Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

Leave blank

General Certificate of Education
January 2002
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) PHA9/W
Unit 9 Nuclear Instability: Electronics Option

Monday 28 January 2002 Morning Session

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 15 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 40.
- Mark allocations are shown in brackets.
- The paper carries 10% of the total marks for Physics Advanced.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

DATA SHEET

DATA SHEET

TURN OVER FOR THE FIRST QUESTION

SECTION A NUCLEAR INSTABILITY

Answer **all** parts of the question.

1 (a) The nuclide $^{203}_{83}\text{Bi}$ can decay by *electron capture* to become an isotope of lead as shown in the following equation,

$$^{203}_{83}\text{Bi} + {}^{0}_{-1}\text{e}^{-} \longrightarrow {}^{203}_{82}\text{Pb} + \nu_e + Q.$$

(i) Explain what is meant by electron capture.

.....

.....

.....

.....

(ii) Give **one** reason why electromagnetic radiation is emitted following this process.

.....

.....

.....

(iii) Give the equation for another process in which $^{203}_{83}\text{Bi}$ is converted into an isotope of lead.

$^{203}_{83}\text{Bi} \longrightarrow$

(5 marks)

(b) The nuclide $^{203}_{83}Bi$ is also an α particle emitter. An initial measurement of the α particle activity of a sample of this isotope gives a corrected count rate of 1200 counts s^{-1}. After an interval of 24 hours the corrected rate falls to 290 counts s^{-1}.
Assume that corrections have been made for the radiation both from daughter products and background radiation.

(i) Show that the decay constant of $^{203}_{83}Bi$ is about $1.6 \times 10^{-5} s^{-1}$.

.....

.....

.....

.....

.....

(ii) Calculate the half-life of this sample.

.....

.....

.....

(iii) Calculate the number of $^{203}_{83}Bi$ nuclei in the sample when the corrected count rate was 1200 counts s^{-1}.

.....

.....

.....

.....

.....

(5 marks)

10

SECTION B ELECTRONICS

Answer **all** questions.

2 A 6.8 V, 400 mW zener diode is connected to a 15 V supply as shown in **Figure 1**.

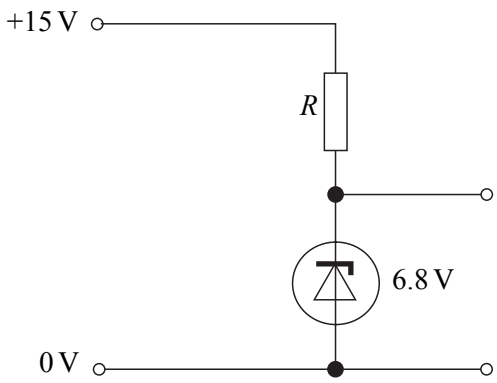


Figure 1

(a) (i) Calculate the current in the resistor and diode when $R = 200\,\Omega$.

.....

.....

.....

(ii) Calculate the smallest value of R if the diode is **not** to overload.

.....

.....

.....

.....

(4 marks)

(b) The dc source is replaced by an ac source of frequency 50 Hz and peak voltage 15 V. An oscilloscope is connected across the zener diode as shown in **Figure 2**.

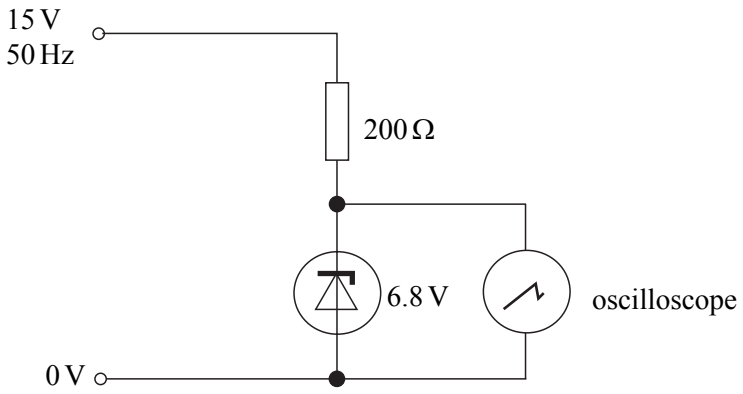


Figure 2

Figure 3 represents the oscilloscope screen. Draw on **Figure 3** the waveform you would expect to see on the screen. Give voltage and time values and draw at least **two** full cycles.

.....

.....

