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FORM TP 2010236

MAY/JUNE 2010

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1}
			$\frac{1}{4\pi\varepsilon_o} = 9.0 \times 10^{9}$ m f^{-1}
Elementary charge	e	=	1.60×10^{-19} C
Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant (Energy equivalence: $1u$ = 93 Mev)	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 due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

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SECTION A

Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) (i) Define the term 'capacitance'.

_____

_____

[1 mark]

(ii) A capacitor with a capacitance of 2100 μF is charged until the potential difference between its plates is 6.0 V. Determine

a) the charge on one of the plates

[2 marks]

b) the energy stored by the capacitor.

[2 marks]

(b) A student set up the circuit shown in Figure 1 and after closing the switch, S, observed how the voltmeter reading varied with time. A graph of the data obtained is shown in Figure 2. Noting that the voltmeter reading decreased as time elapsed the student proposed the hypothesis that the voltmeter reading V is inversely proportional to the elapsed time t.

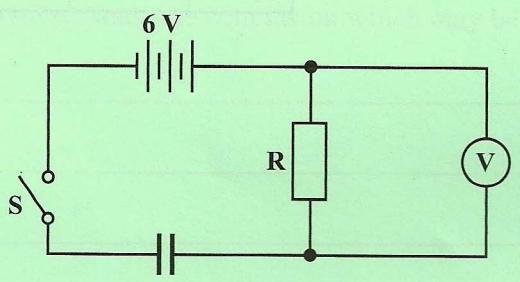


Figure 1

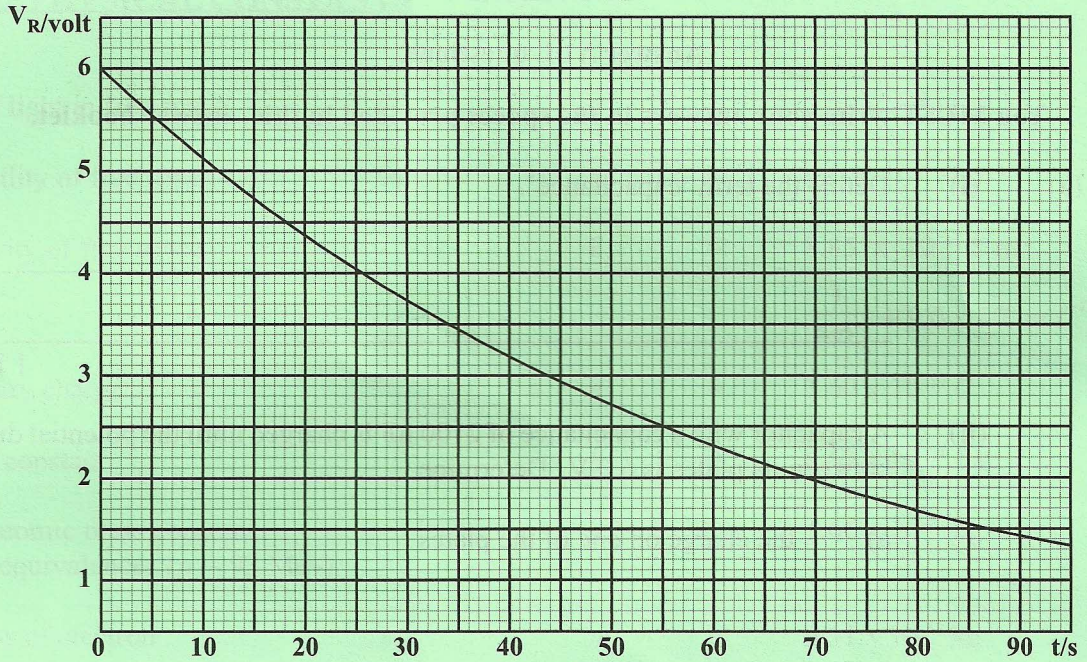


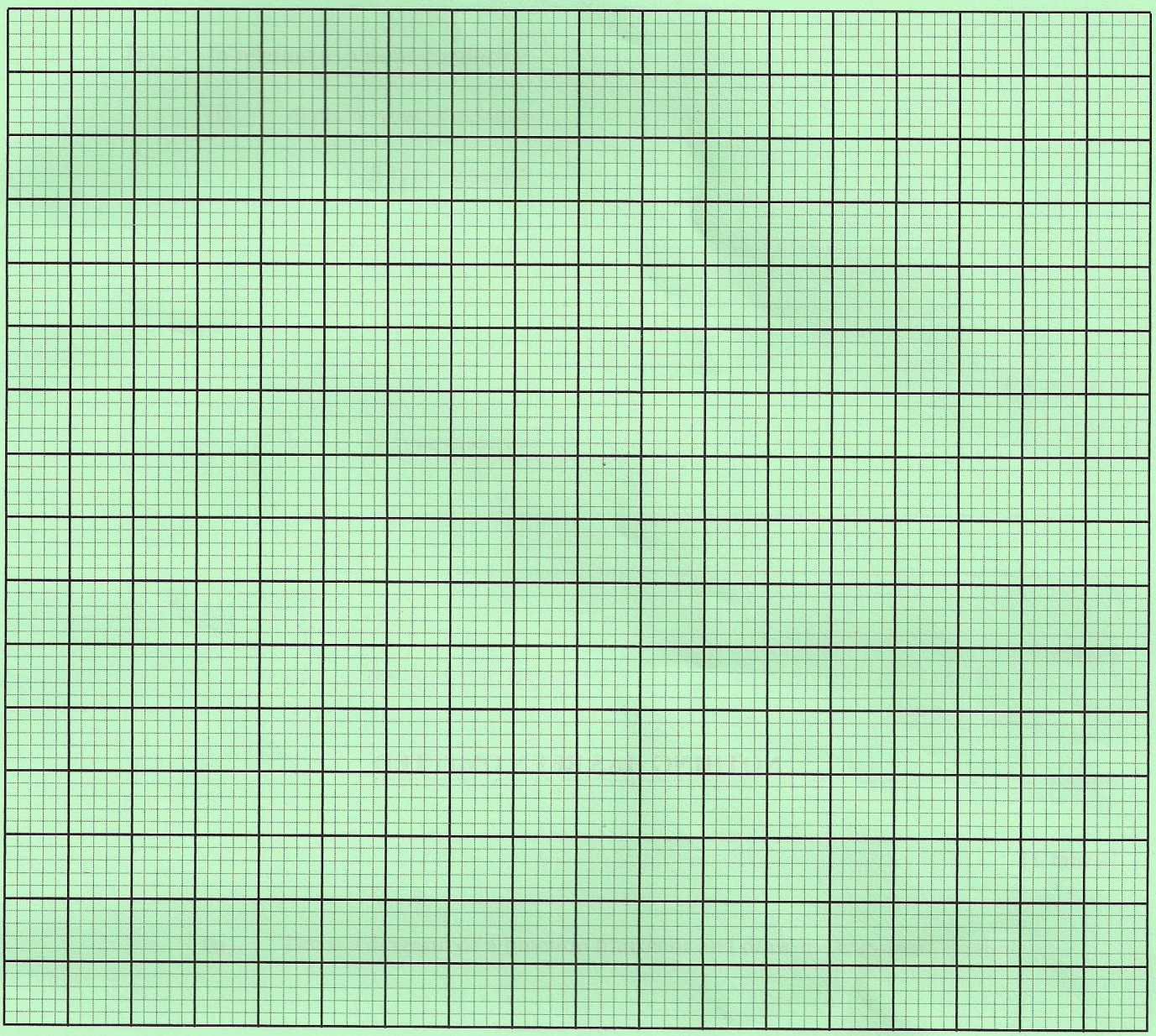
Figure 2. Graph of V_R vs Time

