Lebanon Evangelical School for Boys and Girls

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 01

17FEB2025

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

Subject :	A Level : Physics 2 : RB
Class :	12A
Teacher :	Dr Ruth Brett
Duration :	1 hour

Give your final answers to an appropriate number of significant figures and write the unit if there is one.
You should have a physics formula booklet.

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.

Answer the multiple choice questions with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Q1. Which of the following is a fundamental particle?

- ☐ **A** antiproton
- ☐ **B** muon
- ☐ **C** neutron
- ☐ **D** pion

(Total for question = 1 mark)

Q2. In 2016 the element oganesson was added to the periodic table.

One isotope of oganesson has the symbol $^{294}_{118}\mathrm{Og}$.

Which row of the table shows the number of protons and the number of neutrons in a nucleus of this isotope of oganesson?

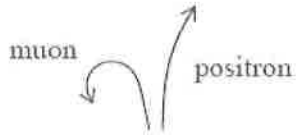
	Number of protons	Number of neutrons
☐ **A**	118	176
☐ **B**	118	294
☐ **C**	176	294
☐ **D**	294	118

(Total for question = 1 mark)

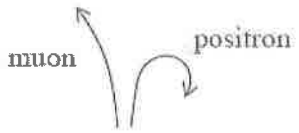
Q3. A positron and a muon travel at the same speed through a magnetic field.
The magnetic field is directed into the page.

Which of the following diagrams best represents the motion of the particles?

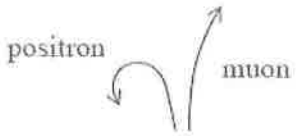
☐ **A**



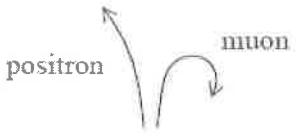
☐ **B**



☐ **C**



☒ **D**



(Total for question = 1 mark)

Q4. The table shows the relative charges on up and down quarks.

u	$\frac{2}{3}e$
d	$-\frac{1}{3}e$

Which of the following could be the quark composition for a baryon with a charge of $+2e$?

☒ **A** ddd

☐ **B** $u\bar{d}$

☐ **C** $u\bar{u}$

☐ **D** uuu

(Total for question = 1 mark)

Q5. In 2015, a pentaquark was discovered. The pentaquark was made of 5 quarks, $c, \bar{c}, d, u, u$.

The pentaquark can form a baryon-meson combination.

Which row of the table shows a possible arrangement of the quarks?

		Quarks in baryon	Quarks in meson
☐	A	d u u	c $\bar{c}$
☐	B	u $\bar{c}$ u	d c
☐	C	$\bar{c}$ u	d u c
☐	D	u d	c $\bar{c}$ u

(Total for question = 1 mark)

Q6. A particle has a mass of 3.17×10^{-27} kg.

Which of the following gives the mass in GeV/c^2?

☒ **A** $\dfrac{3.17 \times 10^{-27} \times 10^{9} \times 1.6 \times 10^{-19}}{3.00 \times 10^{8}}$

☐ **B** $\dfrac{3.17 \times 10^{-27} \times 10^{9} \times 1.6 \times 10^{-19}}{(3.00 \times 10^{8})^{2}}$

☒ **C** $\dfrac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^{2}}{1.6 \times 10^{-19}}$

☐ **D** $\dfrac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^{2}}{10^{9} \times 1.6 \times 10^{-19}}$

(Total for question = 1 mark)

Q7. Which of the following describes why electrons are released from the metal filament during thermionic emission?

☐ **A** The metal filament is heated by an electric current.

☐ **B** The metal filament is contained within a vacuum.

☐ **C** The metal filament is bombarded by high-energy electrons.

☐ **D** The metal filament is maintained at a high potential.

(Total for question = 1 mark)

Q8. A neutron can decay to produce a proton.

Which of the following equations correctly shows neutron decay?

