TEST CODE **002474**

FORM TP 21228

MAY/JUNE 2001

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.

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

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1. (a) Coulomb established the fundamental law of electric force between two stationary, charged particles.

State THREE properties of this electric force.

_____

_____

_____

_____

_____

_____

[3 marks]

(b) Write an equation to express the magnitude of the electric force between two charges.

_____

_____

[1 mark]

(c) Figure 1 shows three points charges located at the corners of a triangle where $Q_1 = Q_3 = 5\ \mu C$, $Q_2 = -2\ \mu C$ and $r = 10$ cm.

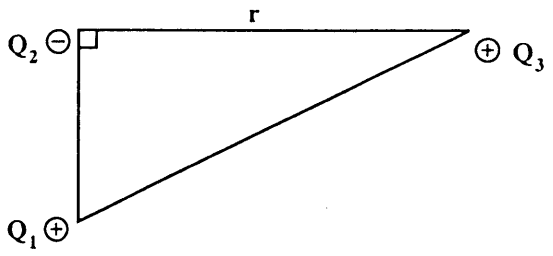

Figure 1

(i) Locate on the diagram the forces F_1 and F_2 acting on Q_3 due to Q_1 and Q_2 respectively. **[1 mark]**

(ii) Calculate a value for F_1.

[2 marks]

(iii) Calculate a value for F_2.

[1 mark]

(iv) Hence calculate the magnitude of the resultant force acting on Q_3.

[2 marks]

Total 10 marks

2. (a) A charged particle, q, moves anticlockwise in a magnetic field which acts at right angles to the velocity of the charge. (See Figure 2.)

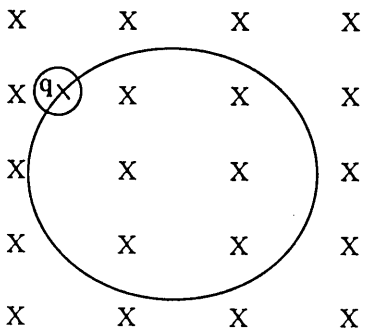

Figure 2

Indicate on the diagram the direction of the

(i) velocity of the charged particle, v **[1 mark]**

(ii) magnetic force acting on the charge particle, F. **[1 mark]**

(b) Explain why the magnetic field does not affect the kinetic energy of the charged particle.

_____

_____

_____

_____

[4 marks]

(c) A proton is moving in a circular orbit of radius 7.5 cm in a uniform magnetic field of magnitude 0.4 T directed perpendicular to the velocity of the proton.

Calculate the

(i) orbital speed

[3 marks]

(ii) period of revolution of the electron.

[1 mark]

Total 10 marks

3. (a) Define 'capacitance'.

_____

_____

_____

[1 mark]

(b) Figure 3 shows a parallel plate air capacitor with a constant electric field strength, E, between the plates. The area of the plates is A and d is their distance apart.

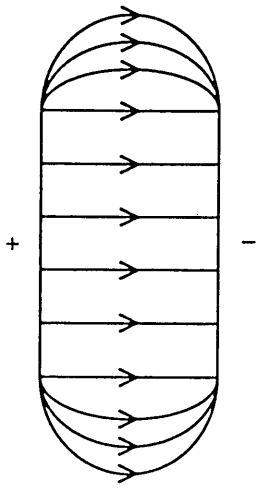

Figure 3

(i) Write a formula for the capacitance of this capacitor in terms of the area of the plates, A, and, d, their distance apart.

_____

_____

[1 mark]

(ii) Hence show that the energy per unit volume, U, of the capacitor is given by $U = \frac{\varepsilon_0 E^2}{2}$ where ε_0 is the permittivity of free space.

_____

_____

_____

_____

_____

[3 marks]

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(c) A parallel-plate capacitor has area A = 20.0 cm^2 and a plate separation d = 4.5 mm. The electric field strength, E, is 3 x 10^6 V m^{-1}. Calculate the

(i) capacitance in air

[2 marks]

(ii) energy per unit volume, U

[3 marks]

Total 10 marks

4. (a) Figure 4 shows how the value of an alternating current changes with time.

