**Q1.**

A sequence of radioactive decays starts with nuclide **P** and ends with an isotope of **P**.

Which is a possible sequence for these decays?

Proton No. $\rightarrow$ constant

A one alpha decay followed by four β^- decays

☐

B one alpha decay followed by two β^- decays

☐

C two alpha decays followed by two β^- decays

☐

D two alpha decays followed by one β^- decay

☐

(Total 1 mark)

Q2.

The alpha particle, positron and proton have different charge-to-mass ratios.

Which row shows the particles that have the greatest and the smallest value of this ratio?

from formula sheet

Charge/mass

electron: 1.76×10^{11}

proton: 9.58×10^7

$$\alpha: \frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.67 \times 10^{-27}} = 4.8 \times 10^7$$

	Greatest charge-to-mass ratio	Smallest charge-to-mass ratio	
A	positron	alpha particle	☐
B	positron	proton	☐
C	alpha particle	proton	☐
D	alpha particle	positron	☐

(Total 1 mark)

Q3.

The quark structure of the antiparticle of the K^+ meson is

A $u\bar{s}$

☐

$$+\frac{2}{3}e + \frac{1}{3}e = +e \quad \checkmark$$

B $\bar{u}d$

☐

C $\bar{u}s$

☐

$$-e$$

D $\bar{d}s$

☐

(Total 1 mark)

Q4.

Which nuclear change results in the nucleus with the greatest specific charge?

- A the alpha decay of a $^{209}_{82}\text{Po}$ nucleus $\rightarrow$ $\frac{80(p)}{205(n+p)}$ ☐
- B the beta-minus decay of a $^{28}_{12}\text{Mg}$ nucleus $\frac{13}{28}$ ☐
- C the beta-plus decay of a $^{39}_{20}\text{Ca}$ nucleus $\frac{19}{39}$ ☒
- D electron capture by a $^{105}_{47}\text{Ag}$ nucleus $\frac{46}{105}$ ☐
- $e + p \rightarrow n$

(Total 1 mark)

Q5.

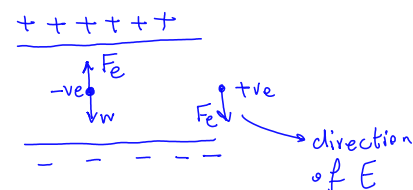
An ion has a specific charge of $-7.1 \times 10^7 \text{ C kg}^{-1}$.

test charge = +1c

It is held stationary in a vertical electric field on the surface of the Earth.

What are the magnitude and direction of the electric field?

- A $1.38 \times 10^{-7} \text{ V m}^{-1}$ upwards ☐
- B $1.38 \times 10^{-7} \text{ V m}^{-1}$ downwards ☐
- C $7.24 \times 10^6 \text{ V m}^{-1}$ upwards ☐
- D $7.24 \times 10^6 \text{ V m}^{-1}$ downwards ☐



$$\text{if } m = 1 \text{ kg} \rightarrow Q = -7.1 \times 10^7 \text{ C}$$

$$W = mg = 9.81 \text{ N}$$

(Total 1 mark)

$$F_e = W = 9.81 \text{ N} = \frac{9.81}{7.1 \times 10^7} = 1.38 \times 10^{-7} \text{ V/m} \rightarrow B$$

$$E = \frac{V}{d} \equiv \frac{V}{m}$$

$$F = Eq \rightarrow E = \frac{F}{Q}$$

Q6.

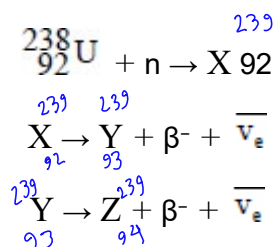
electrostatic forceWhich particle pair has the largest magnitude of gravitational force when separated by the same distance?

- A an electron and a positive pion ☐
- B a helium nucleus and a proton ☐
- C a proton and a positive pion ☐
- D a proton and an electron ☐

(Total 1 mark)

Q7.

Uranium-238 absorbs a neutron in the first stage in a series of nuclear reactions that end in a nucleus Z.



How many neutrons does Z have?

A 144

☐

B 145

☐

C 149

☐

D 237

☐

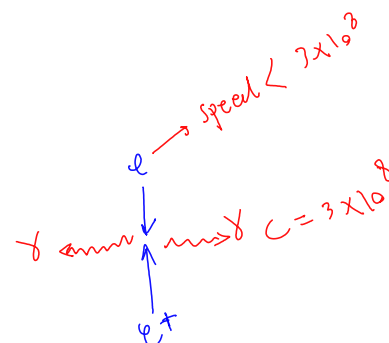
$$n_n = 239 - 94 = 145 \rightarrow B \checkmark$$

(Total 1 mark)

Q8.

An electron and a positron annihilate each other.

