

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

Question		Answer	Marks	Guidance
2	(a)	is a transfer of energy as a result of oscillations (of the source/medium/particles through which energy is travelling)	M1 A1	allow carries allow information accept 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	allow vibrations allow to direction of <u>wave</u> motion/propagation/velocity/travel NOT 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	NOT 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	accept doorway/end of wall accept position of detector beyond doorway N.B. good diagram can illustrate first 3 marking points allow 'hears sound' in suitable context only observation mark which is QWC mark must be in words 2 marks max for double slit experiment(1 st and 3 rd 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 N.B. $\lambda = 0.3$ SF error (remember apply only once)
		(ii) waves superpose/interfere at points along PQ (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	max 2/3 for writing phase difference is $n\lambda$ or path difference is 2π i.e. mixing path and phase consistently through answer allow waves arrive in phase ($0, 2\pi, 360^\circ$, etc) allow waves arrive in anti-phase ($\pi, 180^\circ$, etc) do not allow waves arrive out of phase or answers in terms of peaks and troughs for 2 nd and 3 rd marks
		(iii) $a = \lambda D/x$ giving $a = 0.28 \times 3.0/0.50$ $a = 1.7$ m	C1 A1	ecf (d)(i) 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	allow volume or amplitude
Total			18	

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	accept any two sensible but different features allow there are nodes and antinodes as 1 marking point penalise 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)	(points which are the same distance from the nodes will have the same amplitude so Y (has the same amplitude as X)	M1 A1	N.B. some will add Z stating it is the same distance from the node – these candidates can score the first mark
		(ii) all points on the string oscillate with the same frequency so Y and Z (have the same f as X)	M1 A1	
		(iii) all points in alternate segments of the string oscillate in phase/AW so Z (is in phase with X)	M1 A1	accept e.g. have positive displacement at the same time
		Total	10	

Question			Answer	Marks	Guidance
4	(a)	(i)	gamma rays, u.v., visible/light, i.r., microwaves	B1	two 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 λ , f, (photon) energy	B1 B1	any one for mark NOT can be reflected/refracted/diffracted/interfere, etc. any one for mark
		(iii)	<u>wavelength</u> of X-rays is close to atomic spacing/AW or <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)		advantage produces vitamin D (in skin cells) disadvantage damage DNA/cause cancer/sunburn, etc.	B1 B1	allow any sensible use, e.g. sterilise equipment, forensic science, disco lighting, etc. NOT tanning, photosynthesis
	(c)	(i)	2×10^{-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 = 1×10^9	C1 C1 A1 B1	Select equation and attempt to apply it ecf (c)(i) accept 1×10^{-15} , i.e 1 SF mark scored for 1×10^{-6} /value of E
	(d)	(i)	diode symbol all three components in series	B1 B1	allow LED symbol; basic requirement is triangle along wire direction with bar, with or without circle and line through ecf for diode symbol
		(ii)	maximum ammeter reading when aerials in line/parallel zero signal/current when aerials at 90° to each other at 180° same signal/ammeter reading as at 0° quoting $I = I_0 \cos^2 \theta$ to indicate variation through 180°	B1 B1 B1 B1	accept ammeter reading falls as aerial is rotated accept minimum allow full marks for answers in terms of only ammeter reading or signal strength max 3 out of 4 marking points
Total				17	