This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School
for Boys and Girls Loueizeh - Baabda

SE01 Exam

09NOV2026

Do NOT write in this box. Your MARK will be placed here.

Subject :	A Level : Physics 2 : SN
Class :	12A
Teacher :	Mr. Sam
Duration :	30 minutes
You are to answer the questions to this exam on : this exam paper	

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

Q1.

In 1961 Murray Gell-Mann predicted the existence of a new particle called an omega (Ω) minus. It was subsequently discovered in 1964.

At this time the quark model consisted of three particles, the properties of which are given in the table.

Quark	Charge	Predicted mass in MeV/c^2
Up (u)	$+\frac{2}{3}$	4
Down (d)	$-\frac{1}{3}$	4
Strange (s)	$-\frac{1}{3}$	80

(a) Explain what a charge of $+\frac{2}{3}$ means.

(1)

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(b) State the predicted mass of, and the charge on a $\bar{s}$.

(2)

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(c) Convert 4 MeV/c^2 to kg.

(3)

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Mass = ... kg

(d) The event which led to the discovery of the omega minus particle can be summarised as follows. A negative kaon collided with a stationary proton and produced a positive kaon, a neutral kaon and the omega minus.

(i) Kaons K consist of combinations of either an up or down quark plus a strange quark. The omega minus consists of three strange quarks.

Complete the following table by ticking the appropriate boxes.

(2)

	Meson	Baryon	Nucleon	Lepton
Negative kaon				
Omega minus				

(ii) Write an equation using standard particle symbols to summarise this event.

(2)

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(iii) The negative kaon consists of $\bar{u}s$. Deduce the quark structure of the other two kaons involved in this event.

(2)

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(iv) The total mass of the three particles created after this event is larger than the total mass of the two particles before. Discuss the quantities that must be conserved in interactions between particles and use an appropriate conservation law to explain this increase in mass.

(5)

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(Total for question 1 = 17 marks)

Q2.

The Proton-Antiproton Collider (Sp$\bar{p}$S) was a large particle accelerator. An experiment using the Sp$\bar{p}$S proved the existence of a particle called a Z boson.

(a) The mass of the Z boson is 91 GeV/c^2.26

Show that the mass of the Z boson is nearly 100 times greater than the mass of a proton.

(4)

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(b) Protons and anti-protons were accelerated in the Sp$\bar{p}$S to very high energies before they collided.

Explain why the protons and anti-protons needed high energies to produce the Z boson.

(3)

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(c) Z bosons produced by high energy collisions can have a range of lifetimes. The Z bosons with the longest lifetimes are those that were moving very fast.

Explain this observation.

(2)

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(Total for question 2 = 9 marks)

(Total for paper = 26 marks)

Q1.

In 1961 Murray Gell-Mann predicted the existence of a new particle called an omega (Ω) minus. It was subsequently discovered in 1964.

At this time the quark model consisted of three particles, the properties of which are given in the table.

Quark	Charge	Predicted mass in MeV/c^2
Up (u)	$+\frac{2}{3}$	4
Down (d)	$-\frac{1}{3}$	4
Strange (s)	$-\frac{1}{3}$	80

(a) Explain what a charge of $+\frac{2}{3}$ means.

$\frac{2}{3}$ x Charge of a Proton ($\frac{2}{3} \times 1.6 \times 10^{-19}$ C) (1)

(1)

(b) State the predicted mass of, and the charge on a $\bar{s}$.

Predicted mass: 80 MeV/c^2 (1)

Predicted charge: $+\frac{1}{3}e$ (1)

(2)

(c) Convert 4 MeV/c^2 to kg.

$\frac{4\ \text{MeV}}{c^2} = \frac{4\times10^{6}\times1.6\times10^{-19}}{(3\times10^{8})^2} \simeq 7.11\times10^{-30}\ \text{kg}$ (1) (1)

Mass = 7.11×10^{-30} (1) kg

(3)

(d) The event which led to the discovery of the omega minus particle can be summarised as follows. A negative kaon collided with a stationary proton and produced a positive kaon, a neutral kaon and the omega minus.

(i) Kaons K consist of combinations of either an up or down quark plus a strange quark. The omega minus consists of three strange quarks.

Complete the following table by ticking the appropriate boxes.

	Meson	Baryon	Nucleon	Lepton
Negative kaon	✓ (1)			
Omega minus		✓ (1)		

(2)

(ii) Write an equation using standard particle symbols to summarise this event.

$K^- + p \longrightarrow K^+ + K^0 + \Omega^-$

(1) (1)

(2)

(iii) The negative kaon consists of $\bar{u}s$. Deduce the quark structure of the other two kaons involved in this event.

K^-: $\bar{u}s$ (Given)

K^0: $\bar{d}s$ or $d\bar{s}$ (1)

K^+: $u\bar{s}$ (1)

(2)

(iv) The total mass of the three particles created after this event is larger than the total mass of the two particles before. Discuss the quantities that must be conserved in interactions between particles and use an appropriate conservation law to explain this increase in mass.

Momentum must be conserved (1)

Charge must be conserved (1)

Baryon / lepton number must be conserved (1)

Energy-mass must be conserved. (1)

Since $E = mc^2$ (1) the higher mass is due to the products (K^-) having a higher KE. (1)

The excess energy converts to mass

Max 5 marks

(5)

(Total for question = 17 Marks)

Q2.

The Proton-Antiproton Collider (S$p\bar{p}$S) was a large particle accelerator. An experiment using the S$p\bar{p}$S proved the existence of a particle called a Z boson.

(a) The mass of the Z boson is 91 GeV/c^2.

Show that the mass of the Z boson is nearly 100 times greater than the mass of a proton.

(4)

$m_{boson} = \frac{91 \times 10^9 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2} = 1.62 \times 10^{-25}$ kg (1) (1) (1)

$m_{proton} = 1.67 \times 10^{-27}$

$\frac{m_{boson}}{m_{proton}} = \frac{1.62 \times 10^{-25}}{1.67 \times 10^{-27}} = 97 \approx 100\times$ heavier (1)

(b) Protons and anti-protons were accelerated in the S$p\bar{p}$S to very high energies before they collided.

Explain why the protons and anti-protons needed high energies to produce the Z boson.

(3)

Energy - Mass must be conserved in the interaction. or $E = mc^2$ (1)

The Z boson is much heavier than the protons. (1)

Hence there needs to be a high energy to create a high mass. (1)

(c) Z bosons produced by high energy collisions can have a range of lifetimes.
The Z bosons with the longest lifetimes are those that were moving very fast.

Explain this observation.

(2)

the closer the boson is to the speed of light (1) the more it will feel relativistic effects.

Hence there is time dilation and a relativistic increase in its lifetime (1)

(Total for question = 9 marks)