☐ **A** $n \rightarrow p + e^+ + \overline{\nu}_e$

☐ **B** $n \rightarrow p + e^+ + \nu_e$

☐ **C** $n \rightarrow p + e^- + \overline{\nu}_e$

☐ **D** $n \rightarrow p + e^- + \nu_e$

(Total for question = 1 mark)

Q9. Neutrinos can interact with protons to create neutrons.

Which of the following equations shows this process?

☐ **A** $\nu_e + p \rightarrow e^+ + n$

☐ **B** $\nu_e + p \rightarrow e^- + n$

☐ **C** $\overline{\nu}_e + p \rightarrow e^+ + n$

☐ **D** $\overline{\nu}_e + p \rightarrow e^- + n$

(Total for question = 1 mark)

Q10. A gamma photon of energy 18 MeV produces a particle and its antiparticle.

Which of the following will give the maximum possible mass of the particle in kg?

☐ **A** $\frac{9 \times 1.6 \times 10^{-19}}{3 \times 10^8}$

☐ **B** $\frac{9 \times 10^6 \times 1.6 \times 10^{-19}}{3 \times 10^8}$

☐ **C** $\frac{9 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2}$

☐ **D** $\frac{9 \times 10^6 \times 1.6 \times 10^{-19}}{(3 \times 10^8)^2}$

(Total for question = 1 mark)

Q11. A linac is a particle accelerator. It consists of drift tubes of increasing length with potential differences (p.d.) applied between them.

Which of the following is the reason the drift tubes are of increasing length?

- ☐ **A** So that the p.d. can have a constant frequency.
- ☐ **B** So that the particle gains the same amount of energy in each tube.
- ☐ **C** So that the p.d. between the tubes increases for each successive tube.
- ☐ **D** So that the time spent in each successive tube increases.

(Total for question = 1 mark)

Q12. Which row of the table describes the mass and charge of an anti-proton?

	Mass / kg	Charge / C
☒ **A**	1.67×10^{-27}	1.6×10^{-19}
☐ **B**	1.67×10^{-27}	-1.6×10^{-19}
☐ **C**	-1.67×10^{-27}	1.6×10^{-19}
☒ **D**	-1.67×10^{-27}	-1.6×10^{-19}

(Total for question = 1 mark)

Q13.

(a) Pions belong to a group of particles known as mesons.

State the quark structure of mesons.

(1)

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(b) Muons belong to a family of particles known as leptons.

State one property of leptons.

(1)

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(c) Charged pions usually decay into a muon (μ) and another particle X, as shown by the decay equation:

$$\pi^- \rightarrow \mu^- + X$$

A student suggests that X is an anti-neutrino due to particle conservation laws.
Deduce whether the student is correct.

(4)

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(Total for question = 6 marks)

Q14. 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.

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 = 9 marks)

Q15. At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.
Summarise the results from these experiments and the conclusions that were drawn from them.

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(Total for question = 5 marks)

Q16. A section from the periodic table is shown.

Element symbol	Zr	Nb	Mo	Tc	Ru	Rh	Pd
Atomic number	40	41	42	43	44	45	46

Technetium (Tc) is produced when a deuterium ion collides with a nucleus of one of the other elements shown in the table. In this process a number of neutrons are also released.

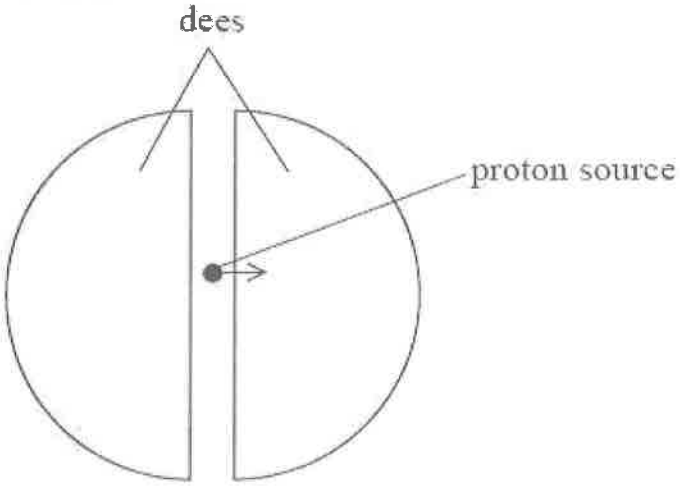
Deuterium is an isotope of hydrogen with 1 proton and 1 neutron.

