Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Mark Schemes

Q1.

(a) the amount of energy required to separate a nucleus ✓
into its separate neutrons and protons / nucleons ✓
(or energy released on formation of a nucleus ✓
from its separate neutrons and protons / constituents ✓)

1st mark is for correct energy flow direction
2nd mark is for binding or separating nucleons (nucleus is in the question but a reference to an atom will lose the mark)
ignore discussion of SNF etc
both marks are independent

2

(b) (i) $2\,{}^{1}_{0}\mathrm{n}$ or ${}^{1}_{0}\mathrm{n} + {}^{1}_{0}\mathrm{n}$ ✓

must see subscript and superscripts

1

(ii) binding energy of U
= 235 × 7.59 ✓ (= 1784 (MeV))
binding energy of Tc and In
= 112 × 8.36 + 122 × 8.51 ✓
(= 1975 (MeV))
energy released (= 1975 – 1784) = 191 (MeV) ✓ (allow 190 MeV)

1st mark is for 235 × 7.59 seen anywhere
2nd mark for 112 × 8.36 + 122 × 8.51 or 1975 is only given if there are no other terms or conversions added to the equation (ignore which way round the subtraction is positioned)
correct final answer can score 3 marks

3

(iii) energy released
= $191 \times 1.60 \times 10^{-13}$ ✓
(= 3.06×10^{-11} J)
loss of mass (= E / c^2)
= $2.91 \times 10^{-11} / (3.00 \times 10^{8})^2$)
= 3.4×10^{-28} (kg) ✓
or
= 191 / 931.5 u ✓ (= 0.205 u)
= $0.205 \times 1.66 \times 10^{-27}$ (kg)
= 3.4×10^{-28} (kg) ✓

allow CE from (ii)
working must be shown for a CE otherwise full marks can be given for correct answer only

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note for CE
answer = (ii) × 1.78 × 10^{-30}
(2.01 × 10^{-27} is a common answer)

2

(c) (i) line or band from origin, starting at 45° up to Z approximately = 20 reading Z = 80, N = 110→130 ✓

initial gradient should be about 1 (ie Z = 20 ; N = 15 → 25) and overall must show some concave curvature. (Ignore slight waviness in the line)
if band is shown take middle as the line
if line stops at N > 70 extrapolate line to N = 80 for marking

1

(ii) fission fragments are (likely) to be above / to the left of the line of stability ✓
fission fragments are (likely) to have a larger N / Z ratio than stable nuclei
or
fission fragments are neutron rich owtte ✓
and become neutron or β^- emitters ✓

ignore any reference to α emission
a candidate must make a choice for the first two marks
stating that there are more neutrons than protons is not enough for a mark
1st mark reference to graph
2nd mark – high N / Z ratio or neutron rich
3rd mark beta minus
note not just beta

3

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Q2.

(a) (i) 1/12 the mass of an (atom) of $^{12}_{6}C$ / carbon−12 / C12 ✓

a reference to a nucleus loses the mark

1

(ii) separated nucleons have a greater mass ✓ (than when inside a nucleus)

an answer starting with 'its' implies the nucleus

because of the (binding) energy added to separate the nucleons or energy is released when a nucleus is formed (owtte) ✓

marks are independent
direction of energy flow or work done must be explicit

2

(b) nuclei need to be close together (owtte) for the Strong Nuclear Force to be involved or for fusion to take place ✓

e.g. first mark – within the range of the SNF

but the electrostatic / electromagnetic force is repulsive (and tries to prevent this) ✓

(if the temperature is high then) the nuclei have (high) kinetic energy / speed (to overcome the repulsion) ✓

3rd mark is for a simple link between temperature and speed / KE

3

(c) (i) 15 ✓

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give the middle mark easily for any e or β with a + in any position

e^+ ✓ (or β^+, ${}^0_1\beta$, ${}^0_1 e$)

12 ✓

3

(ii) Δmass = $4 \times 1.00728 - 4.00150 - (2 \times 9.11 \times 10^{-31} / 1.661 \times 10^{-27})$
or
Δmass = $\{4 \times 1.00728 - 4.00150 - 2 \times 0.00055\}$(u) ✓

(4×1.00728=4.02912)

1st mark – correct subtractions in any consistent unit. use of $m_p = 1.67 \times 10^{-27}$ kg will gain this mark but will not gain the 2nd as it will not produce an accurate enough result

Δmass = 0.02652(u) ✓

2nd mark - for calculated value

0.02652u

4.405×10^{-29} kg

3.364×10^{-12} J

Δbinding energy (= 0.02652 × 931.5) {allow 931.3}

Δbinding energy = 24.7 MeV ✓

3rd mark – conversion to Mev

conversion mark stands alone

award 3 marks for answer provided some working shown - no working gets 2 marks

(2sf expected)

3

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