13(a)	**Either** Unpolarised – oscillations/vibrations in many/all/every direction (1) Polarised – oscillations/vibrations in single/one direction (1) which is perpendicular to the direction of energy transfer (1) **Or** Unpolarised – oscillations/vibrations in many/all/every plane (1) Polarised – oscillations/vibrations in single/one plane (1) which includes direction of propagation (1) (By either method, MP3 is dependent on MP2)	**3**
13(b)	Photograph B (no mark) Reflected light is (partially) polarised (1) Reflected light is not transmitted (by the filter) **Or** Reflected light is absorbed/blocked/stopped (by the filter) (1) (As the plane of polarisation of) reflected light is perpendicular to (the plane of polarisation of) the filter (1)	**3**
	Total for question 13	**6**

Question Number	Answer	Mark

Question Number	Answer		Mark
13(a)	(Light wave with) oscillations/vibrations only in one plane That includes the direction of wave travel **OR** (Light wave with) oscillations/vibrations in only one direction Perpendicular to the direction of wave travel (MP2 dependent on MP1 being awarded)	(1) (1) (1) (1)	**2**
***13(b)**	Maximum (intensity) when filter parallel to (polarised) light **Or** At 0°/180°/360° the filter is parallel to (polarised) light (As filter is rotated) the intensity changes as only the component parallel to the filter is transmitted **Or** (as filter is rotated) the intensity changes as only the component perpendicular to the filter is absorbed Minimum (intensity) when filter perpendicular to (polarised) light **Or** At 90°/270° the filter is perpendicular to (polarised) light Intensity never zero as light is not completely polarised	(1) (1) (1) (1)	**4**
13(c)	Light from the clouds is unpolarised **Or** light from the clouds isn't (plane) polarised **Or** less light from the clouds is (plane) polarised	(1)	**1**
	Total for question 13		**7**

3	**The only correct answer is D** A is not correct because the oscillations may also be in the *y* direction B is not correct because this would describe the situation for a longitudinal wave C is not correct because this would describe the situation for a longitudinal wave	**1**

Question Number	Answer	Mark
13 (a)	**Either** Unpolarised – oscillations/vibrations in all planes **(1)** Polarised – oscillations/vibrations in single plane **(1)** Which includes the direction of the (wave) propagation **(1)** **Or** Unpolarised – oscillations/vibrations in all directions **(1)** Polarised – oscillations/vibrations in a single direction **(1)** Which is perpendicular to the direction of energy transfer **(1)** (MP3 is dependent upon awarding either MP1 or MP2)	**3**
13(b)(i)	After first filter all light (oscillating) in one plane **Or** first filter polarises the light **(1)** Second/rotated filter is perpendicular to the polarised light so light absorbed/blocked **Or** no oscillations/planes/component parallel to second filter so no light transmitted **(1)**	**2**
13 (b)(ii)	(stretched) plastic rotates/changes/alters the plane of polarisation **Or** Plane of polarisation of the (stretched) plastic is not perpendicular to the filters **(1)** So a component of the (polarised) light from first filter can be transmitted (through plastic and second filter) **(1)**	**2**
	Total for question 13	**7**

Question Number	Answer	Mark
17(a)	**Either** Polarised wave has oscillations/vibrations in one direction (1) Perpendicular to the direction of (wave) travel (1) **Or** Polarised wave has oscillations/vibrations in one plane (1) Which includes the direction of (wave) travel (1) (By either method, MP2 is dependent on MP1)	**2**
17(b)	Sunglasses block/absorb light (oscillating) perpendicularly to the (plane of polarisation of the) sunglasses **Or** sunglasses only transmit light (oscillating) in the same plane as the (plane of polarisation of the) sunglasses (1) Reducing the intensity of light (reaching the eye) (1)	**2**
17(c)	Filter A as it blocks/absorbs light (polarised) in horizontal plane **Or** Filter A as it is perpendicular to the reflected light so blocks/absorbs it (1) Light from the fish is unpolarised (so can still be seen) **Or** only a component of the light from the fish is absorbed **Or** a component of the light from the fish passes through (1)	**2**
	Total for question 17	**6**

2	**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)**

Question Number	Acceptable Answer		Additional Guidance	Mark
18(a)(i)	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 (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 direction of (wave) travel (MP3 dependent on MP1 and MP2 being awarded)	(1)		3
18(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

18(b)	Initial orientation:		
	Filter 1 is aligned with filter 2 so light is transmitted through filter 2 **Or** filter 2 transmits the light transmitted by filter 1	(1)	
	Filter 3 is perpendicular to filter 2	(1)	
	so no light passes through filter 3	(1)	
	After rotation:		
	some light transmitted through filter 2 is also transmitted through filter 3	(1)	5
	So intensity of light transmitted through filter 3 increase	(1)	
	Total for question 18		10

10	**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)

2	**The only correct answer is B 4W** ***A** is not correct because only half the intensity is transmitted* ***C** is not correct because this is a quarter of the original intensity* ***D** is not correct because one polarising filter transmits half the intensity*	1

2	**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 plames C is not the correct answer as polarised waves do not contain many directions	**(1)**

Question Number	Answer	Mark
11	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 11	**3**

9	**C is the correct answer** A is not correct because 180° - 90° is 90° B is not correct because 270° - 180° is 90° D is not correct because 270° - 360° is -90°	1

9	**The only correct answer is C (270°, 90°)** A is not correct because 180° - 90° is 90° B is not correct because 270° - 180° is 90° D is not correct because 270° - 360° is -90°	1
10	1	1

12(a)(i)	Angle of incidence measured from the diagram in the range 53° - 55°	**(1)**		1
12(a)(ii)	Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$	**(1)**		
	θ_2 = 32-33° (allow ecf from (a)(i))	**(1)**	Only penalise unit if not penalised in part ai Example of calculation $1 \times \sin 53° = 1.5 \times \sin\theta_2$ $\theta_2 = \sin^{-1}\left(\frac{1 \times \sin 53°}{1.5}\right) = 32°$	2
12(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 direction 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 direction of (wave) travel **(1)** (MP3 dependent on MP2 being awarded)		(MP3 dependent on MP2 being awarded) (MP3 dependent on MP2 being awarded)	3

12(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**