

1. June/2023/Paper_ 9702/11/No.38

A proton has mass m_p and charge $+e$.

What are the mass and charge of an antiproton?

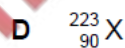
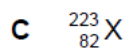
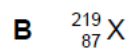
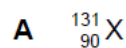
| | mass | charge |
|----------|--------|--------|
| A | $-m_p$ | $+e$ |
| B | $-m_p$ | $-e$ |
| C | m_p | $+e$ |
| D | m_p | $-e$ |

2. June/2023/Paper_ 9702/11/No.39

A uranium nucleus has 92 protons and 143 neutrons.

The nucleus emits a total of 3 α -particles and 4 β^- particles to form nucleus X.

How can nucleus X be represented?



3. June/2023/Paper_ 9702/11/No.40

Which statement about a proton is correct?

- A** A proton is a baryon but not a meson.
- B** A proton is a meson but not a hadron.
- C** A proton is both a hadron and a meson.
- D** A proton is both a meson and a baryon.

4. June/2023/Paper_ 9702/12/No.38

What are isotopes?

- A** nuclei of different elements with the same number of neutrons
- B** nuclei of different elements with the same number of nucleons
- C** nuclei of the same element with different numbers of neutrons
- D** nuclei of the same element with different numbers of protons

5. June/2023/Paper_9702/12/No.39

A neutron ${}_0^1\text{n}$ is fired at a ${}_{92}^{235}\text{U}$ nucleus. The neutron is absorbed by the nucleus which then splits to form nuclei of ${}_{56}^{141}\text{Ba}$ and ${}_{36}^{92}\text{Kr}$.

What is the number of free neutrons emitted when the ${}_{92}^{235}\text{U}$ nucleus splits?

- A 0 B 1 C 2 D 3

6. June/2023/Paper_9702/12/No.40

A π^+ meson has a charge of $+e$, where e is the elementary charge. It consists of an up quark and one other quark.

What could be the other quark in the π^+ meson?

- A anti-down
B anti-up
C bottom
D charm

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The table contains data for four different nuclei P, Q, R and S.

| nucleus | number of neutrons | nucleon number |
|---------|--------------------|----------------|
| P | 5 | 10 |
| Q | 6 | 10 |
| R | 6 | 14 |
| S | 8 | 16 |

Which two nuclei are isotopes of the same element?

- A P and Q B P and S C Q and R D R and S

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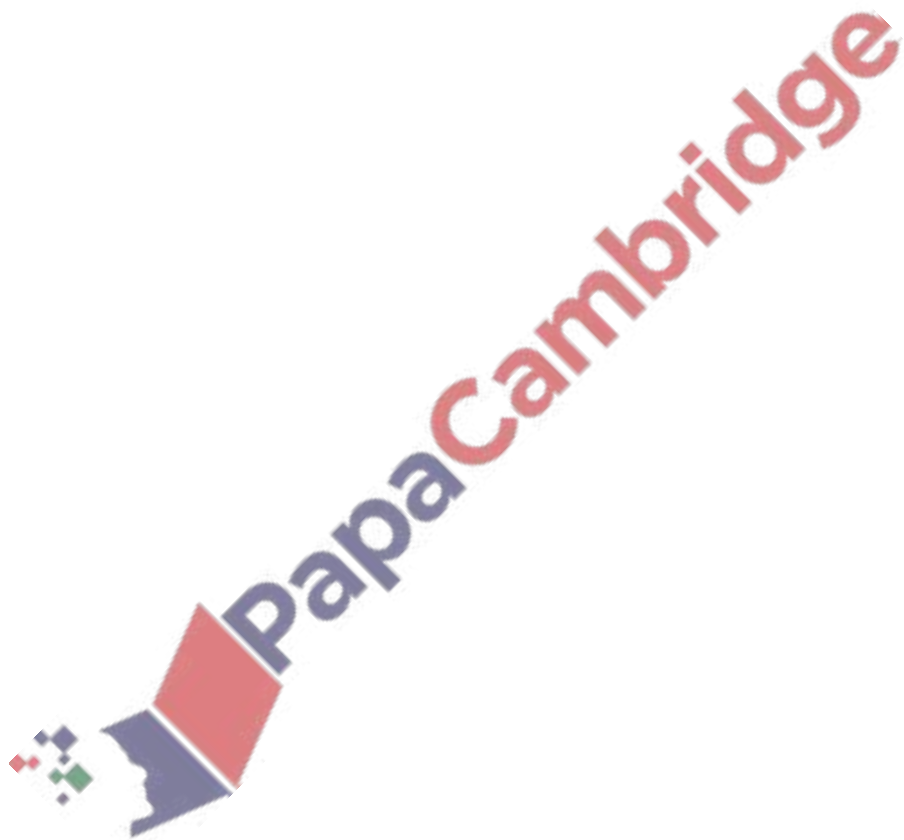
Which statement about β^- decay is correct?

- A A neutron changes to a proton in the nucleus and an electron and an antineutrino are emitted.
B A neutron changes to a proton in the nucleus and an electron and a neutrino are emitted.
C A proton changes to a neutron in the nucleus and an electron and an antineutrino are emitted.
D A proton changes to a neutron in the nucleus and an electron and a neutrino are emitted.

9. June/2023/Paper_9702/13/No.40

What is the quark composition of a hydrogen-3 nucleus, ${}^3_1\text{H}$?

| | number of quarks | |
|----------|------------------|------|
| | up | down |
| A | 4 | 5 |
| B | 5 | 4 |
| C | 5 | 7 |
| D | 7 | 5 |



10. June/2023/Paper_9702/21/No.8

An isolated stationary nucleus X decays by emitting an α -particle to form a nucleus Y.

Nucleus Y and nucleus Z are isotopes of the same element.

(a) By comparing the number of protons in each nucleus, state and explain whether the charge of nucleus Y is less than, greater than or the same as the charge of:

(i) nucleus Z

.....
..... [1]

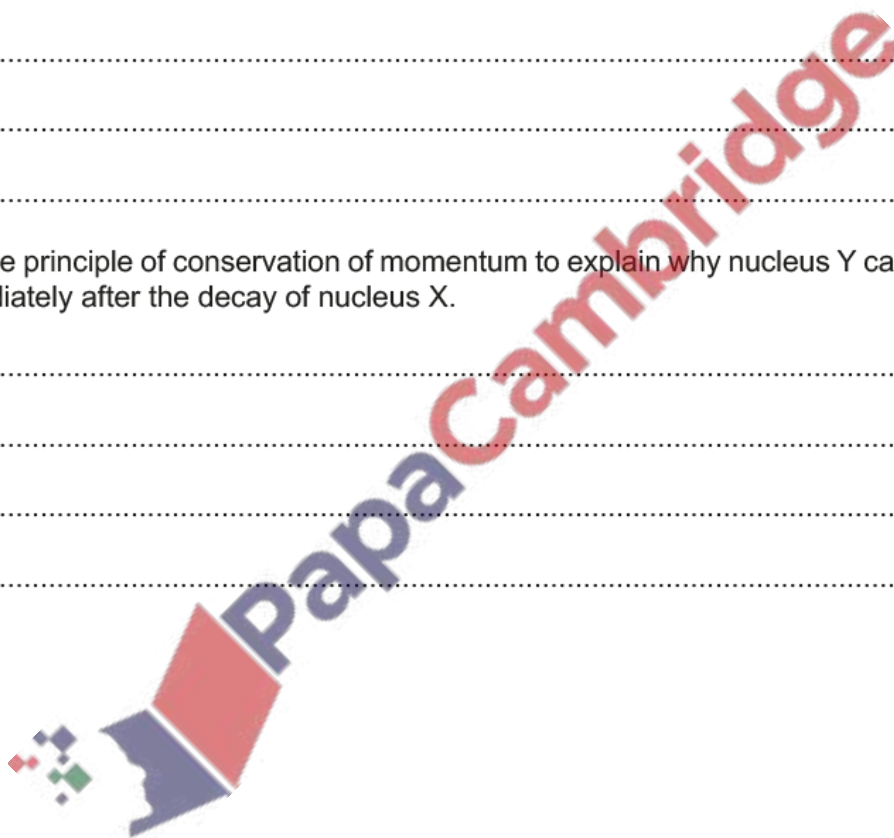
(ii) nucleus X.

