TEST CODE **02238010**

FORM TP 2005260

MAY/JUNE 2005

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's 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 constant	N_A	=	6.02×10^{23} per mole

GO ON TO THE NEXT PAGE

1. (a) (i) Explain what is meant the 'drift velocity' of charge carriers.

_____

_____

_____

[1 mark]

(ii) Figure I shows a current i flowing through a length of wire L, with cross sectional area A. There are n charge carriers per unit volume present. The average drift velocity of the charge carriers is v_d and the charge on each charge carrier is q.

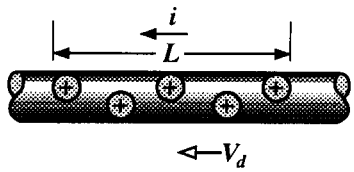


Figure I

Show that the drift velocity, v_d, of the charge carriers is given by $v_d = \frac{I}{nqA}$.

[4 marks]

(b) In Figure II, current of 0.10 A flows through a copper wire 0.10×10^{-3} m in diameter and then through a salt solution contained in a glass tube 0.010 m in diameter. The density of conduction electrons in copper is 1.1×10^{29} m^{-3}. The current in the solution is carried equally by positive and negative ions with charges $2e$ and the number of each ion species per unit volume is 6.1×10^{23} m^{-3}.

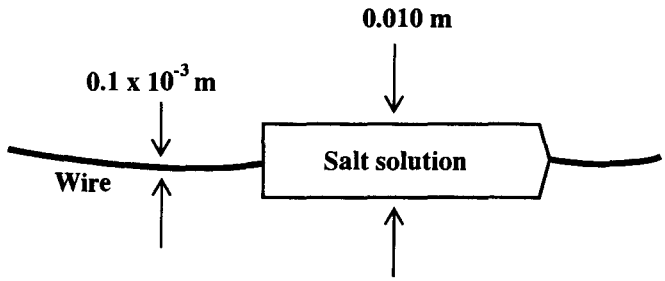


Figure II

(i) Calculate the number of electrons passing through the wire EACH second.

[2 marks]

(ii) Calculate the drift velocity of the charge carriers in the salt solution.

[3 marks]

Total 10 marks

2. (a) Figure III shows a point charge Q at A. B is a point a distance *r* from Q.

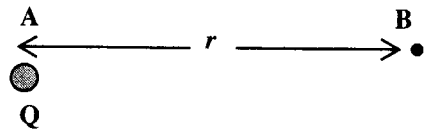


Figure III

(i) Write an expression for

a) the electric field at B

_____

[1 mark]

b) the electric potential at B.

_____

[1 mark]

(ii) Show how the electric field and electric potential of B are related.

_____

[1 mark]

(b) Figure IV shows a small light-conducting sphere supported by a long fine vertical nylon thread, suspended between TWO large metal plates. The plates are connected to a high voltage d.c. supply.

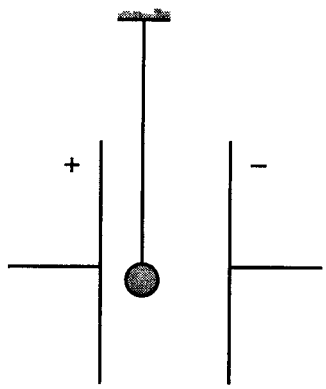


Figure IV

(i) Explain why the uncharged sphere is attracted to the positive plate.

_____

[1 mark]

(ii) Explain why the sphere subsequently oscillates between the plates.

_____

_____

_____

_____

_____

_____

[3 marks]

(iii) When the ball is not touching either plate, the force on the ball is 0.05 N. The plates are 10 cm apart and the supply voltage is set to 1 kV.

Calculate the charge on the sphere.

[3 marks]

Total 10 marks

3. (a) State

(i) Faraday's law of electromagnetic induction

_____

_____

_____

[1 mark]

(ii) Lenz's Law.

_____

_____

_____

[1 mark]

GO ON TO THE NEXT PAGE

(b) Giving an example, explain how Lenz's law can be considered as an application of the law of conservation of energy.

_____

_____

_____

_____

_____

[2 marks]

(c) A flat coil of wire consists of 500 circular loops of radius 2.0 cm. It is placed between the poles of a large electromagnet so that the plane of the coil is perpendicular to a uniform magnetic field of 0.15 T.

(i) Calculate the magnetic flux through each turn of the coil.

[2 marks]

(ii) If the electromagnet is turned off and it takes 0.20 s for the field to go down to zero, what would be the e.m.f. induced in the coil of wire?

[2 marks]

(iii) State TWO reasons why transformers are NOT usually 100 per cent efficient.

