

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



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

.....  
.....

(2)

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

.....  
.....

(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  $X$ .

.....  
.....  
.....  
.....

(3)

(Total 10 marks)

**Q2.(a)** The positive kaon,  $K^+$ , has a strangeness of +1.

(i) What is the quark structure of the  $K^+$ ?

.....

(1)

(ii) What is the baryon number of the  $K^+$ ?

.....

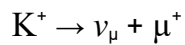
(1)

(iii) What is the antiparticle of the  $K^+$ ?

.....

(1)

(b) The  $K^+$  may decay into a neutrino and an antimuon in the following way.



(i) Complete the table using ticks and crosses as indicated in the first row.

<b>Classification</b>	<b><math>K^+</math></b>	<b><math>\nu_\mu</math></b>	<b><math>\mu^+</math></b>
lepton	×	✓	✓
charged particle			
hadron			
meson			

(3)

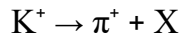
(ii) In this decay, charge, energy and momentum are conserved. Give another quantity that is conserved in this decay and one that is not conserved.

Conserved .....

Not conserved .....

(2)

(c) Another possible decay of the  $K^+$  is shown in the following equation,



(i) Identify  $X$  by ticking **one** box from the following list.

electron	
muon	
negative pion	
neutral pion	
neutrino	
neutron	
positron	

(1)

(ii) Give **one** reason for your choice in part (i).

.....

.....

.....

.....

(1)

(Total 10 marks)

**Q3.(a)** Complete the table to show the four fundamental forces and their corresponding exchange particles.

fundamental force	corresponding exchange particle
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strong nuclear	gluon
electromagnetic	
	$W^+W^- Z^0$
gravitational	graviton

(2)

- (b) Name the physical quantity that a particle must have for the electromagnetic force to act on it.

.....

(1)

- (c) Name the particle believed to be responsible for mass.

.....

(1)

(Total 4 marks)

**Q4.** Under certain circumstances it is possible for a photon to be converted into an electron and a positron.

- (a) State what this process is called.

.....

(1)

- (b) A photon must have a minimum energy in order to create an electron and a positron.

Calculate the minimum energy of the photon in joules. Give your answer to an appropriate number of significant figures.

minimum energy = ..... J

(3)

- (c) A photon of slightly higher energy than that calculated in part (b) is converted into an electron and a positron.

State what happens to the excess energy.

.....  
 .....

(1)

- (d) Describe what is likely to happen to the positron shortly after its creation.

.....  
 .....  
 .....  
 .....

(2)

(Total 7 marks)

- Q5.** (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 <sup>+</sup>	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)

**Q6.** (a) Pair production can occur when a photon interacts with matter. Explain the process of pair production.

.....

.....

.....

.....

(2)

(b) Explain why pair production cannot take place if the frequency of the photon is below a certain value.

.....

.....

.....

.....  
.....  
.....

**(3)**

- (c) Energy and momentum are conserved during pair production. State two other quantities that must also be conserved.

.....  
.....

**(2)**

**(Total 7 marks)**