Question Number	Answer	Acceptable answers	Mark
1(a)	**light** → electrical → **chemical** energy energy energy (1) (1)	These answers must be in the correct order	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(b)(i)	350 (J)	400 – 50 (J)	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)(ii)	Substitution 50 ÷ 400 (1) or $\frac{50 \times 100}{400}$ (%) Evaluation 13(%) (1)	 12.5(%), 0.125, 0.13 or 1/8 Give full marks for correct answer, no working	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(c)(i)	An explanation linking the following points: black (1) (because) (good) absorber (of thermal radiation) (1)	 {absorbs / takes in} heat radiation **ignore** references to: attract good emitter light dark / darker	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(c)(ii)	an explanation linking any **three** of the following points: • (bag / water) absorbs {thermal energy / heat / radiation} (1) • (bag / water) {radiates / emits} {thermal energy / heat / radiation} (1) • more heat radiated at higher temperature (1) • input and output are balanced (at steady temperature) (1)	idea of energy input e.g. "sun heats the bag up" idea of energy output idea of more heat lost (to surroundings)at higher temperature "absorbing heat at same rate as radiating heat" (3) **ignore** (sun) light / rays	**(3)**

Question Number	Answer	Acceptable answers	Mark
2(a)(i)	Gamma/ γ (wave(s)/ ray(s)/radiation)	X-rays/ radiation	**(1)**

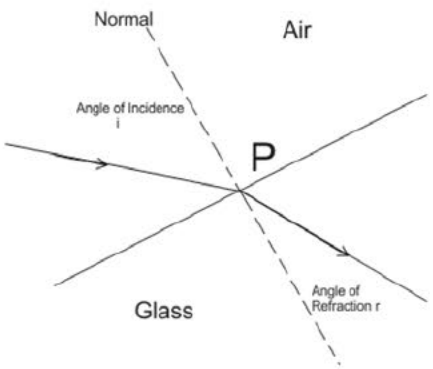
Question Number	Answer	Acceptable answers	Mark
2(a)(ii)	Any two from It fluoresces (1) UV (radiation) transfers/gives energy to ink/ink absorbs energy from UV (radiation) (1) (energy from UV is)(re-)radiated/(re)- emitted by ink at lower frequency/as (visible) light (1)	fluorescent Ink/it absorbs UV (light/radiation) Ignore UV is reflected as visible light Ignore luminous emits visible light	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)	transposition $\lambda = v/f$ (1) substitution $\lambda = 3 \times 10^8/7 \times 10^9$ (1) evaluation 0.043 (m) (1) Ignore any unit given by candidate	Subst. and transform. either order 1 mark only can be scored for correct substitution after incorrect transposition. $3 \times 10^8/7 \times 10^9$ gains 2 marks Accept any number of sig.figs. that rounds to 0.04 0.04 , 0.0428 (m) (1) Give full marks for correct answer with no working. 0.04 x any other power of 10 = 2 marks	**(3)**

Question Number		Indicative Content	Mark
QWC		A discussion including some of the following points Possible dangerous e-m radiations Microwaves Infrared Ultraviolet (UV) X-rays gamma rays Correctly linked to Internal heating of body cells (microwaves) Skin burns (infrared) Damages skin cells/sunburn (UV) Damages eyes (UV) Can cause skin cancer (UV) Can cause cataracts (UV) Damage to cells inside the body(X-rays) Mutate/ kill cells in the body (gamma) Damages DNA (X-rays and gamma rays) Link to frequency As the frequency increases/wavelength decreases (microwave -> gamma) the waves become more penetrating and do more damage/danger as they have more energy.	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. gives at least 2 correct radiations and links both to correct damage OR at least 2 correct radiations named with link to correct damage from one and idea that frequency is linked to damage OR just has link between higher frequency and more damage/dangerous e.g. infrared burns your skin and X-rays can damage cells. OR X-rays have a higher frequency than microwaves and can cause cancer OR Higher frequencies cause more damage to cells. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description e.g. gives most of the correct radiations and links to correct damage, at least one with detail of the damage that is caused OR links two to detail of the damage, AND has a link between frequency and energy/danger e.g. Microwaves are absorbed by water in body cells. UV can cause skin cancer and damages your eyes. X-rays and gamma rays can damage cells inside your body OR Gamma and X-rays can penetrate deep into the body. Gamma does most damage as it has the highest frequency. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. gives most of the correct radiations with detail of the damage AND explains the link between frequency	

		and energy/danger. e.g Microwaves heat up the water in cells. UV can cause cataracts. Gamma rays are the most penetrating and can mutate cells inside the body because they have the highest frequency. • The answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	An explanation linking: Angle (of incidence) in glass (1) greater than critical angle / 42° (1)	Angle in air cannot be greater than 90° for 1 mark Glass has a higher refractive index than air for 1 mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
3 (a)(ii)	 angle i from normal in air (1) angle r from normal in glass (1)	accept for 1 mark angle i in air <u>and</u> angle r in glass/ <u>both</u> angles measured from normal	**(2)**