[2 marks]

Total 10 marks

4. (a) State THREE properties of the ideal operational amplifier (op - amp).

[3 marks]

(b) Figure V shows an op - amp being used as a comparator. The open loop gain of the amplifier is 2×10^5.

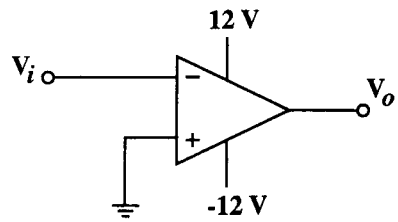


Figure V

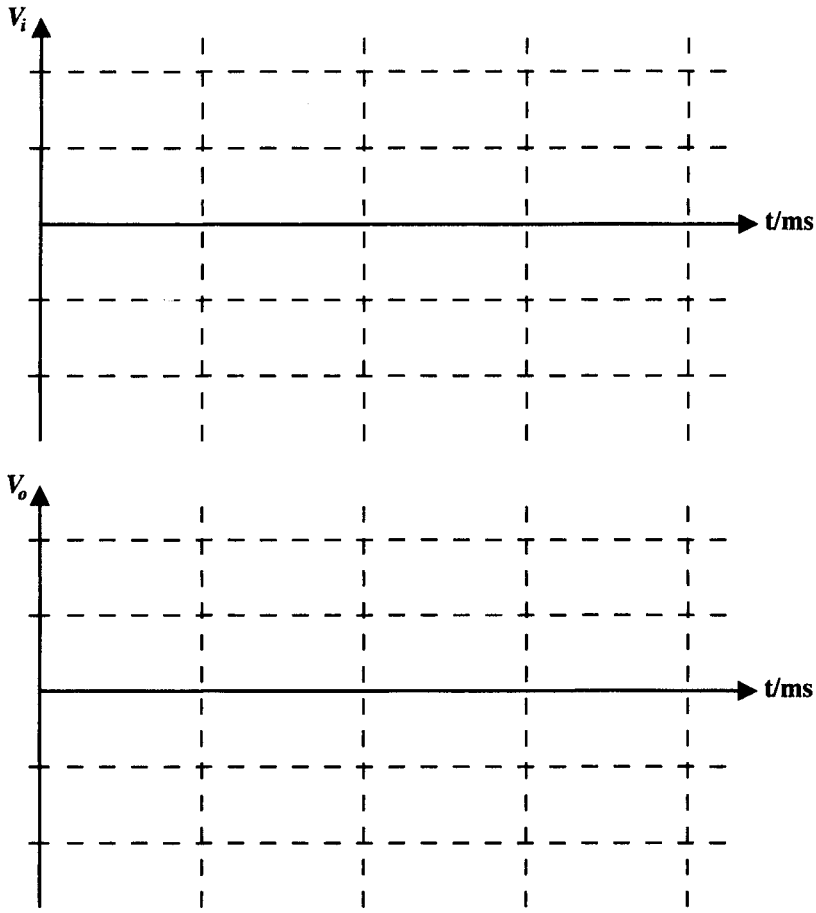
(i) Calculate the positive and negative input voltages at which saturation will be reached.

[2 marks]

(ii) A signal with voltage V_i given by $V_i = 0.2 \sin(100\pi t)$ is applied to the comparator in (b) (i). Calculate the frequency of the signal.

[1 mark]

(iii) On the axes below sketch both the input voltage V_i and the output voltage V_o for TWO complete cycles CLEARLY indicating the maximum voltages and periodic times on the axes.



[4 marks]

Total 10 marks

5. (a) Figure VI shows the pn junction of a silicon diode connected to a power supply. Initially, the switch is in the open position as shown.

