1. An atom of oxygen-15 $\left(^{15}_{8}O\right)$ gains two electrons to form an ion.

What is the specific charge of the ion?

A -1.3×10^7 C kg^{-1}

B -2.4×10^7 C kg^{-1}

C -5.1×10^7 C kg^{-1}

D -6.4×10^7 C kg^{-1}

(Total 1 mark)

2. Which is an exchange particle for the weak interaction?

A   lepton

B   photon

C   pion

D W^+

(Total 1 mark)

3. A particular baryon has a quark structure dss and decays by the weak interaction.

What are possible decay products of this baryon?

The quark structure of Λ^0 is uds.

A $\Lambda^0 + \pi^-$

B $n + \pi^-$

C $\Lambda^0 + e^-$

D $K^+ + K^0$

(Total 1 mark)

4. A muon and an antimuon annihilate to produce the minimum number of photons.

What is the maximum wavelength of the photons?

A 5.9×10^{-15} m

B 1.2×10^{-14} m

C 5.9×10^{-9} m

D 1.2×10^{-8} m

(Total 1 mark)

5. Which row describes the nature of the strong nuclear force between two nucleons at separations of 0.25 fm, 2.0 fm and 8.0 fm?

	At a separation of 0.25 fm	At a separation of 2.0 fm	At a separation of 8.0 fm	
A	attractive	repulsive	negligible	⬭
B	repulsive	attractive	attractive	⬭
C	negligible	repulsive	attractive	⬭
D	repulsive	attractive	negligible	⬭

(Total 1 mark)

6. What are the products when a free neutron decays?

A $p + e^- + v_e$

B $p + e^+ + \bar{v}_e$

C $p + e^- + \bar{v}_e$
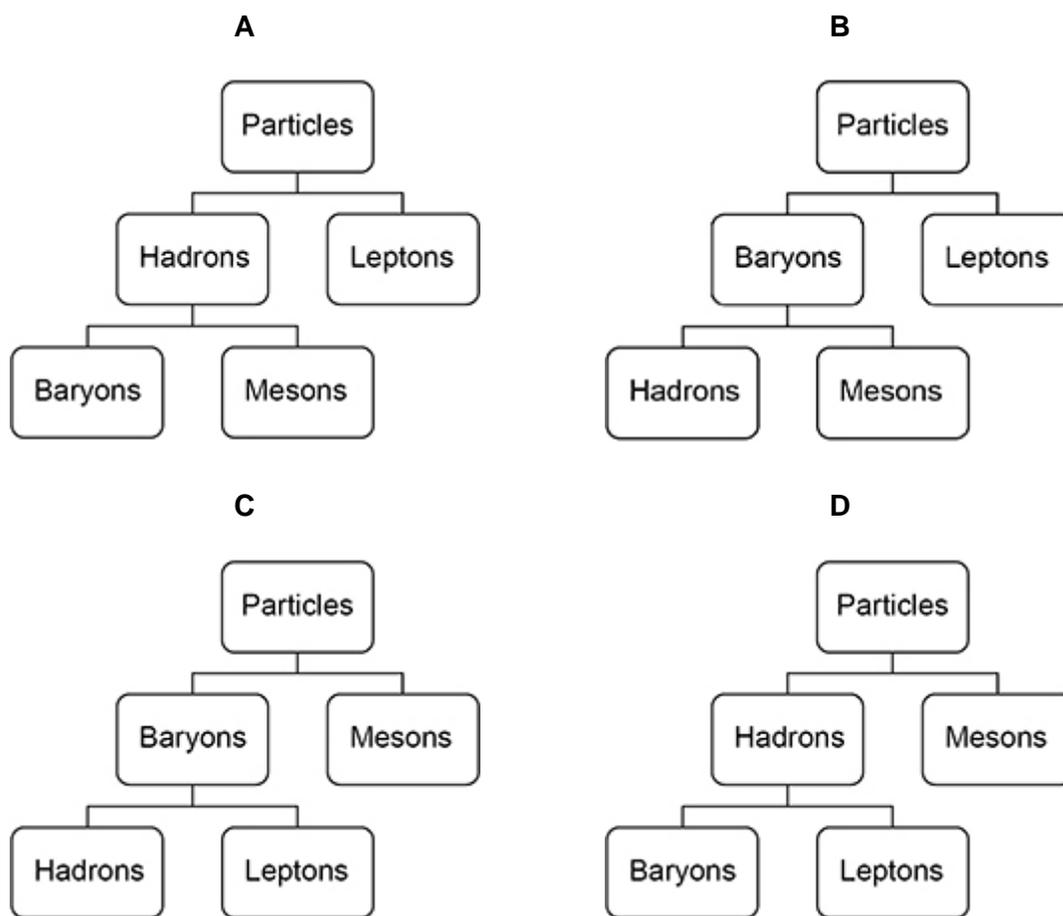
D $p + e^+ + v_e$

