AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.6.2.4

Uses and applications of electromagnetic waves

Past-paper questions

Tier	**Higher**
Question groups	**13**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

6.6.2.4 Uses and applications of electromagnetic waves

Question 01

June 2018 | 8464/P/1H | Original Q4

0 4 The Chernobyl disaster was a nuclear accident that happened in 1986

Radioactive isotopes were released into the environment.

The radioactive isotopes emitted alpha, beta and gamma radiation.

0 4 . 1 What is an alpha particle?

[1 mark]

Tick **one** box.

- 2 charged particles and 2 neutral particles. ☐
- 2 charged particles and 4 neutral particles. ☐
- 4 charged particles and 2 neutral particles. ☐
- 4 charged particles and 4 neutral particles. ☐

0 4 . 2 Which statement about beta radiation is true?

[1 mark]

Tick **one** box.

- It is the fastest moving type of radiation. ☐
- It is the type of radiation with a negative charge. ☐
- It is the type of radiation with the greatest mass. ☐
- It is the type of radiation with the greatest range in air. ☐

6.6.2.4 Uses and applications of electromagnetic waves

Question 01 · continued

0 4 . 3 Which statement about gamma radiation is true?

[1 mark]

Tick **one** box.

- It is a low frequency electromagnetic wave. ☐
- It causes the charge of the nucleus to change. ☐
- It causes the mass of the nucleus to change. ☐
- It has a very long range in air. ☐

Question 4 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 01 · continued

Table 3 shows the half-lives of two of the radioactive isotopes that contaminated the environment.

Table 3

Isotope	Half-life
Caesium–137	30 years
Iodine–131	8 days

0 4 . 4 A soil sample was taken from the area around Chernobyl in 1986

The soil sample was contaminated with equal amounts of caesium–137 and iodine–131

Explain how the risk linked to each isotope has changed between 1986 and 2018

Both isotopes emit the same type of radiation.

[4 marks]

0 4 . 5 Determine the year when the activity of the caesium–137 in the soil sample will be 1/32 of its original value.

[3 marks]

Year = _____

10

6.6.2.4 Uses and applications of electromagnetic waves

Question 02

June 2018 | 8464/P/2H | Original Q5

0 5 A car aerial receives radio waves from a radio transmitter.

Radio waves are transverse waves.

Sound waves are longitudinal waves.

0 5 . 1 Describe the difference between transverse waves and longitudinal waves.

[2 marks]

0 5 . 2 The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

[3 marks]

Wavelength = _____ m

Question 5 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 02 · continued

0 5 . 3 Describe how the radio waves reaching the car aerial produce signals in the electrical circuit of the car radio.

[3 marks]

8

6.6.2.4 Uses and applications of electromagnetic waves

Question 03

June 2019 | 8464/P/1H | Original Q6

0 6 Lanthanum-140 is a radioactive isotope.

0 6 . 1 A nucleus of lanthanum-140 emits gamma radiation.

What happens to the mass number and the charge of the nucleus when gamma radiation is emitted?

[1 mark]

Tick (✓) **one** box.

Mass number	Charge	
Decreases	Decreases	☐
Decreases	Stays the same	☐
Stays the same	Decreases	☐
Stays the same	Stays the same	☐

0 6 . 2 Why is it difficult to detect gamma radiation?

[1 mark]

Question 6 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 03 · continued

0 6 . 3 Activity is the rate at which a radioactive source decays.

A teacher measured the count-rate from a sample of lanthanum-140 using a Geiger-Muller (G-M) tube.

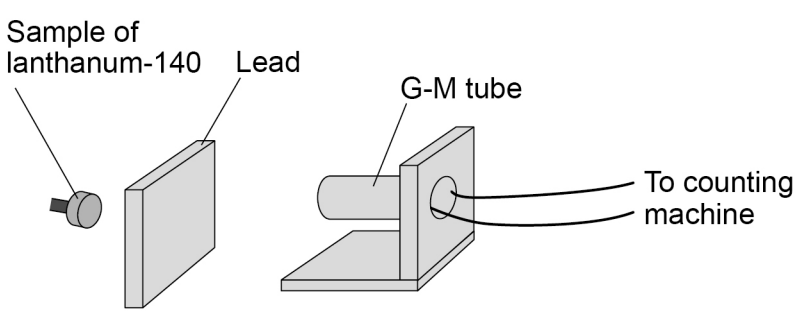
Explain why the count rate was less than the activity of the sample of lanthanum-140

[2 marks]

The teacher investigated how the thickness of lead affected the amount of gamma radiation that could pass through it.

Figure 6 shows the apparatus.

Figure 6



0 6 . 4 Explain why the teacher stood as far away from the apparatus as possible.

[2 marks]

Question 03 · continued

Table 1 shows the results.

Table 1

Thickness of lead in cm	Count rate in counts per second
0.5	110
1.0	60
1.5	33
2.0	18
2.5	10

0 6 . 5 The teacher concluded that the count rate was **not** inversely proportional to the thickness of lead.

Explain why the teacher was correct.

Use the data in **Table 1**.

[3 marks]

0 6 . 6 Lanthanum-140 can also emit beta radiation and change into cerium.

Complete the equation showing the decay of lanthanum (La) 140 into cerium (Ce).