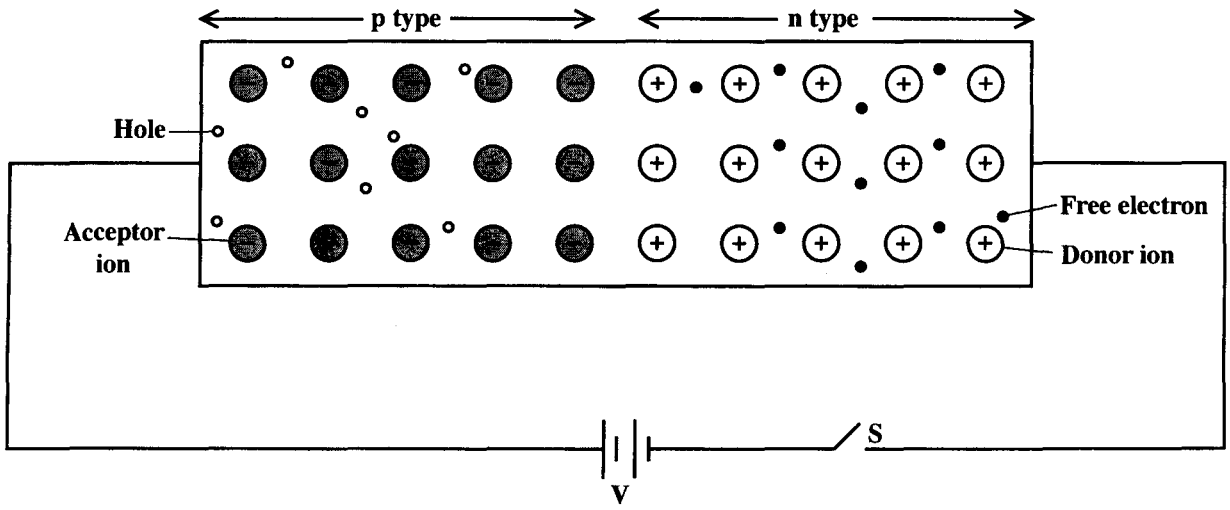


Figure VI

(i) Sketch the I-V characteristic curve for such a diode.

[2 marks]

(ii) Explain what is meant by the depletion layer at a pn junction and indicate this layer on Figure VI.

_____

_____

_____

[1 mark]

(iii) Indicate the following on Figure VI:

a) The direction of the diffusion current. Label this arrow with an X.

b) The direction of the drift current. Label this arrow with a Y.

[2 marks]

(iv) The switch in Figure VI is now closed. Describe how the depletion layer is affected and explain the effect.

_____

_____

_____

_____

[2 marks]

(b) Consider the circuits shown in Figure VII in which each circuit is connected to an a.c. supply and has a cathode ray oscilloscope (c.r.o.) across its output. For each circuit in Figure VII, (ii)-(iv), sketch the output voltage as seen on the cathode ray oscilloscope on the axes beside the circuit diagram.

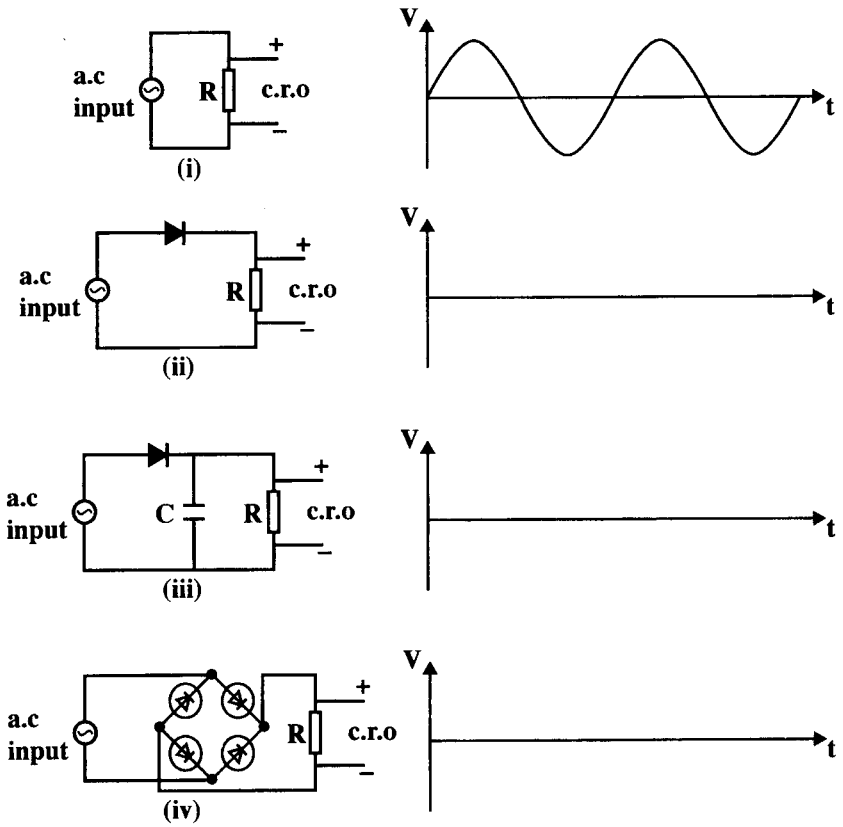


Figure VII

[3 marks]

Total 10 marks

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6. (a) (i) List TWO general areas in which digital electronics is commonly employed.

_____

_____

[2 marks]

(ii) Write down the truth table for the EXCLUSIVE-OR (X-OR) gate.

