

1. Here is a list of waves:

Infrared

Microwaves

Sound

Ultraviolet

X-rays

(a) Use waves from the list to answer the following questions. You may use each wave once, more than once or not at all.

(i) Which wave is not in the electromagnetic spectrum?

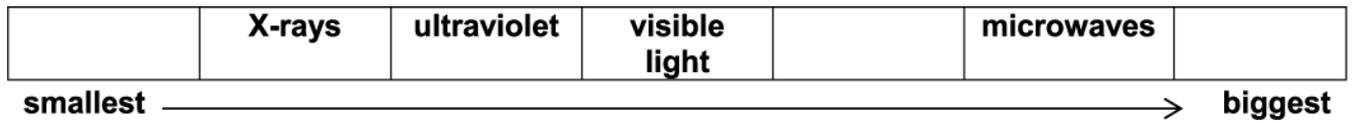
----- [1]

(ii) Which wave can be used to find metal objects in a suitcase?

----- [1]

2(a). Michelle draws a diagram of the parts of the electromagnetic spectrum.

She misses out some parts.



(i) Add the missing parts of the spectrum to the above diagram.

[3]

(ii) Going from left to right, what property is **increasing** in the diagram?

Put a **ring** around the correct answer.

energy

frequency

wavelength

wave speed

[1]

(b). Different parts of the electromagnetic spectrum are used for different purposes.

Draw straight lines to link each part of the electromagnetic spectrum to its use.

Part of the electromagnetic spectrum

Use

X-rays

to produce images of bones

microwaves

to carry information along optical fibres

infra-red

to carry satellite signals

[2]

3(a). Radiographers work in hospitals and are regularly exposed to X-rays. X-rays cause damage to the human body.

State the damage that may be caused by X-rays.

----- [1]

(b). Suggest and explain how people working with X-rays can be protected from damage.

----- [2]

(c). Radiographers also use gamma ray sources.

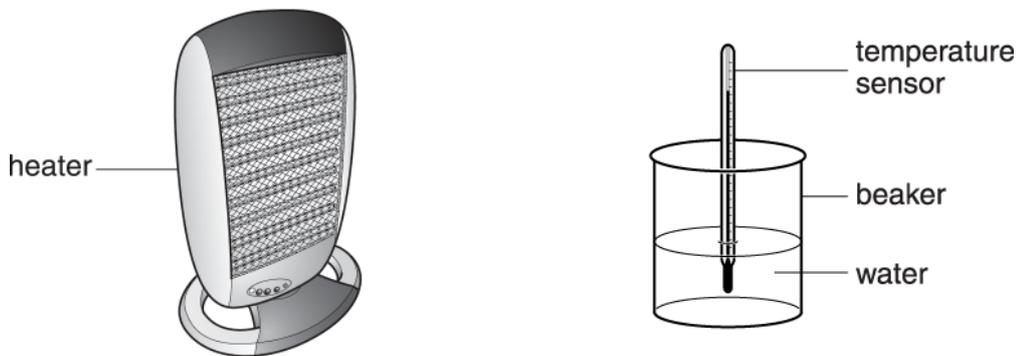
X-rays are produced by electrically powered machines.

Gamma rays cause similar damage to X-rays, but the radioactive materials giving out gamma rays are more dangerous than X-ray machines.

Explain why this is so.

----- [2]

4. Rachel does an experiment to investigate the heating effect of electromagnetic radiation.



She measures the temperature change of the water in the beaker.

Complete the sentences to explain what is happening to the electromagnetic radiation.

Use words from the list.

absorbed

emitted

ionised

transmitted

The electromagnetic radiation is _____ by the heater.

It is then _____ through the atmosphere and finally _____ by the water. **[3]**

5. Brian will not get a microwave oven for his kitchen. He is sure they are dangerous. His ideas are a bit confused.



Brian
Gamma rays are very dangerous. I'm not going to risk getting cancer.

Explain to Brian why he is wrong, and why microwave ovens are safe to use.

[2]

6(a). The Sun gives out a lot of ultraviolet radiation. This can damage living cells.