[2 marks]

$$^{140}_{57}\mathrm{La} \longrightarrow {}^{\quad}_{\quad}\mathrm{e} + {}^{\quad}_{\quad}\mathrm{Ce}$$

6.6.2.4 Uses and applications of electromagnetic waves

Question 03 · continued

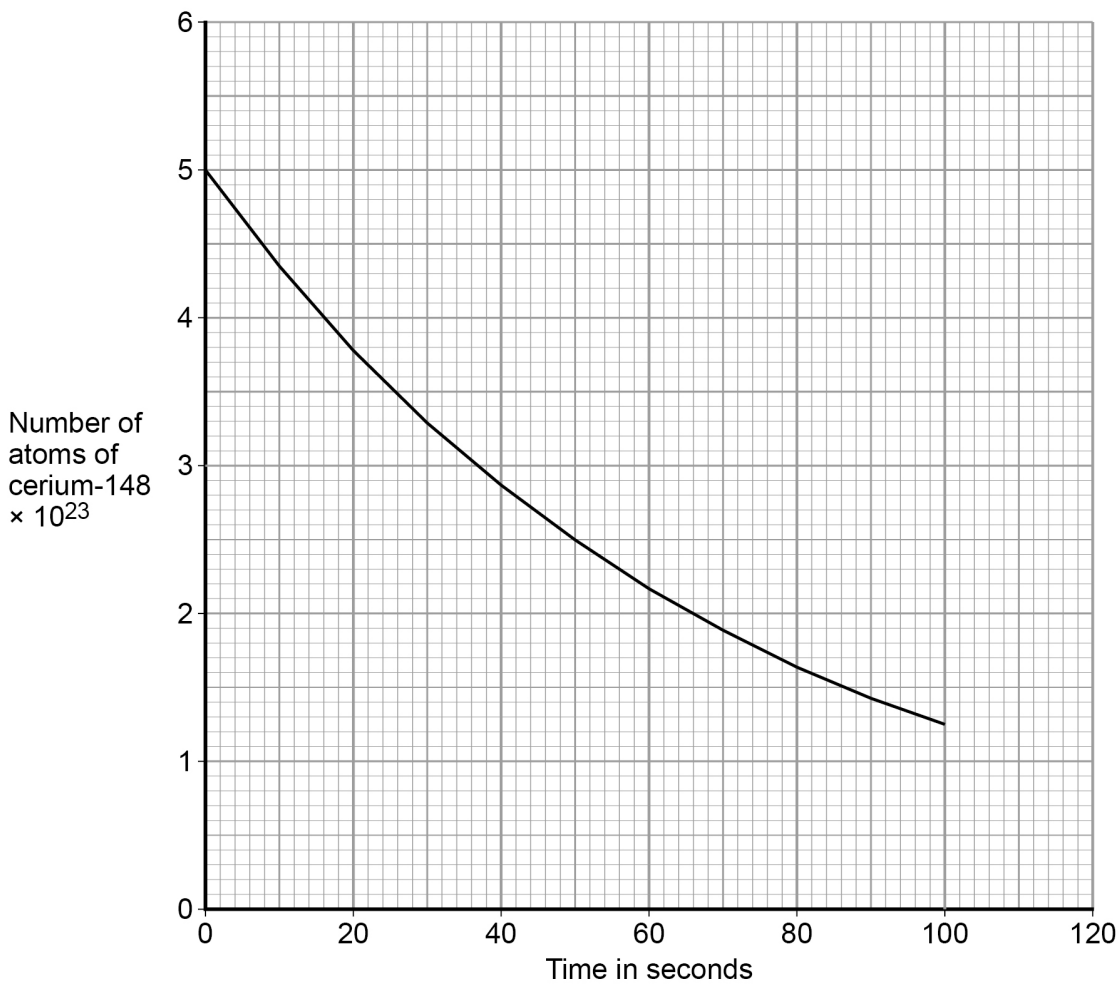
There are other isotopes of cerium which are radioactive.

Different isotopes of cerium have different half-lives.

The half-life of an isotope can be found by studying how the number of atoms changes over time.

Figure 7 shows how the number of atoms of cerium-148 in a 120 g sample changes over time.

Figure 7



6.6.2.4 Uses and applications of electromagnetic waves

Question 03 · continued

0 6 . 7 Determine the ratio of the number of cerium atoms in the sample when it was 100 seconds old compared with when the sample was 350 seconds old.

Use data from **Figure 7**.

[4 marks]

Ratio = _____

0 6 . 8 Determine the activity of the sample of cerium when the sample was 20 seconds old.

Use **Figure 7**.

[3 marks]

Activity = _____ Bq

18

6.6.2.4 Uses and applications of electromagnetic waves

Question 04

November 2020 | 8464/P/1H | Original Q2

0 2 Different radioactive isotopes emit different types of nuclear radiation.

A polonium-210 (Po) nucleus emits an alpha particle (α) and turns into a lead (Pb) nucleus.

This can be represented by the equation:

$$^{210}_{84}Po \longrightarrow {}^{A}_{Z}Pb + \alpha$$

0 2 . 1 What is the value of A in the equation?

[1 mark]

Tick (✓) **one** box.

A = 206 ☐ A = 208 ☐ A = 210 ☐ A = 211 ☐

0 2 . 2 What is the value of Z in the equation?

[1 mark]

Tick (✓) **one** box.

Z = 80 ☐ Z = 82 ☐ Z = 85 ☐ Z = 86 ☐

Question 2 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 04 · continued

0 2 . 3 A strontium-89 nucleus (Sr) emits a beta particle (β) and turns into an yttrium nucleus (Y).

This can be represented by the equation:

$$^{89}_{38}\text{Sr} \longrightarrow {}^{A}_{Z}\text{Y} + \beta$$

What are the values of A and Z in the equation?

[2 marks]

A = _____

Z = _____

0 2 . 4 Gamma radiation is another type of nuclear radiation.