(Total 1 mark)

7. In a Young's double-slit experiment, monochromatic light is incident on two narrow slits and the resulting interference pattern is observed on a screen.

Which change **decreases** the fringe separation?

A   decreasing the separation between the two slits ☐

B   increasing the distance between the slits and the screen ☐

C   using monochromatic light of higher frequency ☐

D   using monochromatic light of longer wavelength ☐

(Total 1 mark)

8. Which shows the classification of particles?

A

Particles
├ Hadrons
│ ├ Baryons
│ └ Mesons
└ Leptons

B

Particles
├ Baryons
│ ├ Hadrons
│ └ Mesons
└ Leptons

C

Particles
├ Baryons
│ ├ Hadrons
│ └ Leptons
└ Mesons

D

Particles
├ Hadrons
│ ├ Baryons
│ └ Leptons
└ Mesons

A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

9. The gravitational force is one of the four fundamental forces.
The ticks in the table match particles with the other fundamental forces.

In which row is the particle matched to the only other fundamental forces it experiences?

	Particle	Electromagnetic force	Weak nuclear force	Strong nuclear force	
A	μ^+	✓	✓		⬭
B	$\bar{p}$	✓		✓	⬭
C	π^0	✓	✓	✓	⬭
D	v_e		✓	✓	⬭

(Total 1 mark)

10. The proton number of uranium is 92 and the proton number of radon is 88

Which series of decays turns a uranium nucleus into a radon nucleus?

A   α + β⁻ + β⁻ + α + α   ⬭

B   β⁻ + β⁻ + α + β⁻ + α   ⬭

C   α + α + α + α + β⁻   ⬭

D   β⁻ + β⁻ + β⁻ + β⁻ + α   ⬭

(Total 1 mark)

11. The diagram represents a particle interaction.
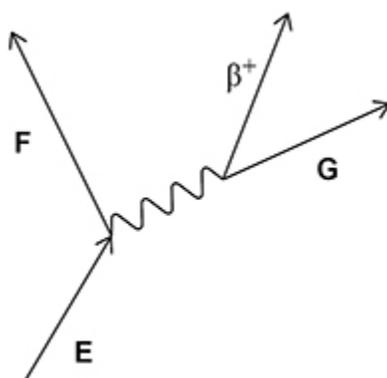
Which row identifies particles **E**, **F** and **G**?

|	E	F	G	
A	up quark	down quark	neutrino	○
B	down quark	up quark	neutrino	○
C	up quark	down quark	antineutrino	○
D	down quark	up quark	antineutrino	○

(Total 1 mark)

12. The quark combination of a particle is sū.

Which is true for this particle?