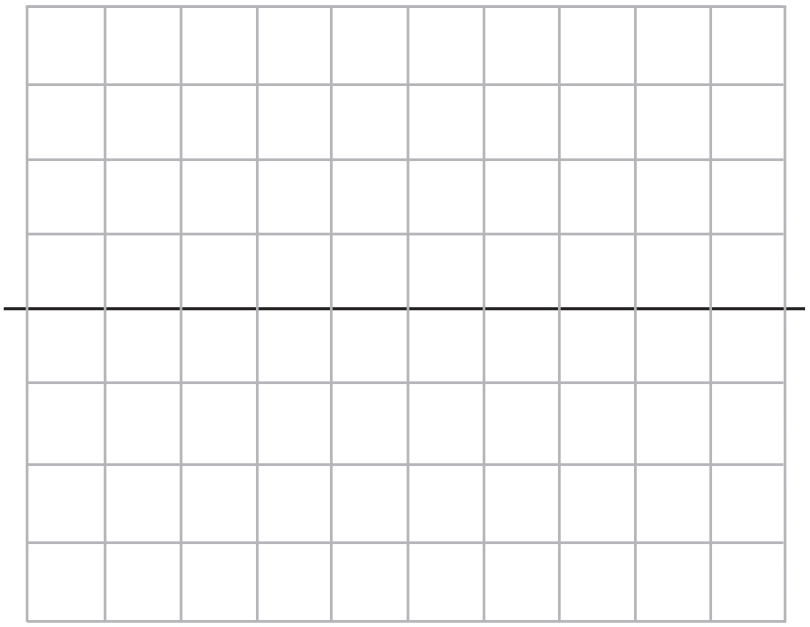


Figure 3

(4 marks)

8

3 **Figure 1** shows an RC circuit to which a square wave input is applied.
The time period of the square wave is 0.20 s.
The time constant of the circuit is 0.020 s.

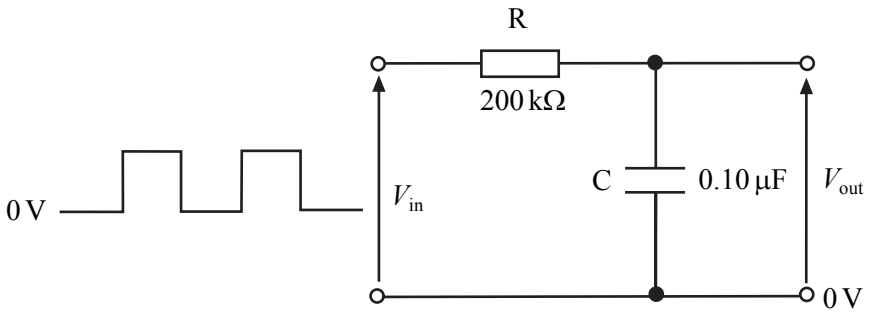


Figure 1

(a) Graph A in **Figure 2** shows the variation of V_{in} for the circuit in **Figure 1**.

