PH2

Question			Marking details	Marks Available
1	*(a)*	(i)	0.04[0 m]	1
		(ii)	T = 0.20 s [or by impl.] (1) f = 5.0 (1) Hz (1) (e.c.f. on T)	3
	(b)		If peak arriving at 0.050 s at **B** is the peak that passed **A** at 0.00 s [or equiv] (1), $v = \frac{0.30\,\text{m}}{0.050\,\text{s}}$ [free-standing](1) [Accept: **B** could be λ/4 from **A**, so λ = 1.2 m (1); $v = f\lambda$ = 5.0 × 1.2 m s^{-1}(1).]	2
	(c)	(i)	Distance [along the direction of wave propagation] between two [consecutive] point (1) oscillating in phase (1) [“Distance between two peaks / troughs → 1]	2
		(ii)	λ = 1.2 m (e.c.f. on f)	1
				[9]

Question			Marking details	Marks Available
2	*(a)*	(i)	Wavefronts [or waves] from each slit spread out (1) [accept: waves diffract at each slit] …….and overlap (1) [or superpose or interfere].	2
		(ii)	I. Sources which emit waves, which are at the same point in their cycle at the same time [accept: "emit peaks at the same time"] II. A maximum on central axis **or** microwave source central w.r.t. S_1 and S_2.	1 1
		(iii)	Correct insertion of values into $\lambda = \dfrac{ay}{D}$ (1) [or by implication] λ = 0.012 m (1)	2
		(iv)	I. Constructive interference at **P** (1) [accept: waves reinforce] So waves are in phase (1) [Accept: phase difference = $2\pi n$ etc]	2
			II. $S_1P - S_2P = n\lambda$ [for $n = 0, \pm1, \pm2….$] (1) [$n = 0$ for central maximum, $n = 1$ for next one out from centre], $n = 2$ at P. (1) So $S_1P - S_2P = 0.024$ m (1) [Geometric method based upon Pythagoras ✓✓✓ if correct]	3
	(b)		Interpose a grille of parallel metal rods and rotate. (1) The signal strength varies. (1) [Accept rotation of the sensor / ærial]	2
	(c)		Any 2 × (1) of: • the radiation penetrates the potato ✓ • absorbed within the potato, heating interior ✓ • waves transfer energy [or equiv] ✓ • water content heated / water molecules made to vibrate more ✓	2 **[15]**

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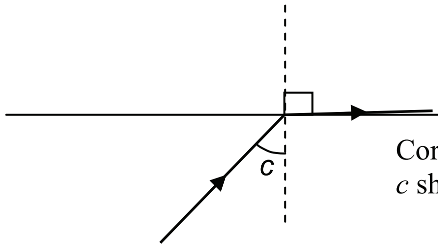
3	*(a)*		 Correctly drawn ray (1) c shown correctly (1)	2
	(b)		$1.520 \sin\theta_A = 1.550 \sin\theta_B$ (1) [or by impl.] $\theta_A = 90°$, $\theta_B = c$ (1) [or by impl.] $c = 79°$ (1)	3
	(c)	(i)	11 ° [± 1°] e.c.f.	1
		(ii)	Some enters the cladding (1) …. and is lost (1) Some is reflected but lost on subsequent reflections (1).	3
	(d)		Paths at different angles to the axis are of different lengths (1). Data travelling on different paths arrive different times [or by clear implic.](1) so data is muddled / smeared out / data pulses overlap (1)	3
				[12]
4.	*(a)*	(i)	Photons hit the caesium surface. (1) Electrons knocked out (1) • Electrons cross vacuum to collecting electrode✓ • returned to the caesium via cell and meter✓ • constituting an electric current✓ • aided by [p.d. of] cell ✓ any 1 ×	3
		(ii)	Larger current (1) because more photons arrive [per second] (1)	2
	(b)	(i)	• Power supply polarity needs reversing ✓ • Voltage needs to be variable ✓ • voltmeter needed ✓ any 2 ×	2
		(ii)	$E_{k\,max} = 6.6 \times 10^{-34} \times 8.6 \times 10^{14} - 3.1 \times 10^{-19}$ J (1) $= 2.6 \times 10^{-19}$ J (1)	2
		(iii)	$E_k = \frac{1}{2}mv^2$ <u>with</u> $m = 9.1 \times 10^{-31}$ kg (1) Convincing substitution of $v = 7.5 \times 10^5$ m s^{-1} to obtain $E_k = 2.6 \times 10^{-19}$ J **or** vice versa (1)	2
		(iv)	Intensity doesn't affect individual photon energies [or equiv.]	1
				[12]