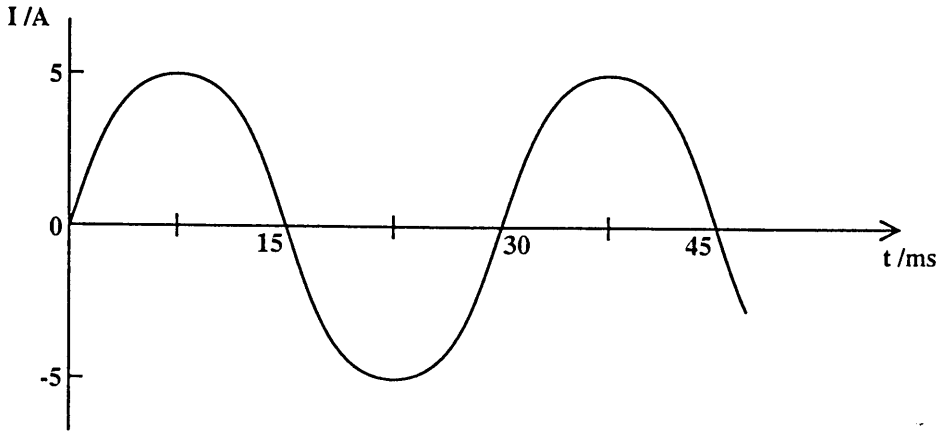

Figure 4

Find the

(i) amplitude of the current

_____

[1 mark]

(ii) period

_____

_____

[1 mark]

(iii) frequency.

_____

_____

[1 mark]

(b) For the waveform represented in Figure 4, write an equation which represents how the alternating current, I, varies with time, t.

_____

_____

_____

[2 marks]

(c) A diode is connected in series with a resistor of resistance, R, to an a.c. supply as shown in Figure 5.

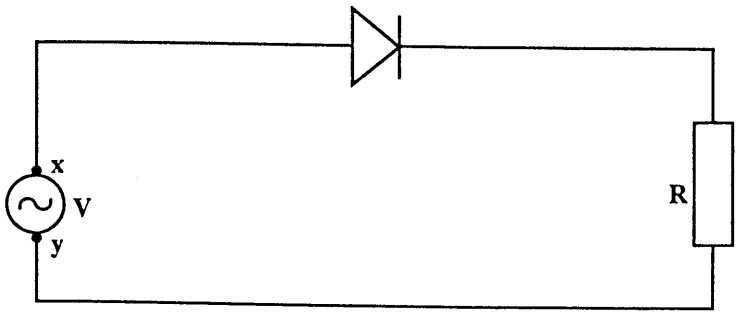

Figure 5

(i) Sketch a graph to show how the current varies as it flows through the resistor.
[2 marks]

(ii) To smoothen the rectified potential difference across the resistor, a capacitor is placed in the circuit of Figure 5. Indicate on Figure 5 where you would place this capacitor.
[1 mark]

(iii) Show on the graph you sketched in part (c) (i) the effect on the current of placing the capacitor in the circuit.
[1 mark]

(iv) On the sketched graph, label the region where the capacitor is being charged.
[1 mark]

Total 10 marks

5. (a) A transformer is a device that uses mutual induction to change a given a.c. voltage into a larger or smaller a.c. voltage. With the aid of a labelled diagram explain the principle of operation of an ideal transformer.

[5 marks]

(b) An ideal transformer steps up the voltage supplied to it by a generator. The generator supplies a current of 15 A at 500 V. This voltage is stepped up to 10 000 V and transmitted along a transmission cable of total resistance 20 Ω. On reaching the consumer this voltage is stepped back down to 500 V.

Calculate the

(i) current in the transmission cable

[1 mark]

(ii) power lost in the transmission cable

[2 marks]

(iii) percentage power lost in the transmission cable if the voltage was not stepped up.

[2 marks]

Total 10 marks

6. Figure 6 shows a logic network.

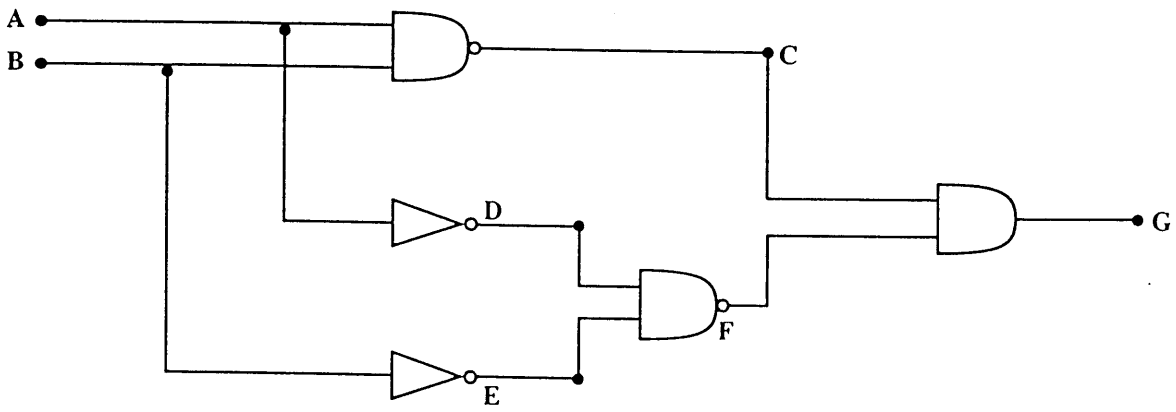

Figure 6

(a) Draw a truth table for this network.