Describe how the Earth's atmosphere helps to protect us against this damage.

----- [2]

(b). We can help prevent ultraviolet damage to our skin by the way we behave in sunny weather. Describe and explain one way we can do this.

----- [2]

7. On a clear night, we can see the Moon.



Some of the light coming from the Moon is ultraviolet light, but we don't get a tan from the moonlight.

Suggest a reason why.

-----[1]

8(a). Ultraviolet, X-ray and gamma radiation are all used in medicine.

What do high-energy ultraviolet, X-ray and gamma radiation have in common?

Put a tick (✓) in the box next to each correct statement.

They are blocked by sun-screens.

They are electromagnetic radiation.

They can remove electrons from atoms.

They have lower frequencies than microwaves.

They are used to carry information in optic fibres.

[2]

(b).

(i) X-rays are used by doctors to produce pictures of the inside of the human body.

Explain how X-rays are used to produce pictures of the inside of the body and why they are used instead of ultraviolet radiation.

[3]

(ii) Joel thinks the X-rays are dangerous and might cause cancer.

He asks each of the patients on a cancer ward if they have ever had an X-ray picture taken.

Here are his results.

	male	female
had an X-ray	15	7
never had an X-ray	0	1

Joel thinks this shows he is correct.

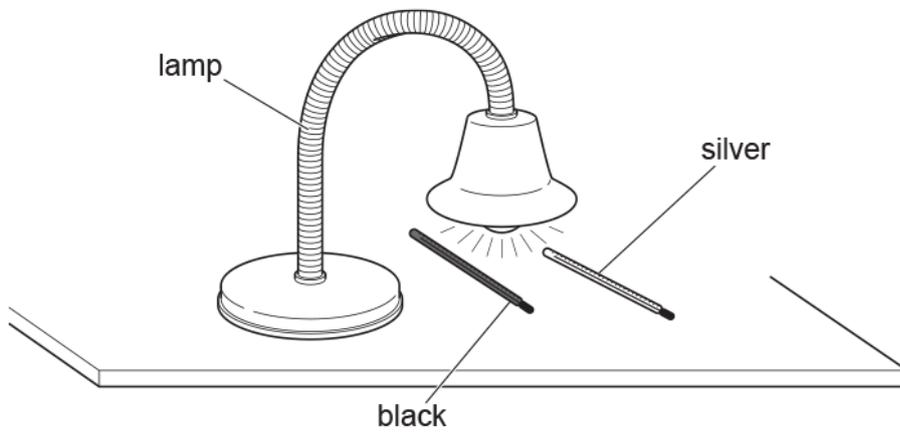
Is Joel correct? Justify your answer.

[3]

12(a) Ben investigates how much radiation is absorbed by different coloured surfaces.

