

24.3 PET scanning

Name: _____ Class: _____ Date: _____

Total: 13 marks

Objective

Build the skills to answer exam questions on **PET scanning**.

You must be able to:

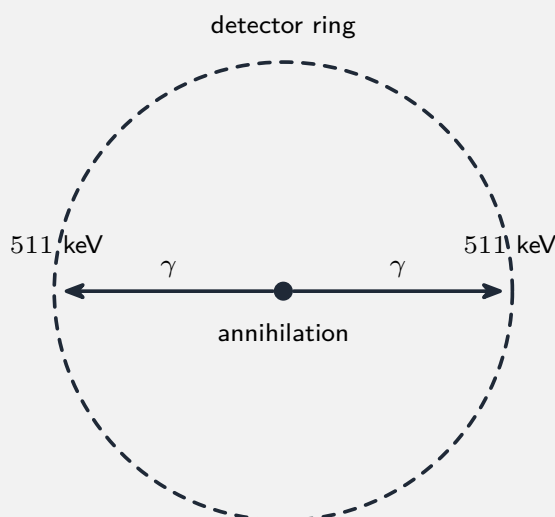
- explain the **tracer** and **annihilation**
- calculate the **annihilation photon energy**
- explain how the photons locate the event

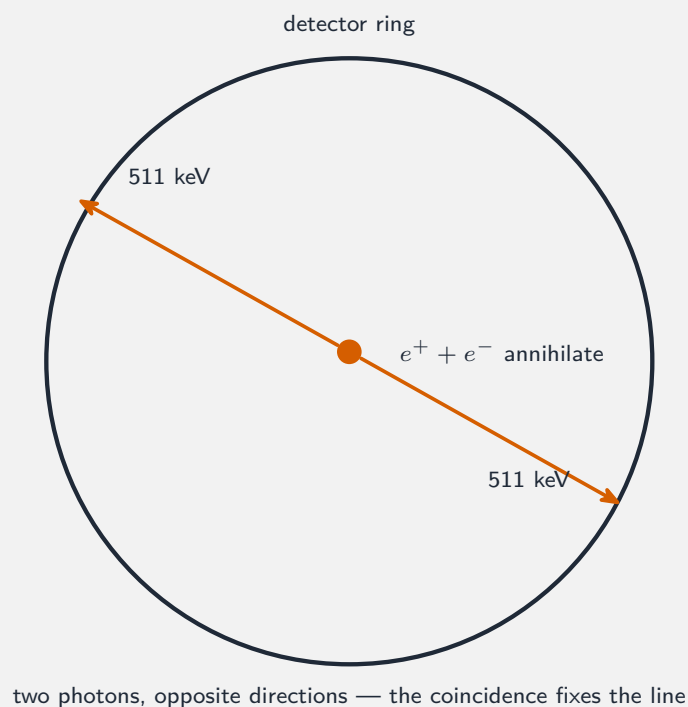
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Tracer and annihilation

A **tracer** is a radioactive substance put into the body and taken up by the tissue studied. In **PET** it is a β^+ (**positron**) **emitter**. The positron meets an **electron** and they **annihilate**:





PET detects annihilation photons

Mass-energy and **momentum** are conserved. Since the total momentum is $\sim$ zero, **two** γ photons go in **opposite directions**, each of energy $m_e c^2 = 511 \text{ keV}$.

Detecting **both** photons (and their arrival times) lets the scanner work out the **line** they came from, building an image of tracer concentration.

2 Practice

Now apply the methods above.

2.1 State what a **tracer** is. [1]

2.2 State the type of **decay** a PET tracer undergoes. [1]

2.3 Explain what **annihilation** is. [2]

2.4 State the **energy** of each annihilation photon. [1]

3 Exam-style questions

3.1 In PET, the two γ photons from an annihilation travel: [1]

- **A** in the same direction
 - **B** in opposite directions
 - **C** at right angles
 - **D** in random directions
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3.2 Calculate the **energy** of each γ photon produced when an electron and positron annihilate. ($m_e = 9.11 \times 10^{-31}$ kg.) [3]

3.3 Explain why **two** photons are produced (not one), travelling in opposite directions. [2]

3.4 Explain how detecting the two photons helps locate the **annihilation** event. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **24.3 PET scanning** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/44 N25 —Q8 (positron emission and annihilation)
- 9702/41 J25 —Q8 (annihilation photon energy)
- 9702/42 M25 —Q9 (annihilation and PET)

Solutions

2.1 A substance containing **radioactive nuclei** introduced into the body and **taken up** by the tissue being studied.

2.2 β^+ (**positron**) decay.

2.3 When a particle meets its **antiparticle**, they are destroyed and their **mass becomes energy** (electromagnetic radiation).

2.4 511 keV ($= m_e c^2$).

3.1 **B** —in opposite directions.

3.2 Total rest energy $= 2m_e c^2$, shared by two photons, so each $E = m_e c^2 = (9.11 \times 10^{-31})(3.0 \times 10^8)^2 = 8.2 \times 10^{-14}$ J ($= 511$ keV).

3.3 Momentum must be **conserved**; the pair's total momentum is $\sim$ zero, so the photons must go in **opposite directions** with equal momentum (a single photon could not conserve momentum).

3.4 Both photons are detected (almost simultaneously) on **opposite sides** of the ring; the annihilation lies on the **straight line** joining the two detectors —combining many such lines builds the image.