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Section A

Answer **all** questions in this section.

0 1 Cosmic rays are high-energy particles that come from space. Most of these particles are protons. There are other particles in cosmic rays, including atomic nuclei.

Table 1 gives the data for one particular nucleus **X**.

Table 1

Mass / kg	8.02×10^{-26}
Specific charge / C kg^{-1}	4.39×10^{7}
Kinetic energy / MeV	215

0 1 . 1 Determine the number of neutrons in nucleus **X**. **[3 marks]**

$\frac{C}{kg} = 4.39 \times 10^7 = \frac{\text{charge}}{\text{mass}} = \frac{Q}{8.02 \times 10^{-26}}$

$\therefore Q = 3.52 \times 10^{-18}$ C. So no. of protons $= \frac{3.52 \times 10^{-18}}{1.6 \times 10^{-19}} = 22$

No of nucleons $= \frac{8.02 \times 10^{-26}}{1.66 \times 10^{-27}} = 48$

$\therefore 48 - 22$

number of neutrons = 26

0 1 . 2 Calculate the speed of **X**. Ignore relativistic effects. **[3 marks]**

Convert 215MeV → J : $215 \times 10^6 \times 1.6 \times 10^{-19} = 3.44 \times 10^{-11}$ J

Now sub into $\frac{1}{2}mv^2 = E_K \Rightarrow \sqrt{\frac{2E_K}{m}} = v$

speed = 2.9×10^7 m s^{-1}

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A pion (π^+) and a kaon (K^+) are produced when cosmic rays interact with the upper atmosphere.

0 1 . 3 The π^+ decays to produce a positron and an electron neutrino.

Show how the conservation laws apply to this decay.

[2 marks]

$\pi^+ \rightarrow e^+ + \nu_e$

charge $+1 \rightarrow +1 + 0$

B $0 \rightarrow 0 + 0$

L_e $0 \rightarrow -1 + +1$

0 1 . 4 The K^+ decays to produce an anti-muon and a muon neutrino.

Explain how strangeness applies in this decay.

[2 marks]

$K^+ \rightarrow \mu^+ + \nu_\mu$ ← anti muon

S $+1 \rightarrow 0 + 0$

no quarks ← no quarks

So Strangeness not conserved

Since strangeness is not conserved this is a decay by the weak interation

0 1 . 5 Write an equation for a K^+ decay that involves only hadrons.

[2 marks]

$K^+ \rightarrow \pi^+ + \pi^0$

q $+1 \rightarrow +1 + 0$

B $0 \rightarrow 0 + 0$

not cons

So. works

$K^+ \rightarrow \pi^+ + \pi^+ + \pi^-$

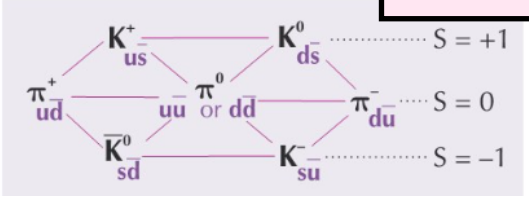
q $+ \rightarrow + + -$

B $0 \rightarrow 0 + 0 + 0$

works too

Kaons decay into pions. There are several options and the Q B L have to balance

12



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0 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?

[1 mark]

charged all hadrons

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

1 0 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?

[1 mark]

A $\alpha + \beta^- + \beta^- + \alpha + \alpha$

B $\beta^- + \beta^- + \alpha + \beta^- + \alpha$

C $\alpha + \alpha + \alpha + \alpha + \beta^-$

D $\beta^- + \beta^- + \beta^- + \beta^- + \alpha$

92 → 88 = 4

4 α, 0 β

2

Need proton number to drop by 4.
A: alphas drop by 6 and the betas push it back up 2. IE change of 4

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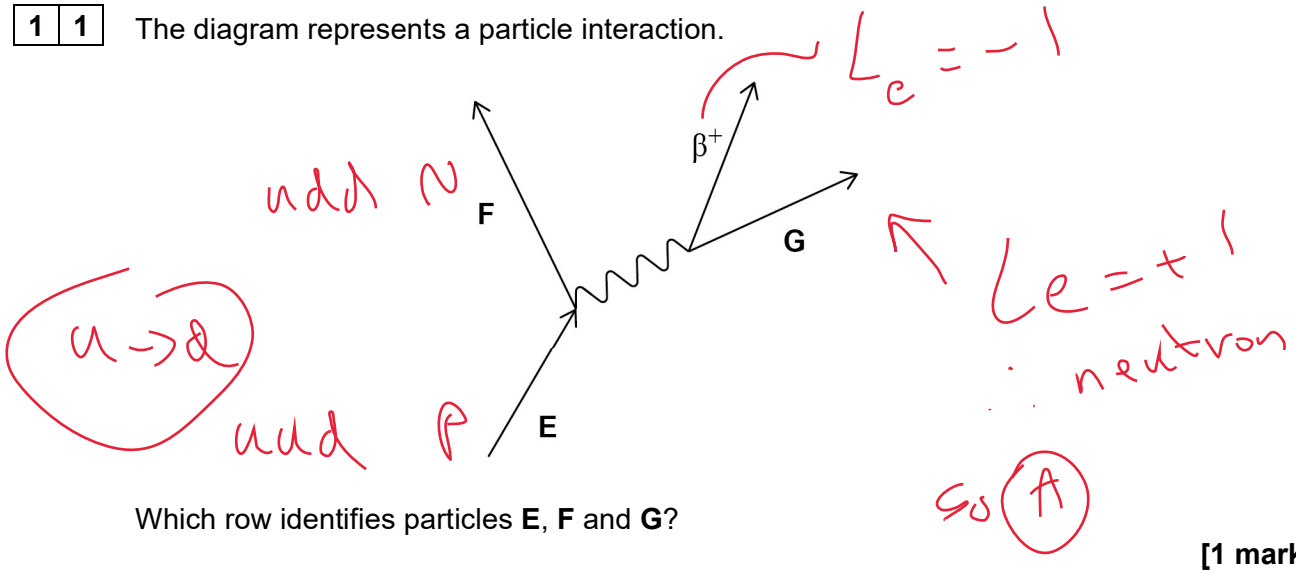
1 1 The diagram represents a particle interaction.



Which row identifies particles **E**, **F** and **G**?

[1 mark]

	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	⬭

1 2 The quark combination of a particle is $s\bar{u}$.

Which is true for this particle?

[1 mark]

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 $-\frac{1}{3}$ ⬭