What does gamma radiation consist of?

[1 mark]

Tick (✓) **one** box.

- High energy neutrons ☐
- Electromagnetic waves ☐
- Particles with no charge ☐
- Positively charged ions ☐

6.6.2.4 Uses and applications of electromagnetic waves

Question 04 · continued

0 2 . 5 Explain the differences between the properties of alpha, beta and gamma radiations.

[6 marks]

11

6.6.2.4 Uses and applications of electromagnetic waves

Question 05

November 2020 | 8464/P/2H | Original Q5

0 5 X-rays form part of the electromagnetic spectrum.

Radiographers use X-rays to produce images of bones inside the body.

0 5 . 1 Explain why X-rays can be used to produce images of the bones inside the body.

[2 marks]

0 5 . 2 **Table 2** shows the effect of exposure to different doses of radiation.

Table 2

Dose in mSv	Effect on the human body
100	slightly increased risk of cancer
1000	5% increased risk of cancer
5000	high risk of death

During an X-ray a person receives a dose of 0.5 mSv

The radiographer takes many X-ray images each day.

Explain why the radiographer stands behind a protective screen when taking an X-ray image.

[3 marks]

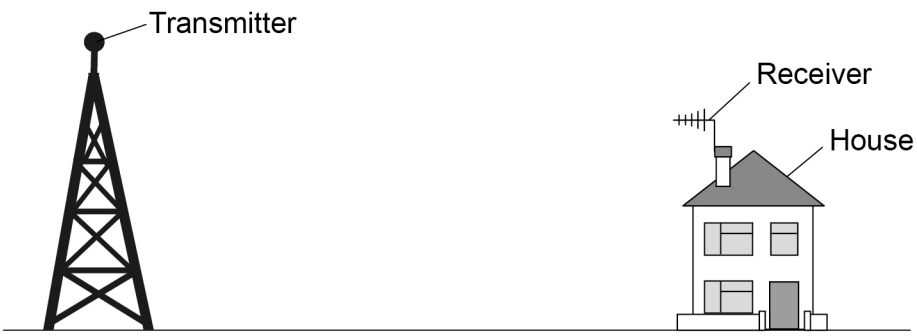
6.6.2.4 Uses and applications of electromagnetic waves

Question 05 · continued

0 5 . 3 Radio waves form part of the electromagnetic spectrum.

Figure 10 shows one use of radio waves.

Figure 10



Explain how electrical signals in the transmitter produce a signal in the receiver.

[3 marks]

8

6.6.2.4 Uses and applications of electromagnetic waves

Question 06

November 2021 | 8464/P/1H | Original Q2

0 2 A radioactive source emits alpha, beta and gamma radiation.

0 2 . 1 An alpha particle is the same as a helium nucleus.

How many times bigger is the radius of a helium atom than the radius of an alpha particle?

[1 mark]

Tick (✓) **one** box.

- Less than 100 times bigger ☐
- Exactly 5000 times bigger ☐
- More than 10 000 times bigger ☐

0 2 . 2 Alpha particles can ionise atoms in the air.

What happens to an atom when it is ionised by an alpha particle?

[2 marks]

Tick (✓) **two** boxes.

- A neutron in the atom becomes a proton. ☐
- The atom becomes a positive ion. ☐
- The atom gains a neutron. ☐
- The atom gains a proton. ☐
- The atom loses an electron. ☐

Question 2 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 06 · continued

0 2 . 3 A spark detector is a device that can be used to detect alpha radiation.

A spark detector works by alpha particles ionising atoms in the air near a wire mesh.

A large potential difference creates a spark when the air near the wire mesh is ionised.

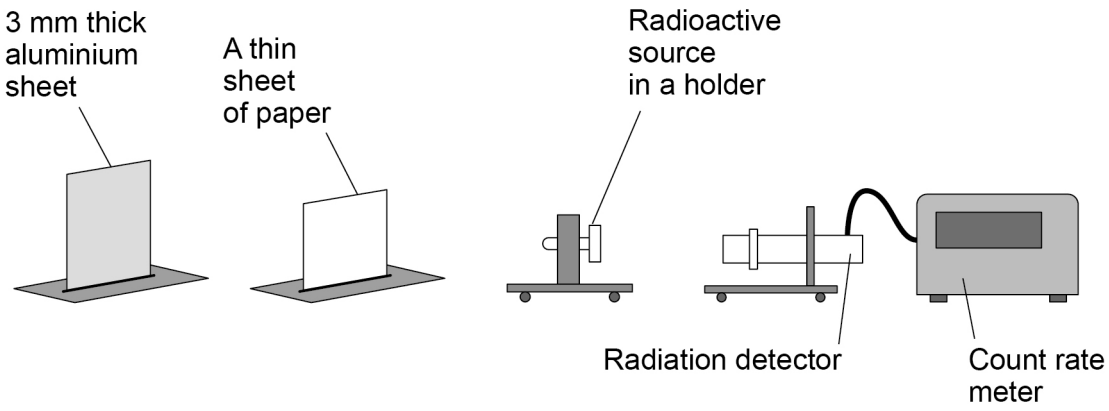
Suggest why a spark detector **cannot** detect beta radiation.

[1 mark]

0 2 . 4 A teacher wants to demonstrate that the radioactive source emits alpha, beta and gamma radiation.

Figure 3 shows the equipment the teacher has.

Figure 3



Describe a method the teacher could use.

