Question Number	Answer		Mark
1(a)	Oscillations/vibrations (of molecules) parallel to direction of propagation **Or** oscillations parallel to direction of wave travel **Or** oscillations parallel to direction of energy transfer Produces compressions and rarefactions	**(1)** **(1)**	**2**
1(b)	Otherwise there wouldn't be a way of telling which bit of reflected sound originated with which bit of emitted sound **Or** so one returns before one emitted	 **(1)**	**1**
1(ci)	time (= 1÷16 Hz) = 0.063 (s) (at least 2 sf)	**(1)**	**1**
1(cii)	Use of factor of 2 Use of $v = s/t$ distance = 48 m (Use of 'show that' value gives 46m) <u>Example of calculation</u> 2 × distance = 1530 m s^{-1} × 0.063 s distance = 48 m	**(1)** **(1)** **(1)**	**3**
1(ciii)	A shorter time between clicks because the distance is shorter **Or** more frequent clicks allow rapid motion to be perceived. **Or** allow position to be determined precisely/accurately.	 **(1)**	**1**
1(d)	Speed in air lower than speed in water So wavelength in air shorter than wavelength in water **Or** pulse length in air is shorter than pulse length in water **Or** attempt at numerical comparison of wavelength or pulse length So bat echolocation will detect smaller targets **Or** detect smaller differences in position (conditional on MP2) (Accept 'show more detail' or 'better resolution')	**(1)** **(1)** **(1)**	**3**
	Total for question 18		**11**

Question Number	Answer		Mark
2(a)	Idea of two or more waves meeting Displacement is sum of individual displacements	**(1)** **(1)**	**2**
2(b)	Electromagnetic waves are transverse, with oscillations ***perpendicular*** to the direction of ***energy transfer*** **Or** ***wave travel*** **Or** ***propagation*** When they pass through a polarising filter all the components of the oscillations perpendicular to the plane of polarisation are ***absorbed***. (accept ***blocked***) **Or** When they pass through a polarising filter all the components of the oscillations ***parallel*** to the plane of polarisation are ***transmitted***. The oscillations of the polarised wave are all in the same plane which ***includes*** the direction of energy transfer. **Or** The oscillations of the polarised wave are all in the same ***direction*** which is perpendicular to the direction of energy transfer	**(1)** **(1)** **(1)** **(1)**	**4**
***2(c)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate – e.g. if the term 'superimpose' is used this mark is not awarded) When in phase constructive interference/superposition occurs **Or** when path difference is $n\lambda$ constructive interference/superposition occurs When in antiphase destructive interference/superposition occurs **Or** when path difference is $(n + ½)\lambda$ destructive interference/superposition occurs Light band forms when in phase **Or** path difference is $n\lambda$ **Or** constructive **Or** Dark band forms when in antiphase **Or** path difference is $(n + ½)\lambda$ **Or** destructive	 **(1)** **(1)** **(1)**	**3**
2(c)(ii)	Oscillations of light from the two filters are perpendicular to each other So there are no opposite components to cancel each other out **Or** so the waves do not interact/interfere So zero amplitude not possible **OR** (If the candidate assumes that it is a source of polarised light) One filter is parallel to the plane of polarisation of the light source, so light is transmitted but the other one absorbs light So light now only reaches the screen from one filter, so there is no interference So zero amplitude not possible	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for Question 17		**12**

Question Number	Answer	Mark
3(a)(i)	Greater refraction at the first face **(1)** Greater refraction at the second face **(1)** (accept new incident ray if parallel)	**2**
3(a)(ii)	Displacement/it increases with concentration **(1)** At increasing rate **OR** not linearly **(1)**	**2**
3(a)(iii)	Evidence that curved line has been drawn **(1)** Concentration 74 % - 76% (dependent mark) **(1)**	**2**
3(a)(iv)	Distance (between prism and screen) affects displacement/ Displacement would increase if the screen is moved away/ Displacement would decrease if screen moved nearer **(1)**	**1**
3(b)(i)	Polarised light is when the oscillations / vibrations (associated with the wave) are in one plane only **(1)** Plane includes direction of travel (of the wave). **(1)** **OR** Polarised light is when the oscillations / vibrations (associated with the wave) in one direction only, **(1)** (oscillations / vibrations are) perpendicular to the direction of travel (of the wave). **(1)**	**2**
***3(b)(ii)**	(QWC- Work must be clear and organised in a logical manner using technical wording where appropriate.) **Max 4** • Mention of polarising filter/Polaroid/polariser **(1)** • Rotation (of filter) until minimum/ maximum intensity (**not** rotation of solution) **(1)** • (Rotation) done with and without the sugar solution **(1)** • identifies correct difference in angles **(1)** • use of protractor/polarimeter **(1)**	**4**
	Total for question 16	**13**

Question Number	Answer		Mark
4(a)	Use of power = intensity x area Use of time = energy / power Time = 19 s <u>Example of calculation</u> P = 8000 W m^{-2} × 1.5 × 10^{-5} m^2 = 0.12 J s^{-1} t = 2.3 J ÷ 0.12 J s^{-1} = 19 s	**(1)** **(1)** **(1)**	**3**
4(b)(i)	Use of $E = IVt$ Energy = 19 000 J (2 sf)(no ue) <u>Example of calculation</u> E = 1.4 A × 3.7 V × (60 × 60) s = 18 648 J	**(1)** **(1)**	**2**
4(b)(ii)	Energy required = 210 x 2.3 J Use of efficiency = output energy / input energy Efficiency = 0.026 or 2.6% <u>Example of calculation</u> efficiency = 210 × 2.3 J × 100 % ÷ 19 000 J = 0.026 or 2.6%	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**8**