Name	Date started	Target end date

GCE A LEVEL — FISSION, FUSION & REACTORS QUESTION PACK

Legacy PH5 · New spec Unit 3 Topic 6b · A2 unit, 25% of A-level

REVISE
.wales

PHYSICS — UNIT 3 · FISSION, FUSION & REACTORS

3.6 Nuclear energy — fission, fusion and reactor physics

Q-values for fission and fusion from the BE/A curve, chain reactions in U-235, moderator/control-rod/coolant roles in legacy reactor questions, stellar fusion, and the biological hazards of ionising radiation.

NEW 2015 SPEC · UNIT 3 TOPIC 6B

Estimated time for entire question pack: ~42m

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 6b (3.6).

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.

For Examiner's use only

Q	Source	Max	Mark
1	PH5 Jun 14 Q1	10	
2	PH5 Jun 12 Q2	10	
3	PH5 Jun 15 Q3	10	
	Total	**30**	

Fission, Fusion & Reactors — what the new spec asks

WJEC GCE A Level Physics (from 2015) · Unit 3: Oscillations & Nuclei · Topic 3.6.

Nuclear fission A

- Heavy nucleus (e.g. U-235) absorbs a slow neutron, splits into two daughters + 2–3 neutrons + ~200 MeV.
- Released neutrons can trigger further fissions — the chain reaction.

Reactor physics A

- Fuel (e.g. enriched U-235), moderator to slow neutrons (legacy spec).
- Control rods absorb neutrons to regulate the chain (legacy questions only).
- Coolant transfers heat to steam generators (legacy questions only).

Nuclear fusion A

- Light nuclei combine, e.g. $^{2}H + ^{3}H \rightarrow ^{4}He + n + 17.6$ MeV.
- Energy per nucleon released is far greater than fission.
- Requires extreme T to overcome Coulomb repulsion (stars, tokamaks).

Hazards & comparisons A

- Ionising radiation damages cells — especially radioactive waste.
- Use BE/A curve to compare fission (heavy → iron peak) vs. fusion (light → iron peak).

Fission, Fusion & Reactors in one page

Quick-reference notes — revisit before each section.

Fission

U-235 + n → X + Y + 2–3 n + ~200 MeV.

~0.85 MeV / nucleon released as products move closer to the iron peak.

Chain reaction

Released neutrons trigger further fissions.

Critical mass: enough fuel that one fission triggers one more on average.

Reactor components

Fuel: enriched U-235 / Pu-239.

Moderator: slows neutrons (water / graphite).

Control rods: absorb neutrons (boron / cadmium).

Coolant: removes heat to a steam generator.

Fusion

$^{2}H + ^{3}H \rightarrow ^{4}He + n + 17.6$ MeV.

Larger BE/A jump ⇒ more energy per nucleon than fission.

Stars

Stars fuse H through to Fe via various chains.

Coulomb barrier overcome by high T (~10^7 K).

Why hard on Earth

Tokamaks use magnetic confinement of plasma.

Net energy gain extremely hard to sustain.

BE/A comparison

Both move products closer to the iron peak.

Fusion of light nuclei: bigger BE/A change ⇒ more energy per nucleon.

Hazards

Ionising radiation damages DNA & tissue.

Long-lived radioactive waste from fission needs deep geological storage.

Strategy

1. List rest masses of all reactants and products.
2. Compute $\Delta m = \Sigma m_{before} - \Sigma m_{after}$.
3. Multiply × c^2 (or 931 MeV/u).
4. State whether Q is released or absorbed.

Section index

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

End of cover material.

SECTION A

*Answer **all** questions.*

1. *(a)* Carbon fuses with helium to produce oxygen and energy.

$$^{12}_{6}\mathrm{C} + {}^{4}_{2}\mathrm{He} \longrightarrow {}^{16}_{8}\mathrm{O} + 7.16\ \text{MeV}$$

The masses of the helium and carbon nuclei are 4.0015 u and 11.9967 u respectively.

(i) Calculate the binding energy **per nucleon** of the carbon nucleus (1 u = 931 MeV, m_{proton} = 1.0073 u, m_{neutron} = 1.0087 u). [3]

(ii) Use the energy released in the above reaction to calculate the mass of the oxygen-16 nucleus to 6 significant figures. (1 u = 931 MeV.) [4]

Examiner only

(b) It is important to choose suitable materials inside a nuclear fission reactor to act as control rods, moderator and coolant. Name **one important property of the materials** used for the:

(i) control rods; .... [1]

....

(ii) moderator; .... [1]

....

(iii) coolant. .... [1]

....

