1 Which of the following nuclei has the smallest specific charge?

A $^{1}_{1}H$ ⬭

B $^{12}_{6}C$ ⬭

C $^{14}_{6}C$ ⬭

D $^{235}_{92}U$ ⬭

(Total 1 mark)

2 $^{232}_{90}Th$ is an unstable nuclide in a radioactive decay series. It decays by emitting an α particle. The next two nuclides in the series emit β^- particles.

What nuclide is formed after these three decays have taken place?

A $^{230}_{90}Th$ ⬭

B $^{228}_{92}U$ ⬭

C $^{228}_{88}Ra$ ⬭

D $^{228}_{90}Th$ ⬭

(Total 1 mark)

3 Which line does **not** give the correct exchange particle for the process?

	Process	**Exchange particle**	
A	gravitational attraction	W boson	⬭
B	electrostatic repulsion of electrons	virtual photon	⬭
C	strong interaction	pion	⬭
D	β^- decay	W boson	⬭

(Total 1 mark)

4 Which line correctly classifies the particle shown?

	Particle	Category	Quark combination	
A	neutron	baryon	$\bar{u}d$	○
B	neutron	meson	udd	○
C	proton	baryon	uud	○
D	positive pion	meson	$\bar{u}d$	○

(Total 1 mark)

5 Which of the following statements about muons is **incorrect**?

A A muon is a lepton. ○

B A muon has a greater mass than an electron. ○

C If a muon and an electron each have the same de Broglie wavelength then they each have the same momentum. ○

D A muon with the same momentum as an electron has a larger kinetic energy than the electron. ○

(Total 1 mark)

6 What is the best estimate for the order of magnitude for the diameter of an atom?

A 10^{-14} m ○

B 10^{-12} m ○

C 10^{-11} m ○

D 10^{-8} m ○

(Total 1 mark)

7 What are the numbers of hadrons, baryons and mesons in an atom of ${}^{7}_{3}Li$?

	hadrons	baryons	mesons	
A	7	3	3	⬭
B	7	4	4	⬭
C	7	7	0	⬭
D	10	7	0	⬭

(Total 1 mark)

8 Electron capture can be represented by the following equation.

$$p + e^{-} \rightarrow \mathrm{X} + \mathrm{Y}$$

Which row correctly identifies **X** and **Y**?

	X	Y	
A	p	K^{-}	⬭
B	e^{-}	e^{+}	⬭
C	n	V_e	⬭
D	n	π^0	⬭

(Total 1 mark)

9 A calcium ion is formed by removing two electrons from an atom of ${}^{40}_{20}Ca$. What is the specific charge of the calcium ion?

A 3.2×10^{-19} C kg^{-1} ⬭

B 2.9×10^{-18} C kg^{-1} ⬭

C 4.8×10^{6} C kg^{-1} ⬭

D 4.8×10^{7} C kg^{-1} ⬭

(Total 1 mark)

10 Which of the following is **not** true?

A Each meson consists of a single quark and a single antiquark.

B Each baryon consists of three quarks.

C The magnitude of the charge on every quark is $\frac{1}{3}$

D A particle consisting of a single quark has not been observed.

(Total 1 mark)

11 The nucleus of ${}^{9}_{4}\mathrm{Be}$ captures a proton and emits an α particle. What is the product nucleus?

A ${}^{9}_{4}\mathrm{Be}$

B ${}^{10}_{6}\mathrm{C}$

C ${}^{7}_{3}\mathrm{Li}$

D ${}^{6}_{3}\mathrm{Li}$

(Total 1 mark)

12 A radioactive nucleus emits a β^-. particle then an α particle and finally another β^-. particle. The final nuclide is

A an isotope of the original element

B the same element with a different proton number

C a new element of higher proton number

D a new element of lower nucleon number

(Total 1 mark)

13 A nucleus of a particular element decays, emitting a series of α and β^- particles.

Which of the following series of emissions would result in an isotope of the original element?

A 1 α and 1 β^- ⬭

B 1 α and 2 β^- ⬭

C 2 α and 1 β^- ⬭

D 2 α and 2 β^- ⬭

(Total 1 mark)

14 Which of the following is **not** made of quarks?

A kaon ⬭

B muon ⬭

C neutron ⬭

D pion ⬭

(Total 1 mark)

15 Which equation shows the process of annihilation?

A $\pi^- + \pi \longrightarrow \gamma$ ⬭

B $\mathrm{p} + \overline{\mathrm{p}} \rightarrow \gamma + \gamma$ ⬭

C $\beta^- + \mathrm{p} \longrightarrow \gamma$ ⬭

D $\gamma + \gamma \longrightarrow \beta^+ + \beta^-$ ⬭

(Total 1 mark)

16 What is the quark structure for antiprotons?

A	$\bar{u}\bar{d}$	⬭
B	$\bar{d}\bar{d}\bar{s}$	⬭
C	$\bar{d}\bar{d}\bar{u}$	⬭
D	$\bar{u}\bar{u}\bar{d}$	⬭

(Total 1 mark)

17 Artificial radioactive nuclides are manufactured by placing naturally-occurring nuclides in a nuclear reactor. They are made radioactive in the reactor as a consequence of bombardment by

A α particles.

B β particles.

C protons.

D neutrons.

(Total 1 mark)

18 In a nuclear reaction $^{14}_{7}N$ is bombarded by neutrons. This results in the capture of one neutron and the emission of one proton by one nucleus of $^{14}_{7}N$. The resulting nucleus is

A $^{13}_{7}N$

B $^{14}_{6}C$

C $^{12}_{6}C$

D $^{14}_{8}O$

(Total 1 mark)

Mark schemes

1 D **[1]**

2 D **[1]**

3 A **[1]**

4 C **[1]**

5 D **[1]**

6 C **[1]**

7 C **[1]**

8 C **[1]**

9 C **[1]**

10 C **[1]**

11 C **[1]**

12 A **[1]**

13 B **[1]**

14 B **[1]**

15 B **[1]**

16 D **[1]**

17 D **[1]**

18 B

[1]

Examiner reports

13 Although decay series per se are on the A2 specification, this question tested the consequence of alpha and beta decay on proton number, as well as the student’s understanding of isotopes. It proved to be very accessible with 84% of students getting the correct answer. The most common distractor was C, confusing alpha and beta decay perhaps.

14 With 87% of students choosing the correct answer, few students had any difficulty with this question. The remaining answers were fairly evenly spread between the three distractors.

15 Students generally find most aspects of the particle physics topic fairly straightforward. This question was no exception with 83% of students remembering the need for two gamma photons to be produced. A was the most common distractor, chosen by students who forgot this important point perhaps.

16 This was the most accessible question on the paper with 95% of students able to recall the quark structure of an antiproton. C was the most popular distractor, chosen by students confusing protons and neutrons perhaps.