

1. The table shows typical wavelengths of different parts of the electromagnetic spectrum.

| Name of region | Typical wavelength (m) |
|----------------|------------------------|
| radio waves | 5.0 |
| microwave | 0.1 |
| infrared | 5.0×10^{-5} |
| visible light | 5.0×10^{-7} |
| ultraviolet | 1.0×10^{-7} |
| X-rays | 1.0×10^{-10} |
| gamma rays | 1.0×10^{-12} |

Very short wavelength radiation can be hazardous.

Which **two** of the following statements, put together, can explain this?

Put ticks (✓) in the two correct boxes.

Very short wavelength radiation has very high frequency.

Radiation of wavelength greater than 1 cm can cause cancer.

The energy of a photon is directly proportional to its frequency.

Long wavelength radiation is not absorbed by living organisms.

Very short wavelength radiation is absorbed by the atmosphere.

[2]

2. Explain the process by which very short wavelength radiation damages living cells.
Use appropriate scientific terms in your answer.

----- [3]

3(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]

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

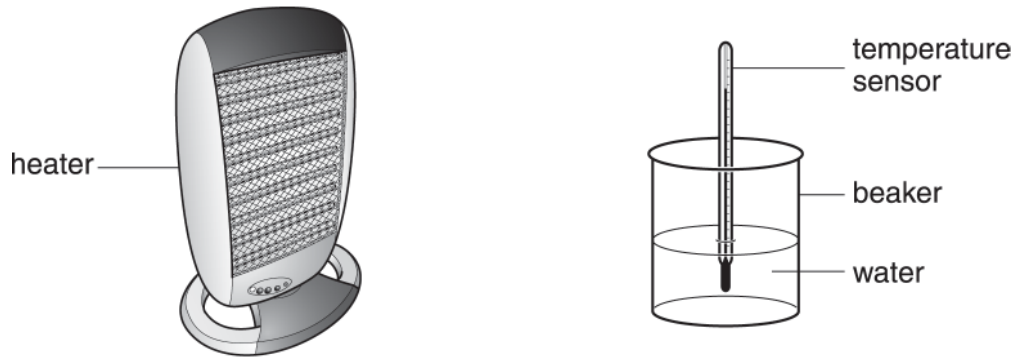
Describe how the Earth's atmosphere helps to protect us against this damage.

[2]

(b). People love to sunbathe in sunny weather even though they know it can be dangerous. Suggest reasons why people are still happy to sunbathe.

[2]

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



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

Describe what is happening to the electromagnetic radiation from the heater.

Your description should include the words absorbed, emitted and transmitted.

[2]

END OF QUESTION PAPER

Mark Scheme

| Question | | Answer/Indicative content | Marks | Guidance | | | | | | | | | | |
|---|---|--|----------------------------------|---|-------------------------------------|---|---------------------------------------|---|--|--|---|--|---|---|
| 1 | | boxes 1(short $\lambda \Rightarrow$ high f) and 3 ($E \propto f$) | 2 | one mark each Examiner's Comments Roughly half of the candidates identified the two correct statements. | | | | | | | | | | |
| | | Total | 2 | | | | | | | | | | | |
| 2 | | they are ionising radiations/can cause ionisation (1); (ionisation) removes electrons (from atoms/molecules) (1); (ionisation) results in chemical reactions /damage DNA/ cause mutations (1) | 3 | Ignore 'gives you cancer' Examiner's Comments The short free-response in part (b) discriminated well between candidates, with the best responses clearly referring to ionisation, electron removal and changes to molecules in the cell. | | | | | | | | | | |
| | | Total | 3 | | | | | | | | | | | |
| 3 | a | <table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="padding: 2px;">They are blocked by sun-screens.</td> <td style="width: 50px; 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> </tbody> </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 | Examiner's Comments One mark was most commonly given for 'they are electromagnetic radiation'. But far fewer recognised that all were ionising and hence 'remove electrons from atoms'. |
| 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. | | | | | | | | | | | | | | |

Mark Scheme

| Question | | | Answer/Indicative content | Marks | Guidance |
|----------|---|----|---|----------|---|
| | b | i | <p>ultraviolet stopped / blocked / absorbed by skin / cannot penetrate body (1)</p> <p>any 2 from X-rays are stopped / blocked / absorbed by (dense) parts of the body</p> <p>X-rays are not stopped / blocked / absorbed by or can penetrate through other (less dense) parts of the body</p> <p>idea of (shadow) picture behind body / on film / screen</p> | 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</p> <p>Examiner's Comments</p> <p>Most candidates stated that an X-ray could travel through parts of the body and was stopped by bones but few realised that reason UV was not used because it was unable to travel through the skin. A rather alarming proportion of candidates seem to think that ultraviolet is not used because it is more dangerous than X-rays, specifically it is more likely to cause cancer.</p> |
| | | ii | <p>any 3 from bias in sample / samples not matched / no control group e.g. all had cancer / might be other cause of cancer (if Joel is 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 e.g. more men than women, don't know when they had X-rays</p> <p>accept example e.g. X-rays are ionising causing cancer</p> <p>Examiner's Comments</p> <p>A good number of candidates were able to score 1 mark here, usually either noting the small sample size or bias, but it was disappointing to see so few who picked up both these problems with Joel's survey. Some candidates did mention the correlation of data.</p> |
| | | | Total | 8 | |

Mark Scheme

| Question | | Answer/Indicative content | Marks | Guidance |
|----------|---|--|----------|---|
| 4 | a | ozone (in atmosphere) (1) absorbs UV / the radiation (1) | 2 | <p>Examiner's Comments</p> <p>Most obtained one mark, which was testing recall of the name of the active chemical and the correct use of the terms absorb/emit/reflect/transmit – in this case, absorb.</p> |
| | b | valid benefit from sunbathing (1) consideration of risk / reducing risk (1) | 2 | <p>e.g. warmth feels nice / to get a tan / vitamin D production improves health / can lower blood pressure e.g. benefit outweighs risk / people underestimate the risks / use protective measure, e.g. high factor sun cream / only do it for short times to keep risk small / skin cancers can be easily seen and dealt with</p> <p>Examiner's Comments</p> <p>Generally well done, with many suggesting not only a benefit of sunbathing but also a consideration of the risk.</p> |
| | | Total | 4 | |

Mark Scheme

| Question | | Answer/Indicative content | Marks | Guidance |
|----------|--|---|----------|---|
| 5 | | <p>emitted by source / heater</p> <p>e.m. radiation transmitted by atmosphere / between source and water / beaker</p> <p>absorbed by water / beaker</p> | 2 | <p>3 correct = 2 marks 2 correct = 1 mark 0 or 1 correct = 0 marks accept photons for e.m. radiation accept transmitted through beaker</p> <p>do not accept absorbed by temperature sensor</p> <p>Examiner's Comments</p> <p>The most common correct idea was that the water (or the beaker) absorbed the radiation. This was closely following by the 'heater emits the radiation'. Transmission ideas caused the most problems as they often did not specify where it was transmitted from or to. Many tried to use the words in the order they were provided in the question (absorbed, emitted and transmitted) and so correctly stated that the water absorbs the radiation which was emitted from the heater but then linked transmission to a stage beyond this e.g. then the heat is transmitted back or the heat sensor then transmits the radiation. Weak candidates did not follow the instructions and used the words 'emit', 'transmit' and absorb'.</p> |
| | | Total | 2 | |