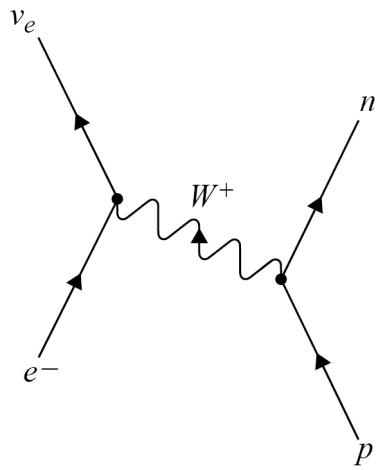
Do not write outside the box

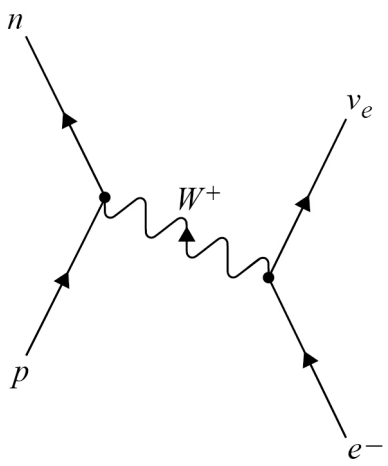
0 8 Which diagram represents the process of electron capture?

[1 mark]

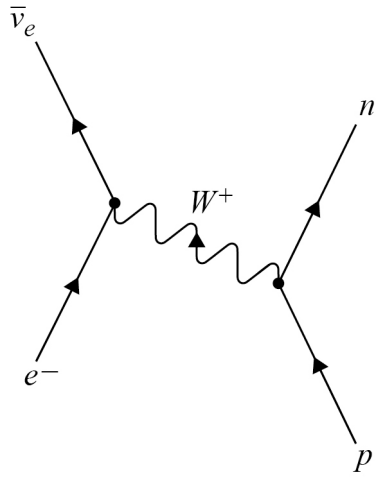
A



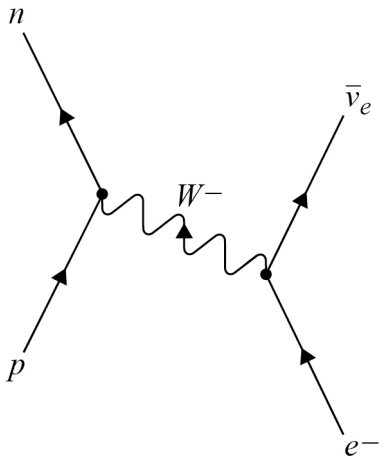
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

Do not write outside the box

0 9 Which row is correct?

[1 mark]

	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	$\bar{u}d$	⬭

1 0 An alpha particle and a nucleus of boron $^{10}_{5}\mathrm{B}$ 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**?

[1 mark]

A $^{13}_{5}\mathrm{B}$ ⬭

B $^{13}_{6}\mathrm{C}$ ⬭

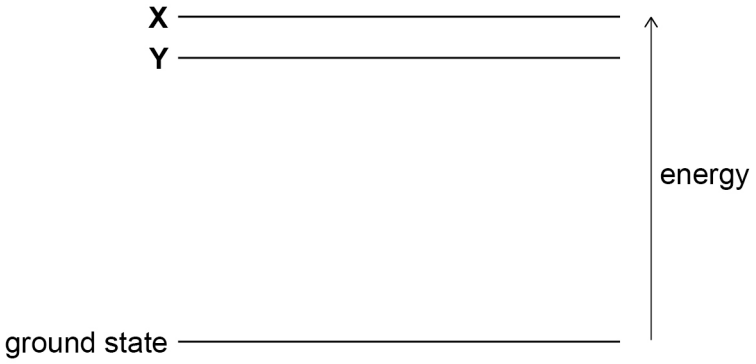
C $^{13}_{7}\mathrm{N}$ ⬭

D $^{13}_{8}\mathrm{O}$ ⬭

Do not write outside the box

1 2 The diagram shows the ground state and two higher-energy states **X** and **Y** of an atom.

A transition from **X** to the ground state produces a photon of wavelength 147 nm.
A transition from **Y** to the ground state produces a photon of wavelength 160 nm.



What is the energy difference between **X** and **Y**?

[1 mark]

A 1.5×10^{-17} J ⬭

B 1.4×10^{-18} J ⬭

C 1.2×10^{-18} J ⬭

D 1.1×10^{-19} J ⬭

1 3 Which provides evidence for discrete atomic energy levels?

