TEST CODE **002474**

FORM TP 22247

MAY/JUNE 2002

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 01

1 hour 45 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions. Candidates must attempt **ALL** questions.
2. Candidates MUST write in this answer booklet and all working MUST be CLEARLY shown.
3. The use of non-programmable calculators is permitted.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's number	N_A	=	6.02×10^{23} per mole

GO ON TO THE NEXT PAGE

1. (a) Define the following terms:

(i) Electromotive force

_____

_____

[1 mark]

(ii) Volt

_____

_____

_____

[1 mark]

(b) An I-V characteristic for a thermistor is shown in Figure 1.

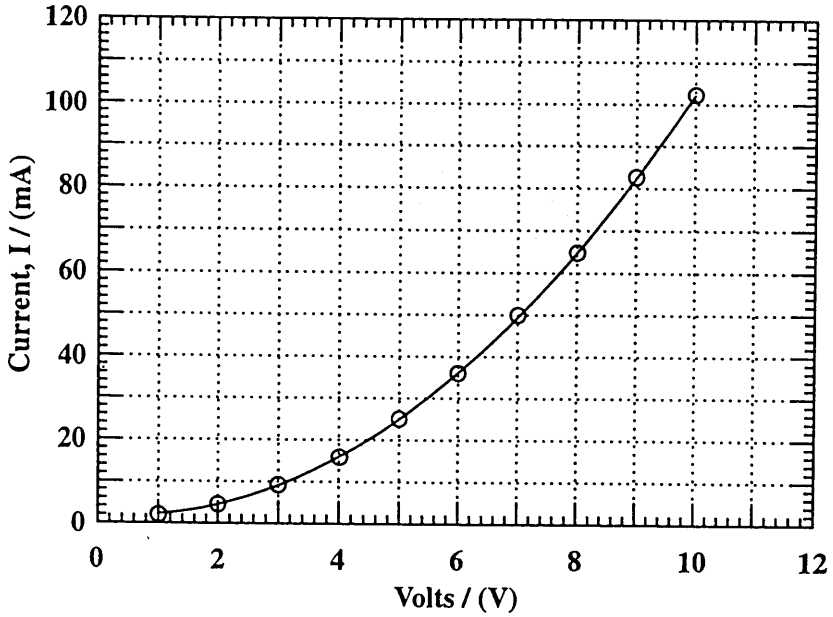


Figure 1

Draw a circuit which could be used to take measurements to obtain the characteristic shown in Figure 1.

[3 marks]

1. (c) The thermistor, which obeys the characteristic curve shown in Figure 1, is used in the circuit shown in Figure 2.

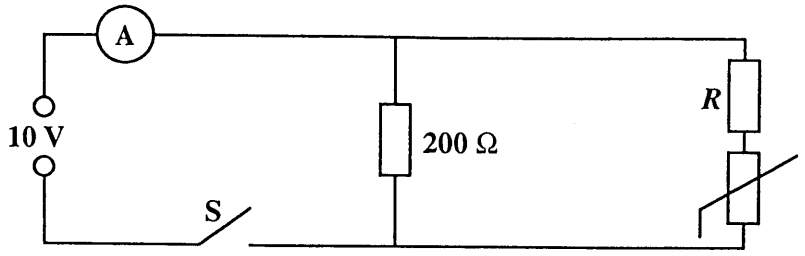


Figure 2

The ammeter reads 100 mA when the switch, S, is closed. Calculate the

(i) current through the 200 Ω resistor

_____

_____

[1 mark]

(ii) potential difference across the thermistor

_____

_____

_____

[2 marks]

(iii) resistance of resistor R.

_____

_____

_____

[2 marks]

Total 10 marks

2. (a) Define the 'Farad'.

