

Question			Answer	Marks	Guidance
1	(a)	(i)	3 correct labels	B1	
		(ii)	the (three) colours add up/superpose to give white light <b>or</b> no dispersion/diffraction of incident white light/AW	B1	<b>allow</b> use of formula $d \sin \theta = n\lambda$ so constructive interference at $\theta = 0$ for all $\lambda$
		(iii)	select $\lambda = d \sin \theta$ $\lambda = 1.67 \times 10^{-6} \sin 19.1$ $\lambda = 546 \times 10^{-9}$ (m)	C1 C1 A1	<b>allow</b> $547 \times 10^{-9}$ as answer is $546.46 \times 10^{-9}$ <b>do not allow</b> $550 \times 10^{-9}$ unless SF mark already deducted
	(b)		select $E = hc/\lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^8/436 \times 10^{-9}$ $E = 4.56 \times 10^{-19}$ (J)	C1 C1 A1	<b>do not allow</b> $4.6 \times 10^{-19}$ unless SF mark already deducted
	(c)	(	1 arrow correctly labelled 2 more arrows correctly labelled	B1 B1	
			<b>Total</b>	<b>10</b>	

Question		Answer	Marks	Guidance
2	(a)	<b>is a transfer of energy</b> as a result of oscillations (of the source/medium/particles through which energy is travelling)	M1 A1	<b>allow</b> carries <b>allow</b> information <b>accept</b> without the transfer of the medium/particles/matter
	(b)	displacement/oscillation (of particles) is normal/perpendicular to direction of energy transfer in transverse wave displacement/oscillation (of particles) is parallel to direction of energy transfer in longitudinal wave	B1  B1	<b>allow</b> vibrations <b>allow</b> to direction of <u>wave</u> motion/propagation/velocity/travel <b>NOT</b> transverse wave can travel through a vacuum  give max 1 mark for 2 similar poor definitions, e.g. direction of travel, waves oscillate, etc. (two such errors scores zero)
	(c)	(i) wavefronts/paths spread out after passing through a gap or around an obstacle/AW	B1	<b>NOT</b> wave changes direction
		(ii) use a slit/hole/ barrier width of gap/position beyond barrier comparable to wavelength microphone/observer's ear suitably placed sound detected/heard outside 'geometrical shadow' region (showing diffraction)	B1 B1  B1 B1	<b>accept</b> doorway/end of wall <b>accept</b> position of detector beyond doorway <b>N.B.</b> good diagram can illustrate first 3 marking points <b>allow</b> 'hears sound' in suitable context only observation mark which is QWC mark must be in words 2 marks max for double slit experiment(1 <sup>st</sup> and 3 <sup>rd</sup> m.p.)
	(d)	(i) $v = f\lambda$ giving $340 = 1200 \times \lambda$ $\lambda = 0.28$ (m)	C1 A1	substitution needed to score mark POT error for using 1.2 kHz giving 280 m <b>N.B.</b> $\lambda = 0.3$ SF error (remember apply only once)
		(ii) waves superpose/interfere at points along <b>PQ</b> (constructively and destructively) path difference from sources of $n\lambda$ for maximum/loud sound/intensity path difference of $(2n + 1)\lambda/2$ for minimum/quiet sound/intensity	B1  B1  B1	<b>max</b> 2/3 for writing phase difference is $n\lambda$ or path difference is $2\pi$ i.e. mixing path and phase consistently through answer <b>allow</b> waves arrive in phase ( $0, 2\pi, 360^\circ$ , etc) <b>allow</b> waves arrive in anti-phase ( $\pi, 180^\circ$ , etc) <b>do not allow</b> waves arrive out of phase <b>or</b> answers in terms of peaks and troughs for 2 <sup>nd</sup> and 3 <sup>rd</sup> marks
		(iii) $a = \lambda D/x$ giving $a = 0.28 \times 3.0/0.50$ $a = 1.7$ m	C1 A1	<b>ecf (d)(i)</b> substitution needed to score mark
		(iv) intensity of sound (at maxima) unchanged/AW <u>positions</u> of maxima and minima <u>reversed</u> /AW	B1 B1	<b>allow</b> volume or amplitude
<b>Total</b>			<b>18</b>	

