

EM waves: production and hazards

4.6.2.3 · Waves · revision notes

How electromagnetic waves are produced and absorbed (by changes in atoms and nuclei), and the harm that ultraviolet, X-rays and gamma rays can do to the body. Expect recall questions and 'use the data' questions on radiation dose.

Key facts

- EM waves can be produced or absorbed by changes in atoms and nuclei
- Ultraviolet: premature skin ageing and higher risk of skin cancer
- Radiation dose (Sv) = a measure of the risk of harm from exposure
- Gamma rays come from changes in the nucleus
- X-rays and gamma rays: ionising; can cause mutation of genes and cancer
- 1 Sv = 1000 mSv

Notes

Producing and absorbing EM waves

- EM waves over a wide range of frequencies can be produced or absorbed by changes inside **atoms** and their **nuclei**. For example, when electrons in atoms change energy level, EM waves such as light can be emitted or absorbed.
- **Gamma rays** come from changes in the **nucleus** of an atom.

Hazards to the body

- Ultraviolet, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the **type** of radiation and the **size of the dose**.
- **Ultraviolet** can cause skin to age prematurely and increases the risk of skin cancer.
- **X-rays and gamma rays** are **ionising** radiation. They can cause the mutation of genes and cancer.

Radiation dose

- **Radiation dose**, in **sieverts (Sv)**, is a measure of the **risk of harm** from the body being exposed to radiation.
- 1000 millisieverts (mSv) = 1 sievert (Sv). You do not need to remember the unit, but you must be able to use it.
- The bigger the dose, the greater the risk. Use given data to compare risks, for example the dose from a medical scan with the yearly dose from background radiation, and to judge whether a benefit is worth the risk.

How to answer each type of question

State the hazards of ultraviolet, X-rays and gamma rays

1 to 4 marks

Grade 4

1. Ultraviolet: skin ageing prematurely and risk of skin cancer.
2. X-rays and gamma rays: ionising, so mutation of genes and cancer.
3. Use these exact effects; 'it damages you' is too vague.

Example. (a) Give **two** harmful effects of ultraviolet radiation on the human body.
(b) Explain why X-rays can cause cancer.

Model answer. (a) It makes skin age prematurely (1). It increases the risk of skin cancer (1).
(b) X-rays are ionising radiation (1), so they can cause mutation of genes, which can lead to cancer (1).

Convert between Sv and mSv

1 to 2 marks

Grade 5

1. Sv to mSv: multiply by 1000.
2. mSv to Sv: divide by 1000.

Example. A radiographer receives a dose of 0.0035 Sv in one year.
Convert this dose into millisieverts.

Model answer. 0.0035×1000 (1) = 3.5 mSv (1)

Don't lose marks

- ✗ Describing radiation dose vaguely as 'how much radiation'. It is a measure of the risk of harm from exposure to radiation.
- ✗ Confusing mSv and Sv: 5 mSv is 0.005 Sv, not 5000 Sv.
- ✗ Saying gamma rays come from electrons. They come from changes in the nucleus.
- ✗ In data questions, writing only 'it is more dangerous' without using the numbers.

More tips

Memory tricks

- The dangerous three are at the high-frequency end: ultraviolet, X-rays, gamma rays.
- Milli means a thousandth: mSv $\rightarrow$ Sv, divide by 1000; Sv $\rightarrow$ mSv, multiply by 1000.

Exam technique

- In data questions, quote values from the table and make a comparison, e.g. 'the CT dose is 400 times bigger'.
- In risk questions, weigh up both sides: the benefit (e.g. a diagnosis) against the risk from the dose.
- Name specific effects: 'skin cancer', 'mutation of genes', 'skin ageing prematurely'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Name the EM waves that harm body tissue

Ultraviolet, X-rays and gamma rays can have hazardous effects on human body tissue.

Grade 4

State the effects of ultraviolet on skin

Ultraviolet can make skin age prematurely and increases the risk of skin cancer.

Grade 5

State the effects of X-rays and gamma rays

They are ionising radiation and can cause mutation of genes and cancer.

Grade 5

State where gamma rays come from

Gamma rays come from changes in the nucleus of an atom.

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