_____

_____

[1 mark]

(b) Write down a formula for the equivalent capacitance for EACH of the following combinations:

(i) Three capacitors in parallel

_____

[1 mark]

(ii) Three capacitors in series

_____

[1 mark]

(c) Show that the energy stored, W, in a parallel plate capacitor of capacitance, C, with a voltage, V, across its plates is given by

$$W = \frac{1}{2}CV^2$$

_____

_____

_____

[2 marks]

2. (d) A 3 μF capacitor is charged so that its p.d. is 200 V, and a 1 μF capacitor is charged so that its p.d. is 100 V. The capacitors are then joined by wire of negligible resistance, so that the plates carrying like charges are connected together. Calculate the

(i) initial charge on the 3 μF capacitor

[1 mark]

(ii) initial charge on the 1 μF capacitor

[1 mark]

(iii) final p.d. across the 3 μF capacitor

[2 marks]

(iv) total energy stored in the capacitors when they are connected together.

[1 mark]

Total 10 marks

3. (a) State Coulomb's law for electrostatic charges.

_____

_____

_____

_____

[1 mark]

(b) Explain the following:

(i) Electric field strength

_____

_____

_____

[1 mark]

(ii) Electric potential

_____

_____

_____

[1 mark]

(c) How are the electric field and electric potential related?

_____

[1 mark]

3. (d) Figure 3 shows two point charges, 40 μC and –10 μC, placed 20 cm apart.

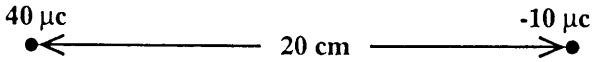


Figure 3

(i) Calculate the electric field strength at the mid point between the two charges.

[5 marks]

(ii) Indicate on Figure 3, along a line joining the two point charges, the approximate position where the net electric field is zero. **[1 mark]**

Total 10 marks

4. (a) The gain of an inverting amplifier is to be determined from an oscilloscope measurement using a sine wave input. The input and output waveforms are shown in Figure 4. The vertical sensitivities of the two channels are indicated.

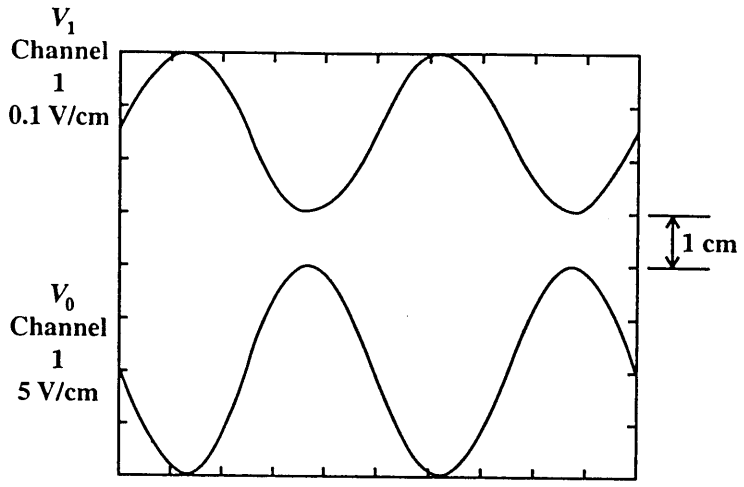


Figure 4

Determine the gain of the amplifier.

[5 marks]

4. (b) Figure 5 shows an operational amplifier circuit.

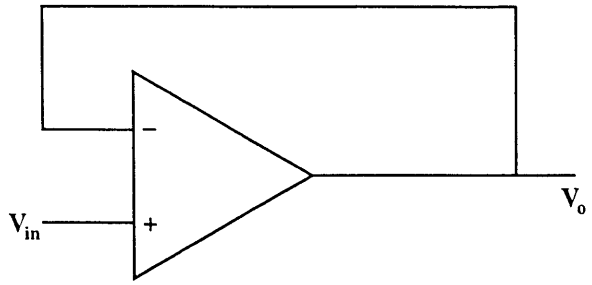


Figure 5

(i) Write down the name of the operational amplifier circuit shown in Figure 5.

_____

_____

[1 mark]

(ii) State TWO practical uses of the circuit shown in Figure 5.

_____

_____

[2 marks]

(c) Figure 6 shows an operational amplifier circuit.