A　It has a baryon number of 1　　　　　　　　○

B　It has a charge of −1.6 × 10⁻¹⁹ C.　　　　　○

C　It is a pion.　　　　　　　　　　　　　　○

D　It has a strangeness of $-\dfrac{1}{3}$　　　　　○

(Total 1 mark)

13. Which diagram represents electron capture?

A

B

C

D
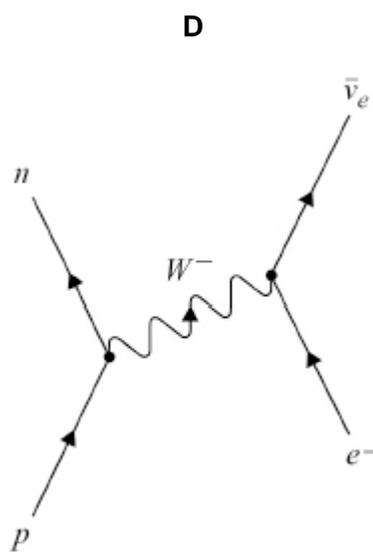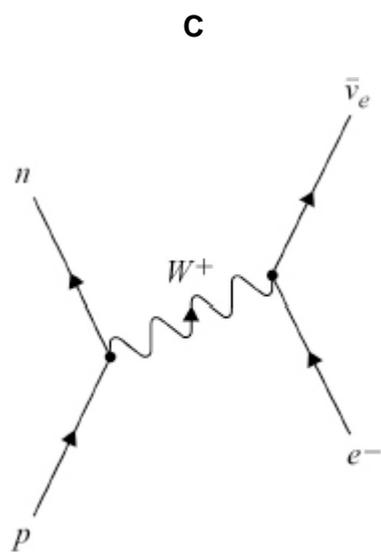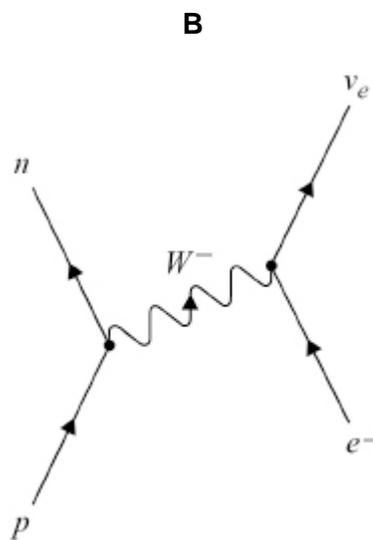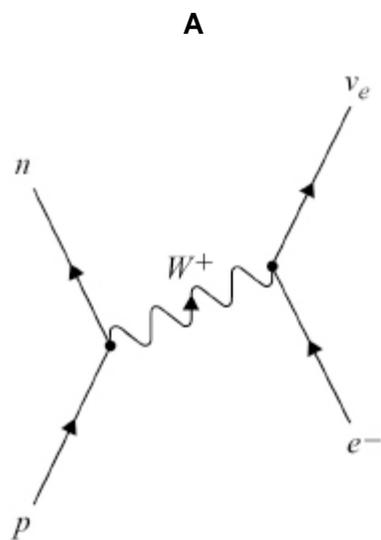
A ☐

B ☐

C ☐

D ☐

(Total 1 mark)

14. $^{x}_{81}\text{Tl}$ decays to $^{206}_{82}\text{Pb}$ by a series of four radioactive decays.

Each decay involves the emission of either a single α particle or a single β⁻ particle.

What is x?

A   207

B   209

C   210

D   212

(Total 1 mark)

15. What is the number of up quarks and down quarks in a $^{9}_{4}\text{Be}$ nucleus?

	Number of up quarks	Number of down quarks	
A	11	16	
B	13	14	
C	14	13	
D	16	11	

(Total 1 mark)

16. Which decay of a positive kaon (K⁺) particle is possible?

A $\text{K}^+ \rightarrow \pi^0 + \text{e}^+ + \bar{v}_e$
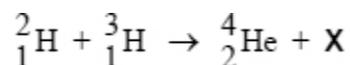
B $\text{K}^+ \rightarrow \text{p} + v_\mu$

C $\text{K}^+ \rightarrow \pi^+ + \pi^+ + \pi^0$

D $\text{K}^+ \rightarrow \mu^+ + v_\mu$

(Total 1 mark)

17. A deuterium nucleus and a tritium nucleus fuse together to produce a helium nucleus and particle **X**.

$$^{2}_{1}\text{H} + ^{3}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + \textbf{X}$$

What is **X**?