[1 mark]

(iii) Explain how an X-OR gate can be used to detect when TWO binary digits are different?

_____

_____

_____

[1 mark]

(b) Figure VIII shows a digital circuit with inputs A and B.

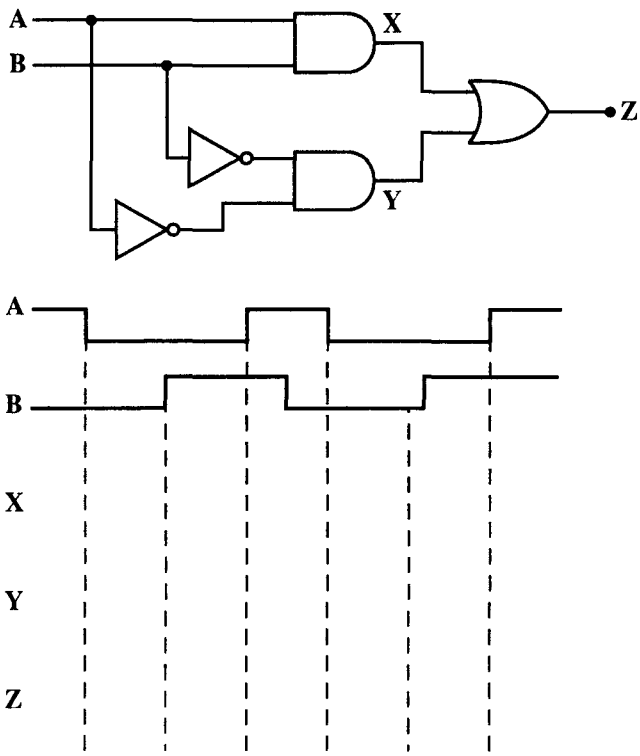


Figure VIII

(i) Complete the truth table below to show the outputs at Y and Z.

A	B	X	Y	Z
0	0	0		
0	1	0		
1	0	0		
1	1	1		

[2 marks]

(ii) Sketch, in the space provided in Figure VIII, the output waveform at X, Y and Z if the input waveforms A and B are as indicated. **[3 marks]**

(iii) What single logic gate is equivalent to the circuit in Figure VIII?

_____

_____

[1 mark]

Total 10 marks

7. Figure IX shows an apparatus for the production of X-rays, using molybdenum as the target metal. Molybdenum's innermost (K-shell) electrons have an energy of 20 keV whilst the outermost (M-shell) electrons have an energy level of 200 eV.

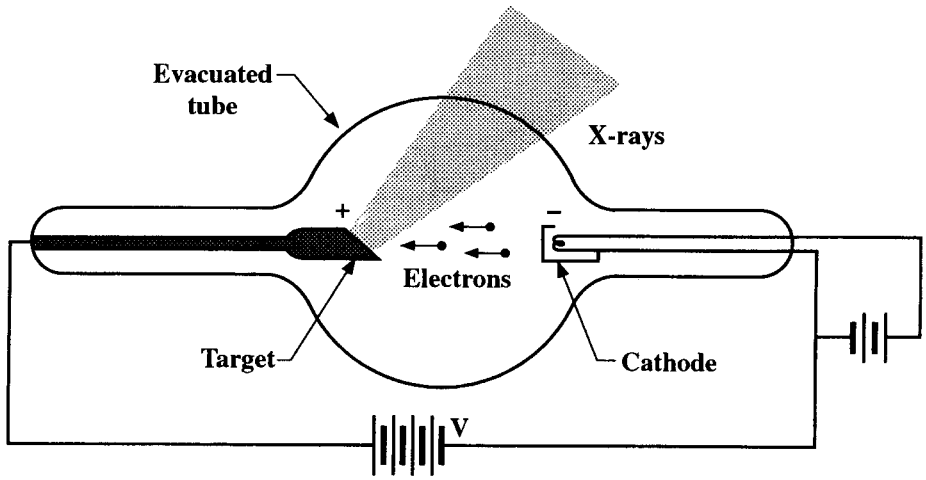
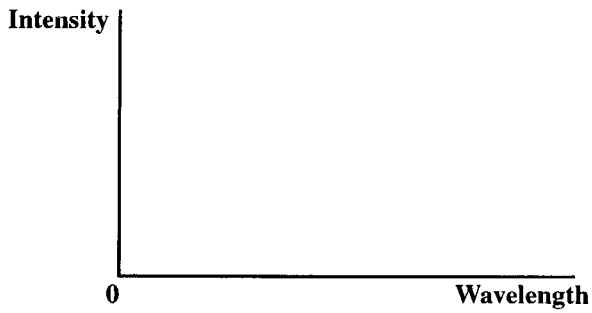


Figure IX

(a) Sketch the typical Intensity-wavelength X-ray spectrum for molybdenum, CLEARLY indicating the minimum continuous X-ray wavelength, λ_{min}, and the characteristic peaks in the intensity.