[6 marks]

10

6.6.2.4 Uses and applications of electromagnetic waves

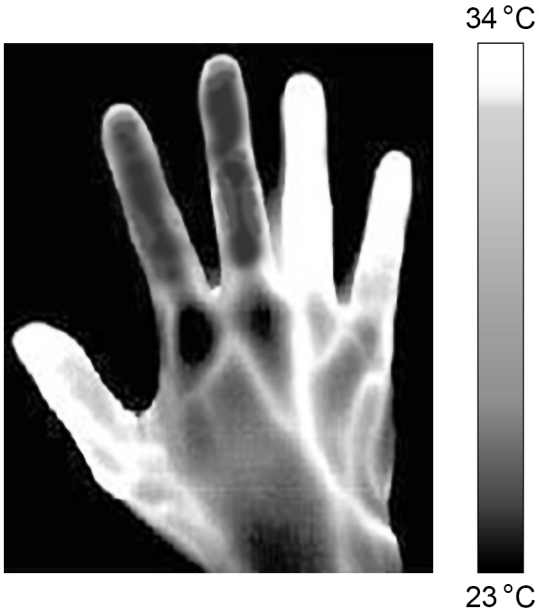
Question 07

November 2021 | 8464/P/2H | Original Q5

0 5 Different parts of the electromagnetic spectrum are used in medical imaging.

Figure 8 shows an image of a person's hand taken with an infrared camera.

Figure 8



0 5 . 1 Explain why the infrared camera is able to show that parts of the hand are at different temperatures.

[2 marks]

Question 5 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 07 · continued

0 5 . 2 Infrared has a range of wavelengths from 700 nm to 1 mm.

Which part of the electromagnetic spectrum would have waves with a wavelength of 6.5×10^{-7} m?

[1 mark]

Tick (✓) **one** box.

- Infrared ☐
- Microwaves ☐
- Radio waves ☐
- Visible light ☐

0 5 . 3 **Figure 9** shows X-rays and gamma rays being used for medical imaging.

Figure 9

X-rays **Gamma rays**



To use X-rays for medical imaging, a machine produces a very brief burst of X-rays.

To use gamma rays for medical imaging, a radioactive isotope is injected into the patient's blood. The isotope is circulated around the body in the blood. The isotope emits gamma rays.

Compare the potential risks to a patient of using X-rays and gamma rays for medical imaging.

[4 marks]

Question 5 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 07 · continued

X-rays are produced by colliding high-energy electrons into a metal target.

The electrons have high energy because they are accelerated to high speeds.

Only a small proportion of the kinetic energy of an electron is converted into an X-ray when it collides with the metal target.

0 5 . 4 An electron is accelerated through a distance of 15 mm.

The work done on the electron is 1.2×10^{-13} J.

Calculate the force on the electron.

[3 marks]

Force = _____ N

0 5 . 5 The metal target is made from tungsten.

Tungsten has the highest melting point of any metal.

Explain why using tungsten as the metal target enables the X-ray machine to be more powerful.

[3 marks]

13

6.6.2.4 Uses and applications of electromagnetic waves

Question 08

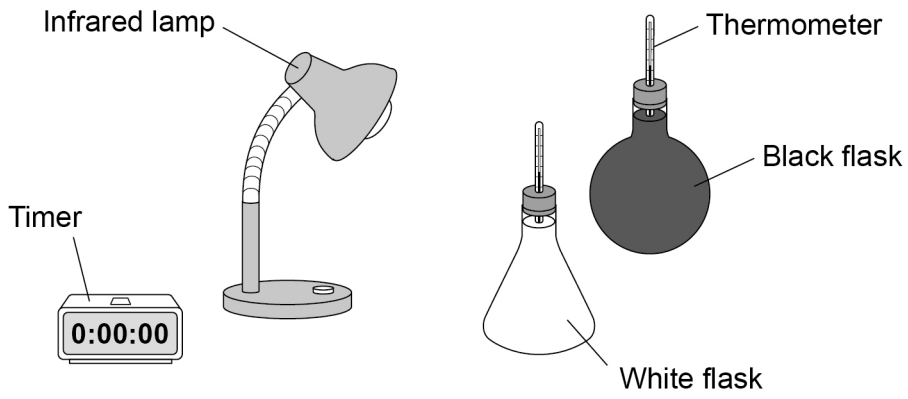
June 2022 | 8464/P/2H | Original Q5

0 5 A student investigated how the colour of a surface affects the amount of infrared radiation the surface absorbs.

Figure 7 shows the equipment used.

The two flasks are painted different colours.

Figure 7



This is the method used.

1. Pour water at 20 °C into each flask.

2. Place a bung and thermometer into each flask.

3. Place each flask in front of the infrared lamp.

4. Measure the temperature of the water every 30 seconds for 10 minutes.

0 5 . 1 Explain **two** improvements to the method the student used.

