Question Number	Answer	Mark
1(a)	Oscillations/vibrations occur in any number of directions/every direction (1) which are perpendicular to the direction of wave travel /wave propagation/energy transfer (do not accept direction of wave) (1) **OR** Oscillations/vibrations may occur in more than one plane (2) (references to particles loses 1st mark marks can be scored from a labelled diagram)	**2**
1(b)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Use of polarising filter /Polaroid (not just filter) (1) Rotation/turning of the filter (1) After 90º rotation (block) intensity changes (1) (Use of two filters and relative rotation 1 mark only)	**3**
1(c)	Reflected light OR light from ice is (partially) polarised (1) (Polarising) filters/lenses/glasses are at right angles to (the plane of polarisation of) the light (1) [1st mark must be about the reflected light being polarised] (Answers which say that the sunglasses are polarising the light score 0/2)	**2**
	Total for question	**7**

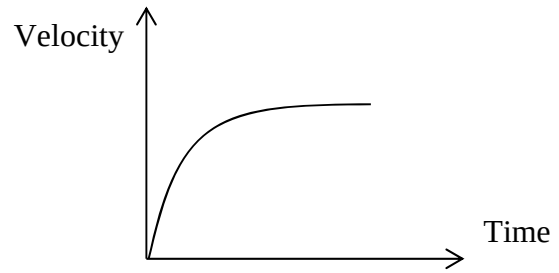
Question Number	Answer	Mark
2(a)	Unpolarised light <u>oscillates/vibrates</u> in many planes/ directions while polarised <u>oscillates/vibrates</u> in one plane/direction only OR labelled diagram	**1**
(b)	Filters at 90° to the (polarised) reflected light. sunglasses cut out the reflected light/polarise light/glare But not the light from the fish OR light from fish is unpolarised.	**1** **1** **1**
(c)	Sound is a longitudinal wave OR sound is not a transverse wave OR oscillations in one direction already OR only transverse waves can be polarised.	**1**
	Total for question	**5**

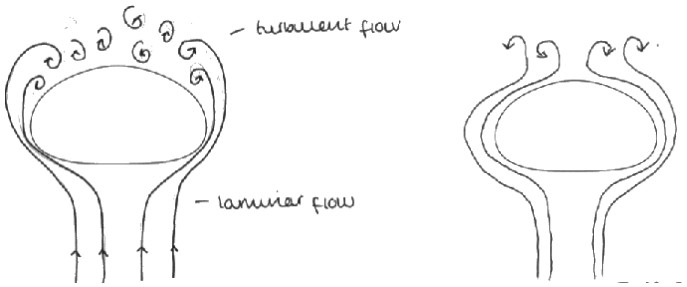
Question Number	Answer	Mark
3(a)	**Di :** Smaller wavelength before gap Less diffraction and same wavelength	 **1** **1**
(b)	Two sets of concentric circles equal spacing Identification of a line of points of destructive interference Identification of a line of points of constructive interference	**1** **1** **1** **1**
(c)(i)	Attempt to use inverse relationship (e.g. 1.2 × 0.60 =constant) Separation =1.8 mm **Example of answer** 1.2 = constant / 0.6 Constant = 0.72 Spacing = 0.72/ 0.4 = 1.8 mm	**1** **1**
(ii)	(Initially bands) will get close together Eventually gap too large for overlap to occur, no fringes seen OR reference to fringes produced providing overlap still occurs	**1** **1**
	Total for question	**10**

Question Number	Answer	Mark
4	**QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** **Any three** Reflected light is polarised (1) Polarised light vibrates/oscillates in one plane/direction (1) Polaroid filter only allows vibrations/oscillations in one direction/plane to pass through (1) When planes are parallel puddle appears light OR when perpendicular puddle appears dark (1) (for 2nd and 3rd mark only one reference to vibrations/oscillations is needed) (candidates who make no reference to puddle and answer in terms of two filters can score 2nd and 3rd marks only)	**Max 3**
	Total for question	**3**

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

Question Number	Answer	Mark
***6 (a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The waves superpose **Or** diffraction at the double slits **(1)** Where they are in phase **Or** when path difference is a whole number of wavelengths constructive interference takes place **(1)** Where they are in antiphase / when path difference is an odd number of half wavelengths destructive interference takes place **(1)** Bright bands are when waves are in phase / when path difference is $n\lambda$ / constructive interference **Or** reverse for dark bands **(1)**	**4**
6 (b)	coherent = constant phase relationship/difference (between light arriving from the two sources) **Or** if they are not coherent the phase relationship/difference will vary. **(1)** The idea that at a given point there would sometimes be constructive interference and sometimes destructive interference etc **(1)**	**2**
6 (c)	Interference (accept diffraction) only occurs with waves. **(1)**	**1**
	Total for question	**7**

Question Number	Answer	Mark
7(a)(i)	Initially: constant acceleration **(1)** Decreasing acceleration followed by constant velocity **(1)** <u>Example of graph</u>  	**2**
7(a)(ii)	Drag increases with speed (this may be implied following a description of acceleration) **(1)** When drag = weight (− upthrust) **(1)** No resultant force **Or** there is no (further) acceleration **Or** the forces are in equilibrium **(1)**	**3**
7(a)(iii)	Density of air is negligible compared to density of water **Or** mass/weight of air displaced is negligible/tiny compared to the mass/weight of the raindrop **Or** the upthrust is negligible/tiny compared to the mass/weight of the raindrop **(1)**	**1**
7(b)(i)	Use of $v = s/t$ **(1)** $v = 7.1$ m s^{-1} **(1)** <u>Example of calculation</u> $v = \frac{1100 \text{ m}}{2.6 \text{ min} \times 60}$ $v = 7.05$ m s^{-1}	**2**
7(b)(ii)	See or use of $\rho Vg = 6\pi r \eta v$ **(1)** See $V = \frac{4}{3}\pi r^3$ **and** values substituted into above equation **(1)** $r = 2.4 \times 10^{-4}$ m (ecf from part (b)(i) for terminal velocity) **(1)** <u>Example of calculation</u> Weight of raindrop = $\frac{4}{3} \times \pi \times r^3 \times 1.0 \times 10^3$ kg m$^{-3} \times 9.81$ N kg^{-1} Drag force = $6 \times \pi \times r \times 1.8 \times 10^{-5}$ Pa s $\times v$ $\frac{4}{3}\pi \times r^3 \times 1.0 \times 10^3$ kg m$^{-3} \times 9.81$ N kg$^{-1} = 6 \times \pi \times r \times 1.8 \times 10^{-5}$ Pa s $\times 7.1$ m s^{-1} $r^2 = \frac{9 \times 1.8 \times 10^{-5} \text{Pa s} \times 7.1 \text{ m s}^{-1}}{2 \times 1.0 \times 10^3 \text{ kg m}^{-3} \times 9.81 \text{ N kg}^{-1}} = 1.04 \times 10^{-7}$ $r = 2.42 \times 10^{-4}$ m	**3**

7(c)	Laminar air flow around main body of rain drop **(1)** (minimum of 2 lines either side) Some turbulence at the top of the rain drop **(1)** (must not start below the top 1/3rd of the rain drop) (1 mark max for correct drawing of laminar and turbulent flow around the rain drop but upside down. Labels and arrows not required) <u>Example of diagram</u> 	**2**
	Total for Question	**13**