[1 mark]

A β^+ decay ⬭

B electron diffraction ⬭

C line spectra ⬭

D the photoelectric effect ⬭

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 A strong interaction between a negative kaon (K^-) and a proton (p) produces an omega-minus (Ω^-) particle, a neutral kaon (K^0) and an unidentified particle **Y**.

The interaction is:

$$K^- + p \rightarrow \Omega^- + K^0 + \mathbf{Y}$$

Table 1 contains information on the particles in this interaction.

Table 1

	K^-	p	Ω^-	K^0	Y
Rest energy / MeV	493.8	938.3	1672	497.8	493.8
Baryon number		+1	+1		0
Charge	$-1e$	$+1e$	$-1e$	0	
Strangeness	−1	0	−3	+1	

0 1 . 1 Complete **Table 1**.

[2 marks]

0 1 . 2 Calculate, in J, the rest energy of the Ω^-.

[2 marks]

rest energy = _____ J

Do not write outside the box

0 1 . 3 Suggest how energy is conserved in this interaction.
Refer to the rest energies of the particles in **Table 1**.

[2 marks]

The quark structure of the Ω^- particle is sss.

The Ω^- is unstable. It decays into a proton through a series of decays:

$$\Omega^- \rightarrow \Xi^0 + \pi^-$$

followed by

$$\Xi^0 \rightarrow \Lambda^0 + \pi^0$$

followed by

$$\Lambda^0 \rightarrow p + \pi^-$$

The Ξ^0 and Λ^0 are both hadrons.

0 1 . 4 Deduce the quark structure of the Λ^0 particle.

[4 marks]

quark structure of Λ^0 = _____

Question 1 continues on the next page

Do not write outside the box

The products of the decay series include π^0 and π^- particles. These particles are unstable and decay.

0 1 . 5 The π^0 decays into gamma photons. Each gamma photon has a wavelength of 1.25×10^{-14} m.

Calculate the energy of one of these photons.

[2 marks]

energy of photon = _____ J

0 1 . 6 The negative pion π^- decays.

Which row shows the particles that could be created in this decay?
Tick (✓) **one** box.

[1 mark]

$\mu^- + \nu_\mu$ ☐

$e^- + \overline{\nu}_e$ ☐

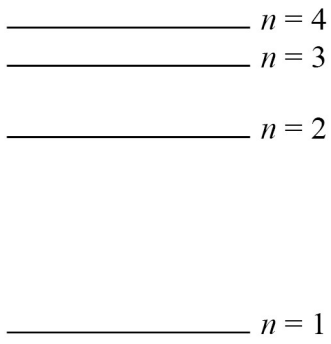
$e^- + \nu_e$ ☐

$e^- + e^+ + e^-$ ☐

13

Do not write outside the box

1 2 The four lowest energy levels of an atom are shown.



A gas contains atoms in the $n = 4$ level.
The atoms de-excite to the $n = 1$ level.

How many photon frequencies are observed?

[1 mark]

A 3 ⬭

B 4 ⬭

C 5 ⬭

D 6 ⬭

Do not write outside the box

1 3 Monochromatic light of frequency f is incident on a metal surface in a vacuum. Photoelectrons are emitted from the surface.

The photoelectric current I is measured.

The magnitude of the stopping potential V_s is then measured.

f is increased without changing the rate at which photons arrive at the metal surface.

What are the new measurements of the photoelectric current and the magnitude of the stopping potential?

[1 mark]

	Photoelectric current	**Magnitude of the stopping potential**	
A	I	V_s	⬭
B	I	$> V_s$	⬭
C	$> I$	V_s	⬭
D	$> I$	$> V_s$	⬭

1 4 An electron and a positron annihilate each other.

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

[1 mark]

A electric charge ⬭

B kinetic energy ⬭

C lepton number ⬭

D momentum ⬭

Do not write outside the box

1 5 Which exchange particle transfers charge during electron capture?

[1 mark]

A meson ⬭

B pion ⬭

C virtual photon ⬭

D W boson ⬭

1 6 A free neutron decays to produce a proton and

[1 mark]

A an electron and an antineutrino. ⬭

B an electron and a neutrino. ⬭

C a positron and an antineutrino. ⬭

D a positron and a neutrino. ⬭

1 7 Two aerials $\mathbf{A_1}$ and $\mathbf{A_2}$ receive radio waves from the same distant transmitter **T**.
The waves have a frequency of $88\ \text{MHz}$.
The phase difference between the waves received by $\mathbf{A_1}$ and $\mathbf{A_2}$ is $6.6\ \text{rad}$.