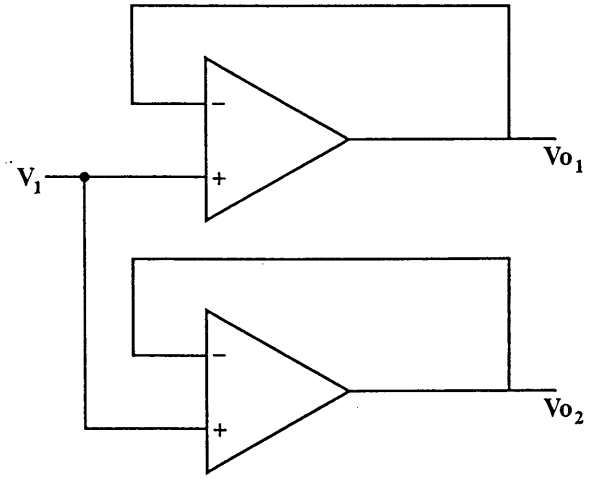


Figure 6

How do the values of V_{0_1} and V_{0_2} relate to V_1?

_____

[2 marks]

Total 10 marks

GO ON TO THE NEXT PAGE

5. (a) (i) What type of semiconductor is produced by doping an intrinsic semiconductor with donor atoms?

_____

[1 mark]

(ii) What are the majority charge carriers in a p-type semiconductor?

_____

[1 mark]

(iii) Explain the origin of the diffusion current in a semiconductor.

_____

_____

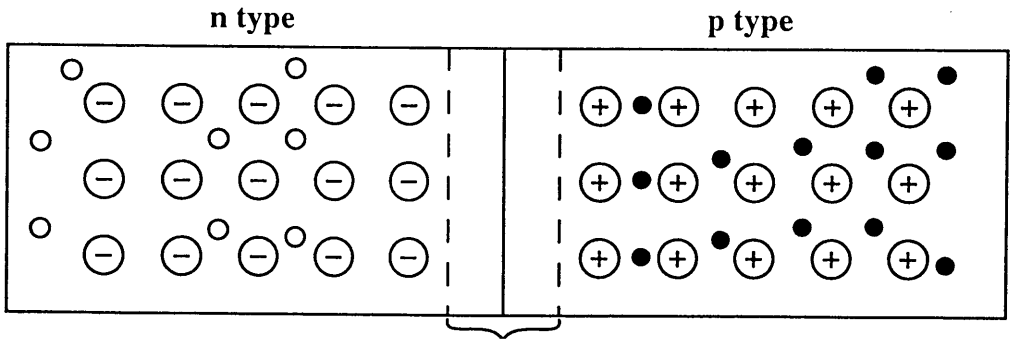
_____

_____

_____

[2 marks]

(b) Figure 7 shows the pn-junction of a semiconductor.



Depletion Layer

Figure 7

(i) Explain what is meant by the 'depletion layer of a pn-junction'.

_____

_____

[1 mark]

5. (ii) How is the depletion layer formed?

_____

_____

_____

[2 marks]

(iii) Draw one arrow on Figure 7 to show the direction of the diffusion current.

[1 mark]

(iv) On Figure 7, use the symbol for a cell to complete a circuit showing how the pn-junction is connected in the forward bias connection. **[1 mark]**

(v) Explain why the circuit you completed in (b) (iv) allows an appreciable current to flow.

_____

_____

_____

_____

[1 mark]

Total 10 marks

6. (a) What do you understand by a 'logic gate'?

_____

_____

[1 mark]

(b) A student was asked to design a logic circuit in order to monitor the opening and closing of two doors. Logic 0 represents a closed door and Logic 1 represents an open door. A Logic 1 is required when only one or the other of the doors is open.

(i) Write down the truth table for the circuit.

[2 marks]

(ii) Draw the single logic gate which gives the same output as in part (b) (i) above.

[1 mark]

(iii) Give the name of the logic gate you drew in part (b) (ii).