Examiner only

2. One of the nuclear reactions that occurs inside a nuclear power station is:

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + 3\,^{1}_{0}n$$

The masses of the relevant nuclei are as follows:

Mass of $^{235}_{92}U$ = 234.9933 u Mass of $^{92}_{36}Kr$ = 91.9064 u

Mass of $^{141}_{56}Ba$ = 140.8836 u Mass of $^{1}_{0}n$ = 1.0087 u

(a) Calculate the energy released in this nuclear reaction (1 u = 931 MeV). [3]

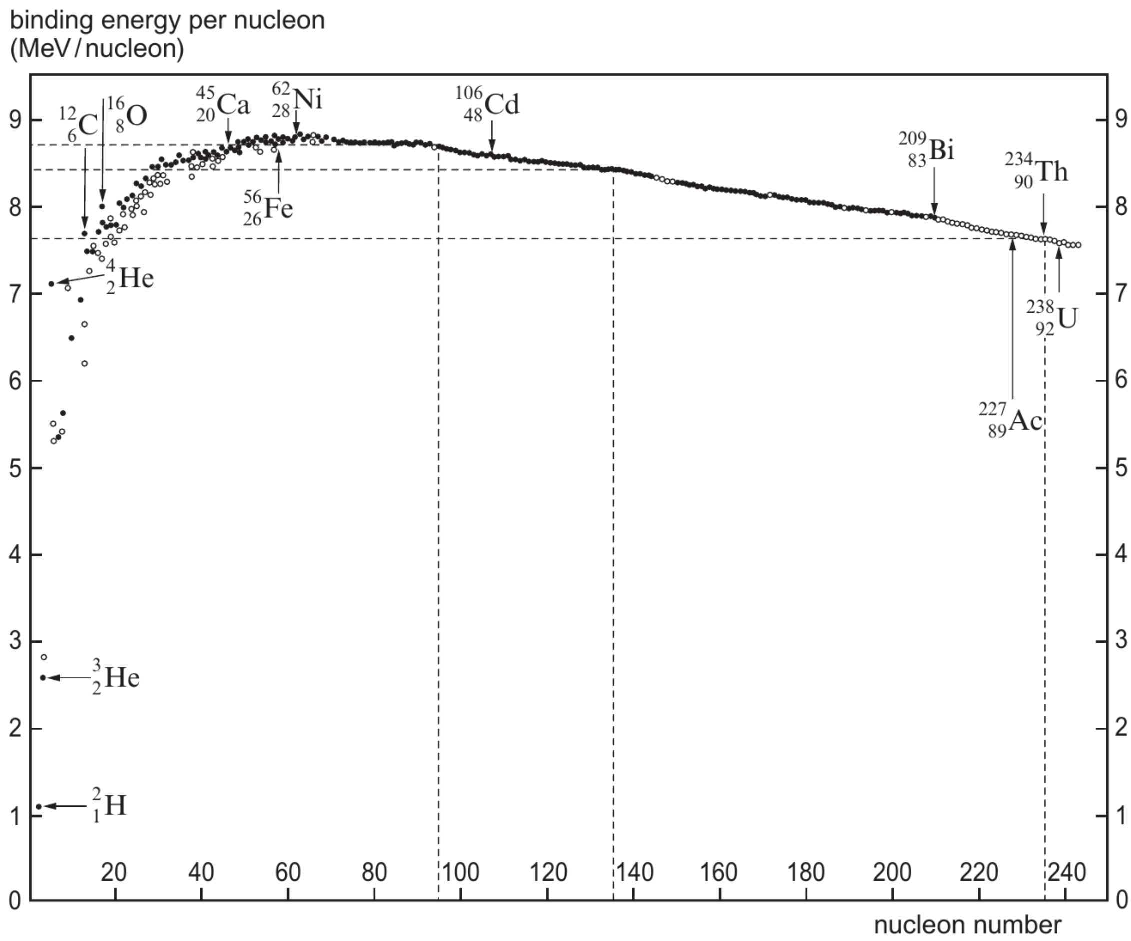
(b) Explain briefly how this reaction can lead to a chain reaction. [2]

(c) Explain briefly the different purposes of the moderator and control rods in a nuclear reactor. [3]

(d) Discuss briefly the problems associated with disposing of waste products from a nuclear power station. [2]

Examiner only

3. *(a)* Some nuclei undergo fusion while others undergo fission. Both processes can result in the release of energy. Discuss these processes in terms of energy and stability. The binding energy per nucleon graph is provided to assist your answer. [4]



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Examiner only

(b) Use data from the graph to estimate the energy released in the reaction. [2]

$$^{1}_{0}\mathrm{n} + ^{1}_{1}\mathrm{p} \longrightarrow ^{2}_{1}\mathrm{H}$$

(c) Use the graph to estimate the energy released in the following reaction. (Hint: use the binding energies on both sides of the reaction equation.) [4]

$$^{1}_{0}\mathrm{n} + ^{235}_{92}\mathrm{U} \longrightarrow ^{137}_{55}\mathrm{Cs} + ^{96}_{37}\mathrm{Rb} + 3\,^{1}_{0}\mathrm{n}$$

END OF QUESTION PACK

3 questions · 30 marks · ~42m

Source: WJEC PH5 (2008 modular spec)

Curated for WJEC Physics 2015 spec A2 Unit 3 — Topic 6b (3.6)