

## 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.

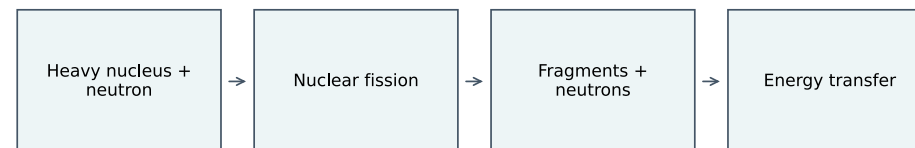
### 1 Key knowledge and worked examples

#### ■ 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  $2.0 \times 10^{-28}$  kg corresponds to  $1.8 \times 10^{-11}$  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.

## 2 Practice

**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]

**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]

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## Solutions

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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** Neutrons =  $235 + 1 - 141 - 92 = 3$ .

**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.

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

**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.