TEST CODE **02238010**

FORM TP 2006265

MAY/JUNE 2006

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

1. (a) (i) What is the physical reason for copper being a better conductor than a material such as nichrome which is used to make resistors?

_____

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_____

(ii) Sketch a graph to show how the resistance per unit length of a wire varies with the cross-sectional area of the wire.

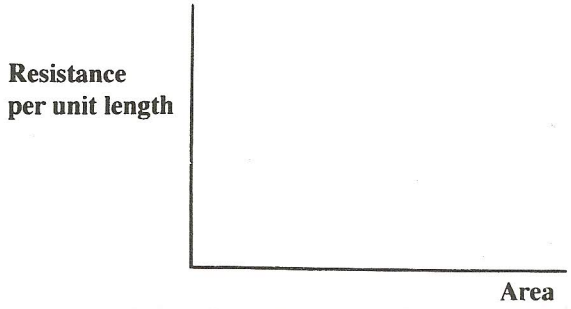


Figure 1

(iii) Write an equation relating the resistance per unit length to the area of the wire.

[3 marks]

(b) A small heater is constructed from nichrome wire with a diameter of 0.45 mm. The heater produces heat at a rate of 25 W from a 9 V supply.

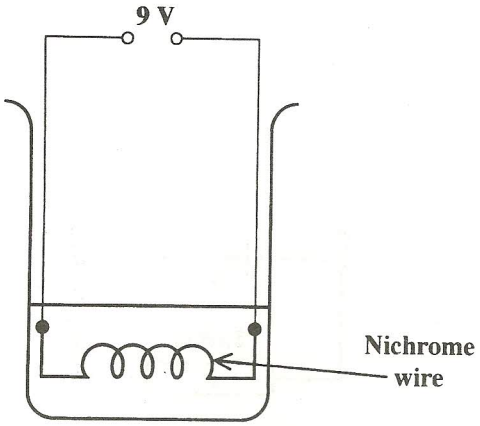


Figure 2

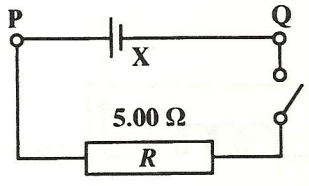
(i) What is the resistance of the heater?

(ii) The length of nichrome wire required to make the heater is 42 cm. Calculate the resistivity of nichrome, remembering to give the correct unit.

[7 marks]

Total 10 marks

2. (a) Complete the circuit below to show how a slide-wire potentiometer could be set up to compare the p.d. across PQ with the switch open to the p.d. when the switch is closed.



[4 marks]

(b) The potentiometer is calibrated so that the p.d. across its 1.00 m wire is 2.00 V.

(i) When the switch is open the balance length is found to be 54.2 cm. What is the e.m.f. of the cell X?

[2 marks]

(ii) When the switch is closed the balance length changes to 36.6 cm. Given that the resistance of R is 5.00 Ω, determine the internal resistance of the cell X.

[4 marks]

Total 10 marks

3. (a) Describe briefly, with the aid of a diagram, a practical application of electrostatics.

_____

_____

_____

_____

[2 marks]

(b) The gowns worn in the operating theatre of a hospital are never made of synthetic materials such as nylon. Suggest a reason for this.

_____

_____

_____

[2 marks]

(c) An electric field is set up by applying a high voltage between two parallel metal plates 1.5 mm apart.

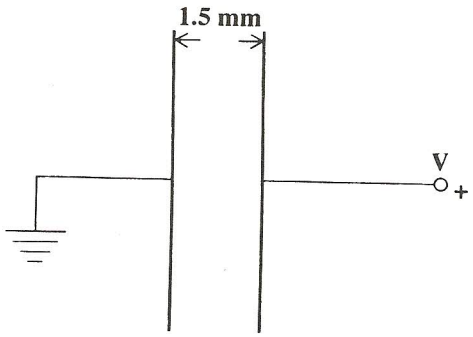


Figure 3

(i) Complete the diagram in Figure 3 to show the electric field between the plates.

