**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.

.....

.....

**(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.

$$K^+ \rightarrow \nu_\mu + \mu^+$$

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

| **Classification** | $K^+$ | $\nu_\mu$ | $\mu^+$ |
|---|---|---|---|
| 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,

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

(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** |
|---|---|

| | |
|---|---|
| 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 $^{+}$ | 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)**