TEST CODE **002474**

FORM TP 23246

MAY/JUNE 2003

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.

1. (a) Define the 'Farad'.

[1 mark]

(b) Derive an expression for the total capacitance, C_T, of three capacitors, C_1, C_2 and C_3, in series.

[3 marks]

(c) A parallel-plate, air-filled capacitor having area 5.0×10^{-3} m^2 and plate separation 1.0×10^{-3} m is charged to a potential difference of 500 V.

Calculate the

(i) capacitance of this capacitor

[3 marks]

(ii) energy stored in this capacitor.

[3 marks]

Total 10 marks

2. (a) Define EACH of the following terms:

(i) Magnetic flux:

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____

____

[1 mark]

(ii) Tesla:

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[1 mark]

(b) State

(i) Faraday's Law

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[1 mark]

(ii) Lenz's Law.

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[1 mark]

(c) Two conducting rods are joined at right angles to each other as shown in Figure 1.

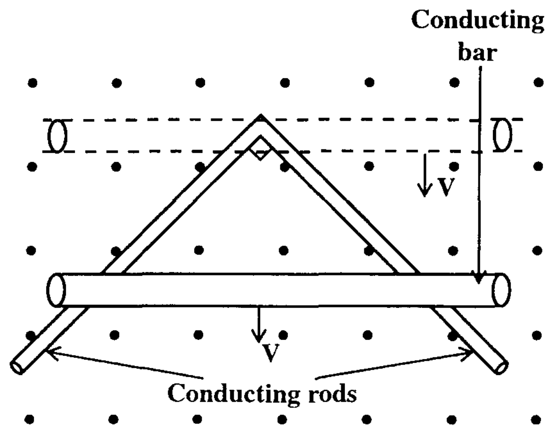

Figure 1

A conducting bar in contact with the rods starts at the vertex and moves with a constant velocity (v) of 4.20 m s^{-1} along them as shown. A magnetic field of magnitude 0.450 T is directed perpendicularly out of the page.

Find the

(i) area of the triangle which is formed at 2 seconds by the conducting bar and conducting rods

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____

____

[2 marks]

(ii) magnetic flux through the triangle at seconds

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____

____

[2 marks]

(iii) electromotive force (e.m.f.) induced in the moving rod at 2 seconds.

____

____

____

[2 marks]

Total 10 marks

3. (a) Write an expression for the total resistance, R_T, of three resistors R_1, R_2 and R_3, in parallel.

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[1 mark]

(b) State Ohm's Law.

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____

[1 mark]

(c) Explain the difference between the electromotive force (e.m.f.) and the terminal potential difference (p.d.) of a battery.

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[2 marks]

(d) A set of measurements were made using the circuit of Figure 2.

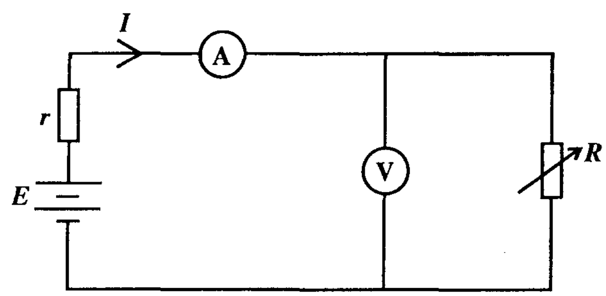

Figure 2

Table 1 below shows some of the results obtained.

R	V	I
0	0	0.15 A
300 Ω	10 V	
∞		

Table 1

Fill in the blank spaces in the table with the missing data.

[6 marks]

Total 10 marks

4. (a) Explain what is meant by EACH of the following:

(i) P-type semiconductor

____

____

[1 mark]

(ii) N-type semiconductor

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____

[1 mark]

(iii) Doping, as applied to semiconductors

____

____

[1 mark]

(iv) Depletion region

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____

[1 mark]

(b) Suggest ONE application of a p-n junction diode.

____

[1 mark]

(c) Figure 3 shows a combination of two silicon diodes in a circuit.

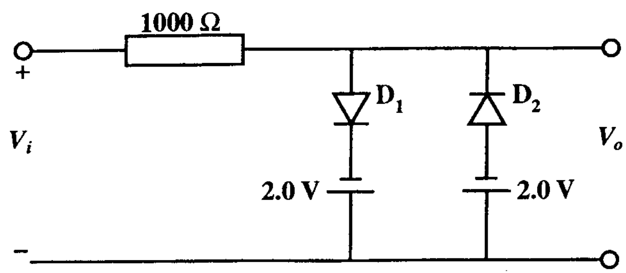

Figure 3

The characteristic I – V curve for the diodes is shown in Figure 4.

