Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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10	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Physics (B): Physics in Context PHYB1

Unit 1 Harmony and Structure in the Universe

Module 1 The World of Music
Module 2 From Quarks to Quasars

Monday 20 May 2013 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet (enclosed).

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Advice
- You are advised to spend about 20 minutes on **Section A** and about 55 minutes on **Section B**.

Section A

Answer **all** questions in this section.

There are **21** marks in this section.

1 (a) Complete the table to show the four fundamental forces and their corresponding exchange particles.

fundamental force	**corresponding exchange particle**
strong nuclear	gluon
electromagnetic	
	$W^+ W^- Z^0$
gravitational	graviton

(2 marks)

1 (b) Name the physical quantity that a particle must have for the electromagnetic force to act on it.

.....

(1 mark)

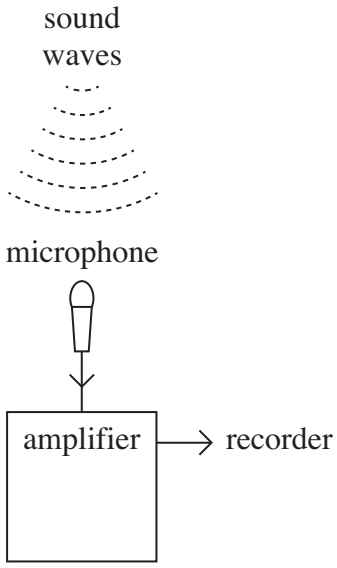
1 (c) Name the particle believed to be responsible for mass.

.....

(1 mark)

2 (a) Some of the main components in an analogue recording chain are shown in **Figure 1**.

Figure 1



When more than one microphone is used, the recording chain may include an additional component not shown in **Figure 1**.

Name this component and state its purpose in the recording process.

name of component .....

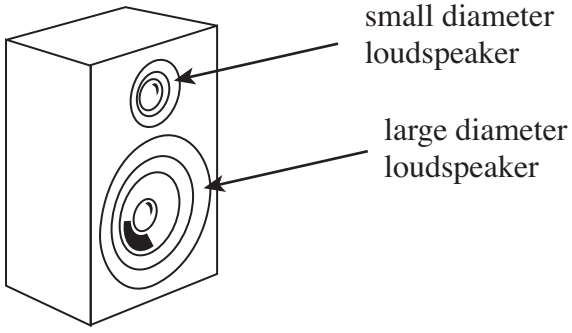
purpose .....

.....

(2 marks)

2 (b) A reproduction chain ends with a loudspeaker which converts the recording's analogue voltage signal into sound. Some reproduction chains have loudspeaker cabinets, as shown in **Figure 2**, which have two loudspeakers of different diameters.

Figure 2



Explain, with reference to diffraction effects, why loudspeakers of different diameters are used and how this enables all listeners seated around the room to hear high quality music.

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(3 marks)

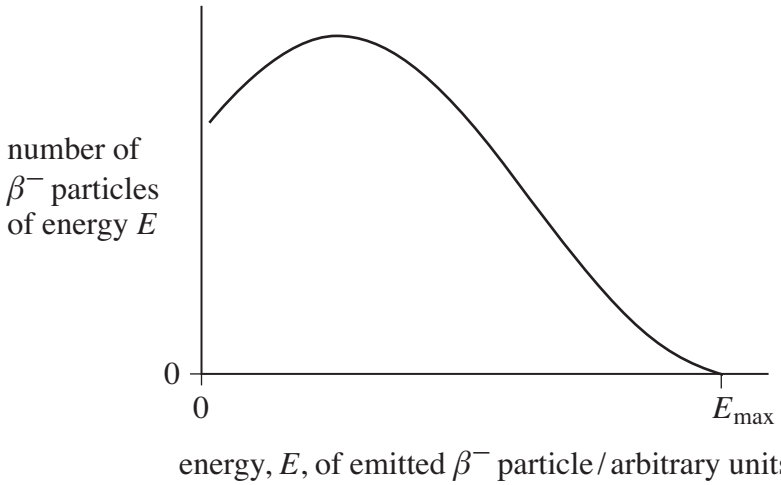
3 (a) Complete the following equation to describe the decay of potassium-40 ($^{40}_{19}$K) by β^- emission.