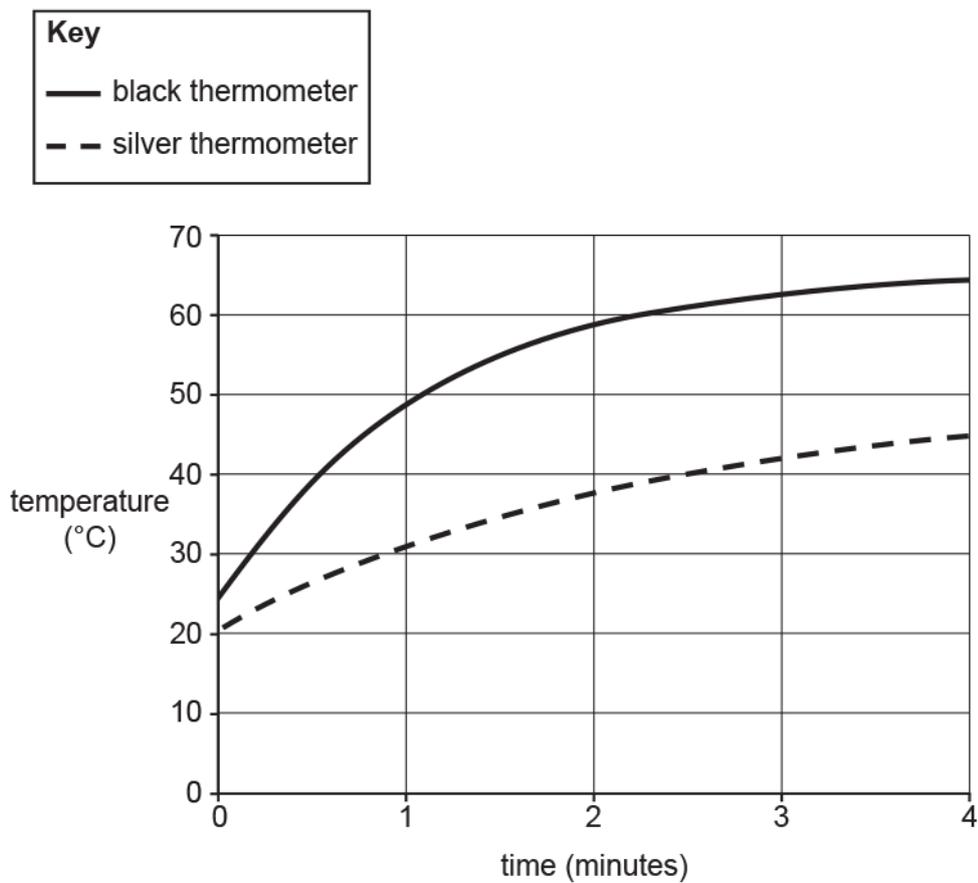
He uses two thermometers and a lamp.

He paints one thermometer black and the other thermometer silver and places them under the lamp.



He records how the temperature of each thermometer changes over four minutes.

The graph shows his results.



Describe **similarities** and **differences** between the results for the black thermometer and the silver thermometer.

Similarities -----

Differences -----

----- [3]

(b). Explain the results of the experiment.

----- [2]

(c). Identify a weakness with Ben's method and suggest how it could be improved using information from the diagram or from the graph.

----- [2]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1		i	Sound	1	
		ii	X-rays	1	
			Total	2	
2	a	i	Gamma (1) Infra-red (1) Radio (1)	3	
		ii	Wavelength	1	
	b			2	all correct = 2 marks 2 correct = 1 mark 1 or 0 correct = 0 marks
			Total	6	
3	a		damage to cells/tissues OR causes cancer	1	<p>Accept answers more appropriate to H-tier or to Unit P6 e.g. ionise atoms, cause mutations in DNA.</p> <p>Accept types of cancer including skin cancer</p> <p>Ignore kill you, make you ill</p> <p>Accept kill cells</p> <p>Examiner's Comments</p> <p>The fact that X-rays can cause cancer was recalled by many candidates. However, answers about sunburn showed that many cannot distinguish between ultraviolet radiation and X-rays. Some of those who wrote 'skin cancer' were probably confusing the radiation ranges rather than showing knowledge of the risk to radiation workers.</p>
	b		<p>Method, any one of: Barrier or example of a barrier;</p> <p>Special/protective clothing /suitable example;</p> <p>Increase distance; Decrease time of exposure</p>	1	<p>Reject: if all examples given will not stop X-rays e.g. 'plastic barrier'</p> <p>Accept: glass</p> <p>Reject: if all examples given are incorrect e.g. unsuitable clothing: goggles, lab coat, gloves</p>