[5 marks]

(b) Design a logic network using a combination of AND and NOR gates to give the same output as in part (a) (i).

[3 marks]

(c) Name and draw the single gate which is equivalent to the network in (i) and (ii).

_____

[2 marks]

Total 10 marks

7. Figure 7 shows the energy level diagram which represents the four lowest energy levels of atomic hydrogen.

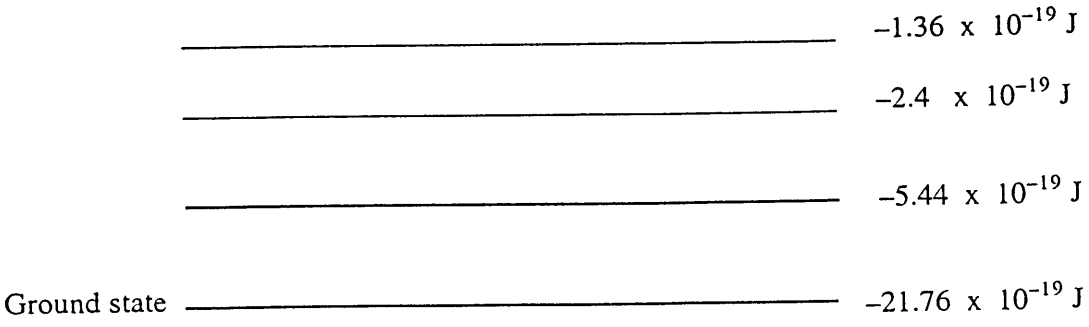

Figure 7

(a) Why are the energy values of these levels negative?

[2 marks]

(b) (i) An incoming electron of kinetic energy 20.0×10^{-19} J collides inelastically with the hydrogen electron in its ground state. Indicate, by means of vertical arrows on the left side of the energy level diagram, possible transitions of the hydrogen electron which can occur as a result of this collision. **[2 marks]**

(ii) What becomes of the incident electron?

[1 mark]

(c) (i) An incoming photon of wavelength 1.02×10^{-7} m collides with a similar hydrogen electron in its ground state also. Calculate the energy of this photon.

[2 marks]

(ii) Indicate on the right side of the energy level diagram the possible level(s), to which the absorbing electron rises. **[1 mark]**

(iii) What becomes of the incident photon?

_____

[1 mark]

(iv) State what would be the case in (c)(i) if the photon had a shorter wavelength of 0.95×10^{-7} m.

_____

_____

[1 mark]

Total 10 marks

8. (a) Complete the following nuclear reactions.

(i) $^{2}_{1}H + {}^{3}_{1}H = {}^{4}_{2}He +$ _____

(ii) $^{235}_{92}U + {}^{1}_{0}n = {}^{148}_{57}La + {}^{85}_{35}Br +$ _____ **[2 marks]**

(b) Using the given masses below

Masses:

$^{2}_{1}H = 3.345 \times 10^{-27}$ kg

$^{3}_{1}H = 5.008 \times 10^{-27}$ kg

$^{4}_{1}He = 6.647 \times 10^{-27}$ kg

$^{1}_{0}n = 1.673 \times 10^{-27}$ kg

$^{235}_{92}U = 390.173 \times 10^{-27}$ kg

$^{148}_{57}La = 245.565 \times 10^{-27}$ kg

$^{85}_{35}Br = 140.960 \times 10^{-27}$ kg

(i) Calculate the energy released in EACH of the reactions give in Part (a).

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_____

[3 marks]

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(ii) Calculate the energy released per unit mass of combining nuclides for EACH of the reactions given in Part (a).

[2 marks]

(c) (i) Give ONE problem associated with using reaction (a) (i) as a source of energy.

[1 mark]

(ii) Give ONE problem associated with using reaction (a) (ii) as a source of energy.

[1 mark]

(iii) How can the second reaction be controlled?

[1 mark]

Total 10 marks

9. (a) For radioactive decay $A = \lambda N$.
Give the name of EACH term and the corresponding S.I. Unit in this relationship.

Term	Name of Term	S.I. Unit
(i) A		
(ii) λ		
(iii) N		

[3 marks]

(b) (i) Radioactivity decay is a random process yet a strict mathematical law $N = N_0 \exp(-\lambda t)$ applies. State the physical condition which ensures a good though not exact obedience to this law.

_____

[1 mark]

(ii) Calculate the number of atoms in 1g of $^{226}_{88}Rn$.

_____

_____

_____

_____

_____

[1 mark]

(c) (i) A particular radioactive element has half-life of 100 years. Calculate its value of λ.

_____

_____

_____

_____

_____

[2 marks]

(ii) After how many years will it take a whole year for this element to emit the same number of particles as it does in one day now?

1 year = 365 days.

[3 marks]

Total 10 marks

END OF TEST