Q1.(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.

.....

.....

.....

.....

(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.

.....

.....

.....

.....

(2)
(Total 16 marks)

Q2. Electron capture can be represented by the following equation.

$$p + e^{-} \rightarrow X + Y$$

Which row correctly identifies **X** and **Y**?

	X	Y	
A	p	K^-	⬭
B	e^-	e^+	⬭
C	n	V_e	⬭
D	n	π^0	⬭

(Total 1 mark)

Q3. (a) State what is produced when an electron and a positron annihilate each other.

.....

.....

(1)

(b) (i) Explain why mass is not necessarily conserved when particles interact or decay.

.....

.....

(1)

(ii) Momentum is conserved in all particle interactions. Name the **three** other conservation laws that are obeyed in **all** nuclear interactions.

.....

.....

.....

(3)
(Total 5 marks)

Q4. (a) (i) Name two baryons.

.....

(2)

(ii) State the quark structure of the pion π^+.

.....

(1)

(b) (i) The K^+ kaon is a strange particle. Give **one** characteristic of a strange particle that makes it different from a particle that is not strange.

.....

.....

(1)

(ii) One of the following equations represent a possible decay of the K^+ kaon.

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

$$K^+ \rightarrow \mu^+ + \overline{\nu_\mu}$$

State, with a reason, which one of these decays is not possible.

.....

.....

(2)

(c) Another strange particle, X, decays in the following way:

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

(i) State what interaction is involved in this decay.

.....

(1)

(ii) Show that X must be a neutral particle.

.....

.....

(1)

(iii) Deduce whether X is a meson, baryon or lepton, explaining how you arrive at your answer.

.....

.....

.....

.....

(2)

(iv) Which particle in this interaction is the most stable?

.....

(1)

(Total 11 marks)

Q5. (a) Complete the table by naming **one** example of each type of particle.

type of particle	example
lepton	
baryon	
meson	

(3)

(b) The following reaction cannot occur.

$$\pi^+ + n \rightarrow p + \pi^-$$

(i) State and explain which conservation law would be broken by this reaction.

.....

.....

.....

.....

.....

(2)

(ii) State and explain **one** conservation law that would **not** be broken in this reaction.

.....

.....

.....

(1)

(c) Describe what happens when a proton and an antiproton collide.

.....

.....

.....

.....

(2)
(Total 8 marks)

Q6. (a) The Σ^+ particle is a baryon with strangeness –1.

(i) How many quarks does the Σ^+ particle contain?

.....

.....

answer .....

(1)

(ii) How many of the quarks are strange?

.....

.....

answer .....

(1)

(b) The Σ^+ decays in the following reaction

$$\Sigma^+ \rightarrow \pi^+ + n$$

(i) State **two** quantities that are conserved in this reaction.

.....

.....

(2)

(ii) State a quantity that is not conserved in this reaction.

.....

(1)

(iii) What interaction is responsible for this reaction?

.....

(1)

(iv) Into what particle will the neutron formed in this reaction eventually decay?

.....

(1)

(Total 7 marks)