Q1. The equation shows an interaction between a proton and a negative kaon that results in the formation of particle, X.

$$K^- + p \rightarrow K^+ + K^0 + X$$

(a) (i) State and explain whether X is a charged particle.

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(2)

(ii) State and explain whether X is a lepton, baryon or meson.

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(2)

(iii) State the quark structure of the K^-, K^+ and the K^0.

K^- .....

K^+ .....

K^0 .....

(3)

(iv) Strangeness is conserved in the interaction.

Determine, explaining your answer, the quark structure of X.

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(3)

(Total 10 marks)

Q2.(a) Baryons, mesons and leptons are affected by particle interactions.

Write an account of these interactions. Your account should:

- include the names of the interactions
- identify the groups of particles that are affected by the interaction
- identify the exchange particles involved in the interaction
- give examples of **two** of the interactions you mention.

The quality of your written communication will be assessed in your answer.

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(6)

(b) Draw a labelled diagram that represents a particle interaction.

(3)
(Total 9 marks)

Q3.(a) Complete the following equation for beta minus (β^-) decay of strontium-90 ($^{90}_{38}\mathrm{Sr}$) into an isotope of yttrium (Y).

$$^{90}_{38}\mathrm{Sr} \longrightarrow \ ^{\cdots\cdots}_{\cdots\cdots}\mathrm{Y} \ + \ ^{\cdots\cdots}_{\cdots\cdots}\beta^- \ + \ ^{0}_{0}\cdots\cdots$$

(3)

(b) During β^- decay of a nucleus both the nucleon composition and the quark composition change.
State the change in quark composition.

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(1)

(c) A positive kaon consists of an up quark and an antistrange quark $(u\,\bar{s})$. This kaon decays by strong and weak interactions into three pions. Two of the pions have quark compositions of $(u\,\bar{d})$. The third pion has a different quark composition.

(i) Name the unique family of particles to which the kaon and pions belong.

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(1)

(ii) Tick the box corresponding to the charge of the third pion.

positive ☐ negative ☐ neutral ☐

(1)

(iii) Positive kaons have unusually long lifetimes.
Give a reason why you would expect this to be the case.

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(1)

(iv) Name the exchange particles which are involved in the strong and weak interactions of the kaon.

strong interaction .....

weak interaction .....

(1)
(Total 8 marks)

Q4.(a) Complete the table comparing some of the properties of the positive pion, π^+, and the proton.

Name	π^+	Proton
Relative charge	+1	
Baryon number		
Quark composition		

(5)

(b) When a positive pion interacts with a proton, a kaon can be produced, along with another strange particle, as shown in this equation

$$\pi^+ + p \rightarrow K^+ + X$$

Circle the type of interaction shown in this equation.

Electromagnetic Gravitational Strong Nuclear Weak Nuclear

(1)

(c) Deduce the relative charge, baryon number and strangeness of particle X.

(3)

(d) Particle X can decay to produce a neutron and positive pion as shown in this equation

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

Circle the type of interaction shown in this equation.

Electromagnetic Gravitational Strong Nuclear Weak Nuclear

(1)

(e) Explain your answer.

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(2)

(f) The neutron and positive pion will then decay. The positive pion can decay into a positron and an electron neutrino.

Write down the equation for the decay of the neutron.

(2)

(g) Explain why no further decays occur.

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(2)
(Total 16 marks)