(i) Test his hypothesis by taking data from the graph in Figure 2 to complete Table 1 and then plotting $1/V$ against t on the grid provided on page 5.

TABLE 1

t/s	*V/V*	*1/V*
15		
30		
45		
60		
75		
90		

[8 marks]



(ii) State, with reasons, the conclusion which may be drawn from the data.

_____

_____

_____

[2 marks]

Total 15 marks

NOTHING HAS BEEN OMITTED

2. (a) In relation to a semi-conductor

(i) explain what is meant by

a) P-type material

_____

_____

_____

[1 mark]

b) N-type material

_____

_____

_____

[1 mark]

c) the depletion region.

_____

_____

_____

[1 mark]

(ii) Draw a diagram of a junction transistor and draw the transistor symbol.

[2 marks]

(b) The current, I, through the p-n junction of a diode is related to the voltage across the junction, V, by the expression

$$I = I_0 \exp\left[\frac{eV}{nkT}\right]$$

where I_0 is the saturation current; n is the junction ideality factor; k is the Boltzman's constant and T is the temperature in kelvin. Some d.c. measurements made on a silicon diode at 300 K, yielded the following results:

TABLE 2

V/Volt	I/μA	ℓn (I/μA)
0.490	1	
0.568	10	
0.647	100	
0.732	1000	
0.818	5000	

(i) Complete Table 2 by filling in the missing values. **[1 mark]**

(ii) Plot a graph of $\ell n\ I$ versus V on the grid opposite . Draw your best straight line through the points. **[4 marks]**

(iii) Write the equation relating $\ell n\ I$ and V.