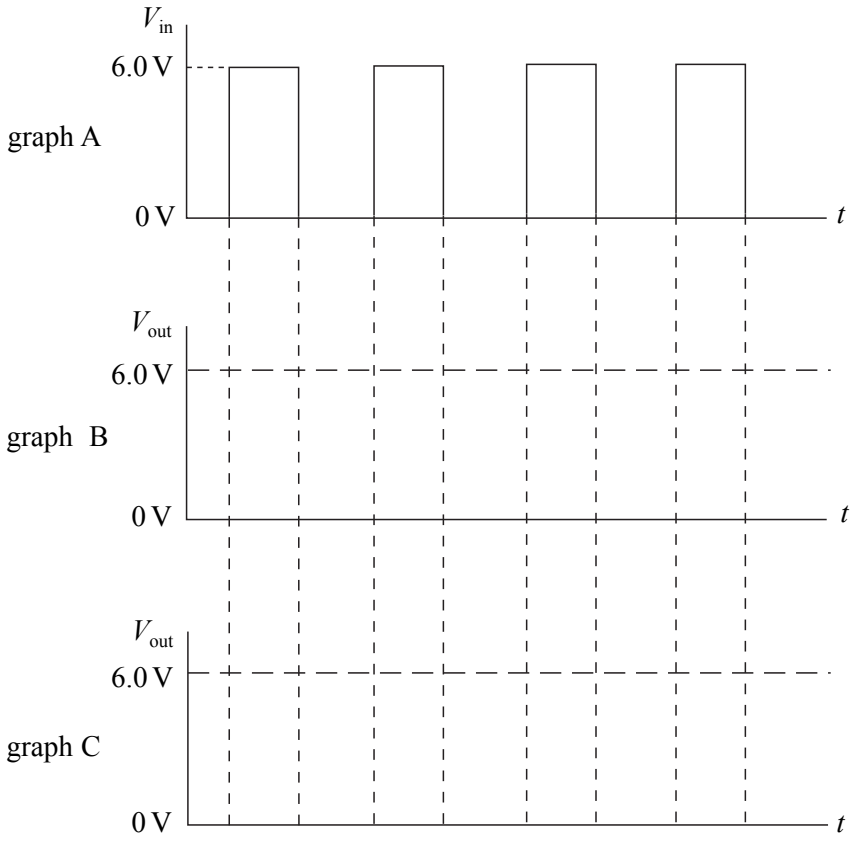


Figure 2

(i) On graph B sketch the corresponding variation of V_{out}, using the same time scale as graph A.

(ii) The capacitor in the circuit is now changed for one of capacitance 1.0 μF. Calculate the time constant of the new circuit.

.....

.....

(iii) On graph C sketch the variation of V_{out} for the new circuit, using the same time scale as graph A.

(6 marks)

(b) Explain how you decided on the shapes of graphs B and C.

graph B .....

.....

.....

graph C .....

.....

.....

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

4 **Figure 1** shows the circuit of a summing amplifier which uses an operational amplifier with *negative feedback*. The power supply to the operational amplifier is ±12 V.

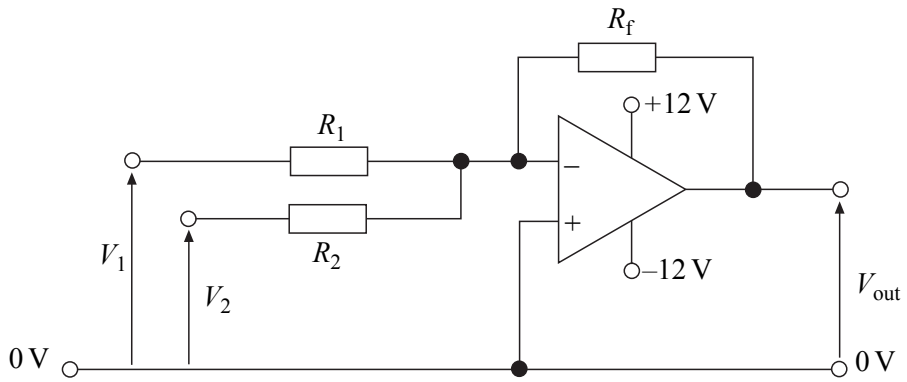


Figure 1

(a) (i) State what is meant by negative feedback. Explain how this is achieved in the above circuit.

.....

.....

.....

.....

(ii) Give **two** reasons for using negative feedback in an amplifier.

.....

.....

.....

(4 marks)

(b) The input voltages to the amplifier in part (a), V_1 and V_2, vary with time according to the graphs shown in **Figure 2**. Given that $R_1 = 40\,\text{k}\Omega$, $R_2 = 20\,\text{k}\Omega$ and $R_f = 40\,\text{k}\Omega$ show on the third set of axes the variation of V_{out} with time. Indicate values of V_{out} on the axis.

.....

.....

.....