Complete the nuclear equation to determine the element and the number of neutrons released.

$$^{96}__ + __^{__}H \rightarrow {}^{95}_{43}Tc + __^{__}n$$

(Total for question = 3 marks)

Q17. A cyclotron is a particle accelerator which can be used to accelerate protons. The cyclotron consists of two semicircular electrodes called 'dees'. An alternating potential difference is applied across the gap between the dees. A uniform magnetic field is applied at right angles to the plane of the dees.



(i) Complete the diagram to show the path of the protons.

(1)

(ii) State the direction of the magnetic field needed in order to produce the path you have sketched.

(1)

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(iii) Explain how the kinetic energy of the protons is increased as they follow the path you have shown.

(3)

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(iv) Show that the magnetic flux density B of the applied magnetic field is given by

$$B = \frac{2\pi f m}{e}$$

where f is the frequency of the alternating potential difference, m is the mass of the proton and e is the charge on the proton.

(3)

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(v) In a particular cyclotron B is 1.2 mT.
Calculate the frequency f of the alternating potential difference.

(2)

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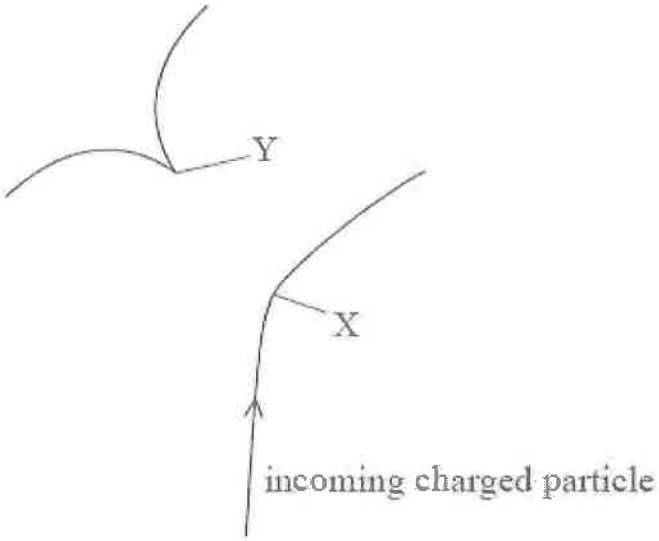
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$f =$ .....

(Total for question = 10 marks)

Q18. The diagram shows the tracks produced in a bubble chamber.



At X an incoming charged particle interacts with a stationary proton.
Describe and explain what can be deduced about the interaction at X and subsequent events. You may add to the diagram to help your answer.

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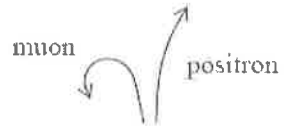
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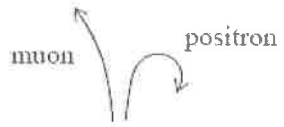
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☐ **A**



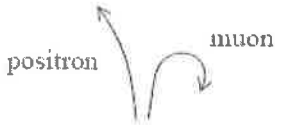
☐ **B**



(1) ☒ **C**



☐ **D**



(Total for question = 1 mark)

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(Total for question = 1 mark)

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(Total for question = 1 mark)

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(Total for question = 1 mark)

Q12. Which row of the table describes the mass and charge of an anti-proton?