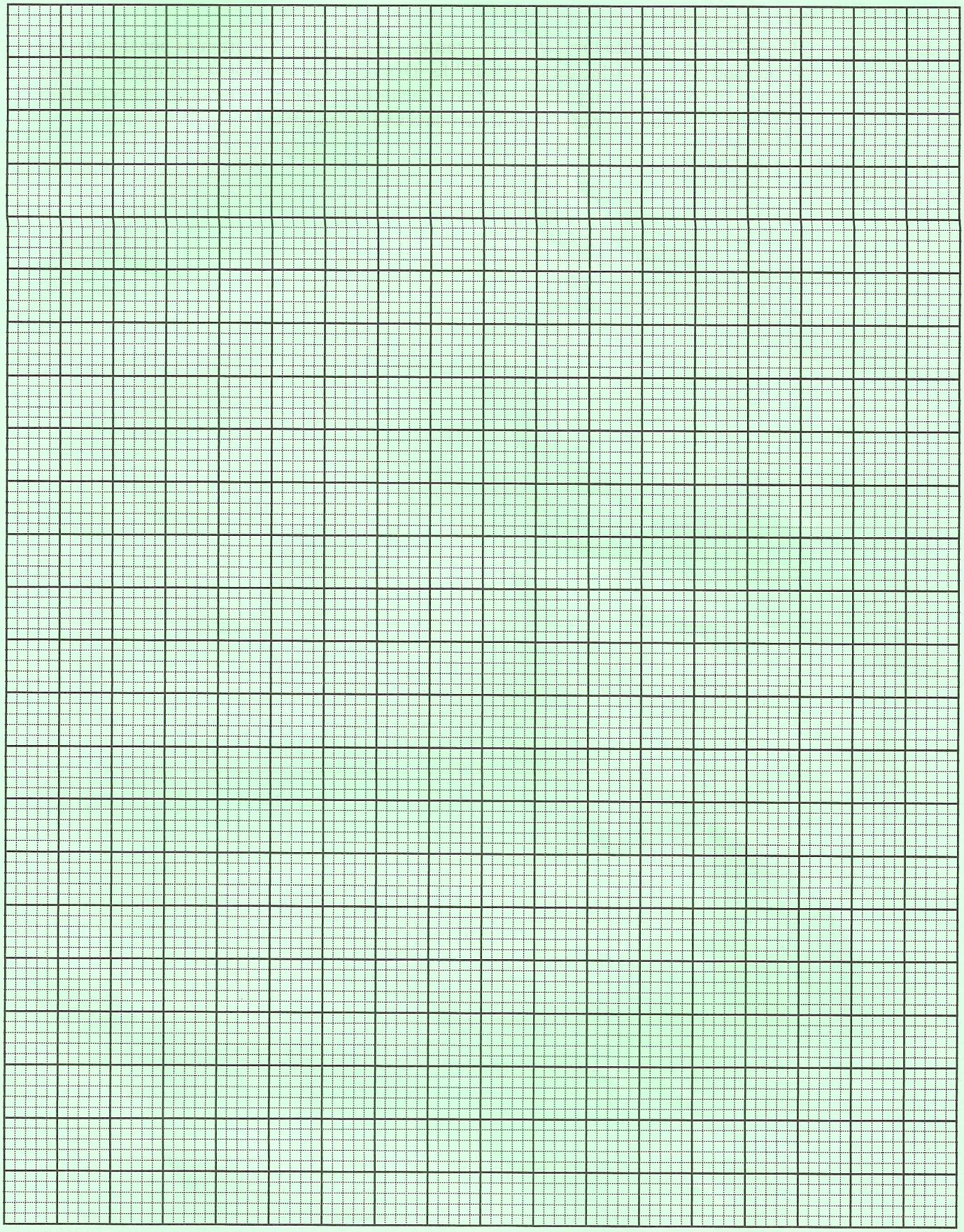
[1 mark]

(iv) Determine the ideality factor n.

[4 marks]

[Data: $k = 1.38 \times 10^{-23}$ J K^{-1}]

Total 15 marks



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3. (a) The radioactive gas Radon-220, an α–emitter, is easily separated from its powdered solid parent and is known to have a short half-life. Describe how you would accurately measure the half-life of Radon. In your account give details of the apparatus required, the procedure to be followed and the way the collected data will be processed.

[7 marks]

(b) The half-life of Radon-220 is actually 54 seconds: it decays by the emission of α-particles, one particle being emitted for each atom decaying.

(i) How many α-particles would be emitted by a 4 mg sample of $^{220}_{86}Rn$ in 108 seconds?

[5 marks]

(ii) A laboratory is deemed safe after a Radon-220 leak when the activity has decreased to less than 0.1% of its original value. What is the MINIMUM number of minutes for which the laboratory must remain closed?

