Particle Physics – 2023 June AS Physics 9702

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?

A $^{131}_{90}X$ **B** $^{219}_{87}X$ **C** $^{223}_{82}X$ **D** $^{223}_{90}X$

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 ${}^{1}_{0}n$ is fired at a ${}^{235}_{92}U$ nucleus. The neutron is absorbed by the nucleus which then splits to form nuclei of ${}^{141}_{56}Ba$ and ${}^{92}_{36}Kr$.

What is the number of free neutrons emitted when the ${}^{235}_{92}U$ 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

7. June/2023/Paper_ 9702/13/No.38

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

8. June/2023/Paper_ 9702/13/No.39

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, ${}^{3}_{1}H$?

	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]

11. June/2023/Paper_ 9702/22/No.8

(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.

$$^{241}_{95}\text{Am} \rightarrow {}^{A}_{Z}\text{X} + \alpha$$

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** $+\frac{2}{3}e$

16. March/2023/Paper_ 9702/22/No.7

(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]