		Mass / kg	Charge / C
☐	**A**	1.67×10^{-27}	1.6×10^{-19}
(1) ☒	**B**	1.67×10^{-27}	-1.6×10^{-19}
☐	**C**	-1.67×10^{-27}	1.6×10^{-19}
☐	**D**	-1.67×10^{-27}	-1.6×10^{-19}

(Total for question = 1 mark)

Q13.

(a) Pions belong to a group of particles known as mesons.

State the quark structure of mesons.

(1)

Quark and anti-quark (1)

(b) Muons belong to a family of particles known as leptons.

State one property of leptons.

(1)

Leptons are fundamental particles (1)

(c) Charged pions usually decay into a muon (μ) and another particle X, as shown by the decay equation:

$$\pi^- \rightarrow \mu^- + X$$

A student suggests that X is an anti-neutrino due to particle conservation laws.
Deduce whether the student is correct.

(4)

LHS charge = 0 − 1 RHS charge = −1 + 0

charge of X = 0 (1)

Lepton number

π^- → μ^{-1} + X

0 (1) 1 (1) + −1

So X is neutral with a lepton number of −1 (1)

So it is an anti-neutrino

(Total for question = 6 marks)

Q14. 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.

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

(4)

Mass of Z in kg = $\frac{91 \times 10^{9} \times 1.6 \times 10^{-19}}{(3 \times 10^{8})^2}$ (1) (1) $= 1.62 \times 10^{-25}$ kg

$\frac{m_Z}{m_p} = \frac{1.62 \times 10^{-25}}{1.67 \times 10^{-27}}$ (1) $= 97$ (96.9)

Z is 97 times heavier than a proton

(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)

Very high energy is needed because the mass of the Z boson is much greater than the mass of a proton. (1) The mass comes from the kinetic energy of the protons (1) according to $\Delta E = \Delta m c^2$ so mass-energy is conserved. (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)

If the speed of the Z boson is close to the speed of light, (1) there will be a relativistic increase in its lifetime. (1)

(Total for question = 9 marks)

Q15. At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.
Summarise the results from these experiments and the conclusions that were drawn from them.

MAXIMUM FIVE MARKS (5)

Most of the alpha particles went straight through undeflected (1), so most of the atom is empty space (1)

Some where deflected by small angles (1), so there the charge must be concentrated in the nucleus. (1)

Very few alpha particles were deflected by more than 90° (1), so the nucleus must be very dense (1)

(Total for question = 5 marks)

Q16. A section from the periodic table is shown.

Element symbol	Zr	Nb	Mo	Tc	Ru	Rh	Pd
Atomic number	40	41	42	43	44	45	46

Technetium (Tc) is produced when a deuterium ion collides with a nucleus of one of the other elements shown in the table. In this process a number of neutrons are also released.

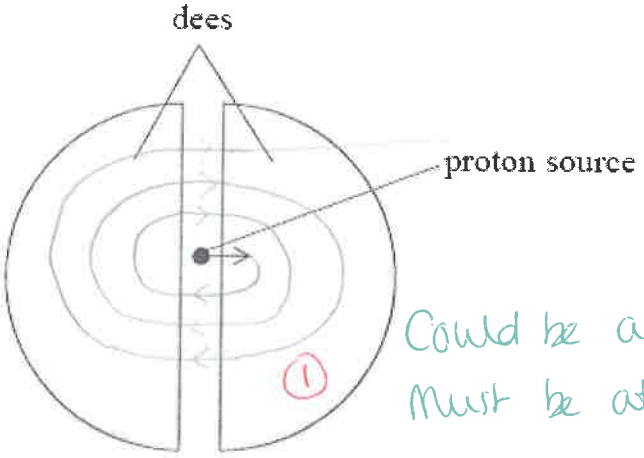
Deuterium is an isotope of hydrogen with 1 proton and 1 neutron.

