Particles and radiation – AS Physics

1. No.1

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	0	+1	+1	0	0
Charge	$-1e$	$+1e$	$-1e$	0	$+1e$
Strangeness	−1	0	−3	+1	+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 $= 1672 \times 10^6 \times 1.6 \times 10^{-19}$

$= 2.68 \times 10^{-10}$ J

rest energy = 2.7×10^{-10} J

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 rest energy of Products is greater than the rest energy of reactants
The KE of products is less than that of the reactants

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

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

$u(\frac{+2}{3}) + d(\frac{-1}{3}) + s(\frac{-1}{3})$
$= 0$

The Ξ^0 and Λ^0 are both hadrons.

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

[4 marks]

Baryon Number (B): $\Lambda^0 \rightarrow p + \pi^-$
$+1 = +1 + 0$ So Λ^0 is a baryon of 3 quarks (qqq)
Electric charge (Q): Λ^0 is neutral, So $Q=0$
Strangeness (S): An intermediate product of Ω^-, so Λ^0 contains one strange quark, $S=-$
so, the s quark has $Q=-\frac{1}{3}$, the remaining 2 quarks sum to $Q=+\frac{1}{3}$ to make charge $=0$, so this is ud ($+\frac{2}{3}$ and $-\frac{1}{3}$) to achieve $Q=0$

quark structure of Λ^0 = uds

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]

$E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3\times10^{8}}{1.25\times10^{-14}}$

$= 1.59\times10^{-11}$ Joules

energy of photon = 1.59×10^{-11} J

0 1 . 6 The negative pion π^- decays.

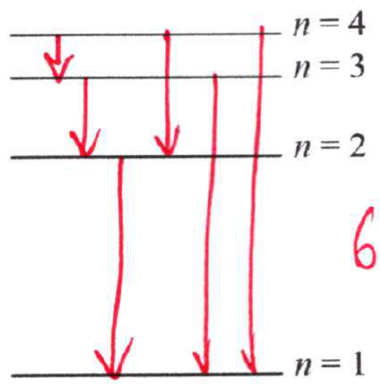
Which row shows the particles that could be created in this decay?
Tick (✓) **one** box.

[1 mark]

$\mu^- + \nu_\mu$	☐
$e^- + \bar{\nu}_e$	✓
$e^- + \nu_e$	☐
$e^- + e^+ + e^-$	☐

2. No.12

The four lowest energy levels of an atom are shown.



6 different energy drops so 6 different photons or frequencies

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 ☒

3. No.13

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

$E_k = hf - \phi$

The photoelectric current I is measured.

So

$f\uparrow$ so $eV\uparrow$

The magnitude of the stopping potential V_s is then measured.

So stopping

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?

Rate of photons unchanged so rate of electrons unchanged so I unchanged

[1 mark]

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

4. No.14

An electron and a positron annihilate each other.

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

[1 mark]

A electric charge ○ – charge is conserved

B kinetic energy ☒ – Loss of kinetic energy is present

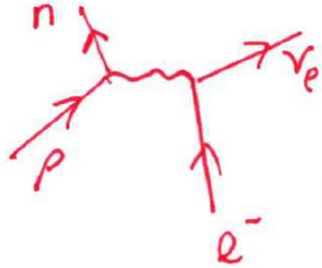
C lepton number ○

D momentum ○

5. No.15

Which exchange particle transfers charge during electron capture?

[1 mark]



So we have W boson

A meson

B pion

C virtual photon

D W boson ☒

6. No.16

A free neutron decays to produce a proton and

[1 mark]

$n \to p + e^- + \bar{\nu}_e$

L: $0 \to 0 + 1 + -1$

A an electron and an antineutrino. ☒

B an electron and a neutrino.

C a positron and an antineutrino.

D a positron and a neutrino.

7. No.22

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]

${}^{210}_{83}Bi \rightarrow {}^{206}_{81}Y + {}^{4}_{2}\alpha \;\Big|\; {}^{206}_{81}Y \rightarrow {}^{206}_{82}X + {}^{0}_{-1}\beta$

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

8. No.23

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. ☐