Question			Marking details	Marks Available
5	*(a)*	(i)	$\Delta E = \dfrac{hc}{\lambda}$ [**or** $\Delta E = hf$ **and** $f = \dfrac{c}{\lambda}$] [**or** by impl.] (1) $\Delta E = 1.9 \times 10^{-19}$ J [or by impl.] (1) $\lambda = 1.0 \times 10^{-6}$ m (1) ((**unit**))	3
		(ii)	infrared	1
		(iii)	[Incident] photon causes emission of a photon (1) + 2 × (1) of: • Incident photon energy needs to be $E_A - E_B$ [or equiv.] ✓ • Emitted photon has same energy (**or** λ or f) as incident photon.✓ • Emitted photon in phase with incident photon. ✓	3
		(iv)	Two photons where there was one before [and the process repeats]	1
	(b)	(i)	More electrons in level A than in level B.	1
		(ii)	If more electrons in B than A, absorption of photons is more likely than stimulated emission.	1
		(iii)	B almost empty [because electrons 'fall' from B to ground state] (1) So not many electrons needed in A to cause population inversion. (1)	2
				[12]
6.	*(a)*		Weak (1) because neutrinos only feel the weak force [as well as gravity] (1) [**Or** because the weak force alone can cause a change of quark type].	2
	(b)	(i)	Ar has 1 more proton than Cl, but electron also appears [so net charge is conserved]. [Or Ar appears as + ion (and picks up an electron)]	1
		(ii)	ν_e on left is a lepton [**or** has a lepton number of 1]; electron on right is a lepton [**or** ….]	1
	(c)		(i) 20 (ii) 19 [both answers correct]	1
	(d)	(i)	udd	1
		(ii)	In version at top, neutron is lost and proton is gained. (1) [**or** $n + \nu_e \rightarrow p + e^-$] We can regard this as a neutron losing a d [quark] and gaining a u [quark] (1)	2
				[8]

Question			Marking details	Marks Available
7	*(a)*		[A body with a surface that] absorbs all radiation[accept: 'light'] falling upon it.	1
	(b)	(i)	Area of sphere of radius 8.1×10^{16} m = $4\pi\times (8.1 \times 10^{16})^2$ (1) [= 8.2×10^{34} m^2] Power reaching surface = $1.2 \times 10^{-7} \times 4\pi \times (8.1 \times 10^{16})^2$ W (1) [Or reverse argument from power to intensity, if clear] e.c.f on numerical factors in area [not for use of $2\pi r$]	2
		(ii)	Absorption / scattering [of radiation by interstellar dust / gas]	1
		(iii)	$9.9 \times 10^{27} = 5.67 \times 10^{-8}\, A \times 9900^4$ [or by impl.] (1) (Data subst. at any stage) Transposition at any stage (1) $r = 1.2 \times 10^9$ m (1) [e.c.f. on A, if πr^2 used]	3
		(iv)	Curve of correct general shape sketched which is • lower throughout (1) • has a maximum at longer λ (1)	2
	(c)		Atoms / ion / [accept molecules]of a star's atmosphere (1) [**or** interstellar space **or** Earth's atmosphere] absorb specific wavelengths (1) [from the continuous spectrum] promoting electrons to higher energy level (1) [**or** re-emitting in all directions]	3
				[12]