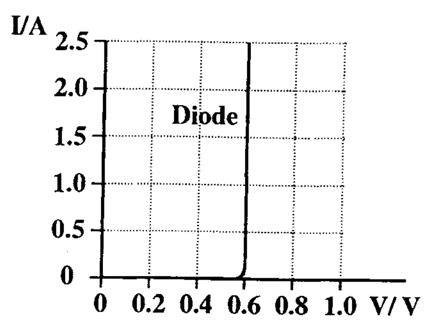

Figure 4

(i) Calculate the value of the output voltage, V_0, when

a) $V_i = 10$ V

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____

____

[2 marks]

b) $V_i = -10.0$ V.

____

____

____

[1 mark]

(ii) Sketch the output when $V_i = 10 \text{ Sin } \omega t$, where $\omega = 100 \text{ rad s}^{-1}$, including appropriate numerical values on the scales.

[2 marks]

Total 10 marks

5. (a) In the space provided below, sketch a typical gain frequency curve for an operational amplifier.

[3 marks]

(b) What is meant by a 'virtual earth' in an operational amplifier circuit?

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[1 mark]

(c) State ONE effect of positive feedback in an operational amplifier circuit.

___

[1 mark]

(d) Figure 5 shows a cascade amplifier circuit.

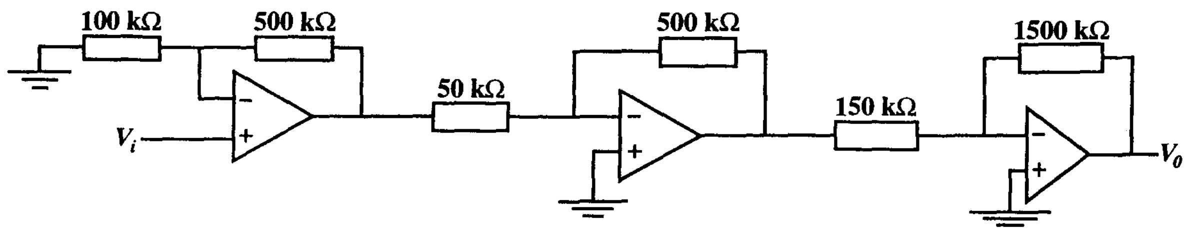

Figure 5

Calculate the

(i) net gain of the circuit

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____

____

____

[4 marks]

(ii) output voltage, V_0, when $V_i = 0.01$ V.

____

____

[1 mark]

Total 10 marks

6. (a) (i) Arithmetic operations are usually performed by adders. A half adder circuit is used to add the 1's column in binary addition. Write the truth table for a half-adder.

[2 marks]

(ii) You are provided with an Exclusive-OR (EX-OR) gate and an AND gate for designing a half adder circuit. Draw a circuit diagram to show how these could be arranged.

[2 marks]

(b) Draw a circuit diagram to show how the NAND gates could be used to build a flip-flop.

[1 mark]

(c) Write the truth table for the circuit shown in Figure 6, indicating the output at X, Y and Z.

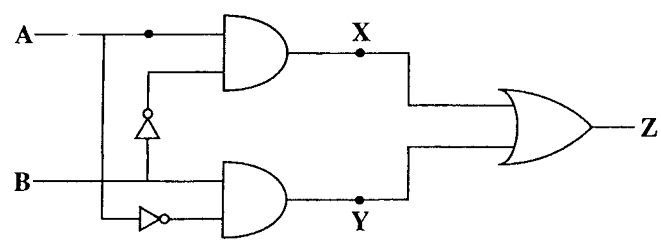

Figure 6

[3 marks]

(d) Draw a simple logic circuit to represent the truth table below in which A and B are inputs and X is the output.

A	B	X
0	0	0
0	1	0
1	0	1
1	1	0

[2 marks]

Total 10 marks

7. (a) State THREE experimental facts about the photoelectric effect which support the particulate (photon) model of light.

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____

____

[3 marks]

(b) When ultraviolet light is incident on an insulated metal plate, the plate emits electrons for a while and then stops.

Explain why the process eventually stops.

____

____

[1 mark]

(c) The energy level scheme for a newly discovered one-electron element is shown in Figure 7. The electron is in its ground state.

n = 4	–2 eV
n = 3	–5 eV
n = 2	–10 eV
n = 1	–20 eV

Figure 7

(i) Determine the amount of energy it will take to ionize an electron from the ground state.