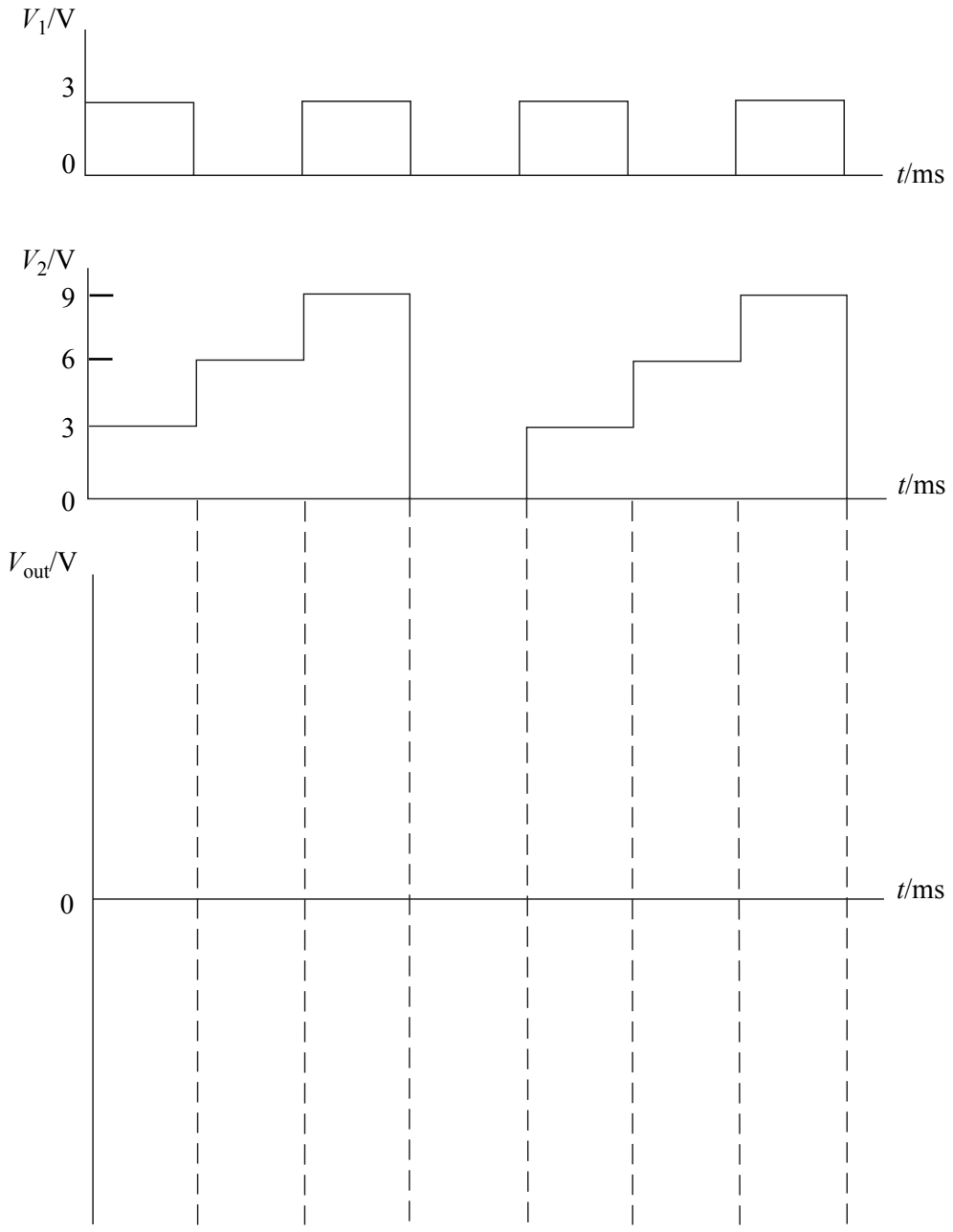


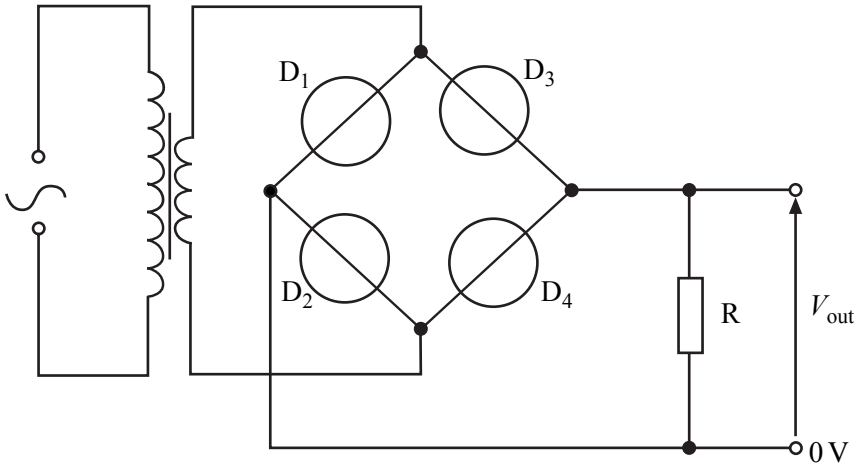
Figure 2

(4 marks)

8

Turn over ▶

5 The figure shows an incomplete circuit for a dc power supply obtained from the ac mains via a transformer. The output from the transformer is 12 V_{rms} giving a peak voltage of 17 V.



(a) Complete the circuit diagram by drawing in the four diodes, D_1, D_2, D_3 and D_4, so that a full-wave rectified output is obtained. *(2 marks)*

(b) The characteristics of four different diodes, given below, are obtained from a catalogue.

diode	forward voltage/V	maximum forward current/mA	peak reverse voltage/V
A	0.2	100	10
B	0.2	150	15
C	0.7	200	50
D	0.7	140	100

If the power supply is to provide a current of up to 150 mA, deduce which diode should be used in the circuit, giving **two** reasons for your choice.

.....

.....

.....

.....

(3 marks)

5

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE