Question Number	Answer	Acceptable answers	Mark
1(a)(i)	A		**(1)**

Question Number	Answer	Acceptable answers	Mark
1 (a)(ii)	an explanation linking the following • very little effect / not effective (1) • X-rays can easily penetrate sunglasses (1)	would not protect eyes do not stop x-rays	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(a)(iii)	cancer damage to cells damage to DNA damage to tissue damage to bones damage to skin damage to organs killing cells mutation mutating cells marks on skin sterilisation infertility re-arrangement of cell structure radiation poisoning	Ignore hair falling out	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(a)(iv)	A suggestion to include any **two** of the following • took a long time for effects to become apparent (1) • it was new /scientific (1) • risks not properly understood (1) • it removed hair successfully (1)	did not realise the damage it was doing believed that it was harmless / believed the advertisement people wanted to look attractive	**(2)**

Question Number		Indi	Mark
QWC	***1(b)**	A discussion to include some of the following facts • infrared frequency much lower than X-rays • X-rays very penetrating • X-rays potentially more dangerous to the operator • infrared can cause skin burns • laser is very concentrated • specialised clinics are controlled environments • safe operation depends on training • our knowledge of EM radiation is still not complete The discussion makes some of the following links • lower frequency of infrared makes it potentially less dangerous than X-rays • high penetration of X-rays makes it difficult provide adequate shielding • the concentration of energy by the infrared laser makes it more dangerous than otherwise • controlled environment of a clinic provides better safety and more thorough training • difficulty of ensuring proper maintenance /correct dosage if used domestically • lack of knowledge could mean there are long term effects still not known The discussion makes some of the following conclusions • easier shielding of infrared compared to X-rays means there is less risk to operators and /or patient • difficulty of ensuring proper control means it is not suitable for domestic use • lack of full understanding of long term effects means it is better to err on side of caution	**(6)**
Level	**0**	No rewardable material	
1	**-2**	• the discussion gives at least two basic facts with no links OR a fact and a conclusion with no links e.g. Infrared can cause burns so it could be dangerous. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**-4**	• the discussion gives a link (or comparison) between at least two facts for infrared and X-rays, eg. infrared has lower frequency than X rays so is less dangerous. We do not know enough about the dangers of infrared and it could still burn you • 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 which has at least two links or comparisons supporting a justified conclusion (about selling or dangers) eg. infrared has lower frequency than X rays so is potentially less dangerous but without proper training there is a danger of overexposure if people used it at home (therefore it should not be sold to the public) • 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
2(a)	18 (°C) (1) Ignore any unit given by candidate.		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	(black is the) best absorber (of radiation/heat)(compared to other colours) (1)	(Black/it) absorbs more (Black/it) is a good absorber (of radiation/heat) (black is) good at taking in (radiation/heat) Ignore (black is a) good emitter Ignore light. Reject black attracts heat/radiation	**(1)**

Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	• Heating effect/temperature greatest at/beyond red (1) • (There is) radiation beyond red (end of spectrum)(1)	(idea of) different colours have different heating effects (Radiation from) sunlight causes a heating effect accept reverse argument Infrared/IR (beyond red end of spectrum)	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(iii)	Any **one** from • To check the thermometers produce the same readings/ temperature (under the same conditions) (1) • To show that temperature changes.	(To check) they were all at the same temperature (before starting the experiment.) To be able to make a comparison (between shade and light) (To allow them to carry out a) fair test	**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)(i)	C damage to the eyes (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)(ii)	D all three signals arrive at the same time (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(c)iii	Description linking **one** of the following pairs: • security marking (1) • ink absorbs UV and re-radiates (visible) light (1) • fluorescent lamps (1) • coating absorbs UV and re-radiates (visible) light (1) • genuine bank notes (1) • watermark absorbs UV and re-radiates (visible) light (1) • disinfecting water (1) • UV kills bacteria (1) • sun beds (1) • UV absorbed by (melanin in) skin (1) Any suitable use gains 1 mark Any suitable use + detail gains 2 marks	 invisible ink/smart water glows under UV (outside of) lamp glows when hit by UV forgeries/fake bank notes/passports/fingerprints/ body fluids etc markings glow under UV tanning beds tans the skin /the body e.g. disco lighting (1) makes clothing glow (1)	**(2)**