$$^{40}_{19}\text{K} \longrightarrow \begin{matrix}\cdots\\\cdots\end{matrix}\text{Ca} + \begin{matrix}\cdots\\\cdots\end{matrix}\beta^- + \begin{matrix}0\\0\end{matrix}\bar{\nu}_e$$

(2 marks)

3 (b) When a sample of potassium-40 decays, the emitted β^- particles have a range of energies from almost zero to a maximum value, E_{max}. The spectrum of energies observed is shown in **Figure 3**.

Figure 3



Explain how this evidence led Pauli to predict the existence of a previously unidentified particle.

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(3 marks)

4 Describe **one** advantage and **one** disadvantage, other than cost factors, of using optical fibres compared with copper cables for carrying telecommunications information.

advantage: .....

.....

disadvantage: .....

.....

(2 marks)

5 The *work function* of sodium is 2.28 eV.

5 (a) State what is meant by the term work function.

.....

.....

.....

(2 marks)

5 (b) Calculate the threshold frequency for sodium.

threshold frequency ..... Hz

(3 marks)

21

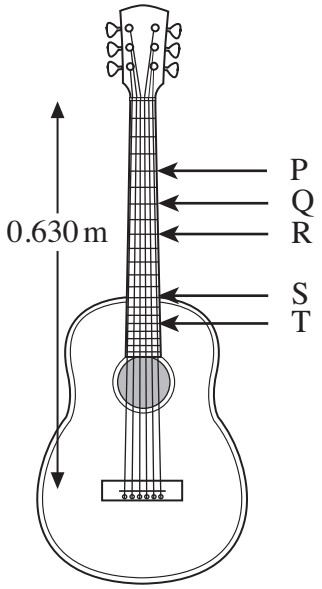
Section B

Answer **all** questions.

There are **49** marks in this section.

6 (a) A guitarist can play different notes on a guitar string by pressing on the string at different fret positions while plucking that string.
Figure 4 shows some of the fret positions for a guitar. The table shows how the length of the vibrating section of a string is affected by the guitarist stopping the string at some fret positions. Each string on the guitar has an unstopped length of 0.630 m.

Figure 4



fret position	string length / m
P	0.525
Q	0.465
R	0.418
S	0.315
T	0.263

6 (a) (i) From the table, select the fret position that a guitarist would use to produce a note one octave higher than that produced by plucking an unstopped string.
Go on to justify the selection you have made.

fret position .....

justification .....

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(3 marks)

6 (a) (ii) One of the guitar strings has a mass per unit length of $1.93 \times 10^{-3}\,\text{kg m}^{-1}$.
Calculate the tension required to produce a fundamental frequency of 147 Hz in this unstopped string.
Give your answer to an appropriate number of significant figures.

tension in string ..... N
(4 marks)