Complete the nuclear equation to determine the element and the number of neutrons released.

$$^{96}_{42}\text{Mo} \; (1) \; + \; ^{2}_{1}\text{H} \; (1) \; \rightarrow \; ^{95}_{43}\text{Tc} \; + \; 3 \; ^{1}_{0}\text{n} \; (1)$$

(Total for question = 3 marks)

Q17. A cyclotron is a particle accelerator which can be used to accelerate protons. The cyclotron consists of two semicircular electrodes called 'dees'. An alternating potential difference is applied across the gap between the dees. A uniform magnetic field is applied at right angles to the plane of the dees.



Could be an anticlockwise spiral
Must be at least 2 loops

(i) Complete the diagram to show the path of the protons.

(1)

(ii) State the direction of the magnetic field needed in order to produce the path you have sketched.

(1)

Out of the page (1) Anticlockwise path would be into the page

(iii) Explain how the kinetic energy of the protons is increased as they follow the path you have shown.

(3)

Kinetic energy increases every time the protons cross the gap between the dees (1) as they are accelerated towards by the electric field (1). When the protons are in the dees, the polarity of the dee switches (1) so the protons are always attracted towards a negatively charged dee.

(iv) Show that the magnetic flux density B of the applied magnetic field is given by

$$B = \frac{2\pi f m}{e}$$

where f is the frequency of the alternating potential difference, m is the mass of the proton and e is the charge on the proton.

(3)

$F = Bqv = \frac{mv^2}{r}$ (1)

So here, $B = \frac{mv}{er}$

But $v = \frac{2\pi r}{T}$ (1) and $f = \frac{1}{T}$ (1) so $v = 2\pi r f$

$\therefore B = \frac{m(2\pi r f)}{er} = \frac{2\pi f m}{e}$

(v) In a particular cyclotron B is 1.2 mT.
Calculate the frequency f of the alternating potential difference.

(2)

$B = \frac{2\pi f m}{e}$

$f = \frac{eB}{2\pi m} = \frac{1.6 \times 10^{-19} \times 1.2 \times 10^{-3}}{2\pi \times 1.67 \times 10^{-27}} = 1.83 \times 10^{4}$ (1)

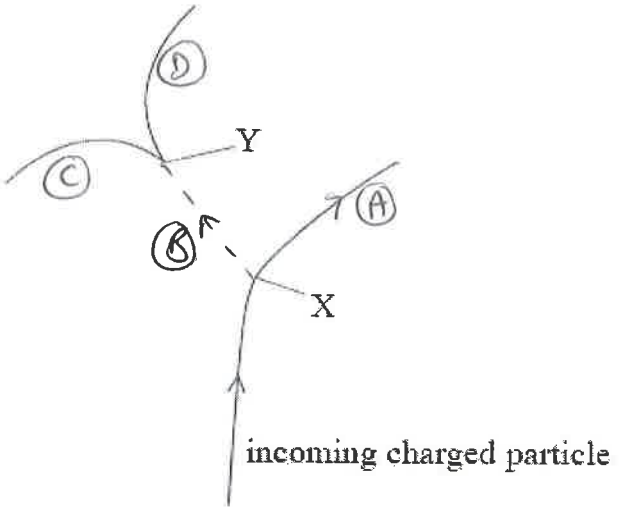
← it's a proton, not an electron

(1)

$f = 1.8 \times 10^{4}$ Hz

(Total for question = 10 marks)

Q18. The diagram shows the tracks produced in a bubble chamber.



At X an incoming charged particle interacts with a stationary proton.
Describe and explain what can be deduced about the interaction at X and subsequent events. You may add to the diagram to help your answer.

(5)

At X, 2 particles are produced (1). One leaves a track marked (A) on the diagram and is charged (1). The other travels to Y along the dotted line labelled (B) on the diagram. This particle is uncharged as there is no track (1).

At Y, the neutral particle decays into 2 charged particles (1), shown by tracks (C) and (D). These particles have opposite charges to conserve charge (1) and this can be seen by the way their tracks curve in opposite directions.

(Total for question = 5 marks)