[4 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

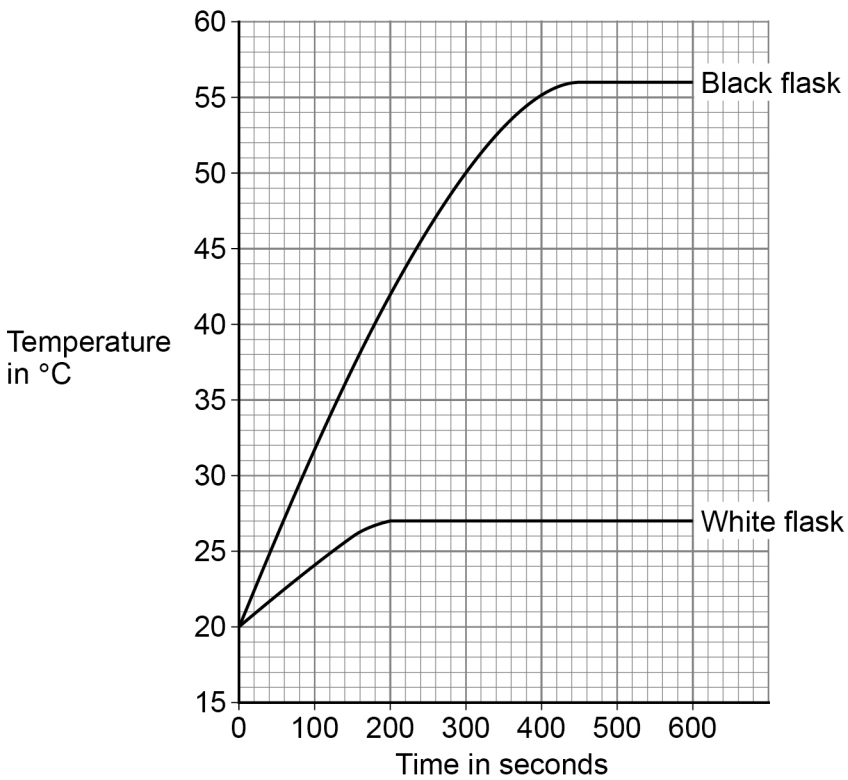
_____

6.6.2.4 Uses and applications of electromagnetic waves

Question 08 · continued

Figure 8 shows the results for each flask.

Figure 8



0 5 . 2 Complete the sentences.

[2 marks]

After 100 seconds the temperature difference between the black flask and the white flask was _____ °C

The temperature of the white flask stopped increasing. The temperature inside the black flask continued to increase for a further _____ seconds.

6.6.2.4 Uses and applications of electromagnetic waves

Question 08 · continued

0 5 . 3 The initial rate of absorption of infrared radiation by the black flask was greater than the initial rate of absorption by the white flask.

How does **Figure 8** show this?

[1 mark]

0 5 . 4 Explain why the temperature of the water in the flasks increased and then became constant.

[4 marks]

11

6.6.2.4 Uses and applications of electromagnetic waves

Question 09

0 1 The Sun emits a continuous spectrum of electromagnetic waves.

Figure 1 names some of the groups of waves in the electromagnetic spectrum.

Figure 1

A	**B**	Infrared	Visible light	Ultraviolet	**C**	Gamma rays

0 1 . 1 Name groups **A**, **B** and **C** in **Figure 1**.

[2 marks]

A _____

B _____

C _____

0 1 . 2 Give **one** similarity and **one** difference between the properties of ultraviolet waves and gamma rays.

[2 marks]

Similarity _____

_____

Difference _____

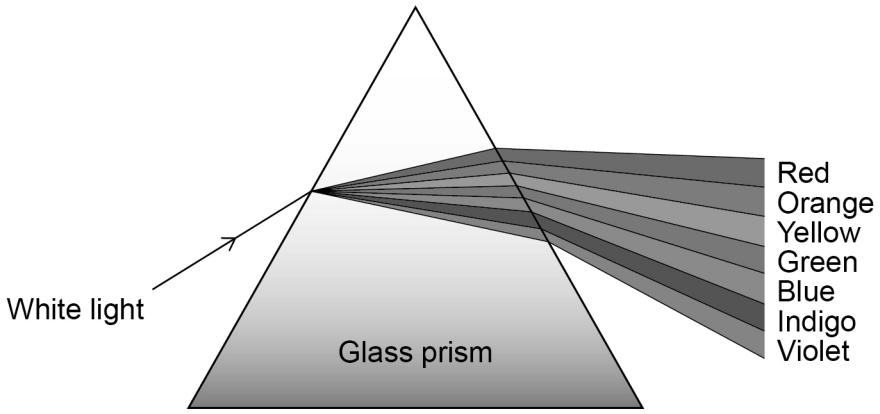
_____

6.6.2.4 Uses and applications of electromagnetic waves

Question 09 · continued

Figure 2 shows white light split into a spectrum of different colours by a glass prism.

Figure 2



0 1 . 3 Light changes direction when it enters the glass prism.

What name is given to this process?

[1 mark]

_____

Question 1 continues on the next page

6.6.2.4 Uses and applications of electromagnetic waves

Question 09 · continued

Use the Physics Equations Sheet to answer questions **01.4** and **01.5**.

0 1 . 4 Write down the equation that links frequency (f), wavelength (λ) and wave speed (v).

[1 mark]

0 1 . 5 The wave in the middle of the spectrum has a wavelength of 5.0×10^{-7} m.

wave speed of light = 3.0×10^{8} m/s

Calculate the frequency of the wave.

[3 marks]

Frequency = _____ Hz

9

6.6.2.4 Uses and applications of electromagnetic waves

Question 10

June 2024 | 8464/P/2H | Original Q3

0 3 Electromagnetic waves are grouped according to their wavelength and frequency.

Electromagnetic waves are transverse waves and can travel through a vacuum.

0 3 . 1 Give one **other** property that is the same for all types of electromagnetic wave.

[1 mark]

0 3 . 2 What is meant by 'transverse wave'?

[1 mark]

0 3 . 3 Which group of electromagnetic waves is used for satellite communications?

[1 mark]

0 3 . 4 Visible light is the only group of electromagnetic waves that the human eye can detect.

Which colour of visible light has the shortest wavelength?

[1 mark]

6.6.2.4 Uses and applications of electromagnetic waves

Question 10 · continued

0 3 . 5 The three highest frequency groups of electromagnetic waves are hazardous.

Describe a risk linked to each group of high frequency electromagnetic wave.