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
		<p>Explanation, any one of: To block/absorb radiation; To stop them penetrating the body; To reduce exposure/dose</p>	1	<p>Allow: 'stand behind absorbent material' (2)</p> <p>Accept: wear a badge (to monitor dose received) with explanation e.g. so they can make sure dose is not too high (2);</p> <p>Examiner's Comments</p> <p>There were good answers suggesting a barrier, or an example of a barrier, that would protect from X-rays, but also a small but significant number of unsuitable suggestions, such as face-masks, lab-coats and gloves. Some candidates had the impression that glasses or goggles were all that was needed. Explanations were not often given, so it was rare for a second mark to be scored.</p>
	c	<p>Any two of the following: X-ray machine can be switched off; radioactive sources produce gammas all the time; Gamma rays have higher energy/power/frequency; direction of X-rays predictable; Gamma rays come out in all directions; Gamma rays more penetrating; Gamma rays need (more) shielding; Danger of contamination by radioactive material; Gammas are more ionising.</p>	2	<p>Allow reverse argument</p> <p>Ignore rewording of question e.g. 'more harmful'</p> <p>Ignore 'stronger', 'gamma causes more damage', 'causes cancer'</p> <p>Examiner's Comments</p> <p>Correct answers commonly described gamma rays as having higher power or frequency, being more ionising and, sometimes, being more penetrating. There are impressions that gamma rays are 'more radioactive' and 'stronger' than x-rays. There were some good answers stating higher energy photons, higher frequency, more ionising – although some candidates did not score for 'highest' or 'top' of the electromagnetic spectrum. They may have had more experience with comparing an ionising with a non-ionising radiation, as some candidates failed to score marks with answers, such as 'gamma rays are ionising' and 'gamma rays have a high frequency'.</p>

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	5	
4			emitted transmitted absorbed	3	<u>Examiner's Comments</u> 'Absorbed' was often correct but a large number swapped 'emitted' with 'transmitted'
			Total	3	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
5		<p>(the oven) uses microwaves OR (the oven) does not use gamma (1)</p> <p>Max 1 microwaves are less dangerous than gamma metal reflects / stops microwaves microwaves do not increase the risk of cancer microwaves are not ionising (1)</p>	2	<p>not microwaves are not harmful</p> <p>assume 'microwaves' (on their own) refers to waves not to the oven</p> <p>allow one mark for 'gamma rays increase risk of cancer'</p> <p>allow for 2 marks: The microwaves are kept / stay / reflected inside the oven</p> <p>allow for 1 marks: 'The radiation is kept / stays / reflected inside the oven' if it does not refer to gamma rays</p> <p>Examiner's Comments</p> <p>Most candidates understood that the radiation, whatever it was, was safely contained inside the oven. Many candidates knew that microwave ovens use microwaves not gamma rays.</p>
		Total	2	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
6	a	ozone (in atmosphere) (1) absorbs UV / the radiation(1)	2	<p>Examiner's Comments</p> <p>To get marks for this questions candidates needed to state that 'the ozone protects us by absorbing the radiation'. Some candidates knew the correct scientific words 'ozone' and 'absorb'.</p>
	b	use suncream / sunscreen / sunblock OR cover-up with clothing OR wear hat (1) to reflect / absorb / block / reduce exposure to UV (1) OR stay in shade OR stay out of sun at mid- day OR stay out of sun when UV is most intense (1) idea of reducing exposure to UV (1)	2	<p>accept other reasonable suggestions accept radiation for UV ignore sunlight / light / heat for UV ignore 'to stop UV damaging skin' as given in question ignore 'stop skin cancer' ignore 'sun protection'</p> <p>If there are two methods and one explanation mark the method explanation pair and ignore the other method</p> <p>Examiner's Comments</p> <p>Most candidates were able to give a method of protection against ultraviolet radiation. Some explained how their method worked, for example by absorbing radiation or reducing exposure.</p>
		Total	4	
7		absorbed by ozone layer / not enough ultraviolet	1	<p>accept there is not enough light accept absorbed by the atmosphere / clothing</p> <p>Examiner's Comments</p> <p>This was well answered but there was a common misunderstanding that it was the lack of heat from moonlight that stopped the tan.</p>
		Total	1	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance										
8	a	<p>*</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">They are blocked by sun-screens.</td> <td style="width: 30px; text-align: center;"> </td> </tr> <tr> <td style="padding: 2px;">They are electromagnetic radiation.</td> <td style="text-align: center;">?</td> </tr> <tr> <td style="padding: 2px;">They can remove electrons from atoms.</td> <td style="text-align: center;">?</td> </tr> <tr> <td style="padding: 2px;">They have lower frequencies than microwaves.</td> <td style="text-align: center;"> </td> </tr> <tr> <td style="padding: 2px;">They are used to carry information in optic fibres</td> <td style="text-align: center;"> </td> </tr> </table>	They are blocked by sun-screens.		They are electromagnetic radiation.	?	They can remove electrons from atoms.	?	They have lower frequencies than microwaves.		They are used to carry information in optic fibres		2	<p><u>Examiner's Comments</u></p> <p>Many candidates scored one mark for both types of radiation being electromagnetic but after that all responses were seen with the most common incorrect answer being they had lower frequencies than microwaves.</p>
They are blocked by sun-screens.														
They are electromagnetic radiation.	?													
They can remove electrons from atoms.	?													
They have lower frequencies than microwaves.														
They are used to carry information in optic fibres														
	b	i	3	<p>ignore comments about damage caused</p> <p>accept bones for dense parts of the body accept skin and soft tissues as less dense parts of the body</p> <p>'picture' unqualified is insufficient accept bones for dense parts of the body</p> <p><u>Examiner's Comments</u></p> <p>Many candidates scored two marks by explaining that X-rays can travel through soft tissue but not through bone but few could explain that ultraviolet cannot pass further than the skin. Many candidates incorrectly concentrated on the danger from ultraviolet radiation to the exclusion of X-rays or stating that ultraviolet was more dangerous than X-rays.</p>										