[3 marks]

(b) Explain the origin of the characteristic peaks observed in your sketch in (a).

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_____

_____

[2 marks]

GO ON TO THE NEXT PAGE

(c) One of the K-shell electrons is removed from the atom by electron bambardment and its vacancy is filled by an M-shell electron.

Calculate the wavelength of the emitted X-rays.

[3 marks]

(d) The tube is operated from a 25 kV supply. What is the minimum wavelength of the continuous spectrum of X-rays?

[2 marks]

Total 10 marks

8. (a) Explain what is meant by the following terms when referring to a radioactive source.

(i) Half-life

_____

_____

[1 mark]

(ii) Decay constant

_____

_____

[1 mark]

(b) The half-life of a radioactive sample of Radium, $^{226}_{88}Ra$, is 1.6×10^3 years.

(i) Calculate the decay constant of $^{226}_{88}Ra$.

[3 marks]

(ii) The sample contains 5.0×10^{16} such nuclei at $t = 0$. Calculate its activity at this time.

[2 marks]

(iii) Calculate the decay rate when the sample is 2.5×10^3 years old.

[Data: 1 year = 3.2×10^7s]

[3 marks]

Total 10 marks

9. (a) Figure X shows a section of a Geiger-Muller tube.

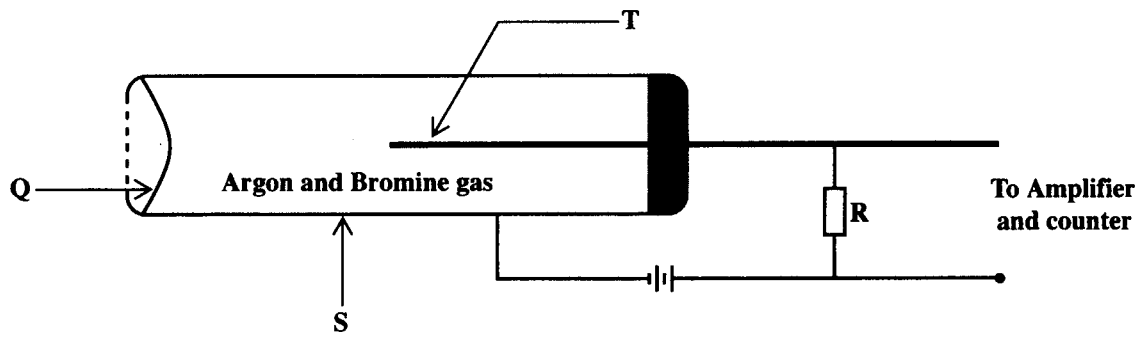

Figure X

(i) Beside EACH letter write the name of the parts labelled Q, S and T in Figure X.

Q _____

S _____

T _____

[3 marks]

(ii) Describe the principle of the operation of a G - M tube.

_____

_____

_____

[1 mark]

GO ON TO THE NEXT PAGE

(iii) Explain why a mixture of argon and bromine gas is used in the tube.

_____

_____

_____

_____

_____

_____

_____

[2 marks]

(b) A radioactive source is known to emit α , β and γ radiation. The source is placed in a magnetic field as shown in Figure XI. The field is directed into the page. A Geiger-Muller tube moves from position A to position B.

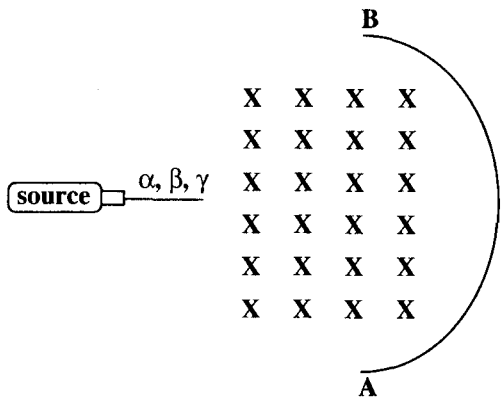

Figure XI

(i) Identify the type of radiation recorded at position A.

Position A

_____

[1 mark]

(ii) Show on Figure XI the region where γ radiation would be detected.

[1 mark]

(iii) If the distance from the source to the Geiger-Muller tube is about 15 cm α -particles cannot be detected. Explain why.

_____

_____

[2 marks]

Total 10 marks

END OF TEST