# Particle Physics

1.

**(a)** An electron is an example of a *lepton* and a proton is an example of a *hadron*.
State a property of a hadron.

……

…… **[1]**

**(b)** State the charge, in terms of the elementary charge *e*, on an up quark and a down quark.

charge on up quark = …… *e* charge on down quark = …… *e* **[1]**

**(c)** The quark composition of a neutron is u d d.
State the quark composition of a proton.

…… **[1]**

**(d)** In large particle accelerators, short-lived particles called pions are created by colliding high-speed protons (p) with stationary neutrons (n). The equation below shows a reaction in which a negative pion ($\pi^-$) is produced.

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

The $\pi^-$ particle consists of a quark and an anti-quark.
Use the information provided about the neutron and your answer to **(c)** to write an equation for the reaction in terms of up (u) and down (d) quarks. Hence determine the quark composition of the $\pi^-$ particle.

……

……

……

…… **[3]**

**(e)** **(i)** State Einstein's mass-energy equation and define all the terms.

.....

..... **[1]**

**(ii)** In the reaction

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

the $\pi^-$ particle is produced when the proton colliding with a stationary neutron has a minimum kinetic energy of $1.4 \times 10^8$ eV. The mass of a proton and a neutron may be assumed to be the same.
Calculate the mass of the $\pi^-$ particle.

mass = ..... kg **[2]**

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2.

Fig. 6.1 shows the quark composition of some particles.

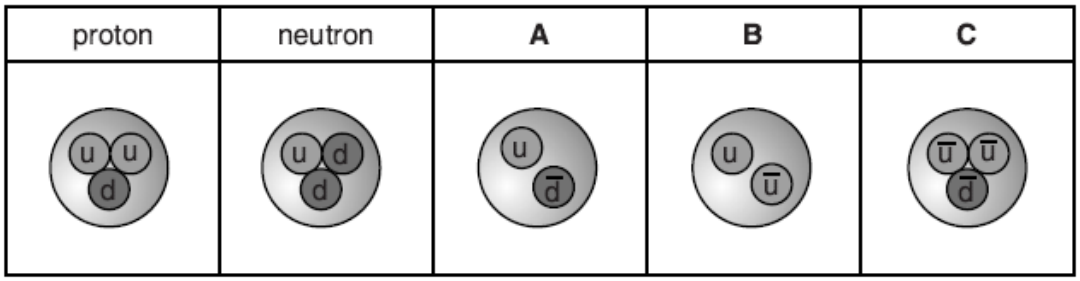


**Fig. 6.1**

**(i)** Identify the anti-proton from the table of particles shown in Fig. 6.1.

..... **[1]**

**(ii)** State the value of the charge of particle **B**.

..... **[1]**