Practice Question Set For A-Level
Subject : Physics
Paper-2 Topic: Fields And Their Consequences(Nuclear Physics)

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Name of the Student:____
Max. Marks : 19 Marks **Time : 19 Minutes**

Mark Schemes

Q1.

(a) Energy required/work done to separate the nucleus ✔
into its individual nucleons/protons and neutrons ✔
OR
Energy given out when a nucleus is formed ✔
from its individual nucleons/protons and neutrons ✔

MP2 can only be awarded when there is some reference to energy via MP1.

Alternative words may be used instead of 'separate' but when used they must convey the correct idea.

If no other marks are awarded, condone the idea that "binding energy is how much greater the rest energy/mass of the constituent nucleons is than that of the nucleus" for one mark.

2

(b) Statement of binding energy/mass defect = (mass of nucleons) – (mass of nucleus) ✔$_1$ (which may be seen from a full equation with data or implied from clear statements of what numbers represent)

Use of Data Booklet values leads to a correct answer of 338 (337.6)MeV. Allow 340 ± 10 RB TO CONFIRM.

Standing alone or contained in the binding energy equation show the total mass of nucleon constituents of $^{56}_{26}\mathrm{Fe}$ ✔$_2$

✔$_1$ condone simple numerical errors such as powers of 10 if mark comes from substituted equation.

the correct binding energy converted to
MeV = 490 ± 10 (MeV)
Or use of data booklet values and $E = mc^2$
= 340 ± 10 (MeV) ✔$_3$

✔$_2$ for giving data to at least 4 sig figs but calculations can use less.

Examples looked for are

$26 \times 1.673 \times 10^{-27} + 30 \times 1.675 \times 10^{-27}$ (= 9.375×10^{-26} kg)

OR

$26 \times 938.257 + 30 \times 939.551$ (= 52580 MeV)

OR

$26 \times 1.00728 + 30 \times 1.00867$ (= 56.44938 u)

✔$_3$ no ecf. and mark is only available if the mass of a neutron and proton are different in part 2.

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Might see

$(9.375 \times 10^{-26} - 9.288 \times 10^{-26}) \times 931.5 / 1.661 \times 10^{-27}$

$= 488 \pm 2$ MeV

OR

$52580 - (9.288 \times 10^{-26} \times 931.5 / 1.661 \times 10^{-27})$

$= 492 \pm 2$ MeV

OR

$\{56.44938 - 9.288 \times 10^{-26}/1.661 \times 10^{-27}\} \times$

931.5

$= 495 \pm 2$ MeV

OR

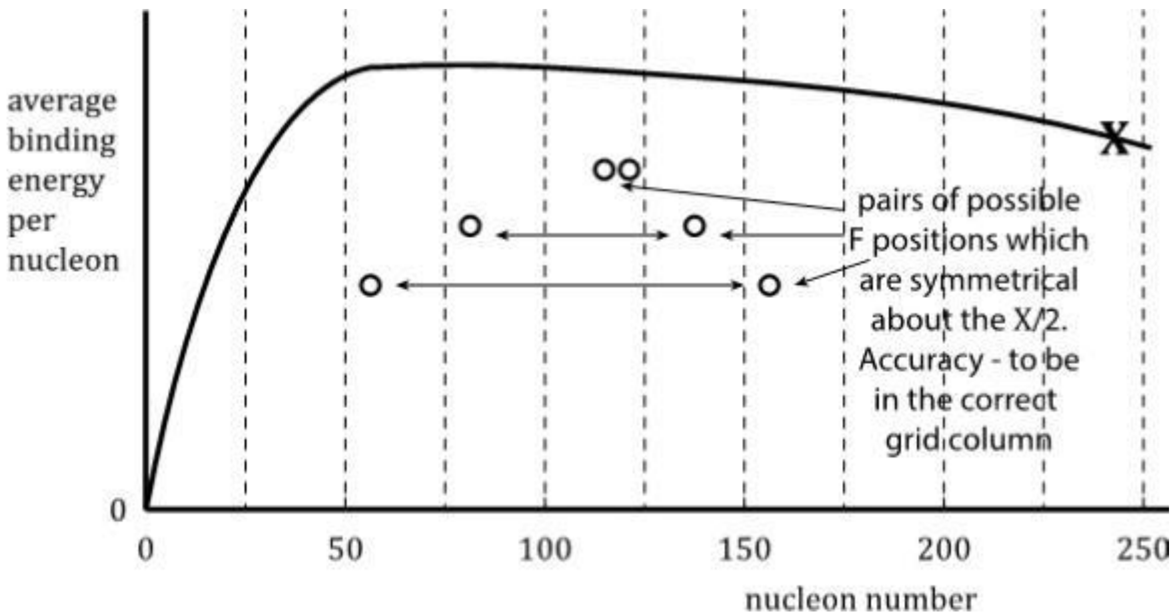
when the calculation involves the use of $E = mc^2$

338 ± 2 MeV

Note calculations may vary being dependant on how may sig figs are retained and how many individual stages of calculation are used.

