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QUESTION WORKBOOK

# Fission and fusion

Nuclear physics · Year 13

AQA 3.8.1.6, 3.8.1.7 · CIE 23.1.2, 23.1.5, 23.1.6, 23.1.7 · OCR A 6.4.4(b), 6.4.4(g), 6.4.4(j), 6.4.4(k)

18 questions · 50 marks

NAVY SCREEN EDITION


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## SECTION A · Warm-up

**A1** Describe what happens in induced nuclear fission. [2]

**A2** Explain what is meant by a chain reaction in a fissile material. [2]

**A3** State what is meant by the critical mass of a fissile material. [2]

**A4** State what is meant by a thermal neutron. [1]

**A5** State the two number balances that must hold in any nuclear reaction equation. [2]

**A6** State the form in which most of the energy released in a fission event appears. [1]

## SECTION B · Standard

**B1** In one fission reaction, $^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + x\,{}^{1}_{0}n$. Determine the value of x and show that the proton numbers balance. [3]

**B2** A single fission event converts a mass of $3.5 \times 10^{-28}$ kg into energy. Calculate the energy released in joules and in MeV.
$c = 3.0 \times 10^{8}$ m s$^{-1}$, 1 MeV = $1.60 \times 10^{-13}$ J [3]

**B3** Explain why very high temperatures are needed for nuclear fusion to occur. [3]

**B4** A fusion reaction releases 17.6 MeV of energy. Calculate the energy released in joules and the mass converted into energy.
$c = 3.0 \times 10^8$ m s$^{-1}$ [3]

**B5** Explain why the fragments produced by the fission of uranium-235 are radioactive, and state the type of decay they undergo. [3]

**B6** In one fusion reaction, two deuterium nuclei form helium-3 and a neutron:
$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$
Nuclear masses: $^{2}_{1}H$ 2.01355 u, $^{3}_{2}He$ 3.01493 u, neutron 1.00867 u. Calculate the energy released, in MeV.
1 u = 931.5 MeV [3]

**B7** A reactor core produces thermal power at a steady 600 MW. Each fission releases about 200 MeV. Calculate the number of fissions occurring each second. Go on to determine the mass converted into energy in one day of operation.
1 MeV = $1.60 \times 10^{-13}$ J, c = $3.0 \times 10^{8}$ m $s^{-1}$, 1 day = 86 400 s [4]

## SECTION C · Stretch

**C1** Each fission of a uranium-235 nucleus releases about 200 MeV. Estimate the energy released by the complete fission of 1.0 kg of uranium-235.
$N_A = 6.02 \times 10^{23}$ $mol^{-1}$, 1 MeV = $1.60 \times 10^{-13}$ J [4]

**C2** Compare nuclear fission and nuclear fusion in terms of the fuel used, the conditions required and the products formed. [4]

**C3** Use the binding energy per nucleon curve to explain why energy is released in both fission and fusion. [3]

**C4** The fusion of deuterium and tritium releases 17.6 MeV from nuclei totalling five nucleons. The fission of uranium-235 releases about 200 MeV from 236 nucleons (the nucleus plus the absorbed neutron). A journalist writes that fission must release more energy per kilogram of fuel, because 200 MeV is far greater than 17.6 MeV. Deduce whether the journalist is correct. [4]

**C5** A fixed mass of fissile material can be formed into different shapes. Suggest why a sphere is the shape most likely to sustain a chain reaction. [3]