A   an electron

B   a neutron

C   a positron

D   a proton

(Total 1 mark)

18. Which row gives a particle with its quark combination and category?

	Particle	Quark combination	Category	
A	Negative pion	dū	baryon	
B	Positive pion	u$\bar{\text{d}}$	hadron	
C	Negative pion	u$\bar{\text{d}}$	meson	
D	Positive pion	dū	hadron	

(Total 1 mark)

19. Which row gives the numbers of baryons and leptons in an atom of $^{12}_{6}\text{C}$?

	Number of baryons	Number of leptons	
A	6	6	
B	12	6	
C	6	12	
D	18	0	

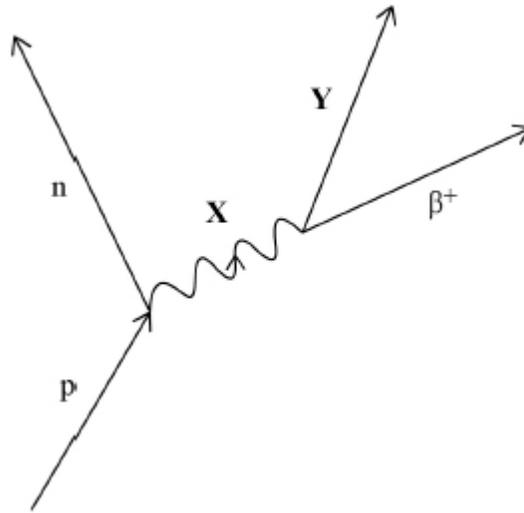**(Total 1 mark)**

20. A muon

    A is subject to the strong interaction. ⬭

    B can decay into an electron only. ⬭

    C is a stable particle. ⬭

    D is subject to the weak interaction. ⬭

(Total 1 mark)

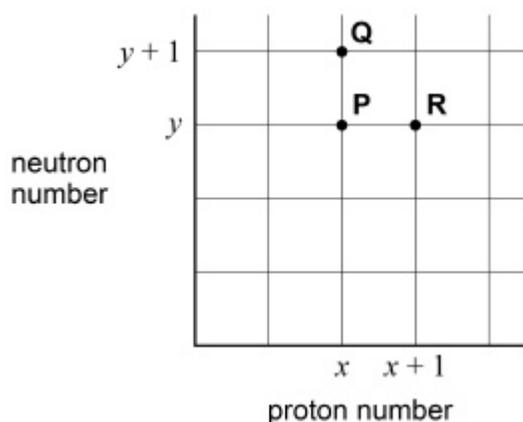**21.** The process of beta plus (β^+) decay can be represented by

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

	X	Y	
A	W^+	ν_e	⬭
B	W^+	$\overline{\nu_e}$	⬭
C	W^-	ν_e	⬭
D	W^-	$\overline{\nu_e}$	⬭

(Total 1 mark)

22. The graph of neutron number against proton number shows three nuclei **P**, **Q** and **R**.

Which row identifies an isotope of **P** and the nucleon number of this isotope of **P**?