3

(c) Both $\mathbf{F_1}$ and $\mathbf{F_2}$ to be to the right of the peak and marked on the graph or x-axis ✔
$\mathbf{F_1}$ and $\mathbf{F_2}$ to be in the correct grid regions t symmetrical about half the nucleon number corresponding to **X**. ✔[2]



*Note that an **F** position cannot have a nucleon lower than the peak. So the 3 examples shown indicate the possible range of an answer.*

The position of F_1 and F_2 are taken from the centre of the cross or blob drawn by the candidate. The range of each grid region includes the boundary dotted line.

✔[1] If it is clear that nucleon numbers of F_1 and F_2 add to 240 give mark

The circles shown in the diagram show the horizontal positions – to gain the marks the circles have to be on the line or the x-axis.

2

(d) The starting point of the fission fragments is given the first mark ✔$_1$

✔$_1$ fission fragments have a high N/Z ratio

OR

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fission fragments are positioned above/left of the line plot in Fig 2

too many neutrons is not given a mark – high N/Z ratio or neutron rich terms must be used

(normally the initial decay mode is) β^- ✔$_2$

✔$_2$ *Mark may be given in isolation but the minus must be indicated*

Moves closer to the stable region as:
a neutron changes to a proton OR
position (on the graph) moves down and to the right ✔$_3$

The discussion of the decay and positioning of F_1 and F_2 must be the same. Any differences will be marked as a contradiction.

✔$_3$ *the mark could be seen on Fig 2*

3

[10]

Q2.

(a) Total Mass of nuclei is more than the mass of the fusion product ✔$_1$

✔$_1$ *Alternatively the B/A of the fusion product is greater than B/A of both the starting nuclei.*

Binding energy or Binding energy per nucleon increases when a nucleus is formed by fusion ✔$_2$

✔$_2$ *In order to release energy, the total binding energy of the two nuclei must be less than the binding energy of the nuclide formed*

2

(b) $(\Delta m = \left(\text{mass } {}^3_2\text{He} + \text{mass } {}^{17}_{8}\text{O}\right) - \text{mass } {}^{20}_{10}\text{Ne})$

✔$_1$ *Δm = (3.01603 + 16.99913) – 19.99244) = 0.02272 u (must have at least 3 sig fig)*

Δm = 0.02272 (u) ✔$_1$

Energy released = 3.38 to 3.40 $\times 10^{-12}$ J ✔$_2$ (allow an ecf for the conversion of units)

✔$_2$ *$\Delta m = 0.02272 \times 1.661\ 10^{-27}$ kg $= 0.02272 \times 1.661\ 10^{-27} \times (3.00 \times 10^{8})^{2}$ J $= 3.39 \times 10^{-12}$ J*

OR

$\Delta m = 0.02272 \times 931.5$ MeV

$= 21.16 \times 1.60 \times 10^{-13}$ J $= 3.39 \times 10^{-12}$ J

2

(c) Mark for use of potential energy formula and identifying the 2(e) and the 8(e) ✔$_1$

✔$_1$ *condone other numerical errors*

$$\left(V = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r} = \frac{2 \times 8 \times \left(1.60 \times 10^{-19}\right)^2}{4\pi \times 8.85 \times 10^{-12} \times 5.1 \times 10^{-15}}\right)$$

$V = 7.2(2) \times 10^{-13}$ (J) ✔$_2$ (correct answer only)

✔$_2$ *correct final answer gains both marks*

2

(d) Making reference to the doubling charge which increases the gain in potential energy or force

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needed (to bring nuclei together) ✔$_1$ (owtte)

✔$_1$ no computation is expected

Condone increase instead of doubling

(So) the larger charge (of $^{34}_{16}S$) requires greater kinetic energy or pressure for fusion and decreases the rate of fusion ✔$_2$ (owtte)

Making reference to the larger radius/size of the sulphur nucleus compared to the oxygen nucleus

(So) the larger radius (of = $^{34}_{16}S$) (requires smaller kinetic energy or pressure for fusion) and the separation can be larger for fusion to take place so increases the rate of fusion ✔$_3$ (owtte)

✔$_3$ A full calculation is not expected, such as

$$\frac{R_S}{R_O} = \sqrt[3]{\frac{A_S}{A_O}} = \sqrt[3]{\frac{34}{17}} = \sqrt[3]{2}$$

If no marks are awarded accept number of protons for charge in mp1.

3

[9]

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