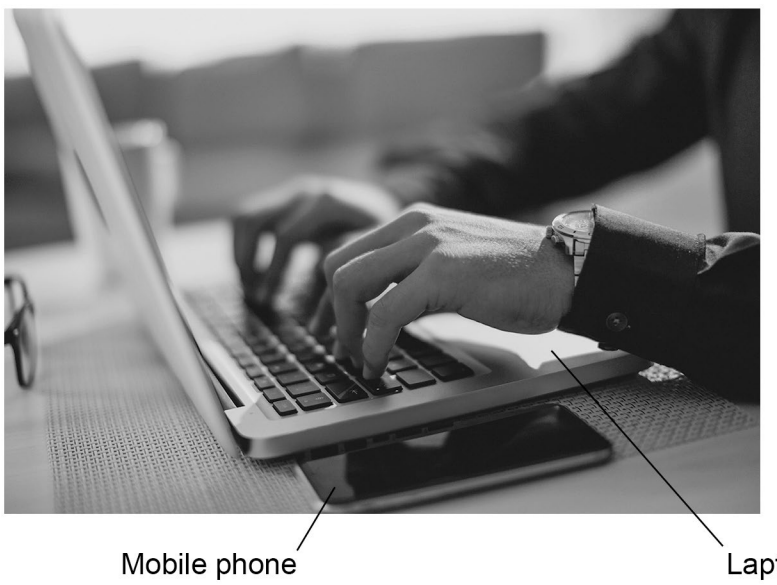
[2 marks]

Question 3 continues on the next page

Question 10 · continued

Figure 5 shows a person using a mobile phone to allow a laptop to access the Internet.

Figure 5



The electromagnetic waves emitted by the mobile phone send information to the laptop.

0 3 . 6 The electromagnetic waves emitted by the mobile phone have a period of 4.0×10^{-10} s.

Calculate the frequency of the waves.

Use the Physics Equations Sheet.

Give your answer in standard form.

[3 marks]

Frequency (in standard form) = _____ Hz

6.6.2.4 Uses and applications of electromagnetic waves

Question 10 · continued

0 3 . 7 The electromagnetic waves are produced by oscillations in the transmitter of the mobile phone.

Explain how oscillations in the transmitter enable information to be transferred to the detector in the laptop.

[4 marks]

13

6.6.2.4 Uses and applications of electromagnetic waves

Question 11

June 2025 | 8464/P/1H | Original Q4

0 4 Three types of radiation emitted by unstable nuclei are:

- alpha particle
- beta particle
- gamma ray.

0 4 . 1 Describe each type of radiation.

[3 marks]

Alpha particle _____

_____

Beta particle _____

_____

Gamma ray _____

_____

0 4 . 2 The radioactive isotope gold-198 (Au) decays to mercury (Hg) by emitting beta radiation.

Complete the nuclear equation for the decay of gold-198.

[2 marks]

$$^{198}_{79}\text{Au} \rightarrow \text{__}^{\text{__}}_{\text{__}}\text{Hg} + \text{__}^{\text{__}}_{\text{__}}\beta$$

Question 4 continues on the next page

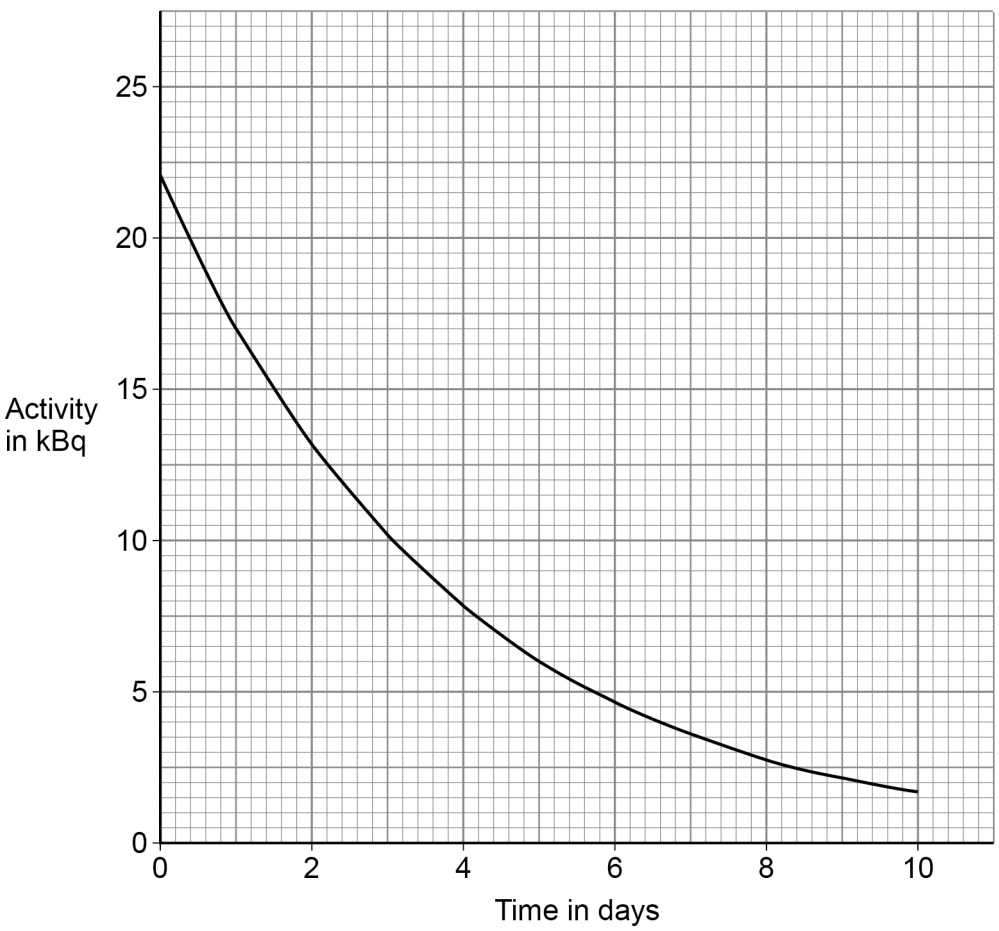
Question 11 · continued

Gold-198 is used in the treatment of cancer.