_____

[1 mark]

6. (c) Figure 8 is a circuit used to achieve half wave rectification.

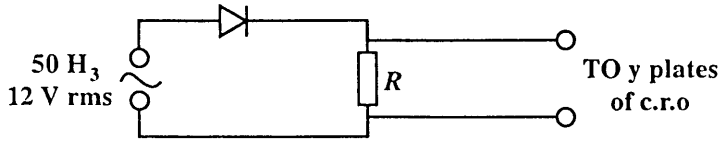


Figure 8

The supply to the rectifier is rated at 50 Hz, 12 V r.m.s.

A cathode ray oscilloscope (c.r.o) has its Y plates connected across the load resistor, *R*, and the trace of Figure 7 is shown below in Figure 8.

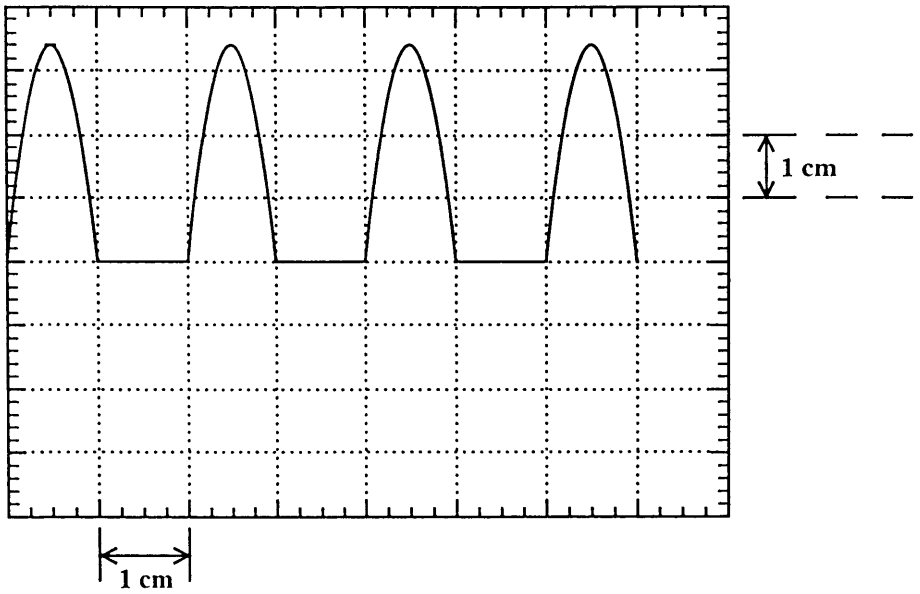


Figure 9

(i) Calculate the y-plate sensitivity of the c.r.o.

[4 marks]

(ii) How could the waveform in Figure 9 be "smoothed"?

[1 mark]

Total 10 marks

GO ON TO THE NEXT PAGE

7. (a) (i) Write an equation for the energy, E, associated with a photon and wavelength, λ.

_____

_____

[1 mark]

(ii) Write an equation relating Einstein's mass-energy relationship.

_____

_____

[1 mark]

(iii) Hence, derive de Broglie equation which suggests the wave-particle nature of light.

_____

_____

[2 marks]

(b) An electron is accelerated from rest through a potential difference of 5.3 kV.

(i) Calculate its de Broglie wavelength.

_____

_____

_____

_____

_____

[4 marks]

(ii) An oscillating molecule de-excites from one allowed energy level to the next lower one. Its energy changes by 2.2 eV.

Calculate the frequency of the emitted radiation.

_____

_____

_____

[2 marks]

Total 10 marks

8. (a) According to electromagnetic theory, radiation striking a metallic surface ejects electrons from that surface. The kinetic energy of the electrons should depend on the intensity of the incident radiation. However, experimental evidence shows that it is the frequency of the electromagnetic radiation, and not the intensity, which controls the maximum kinetic energy of the emitted electrons.

(i) What is the name given to the effect of using electromagnetic radiation to cause electrons to be emitted from a metal surface?