What is the distance $\mathbf{A_1T} - \mathbf{A_2T}$?

[1 mark]

A $1.6\ \text{m}$ ⬭

B $3.2\ \text{m}$ ⬭

C $3.6\ \text{m}$ ⬭

D $7.2\ \text{m}$ ⬭

Do not write outside the box

2 2 A nucleus of bismuth-209 $\left(^{209}_{83}\mathrm{Bi}\right)$ 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**?

[1 mark]

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

2 3 The concept of exchange particles was introduced to explain forces between elementary particles.

This concept requires that exchange particles have

[1 mark]

A charge. ⬭

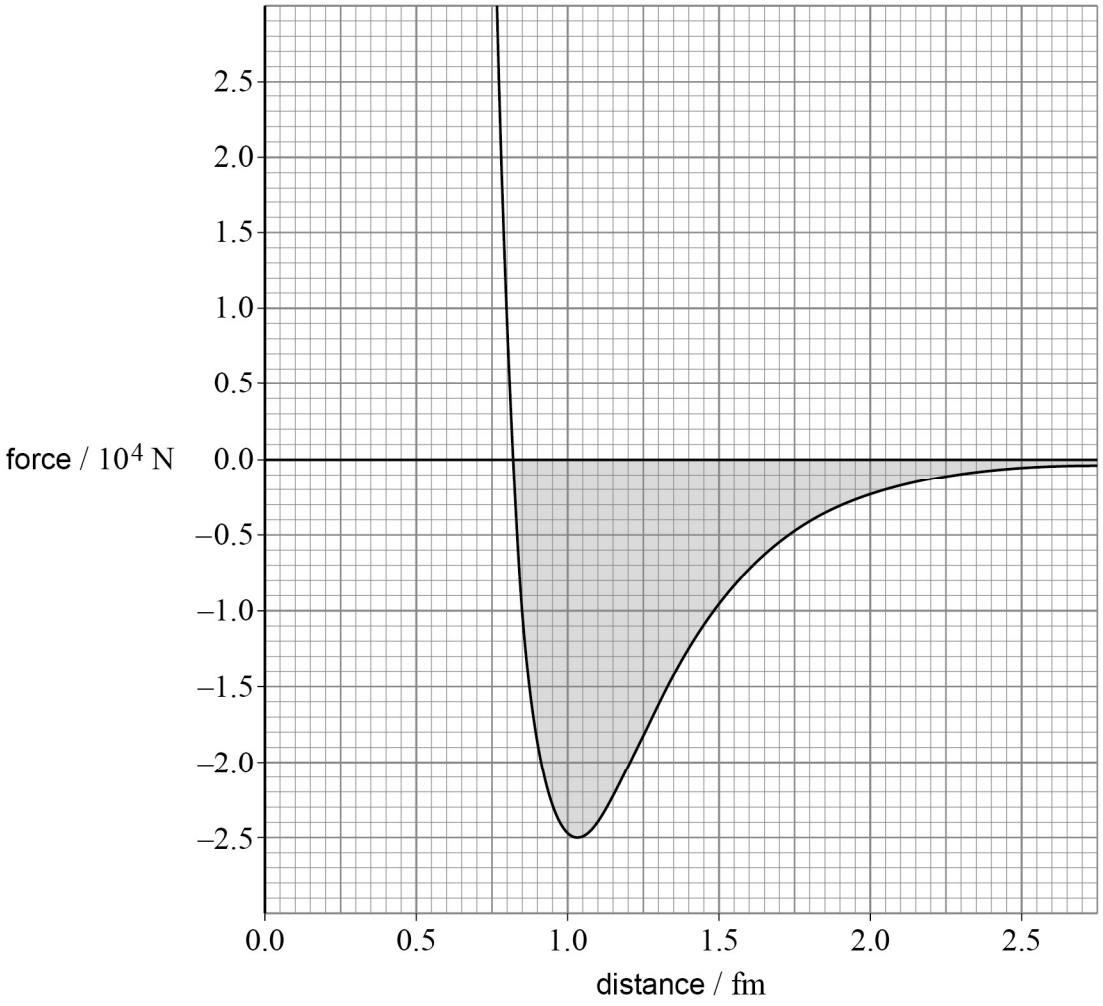
B momentum. ⬭

C phase. ⬭

D rest mass. ⬭

Do not write outside the box

3 4 The graph shows the variation of force with distance between a proton and a neutron.



The shaded area represents

[1 mark]

A acceleration. ⬭

B impulse. ⬭

C rate of change of kinetic energy. ⬭

D work done. ⬭

30

END OF QUESTIONS