Which quantity is **not** conserved in the annihilation?

A electric charge $\checkmark$
☐
B kinetic energy $\times$
☐
C lepton number $\checkmark$
☐
D momentum $\checkmark$
☐


(Total 1 mark)

Q9.

Which exchange particle transfers charge during electron capture?

A meson

☐

B pion

☐

C virtual photon

☐
D W boson $\checkmark$
☐

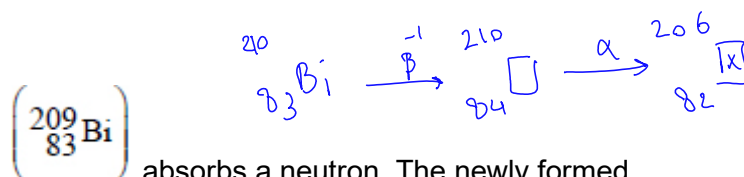
(Total 1 mark)

Q10.

A free neutron decays to produce a proton and

- ✓ **A** an electron and an antineutrino. ☐
- B** an electron and a neutrino. ☐
- C** a positron and an antineutrino. ☐
- D** a positron and a neutrino. ☐

(Total 1 mark)

Q11.

A nucleus of bismuth-209 $\left(\begin{smallmatrix} 209 \\ 83 \end{smallmatrix} \text{Bi} \right)$ absorbs a neutron. The newly formed nucleus subsequently decays in two stages to form a nucleus of nuclide **X**. One beta-minus particle and one alpha particle are emitted during these two decays.

What are the nucleon number and the proton number of **X**?

	Nucleon number	Proton number	
A	205	82	☐
B	205	83	☐
C	206	82	☐
D	206	83	☐

(Total 1 mark)

Q12.

The concept of exchange particles was introduced to explain forces between elementary particles.

This concept requires that exchange particles have

- A** charge. ☐
- B** momentum. ☐
- C** phase. ☐
- D** rest mass. ☐

(Total 1 mark)

Q13.

A nucleus contains N neutrons and Z protons.

Which combination of N and Z gives a nucleus with the greatest specific charge?

	N	Z	
A	6	5	☐
B	8	7	☐
C	16	13	☐
D	20	17	☐

(Total 1 mark)

Q14.

Which statement about muons is correct?

A They consist of a quark and an antiquark.

☐

B They include pions and kaons.

☐

C They are subject to the strong interaction.

☐

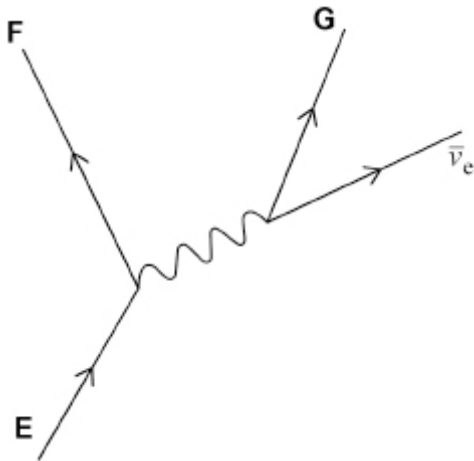
D They decay into electrons.

☐

(Total 1 mark)

Q15.

The diagram represents a quark change in which an electron antineutrino is produced.



What are **E**, **F** and **G**?

	E	F	G	
A	up quark	down quark	β^-	☐
B	down quark	up quark	β^-	☐
C	up quark	down quark	β^+	☐
D	down quark	up quark	β^+	☐

(Total 1 mark)

Q16.

