

Name	Date started	Target end date
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GCE A LEVEL – NUCLEAR RADIATIONS & EQUATIONS QUESTION PACK

Legacy PH5 · New spec Unit 3 Topic 5a · A2 unit, 25% of A-level

REVISE
.wales

PHYSICS – UNIT 3 · NUCLEAR RADIATIONS & EQUATIONS

3.5 Nuclear decay – α , β , γ radiations and balanced nuclear equations

Properties of α , β and γ radiation (charge, mass, range, ionising power, shielding), and balancing nuclear equations using nucleon (A) and proton (Z) numbers for decays and chains.

NEW 2015 SPEC · UNIT 3 TOPIC 5A

Estimated time for entire question pack: ~48m

Derived from the legacy PH5 paper's pace of 120 marks in 1h 45m.

You are advised to **not** attempt to complete all of this in one sitting.

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH5 papers (2008 modular spec) that maps onto new-spec Unit 3 Topic 5a (3.5).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required. The Data Booklet is allowed.

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Q	Source	Max	Mark	Q	Source	Max	Mark
1	PH5 Jun 13 Q1	11		3	PH5 Jun 12 Q1	11	
2	PH5 Jun 11 Q4	12		Total			
						34	

Nuclear Radiations & Equations – what the new spec asks

WJEC GCE A Level Physics (from 2015) · Unit 3: Oscillations & Nuclei · Topic 3.5.

α alpha radiation A

- ${}^4_2\text{He}$ nucleus: +2e charge, ~4 u mass.
- Stopped by paper / few cm of air; strongly ionising; dangerous if ingested or inhaled.

β beta radiation A

- Fast electron ${}^0_{-1}\beta$: -e charge, almost no mass.
- Range up to several m in air, stopped by ~3 mm aluminium.
- Moderately ionising; used in paper-thickness gauges.

γ gamma radiation A

- High-energy electromagnetic photon: no charge or mass.
- Very penetrating – attenuated by lead / concrete.
- Weakly ionising; used to sterilise instruments.

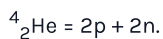
Nuclear equations A

- Conserve nucleon number A and proton number Z.
- α : $A \rightarrow A-4$, $Z \rightarrow Z-2$.
- β^- : A unchanged, $Z \rightarrow Z+1$ (with antineutrino).
- Multi-step decay chains: cumulate ΔA and ΔZ .

Nuclear Radiations & Equations in one page

Quick-reference notes – revisit before each section.

α alpha



Charge +2e, mass 4 u.

Range a few cm of air; paper / skin stops it.

Strongly ionising; dangerous if ingested.

β beta

${}^0_{-1}\beta$: charge -e, almost no mass.

Range up to several m in air; ~3 mm Al stops it.

Moderately ionising.

γ gamma

No charge, no rest mass.

Very penetrating – attenuated by lead / concrete (never fully stopped).

Weakly ionising.

Comparison

Ionising power: $\alpha \gg \beta > \gamma$.

Penetrating power: $\gamma > \beta > \alpha$.

Each radiation has opposing trends – remember by inversion.

Nuclear equations

Conserve A (top) and Z (bottom) on both sides.

α : A-4, Z-2.

β^- : A unchanged, Z+1, ν^-_e on the right.

γ : A, Z unchanged (energy emission only).

Decay chains

$n_\alpha \alpha + n_\beta \beta^-$ over a chain:

$$\Delta A = -4 n_\alpha.$$

$$\Delta Z = -2 n_\alpha + n_\beta.$$

Section index

Use this index to jump straight to the section you need.

Section	Questions	Marks
A α , β , γ properties & nuclear equations	Qs 1-3	34 marks

Examiner only

SECTION A

1. A student is uncertain whether or not a radioactive source emits α , β or γ radiation or a combination of these radiations.

(a) Describe how the student would use a detector and counter along with suitable absorbers to find which radiation(s) are emitted by the radioactive source. [4]



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(b) A radioactive isotope has a starting activity of 76.0×10^{15} Bq and a half life of 25.6 days.

(i) Calculate the activity after 51.2 days. [1]

(ii) Calculate the activity after 1 year. [4]

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(iii) Calculate the number of radioactive nuclei present at the start.

[2]

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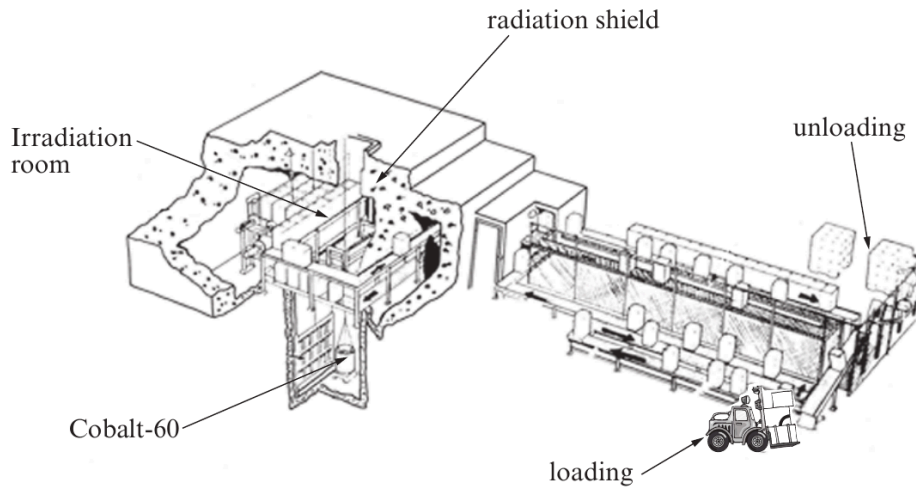
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4. Radioactive cobalt-60 (${}^{60}_{27}\text{Co}$) is used to irradiate and sterilise surgical equipment. Many instruments can be irradiated simultaneously as shown.



- (a) Explain briefly which type of radiation (α , β , or γ) would be most appropriate to irradiate metallic surgical instruments in this way. [2]

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Examiner
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(b) The half life of cobalt-60 is 5.3 years.

(i) Calculate the decay constant of cobalt-60. [2]

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(ii) Calculate the activity of 1 mg of cobalt-60. [3]

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(iii) Calculate the time taken (in years) for the activity of a cobalt-60 source to drop from 4.16×10^{10} Bq to 1.04×10^{10} Bq. [3]

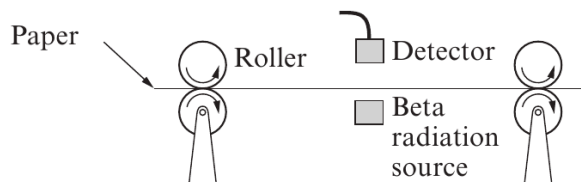
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SECTION A

1. The thickness of paper is measured using a beta radiation source and detector (see below).



- (a) Explain why it would be inappropriate to use either alpha radiation or gamma radiation for this task. [2]

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- (b) The beta radiation source most commonly used is strontium-90 which decays as shown. Place the correct numbers on the dotted lines. [2]



- (c) The half life of strontium-90 is 28.8 years. Show that its decay constant is $7.6 \times 10^{-10} \text{ s}^{-1}$. [2]

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(d) If the initial activity of the strontium-90 source is 140 GBq, calculate its activity after 10 years. [2]

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(e) Calculate the mass of strontium-90 required to produce an activity of 140 GBq. [3]

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END OF QUESTION PACK

3 questions · 34 marks · ~48m

Source: WJEC PH5 (2008 modular spec)

Curated for WJEC Physics 2015 spec A2 Unit 3 – Topic 5a (3.5)

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