

Student: _____

Max. Marks : 26 Marks

Time : 26 Minutes

Q1.

Subatomic particles such as pions are produced after collisions between protons that have been accelerated in a cyclotron.

*(a) Explain briefly the role of electric and magnetic fields in the cyclotron.

(5)

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(b) The mass of a pion is 2.5×10^{-28} kg.

Calculate the mass of a pion in GeV/c^2 .

(3)

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Mass = GeV/c^2

(c) The table shows the charge of some quarks.

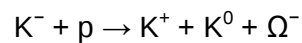
Type of quark	Charge/ e
u	$+2/3$
d	$-1/3$
s	$-1/3$

Explain what is meant by a charge of $+2/3$

(1)

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(d) The omega (Ω) minus particle consists of three strange quarks and is produced by the following interaction.



Kaons are mesons and consist of a strange quark and either an up or a down quark.

(i) Complete the table to show a possible quark combination for each kaon.

(3)

Particle	Quark combination
K^-	
K^+	
K^0	

(ii) The total mass of the particles produced in this interaction is greater than the total mass of the two particles that collided.

Explain this increase in mass.

(3)

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(Total for question = 15 marks)

Q2.

Pions (π^+ , π^- , π^0) are created in the upper atmosphere when cosmic rays collide with protons. Pions are unstable and decay rapidly.

(a) Pions are the lightest of the hadrons. Charged pions (π^+ and π^-) decay to produce muons which then decay to positrons or electrons.

(i) A positive pion π^+ has a quark composition $u\bar{d}$.

State with a justification the possible quark compositions of a neutral pion π^0 .

(2)

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(ii) Muons are examples of leptons whereas pions are examples of mesons.

State a structural difference between leptons and mesons.

(1)

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(b) Muons with a speed of $0.99c$ travel a distance of 15 km to reach the surface of the Earth from the upper atmosphere.

(i) Show that the time it takes a muon to travel this distance is about 51 μs .

(2)

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(ii) The muons are unstable particles.

Calculate the fraction of muons which would remain after a time of 51 μs .

half-life of muon = 2.2 μs

(4)

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Fraction =

(iii) In fact the fraction of muons reaching the surface of the Earth is about 0.1 Explain the discrepancy.

(4)

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(Total for question = 11 marks)