Question Number	Answer	Acceptable answers	Mark
3 (a)(iii)	☒ **C** speed decreases		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	An explanation linking any three of the following: (Optical fibres) bend (1) some fibres carry light to the inside of the patient (1) some fibres transmit the reflected light (1) light passes up/down fibres by TIR (1) light is reflected inside the patient (1) image is analysed by computer (1)	Accept suitable labelling on a Diagram Image projected on a screen	**(3)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	Either Breaks/blasts/smashes (1) Kidney stones (1) or Energy absorbed (1) to help repair muscle tissue (1) or Use of gel (1) to prevent loss of intensity (1) or	bruising/clots increases blood flow Allow (1) mark for suitable diagnosis e.g. prenatal scan	**(2)**

Total mark for question 3 = 10

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	Any one of • radio • visible • microwave	• infrared / IR • ultraviolet / UV	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	Any one of • X-ray • gamma ray • far infrared	• infrared / IR • ultraviolet / UV	**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	N = 39 (A.U.) (1) P = 77 (A.U.) (1)	range 38 – 39 inclusive range 76-78 inclusive	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	An explanation linking • actual value for Neptune is {different from / lower than} predicted value (1) with **one** of these • (so) the rule does not work (for Neptune) (1) • the rule gives too high a value (1) • (so) Neptune might have been {captured / entered} from outside the original Solar System (1)	actual value for Neptune put on to chart by cross or dot etc. (no need for label) (1) (Neptune) is an anomaly ignore references to age of Neptune	**(2)**

Question Number		Indicative Content	Mark

QWC	***4(c)**	A discussion including some of the following points
		
		• Methods
		  ○ space probes
		  ○ soil experiments by landers
		  ○ SETI
		  ○ telescopes
		  ○ robotic machines
		
		• Problems
		  • expense / international collaboration needed
		  • large distances involved
		  ○ if problem difficult to correct
		  ○ time to react to problem is long
		  ○ time to respond to any communication would be long
		  ○ complex technology
		  ▪ for human visit
		  ▪ for robot investigation
		  ▪ fuel
		  • recognition of alternative life-forms
		  • pattern recognition
		  ○ for SETI
		  ○ communication if intelligent life-form
		  • possibility of cross-contamination
			(6)

Level	**0**	No rewardable content	
1	**1 – 2**	• a limited discussion including EITHER two named problems, OR two named methods, OR a named problem + a named method e.g. It would be expensive and the distances are large OR Space probes and SETI can be used OR can listen for communications, life beyond Earth may not be water based. • the answer communicates ideas using simple language and uses limited scientific terminology. • spelling, punctuation and grammar are used with limited accuracy.	
2	**3 – 4**	• a simple discussion including EITHER a problem with its associated method + some other named problem OR a detailed problem + one other named problem e.g. It is expensive to send a space probe to Mars; the distance to Mars very large OR It is difficult to search through the data from space because there is a huge amount of it. Also, any message would be hard to decode. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately. • spelling, punctuation and grammar are used with some accuracy.	

3	**5 – 6**	• a detailed discussion including EITHER two problems with their associated method(s) + some other named problem OR two detailed problems + one other named problem OR a problem with its associated method + a detailed problem + one other named problem e.g. We can analyse radiowaves from space, but they take so long to arrive that the aliens that sent them could have already died out. It is very expensive to develop the technology needed to go to other planets. Also, we might not recognise alien life-forms there. OR It is difficult to search through the data from space because there is a huge amount of it. Radiowaves in space take a long time to arrive because the distances are so vast. It all costs a lot of money. OR It is very expensive to develop the technology needed to go to other planets. It is difficult to search through the data from space because there is a huge amount of it. Also, we might not recognise alien life-forms there. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately. • spelling, punctuation and grammar are used with few errors.