Total for Question 3 = 9 marks

Question Number	Answer	Acceptable answers	Mark
3(a)	A		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)	alpha particles (In the left section) gamma rays (centre section) infrared radiation (right section) (2)	Any one in correct position for one mark, all three in correct position for two marks	**(2)**

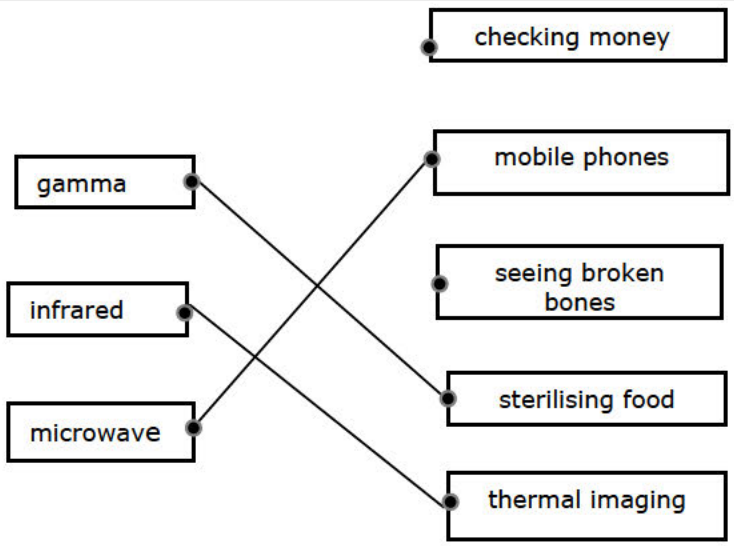
Question Number	Answer	Acceptable answers	Mark
3(c)	C		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(d)	A description to include The purpose of using gamma radiation (1) Some relevant detail about how it achieves the purpose (1)	Purposes may include sterilising food /medical equipment detection / treatment of cancer imaging /detect flaws in materials	**(2)**

Question Number		Indicative Content	Mark
QWC	*)	An explanation including some of the following points Results obtained: • Herschel: temperature on thermometer • Ritter: speed of darkening of silver chloride paper Trend of results: • Herschel: hotter towards red end • Ritter: quicker towards blue/violet end Extension of experiment to get more results: • Herschel: measure below red; found it even hotter • Ritter: measure above blue/violet; paper darkened quicker Conclusion: • Herschel: Must be radiation below red (Infra Red) • Ritter: Must be radiation above blue/violet (UV)	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• A limited description of either some results or conclusions from either experiment. For example: They measured temperature across the spectrum and found that temperature changed. They put silver chloride paper in the spectrum and found that it darkened at different speeds with different colours. 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 explanation of results and conclusions from both experiments . For example: Herschel measured the temperature across the spectrum and found it hotter towards the red end. This was infra red radiation. Ritter measured the darkening of chloride paper across the spectrum. It was quicker towards the violet end. They had discovered ultra violet. • 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 explanation of all the results obtained from both experiments and the conclusions from these results. For example a response as for level 2 given above but with detail about results being obtained from outside the visible spectrum • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately elling, punctuation and grammar are used with few errors	

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	B		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	• starting with red (1) • any two others in correct sequence (1)	roygbiv	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)		3 correct 3 marks 2 correct 2 marks 1 correct 1 mark more than 1 line from a wave box no marks for that box	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(c)	A description including the following: • infrared causes burns (to the skin) /('skin) blistering (1) • (whereas) ultraviolet causes {cell damage / (skin) cancer / sunburn} (1)	Ignore {sunburn / cancer} damage to eyes U-V (potentially) more dangerous than IR=1	**(2)**