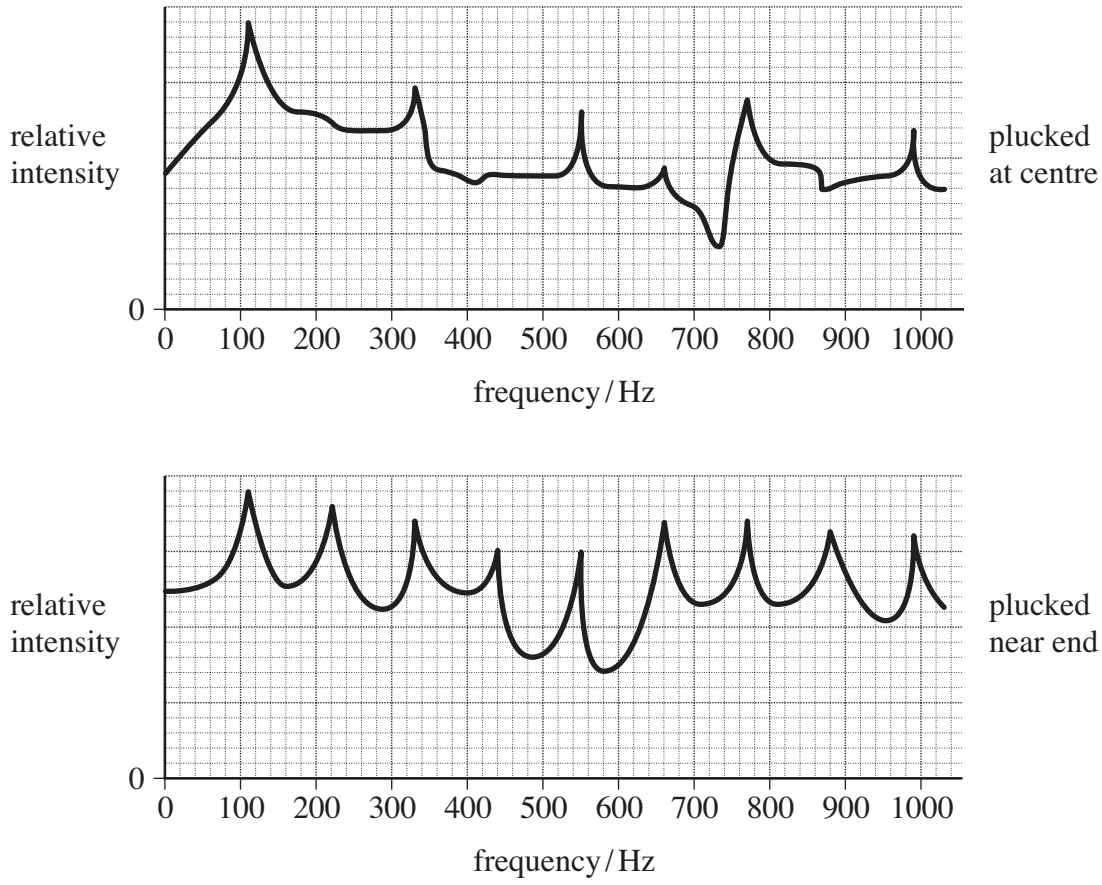
Question 6 continues on the next page

6 (b) The table below gives the fundamental frequency of each guitar string when the string is played at its unstopped length.

string number	fundamental frequency / Hz
1	82
2	110
3	147
4	196
5	247
6	330

A recording engineer sounds a guitar string by plucking it in the centre and analysing the sound produced. The process is repeated but this time the guitar string is plucked near its end. The frequency spectrum of each sound is given in **Figure 5**.

Figure 5



6 (b) (i) Deduce which string has been used in the sound engineer's investigation.
Go on to justify your reasoning in arriving at your conclusion.

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(2 marks)

6 (b) (ii) State and explain **one** difference between the two sounds heard by the engineer.

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(2 marks)

11

Turn over for the next question

7 Describe a **laboratory** experiment to measure the speed of sound in free air.
Your description should include the apparatus you would use and details of how your method and analysis of results would produce a reliable value for the speed of sound.
You may include a diagram of the experimental set up.

The quality of your written communication will be assessed in your answer.

