7 Some subatomic particles are classified as *hadrons*.

(a) What distinguishes a hadron from other subatomic particles? *(1 mark)*

(b) Hadrons fall into two subgroups.
Name each subgroup and describe the general structure of each. *(3 marks)*

(c) The following equation represents an event in which a positive muon collides with a neutron to produce a proton and an antineutrino.

$$n + \mu^+ \longrightarrow p + \bar{\nu}_\mu$$

Show that this equation obeys the conservation laws of charge, lepton number and baryon number. *(3 marks)*

AQA, 2004

8 A negative pion (π^-)is a meson with a charge of –1e.
State and explain the structure of the π^- in terms of the up and down quarks. *(3 marks)*

AQA, 2002

9 The following is an incomplete equation for the decay of a free neutron.

$$^1_0n \longrightarrow {}^1_1p + {}^0_{-1}e + \ldots$$

(a) Complete the equation by writing down the symbol for the missing particle. *(2 marks)*

(b) Use the principles of conservation of charge, baryon number and lepton number to demonstrate that decay is possible. *(3 marks)*

(c) The following reaction can take place when two protons meet head on, provided the two colliding protons have sufficient kinetic energy:

$$p + p \longrightarrow p + p + \bar{p} + p$$

If the two colliding protons each have the same amount of energy, calculate the minimum kinetic energy, in MeV, each must have for the reaction to proceed. *(2 marks)*

AQA, 2005

10 (a) (i) What class of particle is represented by the combination of three antiquarks, $\bar{q}\bar{q}\bar{q}$?

(ii) Name a hadron that has an antiparticle identical to itself. *(3 marks)*

(b) The kaon K^+ has a strangeness of +1.

(i) Give its quark composition

(ii) The K^+ may decay via the process

$$K^+ \longrightarrow \pi^+ + \pi^0$$

State the interaction responsible for this decay.

(iii) The K^+ may also decay via the process

$$K^+ \longrightarrow \mu^+ + \nu_\mu$$

Change each particle of this equation to its corresponding antiparticle in order to complete an allowed decay process for the negative kaon K^-.

$$K^- \longrightarrow$$

(iv) Into what class of particle can both the μ^+ and the ν_μ be placed?

(v) State **one** difference between a positive muon and a positron, e^+. *(6 marks)*

AQA, 2002

11 The equation represents the collision of a neutral kaon with a proton, resulting in the production of a neutron and a positive pion.

$$K^0 + p \longrightarrow n + \pi^+$$

(a) Show that this collision obeys **three** conservation laws in addition to energy and momentum. *(3 marks)*

(b) The neutral kaon has a strangeness of +1.
Write down the quark structure of the following particles.

K^0 π^+ p *(4 marks)*

AQA, 2005