A small sample containing gold-198 is surgically implanted into a patient, very near to the cancer cells.

Figure 4 shows how the activity of the sample changes after it has been implanted.

Figure 4



0 4 . 3 Determine the half-life of gold-198.

[2 marks]

Half-life = _____ days

6.6.2.4 Uses and applications of electromagnetic waves

Question 11 · continued

0 4 . 4 Determine the percentage decrease in the activity at 5 days.

Give your answer to 2 significant figures.

[4 marks]

Percentage decrease (2 significant figures) = _____ %

0 4 . 5 The sample containing gold-198 is implanted very near to the cancer cells.

Give **two** reasons why.

[2 marks]

1 _____

2 _____

0 4 . 6 After treatment, the sample containing gold-198 is **not** removed from the patient.

Suggest why the sample is left in the patient and **not** removed.

[1 mark]

_____

14

6.6.2.4 Uses and applications of electromagnetic waves

Question 12

June 2025 | 8464/P/2H | Original Q3

0 3 A pair of sunglasses has lenses that absorb all ultraviolet and some visible light.

0 3 . 1 Ultraviolet and visible light are both transverse waves.

What is meant by 'transverse waves'?

[2 marks]

0 3 . 2 Ultraviolet can cause sunburn and eye damage.

Give **one** other risk to health from exposure to ultraviolet.

[1 mark]

0 3 . 3 Complete the sentence.

[1 mark]

Compared with the wavelength of visible light, the wavelength of ultraviolet is _____.

Question 3 continues on the next page

0 3 . 4 A wave of visible light has a frequency of 6.25×10^{14} Hz.

speed of light = 3.00×10^{8} m/s

Calculate the wavelength of this light.

Use the Physics Equations Sheet.

Give your answer in nanometres (nm).

[4 marks]

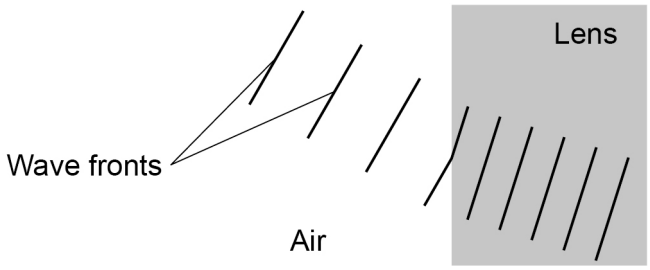
Wavelength = _____ nm

Question 12 · continued

0 3 . 5 A ray of visible light incident on the lens in a pair of sunglasses is refracted.

Figure 3 shows a wave front diagram for visible light incident on the lens.

Figure 3



For each wave front, one end of the wave front enters the lens before the other end.

Explain why the light refracts as it enters the lens.

[2 marks]

Question 3 continues on the next page

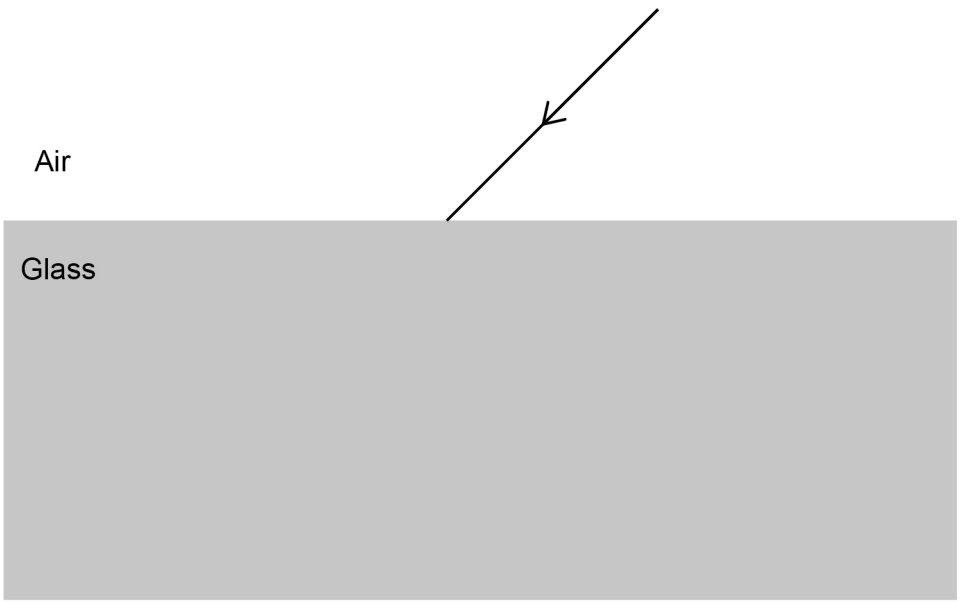
6.6.2.4 Uses and applications of electromagnetic waves

Question 12 · continued

0 3 . 6 **Figure 4** shows a ray of visible light incident on glass.

The angle of incidence is 45°.