_____

[1 mark]

(ii) Explain how this effect provided evidence for the particle nature of electromagnetic radiation.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

[5 marks]

8. (b) Figure 10 shows the maximum kinetic energy of electrons emitted from a surface by light of different frequencies from a halogen light source.

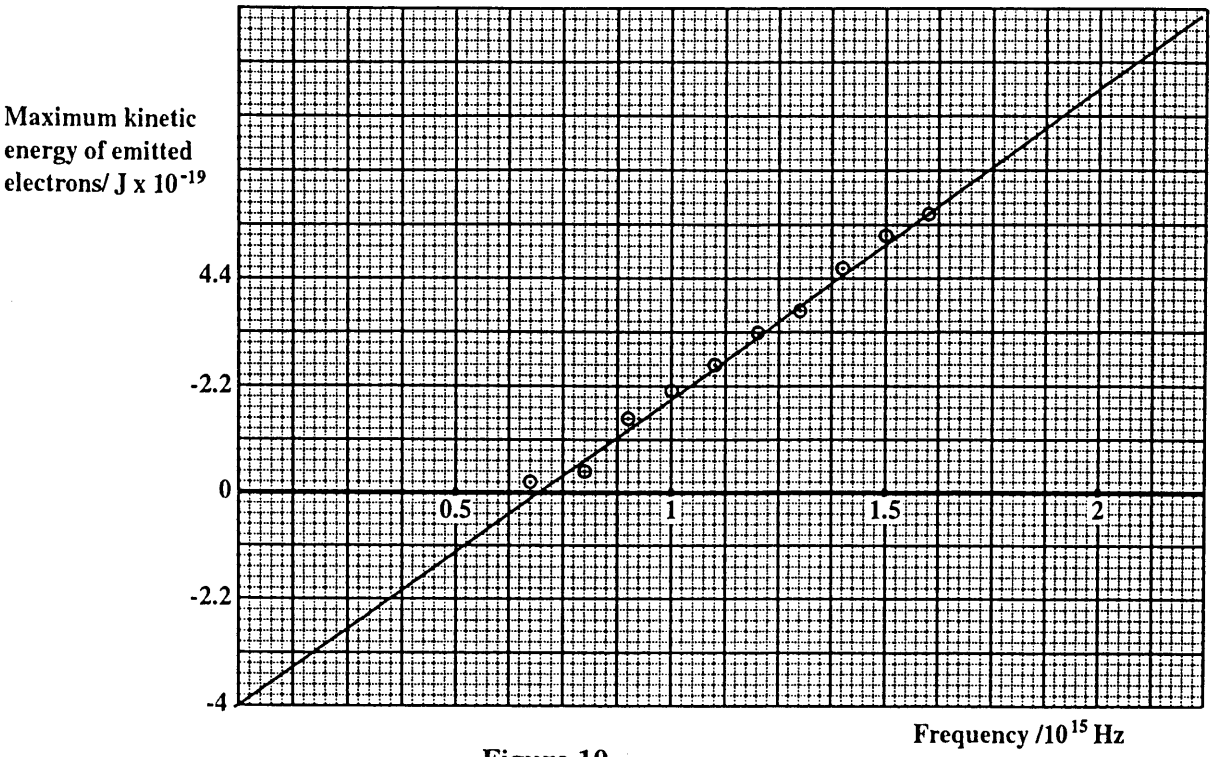


Figure 10

Determine the

(i) threshold frequency

_____

[1 mark]

(ii) work function

_____

[1 mark]

(iii) Planck's constant.

_____

[2 marks]

Total 10 marks

9. (a) Explain what is meant by the following terms of a radioactive source, and give their corresponding units:

(i) Activity

_____

_____

[2 marks]

(ii) Decay constant

_____

_____

_____

_____

[2 marks]

(iii) Half life

_____

_____

_____

[2 marks]

(b) The graph in Figure 11 on page 19 shows some measurements of the decay rate of a sample of radioactive substance.