[3 marks]

Total 15 marks

SECTION B

Answer ALL questions in this section.
Write your answers in the spaces provided in this answer booklet.

4. (a) State Kirchhoff's two laws for electrical circuits and give the physical principle that each law is based on. **[4 marks]**

(b) Distinguish between the 'e.m.f.' and the 'terminal p.d.' of a cell. **[2 marks]**

(c) Figure 3 shows a network of resistors and batteries. The internal resistance of each battery is 1Ω as shown.

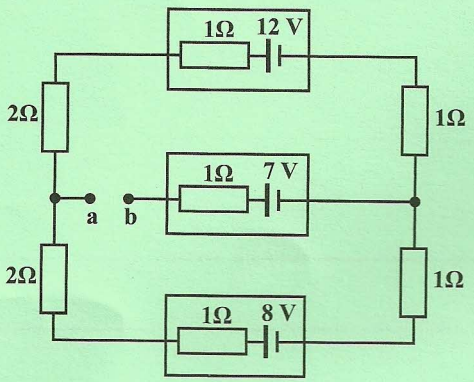

Figure 3

(i) Calculate the current flowing through the 12 V battery.

(ii) Points *a* and *b* are connected by a wire of negligible resistance. Calculate the new value for the current that will flow through the 12 V battery. **[9 marks]**

Total 15 marks

Write your answer to Question 4 here.

Write your answer to Question 4 here.

5. Figure 4 shows an ideal non-inverting operational amplifier (op-amp) circuit.

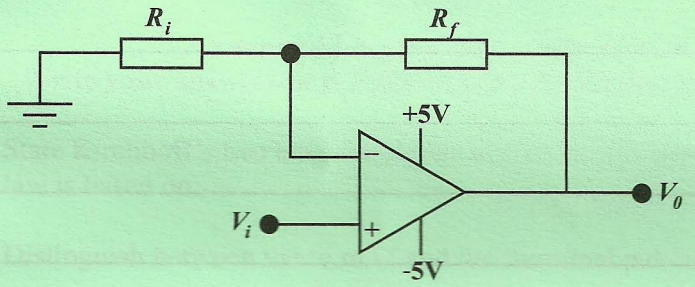

Figure 4

(a) Show that the closed loop gain, A, of the circuit is given by $A = \frac{R_i + R_f}{R_i}$. Clearly state any assumptions made about the properties of the op-amp. **[5 marks]**

(b) A circuit like the one in Figure 4 is set up with $R_f = 440$ kΩ and $R_i = 40$ kΩ. The op-amp is operated from a ± 5.0 V supply.

(i) What is the value of the output voltage when is $V_i = +250$ mV?

(ii) If the op-amp is NOT to be saturated, what is the MAXIMUM voltage amplitude for the input signal?

(iii) Sketch a graph to show the expected output when a sinusoidal signal with an amplitude of 0.75 V is applied to the input of this amplifier.

[6 marks]

(c) In a certain application, it is desired to combine two signals, v_1 and v_2, to form a signal v_0 according to the relation $v_0 = -2\,v_1 - 5\,v_2$ The minimum input resistance for both signal inputs should be NO less than 10.0 kΩ. Design a circuit to meet this requirement.

[4 marks]

Total 15 marks

Write your answer to Question 5 here.

Write your answer to Question 5 here.

6. (a) With the aid of a sketch graph, clearly explain the following terms and how they originate.

(i) Continuous X-ray spectrum

(ii) Characteristic X-ray spectrum

(iii) Cut-off wavelength **[7 marks]**

(b) The x-ray tube in Figure 5 operates at 50 kV and the current through it is 1.2 mA.

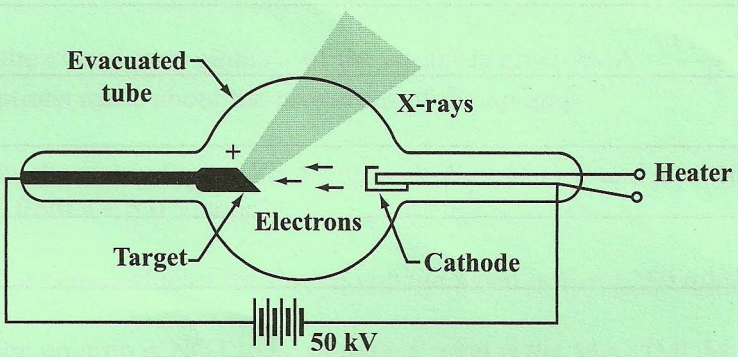

Figure 5

Calculate

(i) the electrical power input

(ii) the speed of the electrons when they hit the target

(iii) the cut-off wavelength of the X-rays emitted.

[8 marks]

Total 15 marks

Write your answer to Question 6 here.

END OF TEST