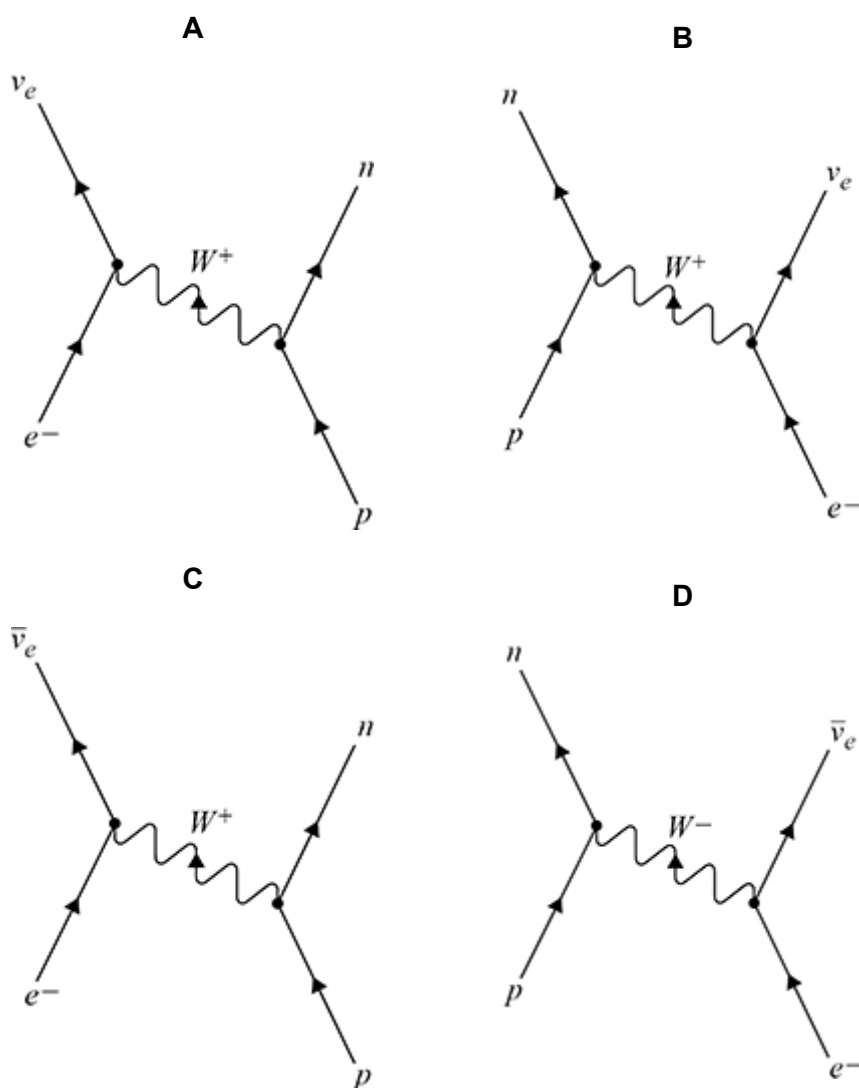
Which row has the largest value for
 $\frac{\text{specific charge of the particle in column X}}{\text{specific charge of the particle in column Y}}$?

	X	Y	
A	electron	alpha particle	☐
B	alpha particle	electron	☐
C	electron	proton	☐
D	proton	alpha particle	☐

(Total 1 mark)

Q17.

Which diagram represents the process of electron capture?



- A** ☐
- B** ☐
- C** ☐
- D** ☐

(Total 1 mark)

Q18.

Which row is correct?

	Name of particle	Classification	Quark structure	
A	antineutron	meson	$\bar{u}\bar{u}\bar{d}$	☐
B	positive kaon	baryon	$\bar{u} s$	☐
C	antiproton	baryon	$\bar{u}\bar{u}\bar{d}$	☐
D	positive pion	meson	$\bar{u} d$	☐

(Total 1 mark)

Q19.

An alpha particle and a nucleus of boron ${}^{10}_5\text{B}$ interact to form an unstable nucleus and a free neutron.

The unstable nucleus decays by positron emission to form a nucleus of nuclide **X**.

What is **X**?

- A ${}^{13}_5\text{B}$ ☐
- B ${}^{13}_6\text{C}$ ☐
- C ${}^{13}_7\text{N}$ ☐
- D ${}^{13}_8\text{O}$ ☐

(Total 1 mark)

Q20.

What is the specific charge of a ${}^{13}_6\text{C}$ nucleus?

- A $4.4 \times 10^7 \text{ C kg}^{-1}$ ☐
- B $5.2 \times 10^7 \text{ C kg}^{-1}$ ☐
- C $8.3 \times 10^7 \text{ C kg}^{-1}$ ☐
- D $2.1 \times 10^8 \text{ C kg}^{-1}$ ☐

(Total 1 mark)

Q21.

Which row describes the variation with distance of the strong nuclear force?

	Attractive	Repulsive	
A	beyond 3 fm	from 0.5 fm to 3 fm	☐
B	from 0.5 fm to 3 fm	beyond 3 fm	☐
C	from 0.5 fm to 3 fm	up to 0.5 fm	☐
D	up to 0.5 fm	from 0.5 fm to 3 fm	☐

(Total 1 mark)

Q22.

Which statement is correct?

- A** All strange particles are mesons. ☐
- B** Strange particles are always created in pairs. ☐
- C** Strangeness can only change in strong interactions. ☐
- D** Strangeness can only have a value of 0 or -1 ☐

(Total 1 mark)

Q23.

Which combination of quarks is possible?

- A** sd ☐
- B** sū ☐
- C** sūd ☐
- D** ud ☐

(Total 1 mark)

Q24.

In photoelectricity, V_s is the stopping potential.

What quantity is eV_s ?

- A** energy of an incident photon
- B** maximum kinetic energy of a photoelectron
- C** threshold frequency $\times$ the Planck constant
- D** work function

☐☐☐☐

(Total 1 mark)