Q1.(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)

Q2.(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.

.....

(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.

.....

(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.

.....

.....

(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)

Q3.(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)

Q4. What are the numbers of hadrons, baryons and mesons in an atom of $^{7}_{3}Li$?

	hadrons	**baryons**	**mesons**	
A	7	3	3	⬭
B	7	4	4	⬭

C	7	7	0	⬭
D	10	7	0	⬭

(Total 1 mark)

Q5. Which of the following is **not** true?

A Each meson consists of a single quark and a single antiquark. ⬭

B Each baryon consists of three quarks. ⬭

C The magnitude of the charge on every quark is $\frac{1}{3}$ ⬭

D A particle consisting of a single quark has not been observed. ⬭

(Total 1 mark)

Q6. Mesons that contain a strange (or antistrange) quark are known as K-mesons or kaons. Mesons are a sub-group of a larger group of particles.

(a) (i) State the name of this larger group of particles.

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(1)

(ii) Determine the charge on a kaon with a quark structure of us.

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(1)

(b) A proposed decay for this kaon is

$$u\bar{s} \longrightarrow \mu^+ + \nu_\mu$$

(i) Apply the law of conservation of strangeness to the proposed decay.

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(1)

(ii) Comment on whether or not this decay is possible.

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(1)
(Total 4 marks)

Q7. (a) The table gives information about some fundamental particles.

Complete the table by filling in the missing information.

particle	quark structure	charge	strangene	baryon number
	uud		0	
Sigma $^{+}$	uus	+ 1		
	ud		0	0

(7)

(b) Each of the particles in the table has an antiparticle.

(i) Give **one** example of a baryon particle **and** its corresponding antiparticle.

particle .....

antiparticle .....

(1)

(ii) State the quark structure of an antibaryon.

.....

(1)

(iii) Give **one** property of an antiparticle that is the same for its corresponding particle and **one** property that is different.

Same .....

.....

Different .....

.....

(2)
(Total 11 marks)