

Name of the Student: _____

Max. Marks : 22 Marks

Time : 22 Minutes

Mark Schemes

Q1.

- (a) (i) Fission occurs at A values above the peak / above A of about 56 and fusion occurs at A values below the peak / below A of about 56 ✓

Fission is the splitting of a nucleus (into two smaller ones) *and* fusion is the joining of two nuclei ✓

First mark uses the graph so 'fission occurs in very large nuclei' does not gain a mark. (allow other interpretations that use the graph eg gradients)

2nd Mark splitting into 2 is not required for fission but if the answer implies something different like the separating of all the nucleons the mark may not be given.

2

- (ii) Energy is released when the binding energy (per nucleon) is increased ✓
 fusion energy is greater as the increase in BE(/A) for fusion > increase in BE(/A) for fission (owtte) ✓

The last point can be given for a reference to the larger gradient at small values of A (fusion region) compared to the gradient at large values of A (fission region)

2

- (b) (i) $\Delta m = (8m_p + 8m_n) - M_{\text{oxygen}}$
 mark for substituting data into the above equation in any workable consistent units

$$= 8(1.00867 + 1.00728) - 15.991 \quad \checkmark$$

$$(\Delta m = 0.1366 \text{ u})$$

$$\Delta m = 0.1366 \times 1.661 \times 10^{-27} = 2.3 \times 10^{-28} \text{ (kg)} \quad \checkmark$$

(range of answers $2.2 - 2.3 \times 10^{-28} \text{ kg}$)

Substitution may take the following form

$$8(1.673 \times 10^{-27}) + 8(1.675 \times 10^{-27}) - (15.991 \times 1.661 \times 10^{-27}) \quad \checkmark$$

$$= 2.23 \times 10^{-28} \text{ (kg)} \quad \checkmark$$

Correct answer gains full marks.

Look out for a physics error in which u is not taken as $1.661 \times 10^{-27} \text{ kg}$

2

- (ii) $E = m \times c^2 = 2.3 \times 10^{-28} \times (3.00 \times 10^8)^2 = 2.07 \times 10^{-11} \text{ J}$
 $\text{BE} = 2.07 \times 10^{-11} / 1.6 \times 10^{-13} = 130 \text{ (MeV)} \quad \checkmark \text{ (129 MeV)}$
 Or using
 using $\Delta m = 0.1366 \text{ u}$ (this must appear in b(i) for this approach)

BE = $0.1366 \times 931.3 = 130$ (MeV) ✓ (127 MeV)
CE is allowed but only if the calculation is shown
Note answer = $b(i) \times 5.625 \times 10^{29}$
answer only is acceptable for one mark.
(factor may be 931 or 931.5)

1

- (iii) read from the graph the BE/A for $^{16}_8\text{O}$ and multiply by the number of nucleons (or 16) ✓

Or show the calculation

BE = $8(\text{Mev}) \times 16(\text{nucleons}) = 130$ (MeV) ✓ (128 MeV) ✓

There must be a reference to $^{16}_8\text{O}$ position on the graph.
with the calculation allow BE = $8.1(\text{Mev}) \times 16(\text{nucleons}) = 130$ (MeV)
A calculation may lead to an answer in joule

1

[8]

Q2.

- (a) A α particles ✓

[auto mark question]

1

- (b) (i)

type of radiation	Typical range in air / m
α	0.04 ✓
β	0.40 ✓

Allow students to use their own distance units in the table

α allow 0.03 → 0.07 m

β allow 0.20 → 3.0 m.

If a range is given in the table use the larger value.

A specific number is required e.g. not just a few cm.

2

- (ii) reference to the inverse square law of (γ radiation)
 or
 reference to lowering of the solid angle (subtended by the detector as it moves away)
 or
 radiation is spread out (over a larger surface area as the detector is moved away) ✓

(owtte)

Ignore any references to other types of radiation.

Any contradiction loses the mark. For example, follows inverse square law so intensity falls exponentially.

1

- (c) dust may be ingested / taken into the body / breathed in ✓

First mark for ingestion not just on the body

causing (molecules in human tissue / cells) to be made cancerous / killed / damaged by ionisation ✓

Q3.

- (a) (i) electromagnetic / electrostatic / Coulomb (repulsion between the alpha particles and the nuclei) ✓

The interaction must be named not just described.

1

- (ii) the scattering distribution remains the same (because the alpha particles interact with a nucleus) whose charge / proton number / atomic number remains the same or the (repulsive) force remains the same

The mark requires a described distribution and the reason for it.

Or

the scattering distribution changes / becomes less distinct because there is a mixture of nuclear masses (which gives a mixture of nuclear recoils) ✓
(owtte)

A reference must be made to mass and not density or size.

1

- (b) (i) use of graph to find r_0
e.g. $r_0 = 6.0 \times 10^{-15} / 75^{1/3}$ ✓
(or $8.0 \times 10^{-15} / 175^{1/3}$)
($r_0 = 1.43 \times 10^{-15}$ m)

Substitution and calculation must be shown.

Condone a gradient calculation on R against $A^{1/3}$ graph (not graph in question) as $R \propto A^{1/3}$

1

- (ii) Escalate if clip shows ²⁷13Al in the question giving $R \approx 4 \times 10^{-15}$ m.

(using $R = r_0 A^{1/3}$)

$$R = 1.43 \times 10^{-15} \times 51^{1/3} \quad \checkmark$$

$$R = 5.3 \times 10^{-15} \text{ (m)} \quad \checkmark$$

$$(R = 5.2 \times 10^{-15} \text{ m from } r_0 = 1.4 \times 10^{-15} \text{ m})$$

First mark for working.

Second mark for evaluation which must be 2 or more sig figs allow CE from (i) $R = 3.71 \times (i)$.

Possible escalation.

2

- (c) Escalate if clip shows ²⁷13 in the question and / or the use of 27 in the working.

density = mass / volume

$$m = 51 \times 1.67 \times 10^{-27}$$

$$(= 8.5 \times 10^{-26} \text{ kg})$$

Give the first mark for substitution of data into the top line or bottom line of the calculation of density.

$$V = \frac{4}{3}\pi (5.3 \times 10^{-15})^3$$

$$(6.2(4) \times 10^{-43} \text{ m}^3)$$

In the second alternative the mark for the substitution is only given if the working equation is given as well.

Or

$$\text{density} = A \times u / 4/3\pi (r_0 A^{1/3})^3$$

$$= u / 4/3\pi (r_0)^3$$

51 × 1.67 × 10⁻²⁷ would gain a mark on its own but 1.66 × 10⁻²⁷ would need u / 4/3 π(r₀)³ as well to gain the mark.

$$\text{top line} = 1.66 \times 10^{-27}$$

$$\text{bottom line} = 4/3\pi (1.43 \times 10^{-15})^3$$

✓ for one substitution

$$\text{density} = 1.4 \times 10^{17} \quad \checkmark$$

$$(1.37 \times 10^{17})$$

$$\text{kg m}^{-3} \quad \checkmark$$

*Expect a large spread of possible answers. For example
If $R = 5 \times 10^{-15}$ $V = 5.24 \times 10^{-43}$ and density = 1.63×10^{17} .*

Possible escalation.