Figure 4



The angle of refraction of the ray in the glass is 28°.

Complete the ray diagram in **Figure 4** to show the path of the ray in the glass.

You should:

- draw the normal line
- draw the refracted ray in the glass.

You do **not** need to draw the ray leaving the glass.

[2 marks]

12

6.6.2.4 Uses and applications of electromagnetic waves

Question 13

June 2025 | 8464/P/2H | Original Q5

0 5 A student used a temperature probe to measure the temperature of melting ice.

This is the method used.

1. Place the temperature probe in iced water and record the temperature.
2. Remove the probe from the iced water and allow the probe to return to room temperature.
3. Repeat steps 1 and 2 four more times.

The measurements were:

–0.5 °C +0.2 °C –0.3 °C +0.5 °C +0.1 °C

0 5 . 1 What type of error is shown by the measurements?

[1 mark]

0 5 . 2 Determine the uncertainty in the measurements.

[2 marks]

Uncertainty = ± _____ °C

Question 5 continues on the next page

The student investigated how the colour of an object affects the rate of change of temperature of the object.

This is the method used.

1. Make two identical cubes using clay.

2. Paint one cube black and paint one cube white.

3. Push a temperature probe into the centre of each cube.

4. Place the cubes 10 cm from an infrared heater.

5. Record the temperature of each cube every two minutes.

Table 1 shows the results for the white cube.

Table 1

Time in minutes	Temperature in °C
0	18
2	55
4	68
6	73
8	65
10	76
12	76

0 5 . 3 Complete **Figure 7**.

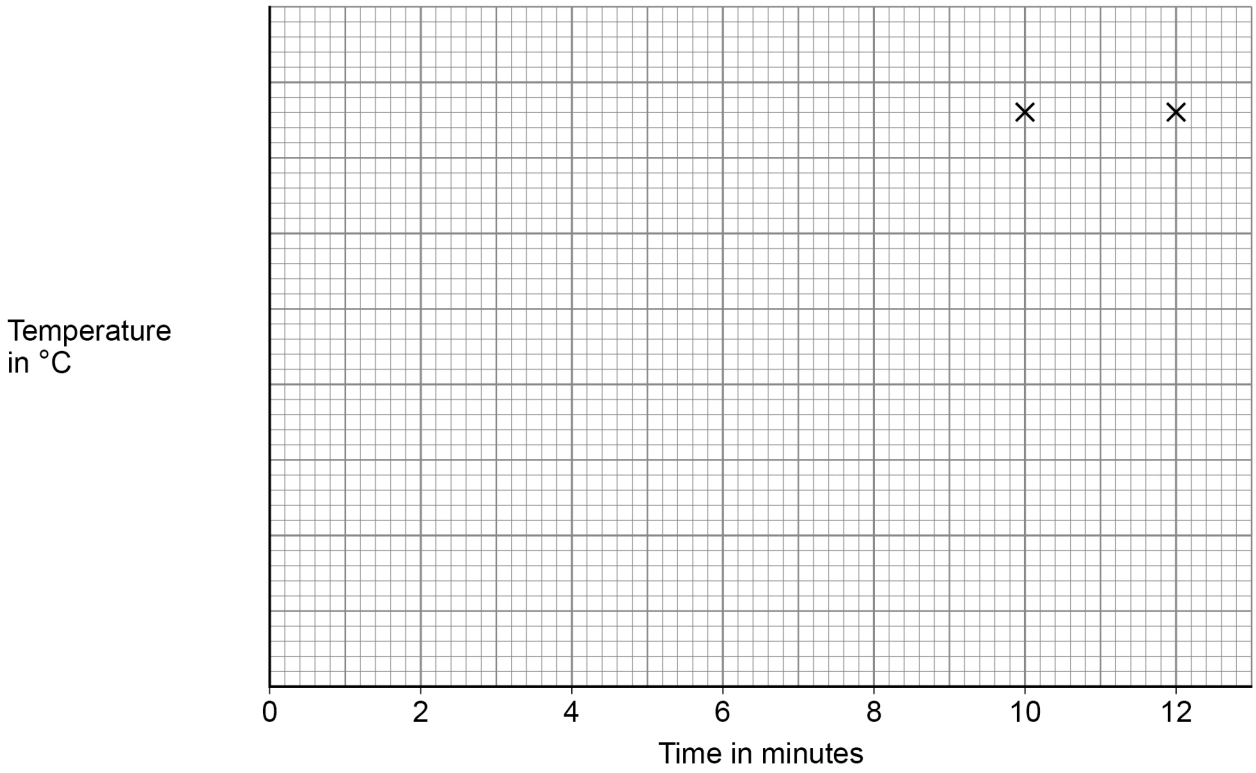
You should:

- use a suitable scale for the *y*-axis
- plot the data from **Table 1**
- draw a line of best fit.

The data for 10 minutes and 12 minutes have been plotted for you.

[4 marks]

Figure 7



Question 5 continues on the next page

0 5 . 4 The temperature of the black cube increased from 18 °C to 63 °C in the first 2.0 minutes.

Calculate the average rate of change of temperature of the black cube in the first 2.0 minutes.

Give your answer in °C/s.

[3 marks]

Average rate of change of temperature = _____ °C/s

6.6.2.4 Uses and applications of electromagnetic waves

Question 13 · continued

0 5 . 5 The student made two observations:

1. The rate of change of temperature was initially greater for the black cube than for the white cube.

2. After a few minutes, both cubes stopped changing temperature.

Explain the student's observations.

You should refer to the absorption and emission of radiation from the surfaces of the cubes.

[4 marks]

Extra space

14