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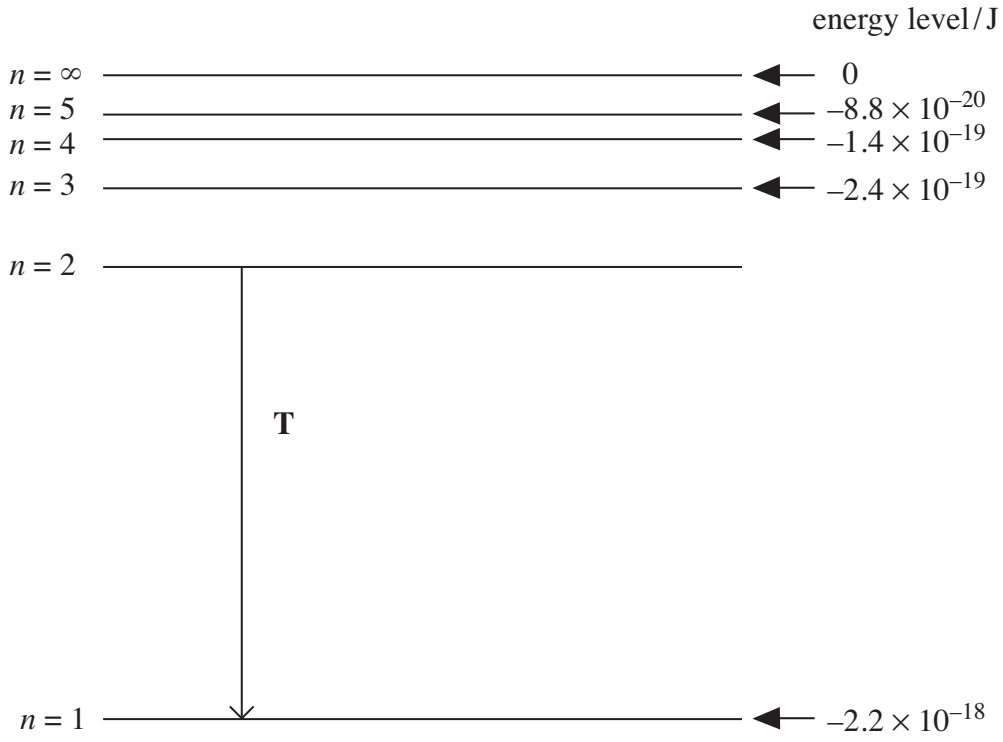
(6 marks)

6

Turn over for the next question

8 (a) **Figure 6** is an energy level diagram for a hydrogen atom.

Figure 6



The arrow labelled **T** indicates an electron transition that produces electromagnetic radiation of wavelength 120 nm.

8 (a) (i) Name the region of the electromagnetic spectrum to which electromagnetic radiation of this wavelength belongs.

.....

(1 mark)

8 (a) (ii) Explain how a collision between a free electron and a hydrogen atom could result in the hydrogen atom emitting electromagnetic radiation.

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(3 marks)

8 (a) (iii) Determine the value of the $n = 2$ energy level shown in **Figure 6**.

energy level ..... J

(4 marks)

8 (b) (i) A *quasar* is an astronomical object.
What does the term quasar stand for?

.....

(1 mark)

8 (b) (ii) Comment on the luminosity of quasars and explain how observations made by astronomers support the comment you have made.

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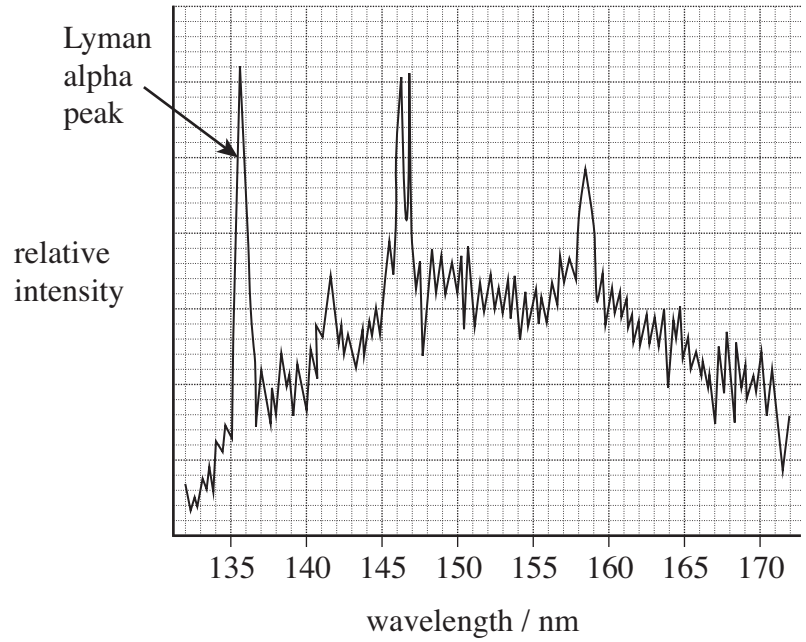
(2 marks)