Use the graph to determine

(i) background count rate

_____

[1 mark]

(ii) half life

_____

_____

[1 mark]

(iii) decay constant.

_____

_____

[2 marks]

Total 10 marks

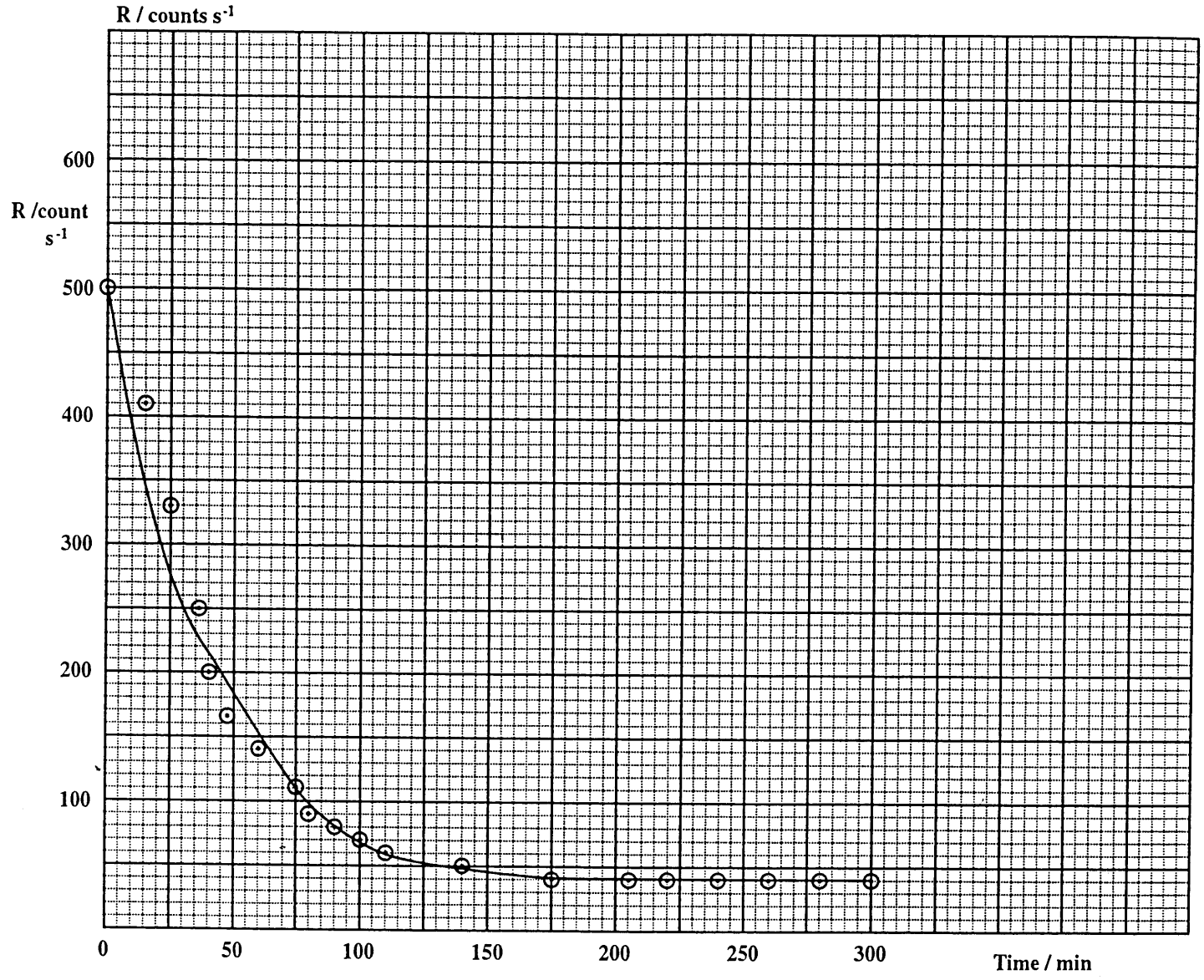


Figure 11

END OF TEST