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<p>any 3 from bias in sample / samples not matched / no control group eg all had cancer / might be other cause of cancer (only if Joel wrong) small sample size / need more data</p> <p>(the data shows a) correlation</p> <p>idea that there is a mechanism for the X-rays causing cancer</p>	3	<p>allow examples eg more men than women, don't know when they had X-rays</p> <p><u>Examiner's Comments</u></p> <p>This proved a good differentiator with stronger candidates addressing the issues such as small or biased sample and many things being the cause of cancer whilst others thought the figures were conclusive proof of X-rays causing cancer.</p>
			Total	8	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
9	<p>(Level 3) Gives a scientific statement related to risk and gives a scientific statement related to scepticism.</p> <p>Quality of written communication does not impede communication of the science at this level.</p> <p style="text-align: right;">(5–6 marks)</p> <p>(Level 2) EITHER Gives a non-scientific statement related to risk and gives a non-scientific statement related to scepticism. OR Gives a scientific statement related to risk or gives a scientific statement related to scepticism.</p> <p>Quality of written communication partly impedes communication of the science at this level.</p> <p style="text-align: right;">(3–4 marks)</p> <p>(Level 1) Gives a non-scientific statement related to risk or gives a non-scientific statement related to scepticism.</p> <p>Quality of written communication impedes communication of the science at this level.</p> <p style="text-align: right;">(1–2 marks)</p> <p>(Level 0) Insufficient or irrelevant science. Answer not worthy of credit. E.g. 'because it produces so much radiation in an hour' - repeats question. 'Because it is dangerous' 'because they are journalists' 'because it's not true'</p> <p style="text-align: right;">(0 marks)</p>	6	<p>This question is targeted at grades up to E</p> <p>Indicative scientific points related to risk may include:</p> <ul style="list-style-type: none"> • mobile phones used close to head • could damage / 'cook / fries' your brain • as brain is mostly water, which absorbs microwaves • idea of skin or cell damage by heating • the longer the use of the phone greater the risk. <p>Indicative scientific points related to scepticism may include:</p> <ul style="list-style-type: none"> • most of the microwave energy escapes (in all directions) • difficult as some heat lost to the environment • no (scientific) evidence (that phones cause harm) • when we use our phones we do not experience this heating effect. <p>Indicative non-scientific points related to risk may include:</p> <ul style="list-style-type: none"> • phones may harm / cook / fry you • their children may use phones • (they may think that) phones may give out ionising radiation and / or increase cancer risk or (cell) mutations. <p>Indicative non-scientific points related to scepticism may include:</p> <ul style="list-style-type: none"> • there's a lot of rubbish on the internet • not everything journalists say is true • wouldn't be allowed to sell phones (if risk) • you don't hear about people getting hurt by phones. <p>Use the L1, L2, L3 annotations in Scoris; do not use ticks.?</p> <p><u>Examiner's Comments</u></p>

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					Most candidates were able to state that people would worry about the harm to their bodies. Better answers specified the head or brain. A few seemed more worried about the damage to the phone. Some candidates thought the egg was cooking because the phones were hot, so this would cause damage to hands and pockets. It was good to see able candidates giving sensible reasons for doubting the journalists – often in terms of lack of evidence and scientific testing. A few candidates wrote statements like ‘Just imagine what it would do to a person’ which sadly, did not answer the question.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
10	<p>[Level 3] States some risks for Gail and states a benefit and a risk for Tom Quality of written communication does not impede communication of the science at this level. (5 – 6 marks)</p> <p>[Level 2] EITHER states some risks for Gail or states a benefit and a risk for Tom OR states a risk for Gail and states a benefit or a risk for Tom. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks)</p> <p>[Level 1] EITHER States a risk for Gail or states a benefit or a risk for Tom OR States a benefit and a risk of X-rays without linking them to Gail or Tom. Quality of written communication impedes communication of the science at this level. (1 – 2 marks)</p> <p>[Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)</p>	6	<p>This question is targeted at grades up to C</p> <p>Indicative scientific points may include:</p> <p>Risks for Gail</p> <ul style="list-style-type: none"> • baby / Gail could be damaged • X-rays damage cells / organs • Dose is similar to background • Dose is relatively high • X rays can cause cancer <p>Benefits for Tom</p> <ul style="list-style-type: none"> • Identifying problems with teeth early on • Allows prompt treatment • Benefit much greater than risk <p>Risks for Tom</p> <ul style="list-style-type: none"> • Dose is much less than background • Risk of cancer is small • Dose is relatively low <p>Use the L1, L2, L3 annotations in Scoris; do not use ticks.</p> <p>Examiner's Comments</p> <p>This question about the risks and benefits of X-ray treatment was well answered by many candidates. A significant number of candidates didn't use the data provided at all, contenting themselves with a general account of the risks and benefit of X-ray imaging of people, restricting the number of marks that they could earn.</p>
	Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
11	<p>(Level 3) States a UV danger and a way in which the danger has been reduced and refers to relevant gas / layer as 'ozone' AND does not include inappropriate reference to CO₂ /global warming issues. Quality of written communication does not impede communication of the science at this level.</p> <p style="text-align: right;">(5–6 marks)</p> <p>(Level 2) States a UV danger and a way in which the danger has been reduced OR States a UV danger and refers to relevant gas / layer as 'ozone' OR States a way in which the danger has been reduced and refers to relevant gas / layer as 'ozone' AND does not include inappropriate reference to CO₂ /global warming issues. Quality of written communication partly impedes communication of the science at this level.</p> <p style="text-align: right;">(3–4 marks)</p> <p>(Level 1) States a UV danger OR states a way in which the danger has been reduced OR refers to relevant gas / layer as 'ozone' and does not include inappropriate reference to CO₂ /global warming issues. Quality of written communication impedes communication of the science at this level.</p> <p style="text-align: right;">(1–2 marks)</p> <p>(Level 0) Insufficient or irrelevant science. Answer not worthy of credit.</p> <p style="text-align: right;">(0 marks)</p>	[6]	<p>This question is targeted at grades up to E Indicative scientific points related to ultraviolet danger may include:</p> <ul style="list-style-type: none"> • Ultraviolet radiation from the Sun reaches Earth's surface / is not absorbed / is transmitted • Ultraviolet radiation is ionising • it can damage skin / eyes • may mutate DNA • may cause cancer <p>Indicative scientific points related to the correct scientific terminology for the gas / layer may include:</p> <ul style="list-style-type: none"> • gas is ozone / O₃ • Natural layer is ozone layer / O₃ <p>Indicative scientific points related to reducing the danger may include:</p> <ul style="list-style-type: none"> • Don't use chemicals that damage the layer • Don't use CFCs • Use chemicals that don't damage the layer • prevent (further) damage to / allow recovery of the layer. • (international laws) ban the (damaging) chemicals • Regulations / methods of disposal of fridges • raise awareness so people reduce exposure • exposure can be reduced e.g. by staying out of the sunshine, wearing sunscreen and covering up. <p>Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.</p>
	Total	6	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
12	a	<p>MAX 3 in total: MAX 2 similarities: temperature increases (as time increases) / both graphs go up ✓</p> <p>both graphs level off/increase less rapidly as time goes on ✓</p> <p>MAX 2 differences: black goes up quicker / graph is steeper (or reverse argument) ✓</p> <p>black reaches higher temperature / silver reaches a lower temperature ✓</p> <p>silver starts at lower temperature / black starts at a higher temperature ✓</p>	<p>3 (AO 3.1a ×3)</p>	<p>ALLOW they both get hotter</p> <p>ALLOW black has a higher temp / silver has a lower temperature as one difference (instead of one of the latter two, but not both)</p> <p>IGNORE any attempt at explanation in this part.</p> <p><u>Examiner's Comments</u></p> <p>Part (a) is another AO3 question which some candidates found difficult. The command word in part (a) is 'describe' so candidates do not need to try to explain the results here, that is what part (b) is about. Many candidates did describe the similarity in the pattern on the graph that the temperature increases. However, some candidates tried to explain the results instead of describing the differences between the results from the two thermometers.</p>

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
b	<p>EITHER black absorbs more radiation/light/infrared than silver ORA ✓</p> <p>OR silver reflects more radiation/light/infrared than black ORA ✓</p> <p>so more <u>energy</u> transferred to black thermometer ORA ✓</p>	<p>2 (AO 1.1 ×2)</p>	<p>ALLOW heat</p> <p>Examiner's Comments</p> <p>In part (b) candidates are expected to use the correct terminology so needed to use either absorb or reflect. Many candidates stated that black attracts heat, which is not using the correct scientific words so did not gain any credit. The second marking point was to refer to the idea that increasing temperature is linked to the amount of energy gained by the thermometers.</p> <p>Exemplar 6</p> <p>Similarities Both thermometers show increase in temperature with time ✓</p> <p>Differences In Black thermometer increase in temperature is rapid and in Silver thermometer increase in temperature is slow ✓</p> <p>The rise in temperature in black thermometer rapid because black absorbs maximum radiation ✓ where as silver reflect maximum radiation</p> <p>In part (a) this candidate correctly identifies the similarity that the temperature increases for both thermometers. Although the candidate gives two statements as differences; that the black thermometer increases rapidly, and the silver thermometer rises slowly, they describe the same difference. For the third mark to be credited the candidate needs to make another observation such as that the black thermometer reaches a higher temperature.</p> <p>In part (b) this candidate correctly states that the black thermometer absorbs radiation and that the silver thermometer reflects radiation, this is again two ways of getting the first marking point. In order to gain the second marking point the candidate needs to refer to the fact that either of these statements mean that the black thermometer gains more energy than the silver one.</p>

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	c	<p>EITHER distance from lamp / intensity of radiation or light is not controlled / the same ✓ method to control this e.g. measure distance / use ruler / clamp thermometers, AW ✓</p> <p>OR initial temperature is not controlled / not the same ✓ method to control this e.g. use separate timers for each thermometer and start them at a specified temperature ✓</p>	<p style="text-align: center;">2 (AO 3.3b ×2)</p>	<p>ALLOW Any valid weakness for first mark and any reasonable method for second mark</p> <p><u>Examiner's Comments</u></p> <p>Many candidates did identify that the thermometers do not look equidistant from the lamp or that they start at different temperatures. However, few candidates were able to explain how to improve the experiment. In order to ensure the thermometers were the same distance away, some method of measuring would be needed e.g. a ruler. It is probably more difficult to explain how to ensure they started at the same temperature.</p>
		Total	7	