8 (b) (iii) **Figure 7** shows a spectrum of radiation from a quasar as observed from Earth.

Figure 7



A hydrogen discharge tube emits a wavelength of 120 nm for the Lyman alpha peak.
The Lyman alpha peak of the quasar is labelled in **Figure 7**. Assume that the observed change in wavelength is due to the relative movement of the quasar.
Show that the recessional speed of the quasar is approximately $4 \times 10^7\ \text{m s}^{-1}$.

(4 marks)

8 (b) (iv) Calculate, in years, the length of time it would take for light to travel from this quasar to Earth.

Hubble constant = $65\,\text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$

time ..... years

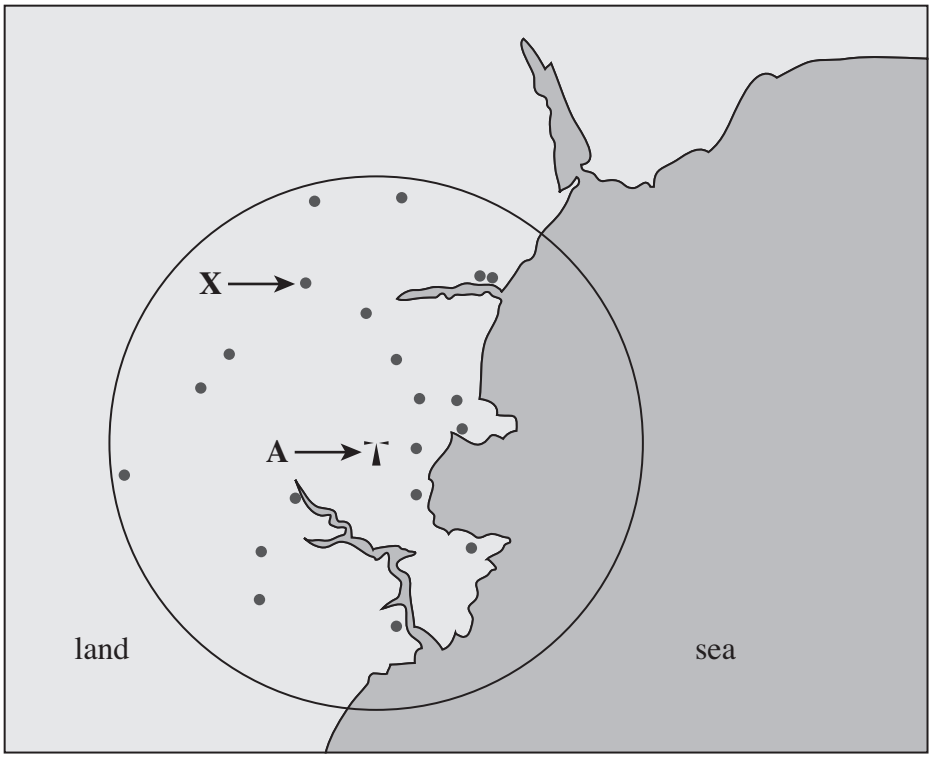
(4 marks)

19

Turn over for the next question

9 Transmitter **A** is a main terrestrial television transmitter. It transmits over the area inside the circle shown in the map in **Figure 8**. Due to the landscape only 60% of the television aerials inside this circle can receive a television signal directly from transmitter **A**. To improve television reception local transmitters are used to relay transmitter **A**'s signal to the remaining 40% of television aerials. The local transmitters are indicated by the small dark circles in **Figure 8**.