.....
.....
..... [2]

(b) Use the principle of conservation of momentum to explain why nucleus Y cannot be stationary immediately after the decay of nucleus X.

.....
.....
.....
..... [2]

[Total: 5]



(a) Nucleus P and nucleus Q are isotopes of the same element.

Nucleus Q is unstable and emits a β^- particle to form nucleus R.

(i) For nuclei P and Q, compare:

- the number of protons

.....

- the number of neutrons.

.....

[2]

(ii) When nucleus Q decays to form nucleus R, the quark composition of a nucleon changes.

State the change to the quark composition of the nucleon.

..... [1]

(iii) State the name of another particle that must be emitted from nucleus Q in addition to the β^- particle.

..... [1]

(b) A hadron consists of two charm quarks and one bottom quark.

Determine, in terms of the elementary charge e , the charge of the hadron.



charge = e [2]

- (a) Table 7.1 shows incomplete data for three flavours (types) of quark. The elementary charge is e .

Table 7.1

| flavour | quark | | antiquark | |
|---------|--------|----------------|-----------|--------------|
| | symbol | charge / e | symbol | charge / e |
| up | u | $+\frac{2}{3}$ | \bar{u} | |
| down | d | | \bar{d} | |
| charm | c | | \bar{c} | |

Complete Table 7.1 by inserting the missing charges. [2]

- (b) Using the symbols given in Table 7.1, state a possible quark combination for the following hadrons:

- (i) a neutral baryon

..... [1]

- (ii) a meson with a charge of $+e$.

..... [1]

- (c) Quarks are fundamental particles.

Electrons are in another group (class) of fundamental particle.

- (i) State the name of this group.

..... [1]

- (ii) State the name of another particle in this group.

..... [1]

[Total: 6]

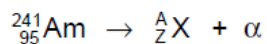
13. March/2023/Paper_9702/12/No.38

What is a conclusion from the alpha-particle scattering experiment?

- A Protons and electrons have equal but opposite charges.
- B Protons have a much larger mass than electrons.
- C The nucleus contains most of the mass of the atom.
- D The nucleus of an atom contains protons and neutrons.

14. March/2023/Paper_9702/12/No.39

Americium-241 is a radioactive nuclide used in smoke detectors. It undergoes α -decay to form nuclide X. This decay may be represented by the equation shown.



What are the values of A and Z?

| | A | Z |
|---|-----|----|
| A | 237 | 93 |
| B | 239 | 91 |
| C | 241 | 94 |
| D | 241 | 96 |

15. March/2023/Paper_9702/12/No.40

A top quark has a charge of $+\frac{2}{3}e$, where e is the elementary charge.

What is the charge of an anti top quark?

- A $-\frac{2}{3}e$ B $-\frac{1}{3}e$ C $+\frac{1}{3}e$ D $+\frac{2}{3}e$

(a) Nuclei X and Y are different isotopes of the same element.

Nucleus X is unstable and emits a β^+ particle to form nucleus Z.

By comparing the number of protons in each nucleus, state and explain whether the charge of nucleus X is less than, the same as or greater than the charge of:

(i) nucleus Y

.....
..... [1]

(ii) nucleus Z.

.....
.....
..... [2]

(b) Hadrons can be divided into two groups (classes), P and Q. Group P is baryons.

(i) State the name of group Q.

..... [1]

(ii) Describe, in general terms, the quark structure of hadrons that belong to group Q.

.....
..... [1]

[Total: 5]

