

Exercise walk-through

23.1

Fission: conserve charge and nucleons, account for energy

International Baccalaureate · IB Diploma · Physics · HL

23.1 Fission: conserve charge and nucleons, account for energy

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS chain reaction • fission

Objective

Fission: conserve charge and nucleons, account for energy. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

1 Key knowledge and worked examples

■ What would explain this observation?

- A neutron can trigger a heavy nucleus to split, releasing energy and further neutrons. Whether the process becomes a **chain reaction** depends on what happens to those neutrons.
- Start with a prediction. State the quantities or features you would compare, then

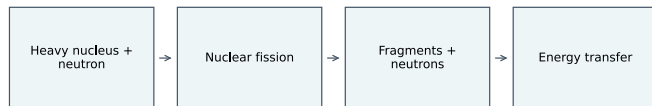
decide what evidence could distinguish two explanations.

■ Build the model

- In nuclear **fission** a heavy nucleus splits into lighter nuclei. Proton number and nucleon number balance in a nuclear equation. The total rest mass can decrease; the difference corresponds to released energy through $E = \Delta mc^2$.
- fission: Splitting of a heavy nucleus into lighter nuclei; chain reaction: A sequence in

which products initiate further events.





■ **Choose evidence that can test it**

- Separate conservation of nucleon number from conservation of total energy. Released neutrons may initiate further fissions, escape or be absorbed. A controlled reactor and an uncontrolled chain reaction have different neutron-management conditions.
- Balance a supplied nuclear equation, use the specified mass data and identify the system. Analyse models or published reactor data; this is not a school attempt to produce fission or handle reactor materials.

■ **Work from known quantities**

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: U-235 absorbs one neutron, forming Ba-141, Kr-92 and three neutrons. Nucleon balance: $235+1 = 141+92+3 = 236$. Proton balance: $92 = 56+36$. A mass decrease of 2.0×10^{-28} kg corresponds to 1.8×10^{-11} J using $c=3.0 \times 10^8$ m/s.

Example:

A U-235 nucleus plus one neutron produces fragments with mass numbers 141 and 92. How many neutrons balance the equation? Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ **Check the conclusion and its limits**

- Mass number is not a precise mass in kilograms. Balanced integer labels alone do not calculate the released energy. Radioactive decay and neutron-induced fission are not interchangeable descriptions.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A balanced nucleon-number equation alone gives the energy release in joules. This claim is false: Mass number is not a precise mass in kilograms. Balanced integer labels alone

do not calculate the released energy. Radioactive decay and neutron-induced fission are not interchangeable descriptions.

Key:

Fission: conserve charge and nucleons, account for energy: Separate conservation of nucleon number from conservation of total energy. Released neutrons may initiate further fissions, escape or be absorbed. A controlled reactor and an uncontrolled chain reaction have different neutron-management conditions.

Exercises 2.1-2.3

2.1 What permits a continuing fission chain reaction? Choose one answer.

- **A** Released neutrons initiate further fissions
- **B** Every emitted neutron must escape
- **C** Charge conservation is suspended

[1]

2.2 A U-235 nucleus plus one neutron produces fragments with mass numbers 141 and 92. How many neutrons balance the equation? Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: A balanced nucleon-number equation alone gives the energy release in joules. [2]

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2.1 What permits a continuing fission chain reaction? Choose one answer.

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2.1 A Separate conservation of nucleon number from conservation of total energy. Released neutrons may initiate further fissions, escape or be absorbed. A controlled reactor and an uncontrolled chain reaction have different neutron-management conditions.

2.2 A U-235 nucleus plus one neutron produces fragments with mass numbers 141 and 92. How many neutrons balance the equation? Show the relation, substitution and units. [2]

2.2 $\text{Neutrons} = 235 + 1 - 141 - 92 = 3$.

2.3 Decide whether this claim is true and justify: A balanced nucleon-number equation alone gives the energy release in joules. [2]

2.3 False. Mass number is not a precise mass in kilograms. Balanced integer labels alone do not calculate the released energy. Radioactive decay and neutron-induced fission are not interchangeable descriptions.

Exercises 2.4-3.1

2.4 Splitting of a heavy nucleus into lighter nuclei: write the technical term. [1]

3 Exam-style questions

3.1 For $^{235}\text{U} + \text{n} \rightarrow ^{141}\text{Ba} + ^{92}\text{Kr} + x\text{n}$, find x and verify proton balance using atomic numbers 92, 56 and 36. Does nucleon conservation mean rest mass is unchanged? [4]

Exercises 2.4·3.1

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3 Exam-style questions

2.4 fission. fission means Splitting of a heavy nucleus into lighter nuclei.

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3.1 $x=3$; proton balance is $92=56+36$. Nucleon number and charge balance while binding-energy differences allow rest mass to become other energy.