____

[1 mark]

(ii) State what will happen if a 6 eV photon strikes the atom.

____

____

[1 mark]

GO ON TO THE NEXT PAGE

(d) An electron makes a transition from the n = 3 state to the n = 1 state.

(i) Calculate the frequency of radiation emitted.

____

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____

[2 marks]

(ii) Calculate the wavelength of radiation emitted.

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____

[1 mark]

(iii) In which region of the electromagnetic spectrum would this radiation be found?

____

[1 mark]

Total 10 marks

8. (a) (i) Explain the principle by which a continuous X-ray spectrum is produced.

____

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[2 marks]

(ii) Why is a vacancy in an inner electron shell usually required for an atom to emit an X-ray photon?

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[2 marks]

(b) A beam of X-rays, of intensity I_0, is incident on a slab of material of thickness x_1 and absorption coefficient μ_1, as shown in Figure 8 a.

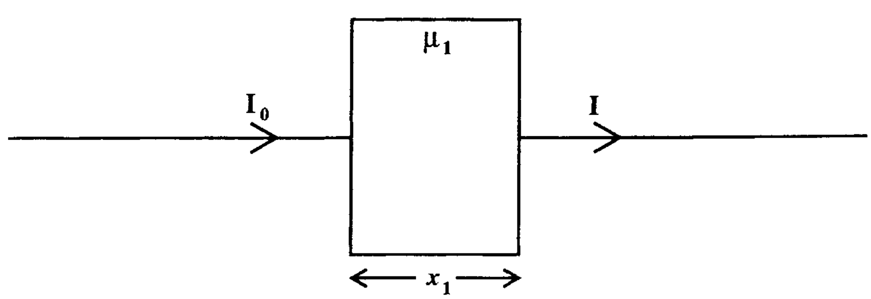

Figure 8 a

(i) Write an expression for the emerging intensity, I, in terms of I_0, μ_1 and x_1.

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[1 mark]

(ii) A second slab of material, of thickness x_2 and absorption coefficient μ_2, is placed alongside the first slab as shown in Figure 8 b.

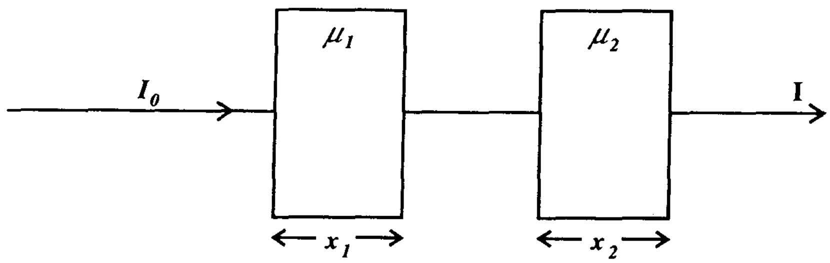

Figure 8 b

a) Show that the Intensity, I, is given by

$$I = I_0\, e^{-(\mu_1 x_1 + \mu_2 x_2)}$$

[3 marks]

b) Calculate the value of I where $I_0 = 500\ \text{Wm}^{-2}$, $\mu_1 = 8.0\ \text{m}^{-1}$, $x_1 = 2.0$ mm, $\mu_2 = 4.0\ \text{m}^{-1}$, $x_2 = 4.0$ mm.

[2 marks]

Total 10 marks

9. (a) Explain what is meant by EACH of the following terms:

(i) Nuclear fission

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[1 mark]

(ii) Nuclear fusion

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____

[1 mark]

(iii) Binding energy

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[1 mark]

(b) The nucleus of an atom of uranium can be represented by $^{235}_{92}U$. How many of EACH of the following particles are there in the nucleus?

(i) Protons

____

[1 mark]

(ii) Neutrons

____

[1 mark]

(c) An induced fission reaction is described by the following equation.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{236}_{92}U^* \rightarrow ^{141}_{56}Ba + ^{92}_{36}kr + 3\,^{1}_{0}n + E$$

Masses:

$^{235}_{92}U$ = 235.0439 u

$^{141}_{56}Ba$ = 140.9141 u

$^{92}_{36}kr$ = 91.9262 u

$^{1}_{0}n$ = 1.0087 u

1 u = 931.5 MeV/c^2

Calculate

(i) the energy E, in eV, released during the reaction

____

____

____

____

[4 marks]

(ii) the energy, in eV, of EACH neutron produced in the reaction.

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[1 mark]

Total 10 marks

END OF TEST