Figure 8



9 (a) (i) State, using appropriate units, a typical value for the frequency of electromagnetic carrier waves transmitted by the transmitter **A**.

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(1 mark)

9 (a) (ii) State and explain why 40% of the television aerials are unable to receive a direct signal from transmitter **A**.

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(2 marks)

9 (b) One of the local transmitters, labelled **X** in **Figure 8**, transmits a vertically polarised electromagnetic carrier wave.

9 (b) (i) Describe what is meant by the term polarisation.
You should draw a diagram to support your answer.

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(2 marks)

9 (b) (ii) State and explain how a television aerial must be aligned to receive maximum possible signal strength from transmitter **X**.

statement: .....

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explanation: .....

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(2 marks)

7

10 (a) The table provides information on the quark structure of some particles.

particle	symbol	quark structure
negative pion	π^-	$\bar{u}\,d$
positive pion	π^+	$u\,\bar{d}$
kaon	K^0	$d\,\bar{s}$
proton	p	uud

10 (a) (i) Name the particle class to which these particles belong.

.....

(1 mark)

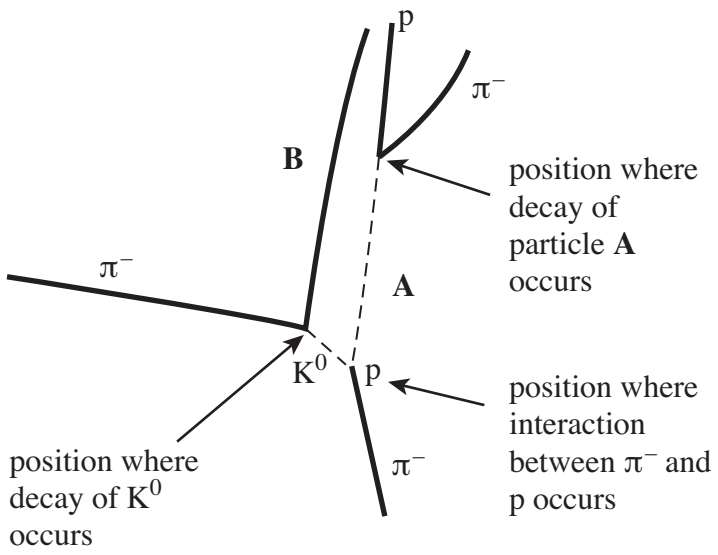
10 (a) (ii) Show that the kaon (K^0) is a neutral particle by considering its quark structure.

.....

(1 mark)

10 (b) **Figure 9** shows the track of a negative pion (π^-) interacting with a proton (p) to produce two particles: a kaon (K^0) and an unidentified particle labelled **A**. Both of these particles subsequently decay through the weak interaction.

Figure 9



10 (b) (i) The interaction between the negative pion (π^-) and the proton (p) is:

$$\pi^- + p \longrightarrow K^0 + \mathbf{A}$$

This interaction involves the strong force and is therefore a strong interaction.
Determine the baryon number and strangeness of particle **A**.

baryon number of particle **A** .....

strangeness of particle **A** .....

(2 marks)

10 (b) (ii) The K^0 particle decays through the weak interaction into a π^- particle and an unidentified particle labelled **B**.

The decay is:

$$K^0 \longrightarrow \pi^- + \mathbf{B}$$

Give **one** reason to support the deduction that particle **B** is a positive pion (π^+).

.....

.....

(1 mark)

10 (b) (iii) State how physicists accounted for the unusually long lifetime of the kaon (K^0).

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(1 mark)

6

END OF QUESTIONS

There are no questions printed on this page

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