.80 \text{ (m)}$ (1) Use of $I = P/A$ (needs to be a dimensionally-correct area) (1) Use of efficiency = useful power output / total power input (1) Efficiency = 14 % (1) <u>Example of calculation</u> P of Sun at solar cell = $I \times A = 1040 \text{ W m}^{-2} \times 1.20 \text{ m} \times 0.80 \text{ m} = 998 \text{ W}$ Efficiency = $\frac{140 \text{ W}}{998 \text{ W}} = 0.14$ (14 %)	4
aii	Any two from: Light from the sun may not be incident on the solar panel at 90° (1) Intensity might be lower due to clouds/rain/fog (1) Light may be reflected at the solar panel (1) Pump may not be 100% efficient (1) Friction between the water and the pipe Or Energy transferred to thermal energy (1)	2
bi	Unpolarised has oscillations/vibrations in all/many planes (1) Plane polarised has oscillations/vibrations in one plane (1) which includes the direction of (wave) travel (1) (MP3 dependent on MP1 or MP2 being awarded) Or Unpolarised has oscillations/vibrations in all/many directions (1) Plane polarised has oscillations/vibrations in one direction (1) which is perpendicular to the direction of (wave) travel (1) (MP3 dependent on MP1 or MP2 being awarded)	3
bii	(Light directed through a) polarising filter (1) No change in intensity as filter is rotated Or if it was polarised, the intensity would change as the filter is rotated (1)	2
	Total for question	11