	Isotope of P	Nucleon number of isotope of P	
A	Q	$y + 1$	○
B	Q	$x + y + 1$	○
C	R	$x + y + 1$	○
D	R	$x + 1$	○

(Total 1 mark)

23. $^{236}_{92}\text{U}$ undergoes a series of decays to produce $^{204}_{82}\text{Pb}$.
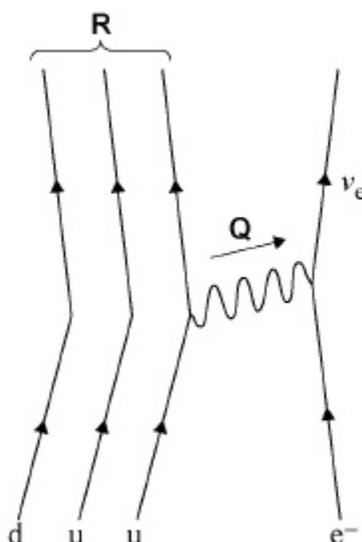
How many alpha decays are involved in this decay series?

A　5　　　　　　　　○

B　6　　　　　　　　○

C　8　　　　　　　　○

D　10　　　　　　　○

(Total 1 mark)

24. The partially completed diagram represents electron capture.

Which row identifies the exchange particle **Q** and the quark structure of particle **R**?

	Particle Q	Quark structure of particle R	
A	W⁻	uuu	
B	W⁺	dud	
C	W⁺	uuu	
D	W⁻	dud	

(Total 1 mark)

25. The decay of a neutral kaon K⁰ is given by the equation

$$K^0 \rightarrow X + Y + \bar{v}_e$$

What are X and Y?

	X and Y	
A	e⁺ and e⁻	
B	μ⁺ and e⁻	
C	π⁺ and e⁻	
D	π⁻ and e⁺	

(Total 1 mark)

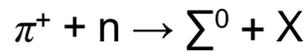**26.** Fluoride ions are produced by the addition of a single electron to an atom of fluorine $^{19}_{9}F$.

What is the magnitude of specific charge of the fluoride ion?

A 3.2×10^{-26} C kg^{-1}

B 8.4×10^{-21} C kg^{-1}

C 5.0×10^{6} C kg^{-1}

D 4.5×10^{7} C kg^{-1}

(Total 1 mark)

27. The Σ^0 baryon, composed of the quark combination uds, is produced through the strong interaction between a π^+ meson and a neutron.

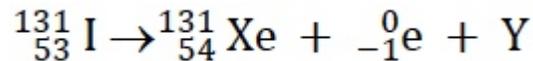$$\pi^+ + n \rightarrow \Sigma^0 + X$$

What is the quark composition of X?

A $u\bar{s}$

B ud

C $u\bar{d}$

D $ud\bar{s}$

(Total 1 mark)

28. An iodine nucleus decays into a nucleus of Xe−131, a beta-minus particle and particle Y.

$$^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + Y$$

Which is a property of particle Y?

A   It has a lepton number of +1

B   It is an antiparticle

C   It is negatively charged

D   It experiences the strong interaction

(Total 1 mark)

29. Which row shows the correct interactions experienced by a hadron or a lepton?

	Particle	Strong interaction	Weak interaction	
A	Hadron	Yes	Yes	⬭
B	Lepton	Yes	Yes	⬭
C	Hadron	Yes	No	⬭
D	Lepton	Yes	No	⬭

(Total 1 mark)

30. When a nucleus of the radioactive isotope $^{65}_{28}$Ni decays, a β^- particle and an electron antineutrino are emitted.

How many protons and neutrons are there in the resulting daughter nucleus?

	Number of protons	Number of neutons	
A	28	65	⬭
B	29	65	⬭
C	29	36	⬭
D	30	35	⬭

(Total 1 mark)

31. What interactions are involved in the production of a strange particle and its decay into non-strange particles?

	Production	Decay	
A	strong	weak	⬭
B	strong	strong	⬭
C	weak	strong	⬭
D	weak	weak	⬭

(Total 1 mark)

32. An atom of $^{16}_{7}N$ gains 3 electrons.

What is the specific charge of the ion?

A 1.80×10^7 C kg^{-1}

B -1.80×10^7 C kg^{-1}

C 4.19×10^7 C kg^{-1}

D -4.19×10^7 C kg^{-1}

(Total 1 mark)