3.19 The Electromagnetic Spectrum: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Describe two ways that exposure to ultraviolet radiation can harm the human body.

(Total for Question 1 is 2 marks)

2 State two precautions a hospital radiographer can take to reduce their own exposure to X-rays while working.

(Total for Question 2 is 2 marks)

3 Required practical: A student wants to compare how much infrared radiation is emitted by different surfaces, all at the same temperature. They have a Leslie cube (a hollow metal cube with four different surface finishes on its sides: matte black, matte white, shiny black and shiny silver) that can be filled with hot water, and an infrared detector.

(a) Describe how the student could use this apparatus to carry out a fair test comparing the infrared radiation emitted by the four surfaces. **(3)**

(b) State which surface would be expected to emit the most infrared radiation, and which would be expected to emit the least. **(2)**

(Total for Question 3 is 5 marks)

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4 The electromagnetic spectrum has many uses in medicine, communication and everyday life, but different types of wave also present different dangers. Discuss the uses and dangers of ultraviolet radiation and γ radiation, and explain how these dangers are managed to keep people safe.

(Total for Question 4 is 6 marks)

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5 A local radio station broadcasts on a frequency of 97.4 MHz. Use the Physics Equations Sheet: wave speed = frequency * wavelength ($v = f * \lambda$), and the speed of electromagnetic waves in air, $v = 3.0 \times 10^8$ m/s, to calculate the wavelength of the radio waves broadcast. Give your answer to 3 significant figures.

(Total for Question 5 is 3 marks)

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6 A γ-ray source used in radiotherapy emits electromagnetic radiation with a frequency of 3.00×10^{19} Hz.

(a) Use the Physics Equations Sheet: wave speed = frequency * wavelength ($v = f * \lambda$), and the speed of electromagnetic waves, $v = 3.00 \times 10^8$ m/s, to calculate the wavelength of this γ radiation. Give your answer in standard form. **(3)**

(b) Radiotherapy uses γ rays, rather than radio waves, to destroy cancer cells deep inside the body. Explain why γ rays, rather than radio waves, are suitable for this use. **(2)**

(Total for Question 6 is 5 marks)

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Mark scheme · 3.19 The Electromagnetic Spectrum: 30-minute Pack

Question 1

skin damage, e.g. premature ageing of the skin, or an increased risk of skin cancer, oe **B1**

eye damage, e.g. damage to the eyes/increased risk of cataracts, oe **B1**

Answer: Skin damage (e.g. premature ageing or an increased risk of skin cancer) and eye damage (e.g. cataracts).

Question 2

any one of: stand behind a lead/protective screen, or leave the room, during the scan; wear a lead apron, oe **B1**

any other one of: wear a film badge/dosimeter to monitor the dose received; maximise distance from the source; minimise the time spent near the source, oe **B1**

Answer: E.g. stand behind a lead screen (or leave the room) during the scan, and wear a dosimeter badge to monitor their exposure.

Question 3

(a) fill the Leslie cube with hot water (at a set/measured starting temperature, using a thermometer) so all four faces are at the same temperature, oe **B1**

(a) hold/place the infrared detector at the same fixed distance from each face in turn, and record the detector reading for each surface, oe **B1**

(a) control other variables (e.g. keep the water temperature, detector distance and time the same for each surface), and repeat each reading to check for reliability, oe **B1**

(a) Answer: Fill the cube with hot water at a set temperature, hold the detector the same fixed distance from each face in turn, controlling other variables and repeating for reliability.

(b) the matte/dull black surface emits the most infrared radiation **B1**

(b) the shiny silver surface emits the least infrared radiation **B1**

(b) Answer: Matte black emits the most; shiny silver emits the least.

Question 4

Level 1 Simple, isolated statements are made about the uses and/or dangers of ultraviolet and/or gamma radiation, with limited or no reference to how the dangers are managed. The answer lacks a logical structure. **1-2**

Level 2 The uses and dangers of both ultraviolet and gamma radiation are described, with some reference to how the dangers are managed to keep people safe. There is some logical structure to the answer, but coverage of one wave type may be more complete than the other. **3-4**

Level 3 A detailed and logically structured discussion of the uses and dangers of both ultraviolet and gamma radiation is given, with a clear explanation of how each danger is managed to keep people safe. Points are linked using scientific reasoning throughout, for example comparing the relative frequency/energy of the two types of wave. **5-6**

Indicative content:

- Ultraviolet uses: sun tanning/sunbeds, fluorescent lamps/energy-efficient lighting, security marking (e.g. pens that show up under UV light, or detecting forged bank notes).
- Ultraviolet dangers: causes premature ageing of the skin, increases the risk of skin cancer, and can damage the eyes (e.g. cataracts).
- Ultraviolet safety: using sunscreen/sun cream, wearing UV-protective clothing or sunglasses, limiting time spent in strong sunlight, and using shade.
- Gamma ray uses: sterilising medical/surgical equipment, treating cancer (radiotherapy), and medical tracers for diagnosis/imaging.
- Gamma ray dangers: gamma radiation is ionising, so it can damage or mutate DNA in living cells, increasing the risk of cancer, and can kill cells at high doses.
- Gamma ray safety: using lead shielding/lead-lined rooms, keeping distance from the source, limiting exposure time, and wearing a dosimeter badge to monitor the dose received by workers.
- Comparative/linking point: gamma rays have a much higher frequency (shorter wavelength) than ultraviolet, so gamma rays are more ionising and more penetrating, making them more hazardous overall and requiring stricter safety precautions, such as shielding and distance, rather than sunscreen alone.

Question 5

converts 97.4 MHz to 9.74×10^7 Hz **M1**

rearranges and substitutes correctly: $\lambda = v/f = (3.0 \times 10^8)/(9.74 \times 10^7)$ **M1**

$\lambda = 3.08$ m (3 s.f.), cao (accept awrt 3.1 m) **A1**

Answer: 3.08 m

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Question 6

(a) rearranges correctly: $\lambda = v/f$ **M1**

(a) substitutes correctly: $\lambda = (3.00 \times 10^{8})/(3.00 \times 10^{19})$ **M1**

(a) $\lambda = 1.00 \times 10^{-11}$ m, cao **A1**

(a) Answer: 1.00×10^{-11} m

(b) γ rays are highly penetrating and ionising, so they can reach and damage cells deep inside the body, whereas radio waves are non-ionising and carry far less energy, so would not damage/kill the cells, oe **B1**

(b) γ rays can be focused/directed at the tumour so that enough energy is transferred to damage the DNA of the cancer cells (killing them), oe **B1**

(b) Answer: Gamma rays are penetrating and ionising, so they can reach and damage cancer cells deep inside the body; they can be focused at the tumour to destroy its cells, unlike low-energy, non-ionising radio waves.

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