Question		Answer	Marks	Guidance
3	(a)	energy is trapped in pockets/ where the shape or energy does not move along/energy is stored/AW there are nodes/positions of zero amplitude/motion there are positions where there is max. amplitude/antinodes different/adjacent points have different amplitudes/AW all points between nodes in phase/all points in adjacent $\lambda/2$ 's in anti-phase/AW	B1 B1 B1 B1 B1	<b>accept</b> any <b>two</b> sensible but different features <b>allow</b> there are nodes and antinodes as 1 marking point <b>penalise</b> displacement for amplitude once only
	(b)	incident wave is reflected (at the fixed end of the string) and the <u>reflected</u> wave (or <u>it</u> ) <u>interferes/superposes</u> with the incident wave (to produce the stationary wave)	B1 B1	
	(c)	( <b>points which are the same distance from the nodes will have the same amplitude</b> so <b>Y</b> (has the same amplitude as <b>X</b> )	<b>M1</b> A1	<b>N.B.</b> some will add <b>Z</b> stating it is the same distance from the node – these candidates can score the first mark
		(ii) <b>all points on the string oscillate with the same frequency</b> so <b>Y</b> and <b>Z</b> (have the same <b>f</b> as <b>X</b> )	<b>M1</b> A1	
		(iii) <b>all points in alternate segments of the string oscillate in phase/AW</b> so <b>Z</b> (is in phase with <b>X</b> )	<b>M1</b> A1	<b>accept</b> e.g. have positive displacement at the same time
		<b>Total</b>	<b>10</b>	

Question			Answer	Marks	Guidance
4	(a)	(i)	gamma rays, u.v., visible/light, i.r., microwaves	B1	<b>two</b> out of five needed for mark
		(ii)	<i>similarity</i> : travel in a vacuum/same speed (in vacuum)/at c/transverse (wave)/can be polarised/caused by accelerating charges/are oscillating electric and magnetic fields <i>difference</i> : different $\lambda$ , f, (photon) energy	B1  B1	any <b>one</b> for mark <b>NOT</b> can be reflected/refracted/diffracted/interfere, etc.  any <b>one</b> for mark
		(iii)	<u>wavelength</u> of X-rays is close to atomic spacing/AW <b>or</b> <u>wavelength</u> of radio waves many/million times the atomic separation <u>maximum/significant</u> diffraction occurs when radiation wavelength $\sim$ spacing (between diffracting planes) within material	B1  B1	
	(b)		<b>advantage</b> produces vitamin D (in skin cells) <b>disadvantage</b> damage DNA/cause cancer/sunburn, etc.	B1 B1	<b>allow</b> any sensible use, e.g. sterilise equipment, forensic science, disco lighting, etc. <b>NOT</b> tanning, photosynthesis
	(c)	(i)	$2 \times 10^{-10}$ m	B1	
		(ii)	$E = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.0 \times 10^8 / 2 \times 10^{-10}$ $= 9.9(5) \times 10^{-16}$ number = $1 \times 10^9$	C1 C1 A1 B1	Select equation and attempt to apply it <b>ecf (c)(i)</b> accept $1 \times 10^{-15}$ , i.e 1 SF mark scored for $1 \times 10^{-6}$ /value of E
	(d)	(i)	diode symbol  all three components in series	B1 B1	<b>allow</b> LED symbol; basic requirement is triangle along wire direction with bar, with or without circle and line through <b>ecf</b> for diode symbol
		(ii)	maximum ammeter reading when aerials in line/parallel zero signal/current when aerials at $90^\circ$ to each other at $180^\circ$ same signal/ammeter reading as at $0^\circ$ quoting $I = I_0 \cos^2 \theta$ to indicate variation through $180^\circ$	B1 B1 B1 B1	<b>accept</b> ammeter reading falls as aerial is rotated <b>accept</b> minimum <b>allow</b> full marks for answers in terms of only ammeter reading or signal strength max 3 out of 4 marking points
<b>Total</b>				<b>17</b>	