[1 mark]

(ii) If the electric field is strong enough sparks will pass through the air between the plates. Explain this process.

_____

_____

_____

_____

[2 marks]

(iii) Calculate the magnitude of the greatest voltage which may be applied to the plates without causing sparks. The breakdown field strength of dry air is 3×10^6 V m^{-1}.

[3 marks]

Total 10 marks

4. (a)

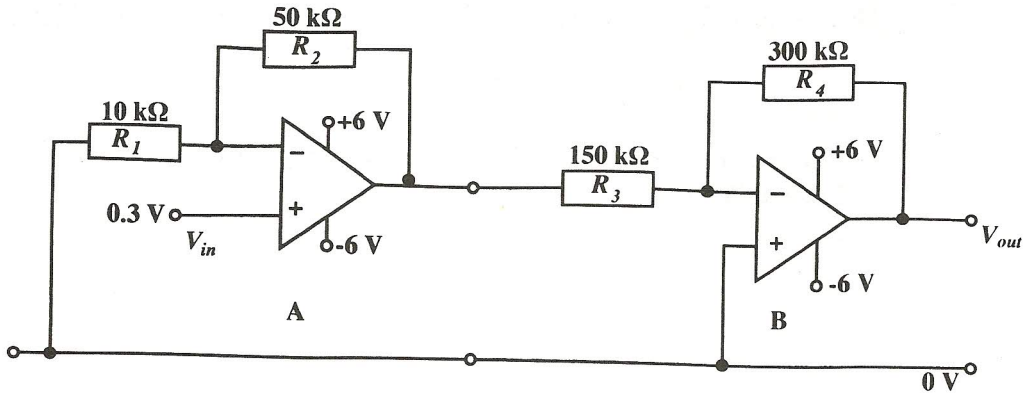


Figure 4

(i) Write the formula for the gain of each of the amplifiers which are cascaded in the diagram above.

A Gain =

B Gain =

[2 marks]

(ii) Mark with an X any point or points on the circuits above which would be regarded as a virtual earth. **[1 mark]**

(iii) If the input voltage is 0.3 V what is the output voltage, V_{out} ?

[3 marks]

(b) Three signals V_1, V_2 and V_3 are to be combined to produce an output V_{out} such that

$$V_{out} = -2V_1 - 8V_2 - V_3$$

Design a circuit to achieve this objective using only resistors with values between 15 kΩ and 200 kΩ.

[4 marks]

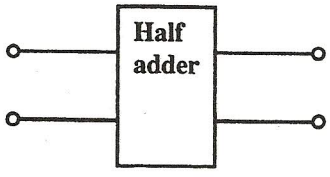
Total 10 marks

5. (a) In the space below draw a circuit diagram to show how a half-adder can be constructed from three other logic gates. Also draw up a truth table to show how it functions.

Input 1	Input 2		

[3 marks]

(b) Complete the circuit below to show how two half-adders and a logic gate may be connected to produce a full-adder.



[2 marks]

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(c) (i) Complete the truth table to show the action of the circuit as shown in Figure 5.

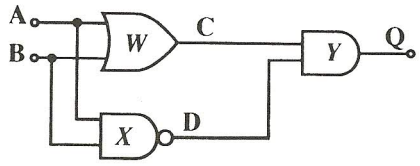

Figure 5

A	B	C	D	Q

[3 marks]

(ii) State the name of the single logic gate which could replace this circuit and draw its usual symbol.

Name _____

Symbol

[2 marks]

Total 10 marks

6. (a) An alternating signal is represented by the equation:

$V = 150 \sin (400 \pi t)$ (V is in mV and t in seconds.)

(i) What is the frequency of the signal?

[1 mark]

(ii) What is the period?

[1 mark]

(iii) Find the r.m.s. voltage of the signal.

[2 marks]

(iv) Using the axes below, draw the graph to show how the voltage varies with time.

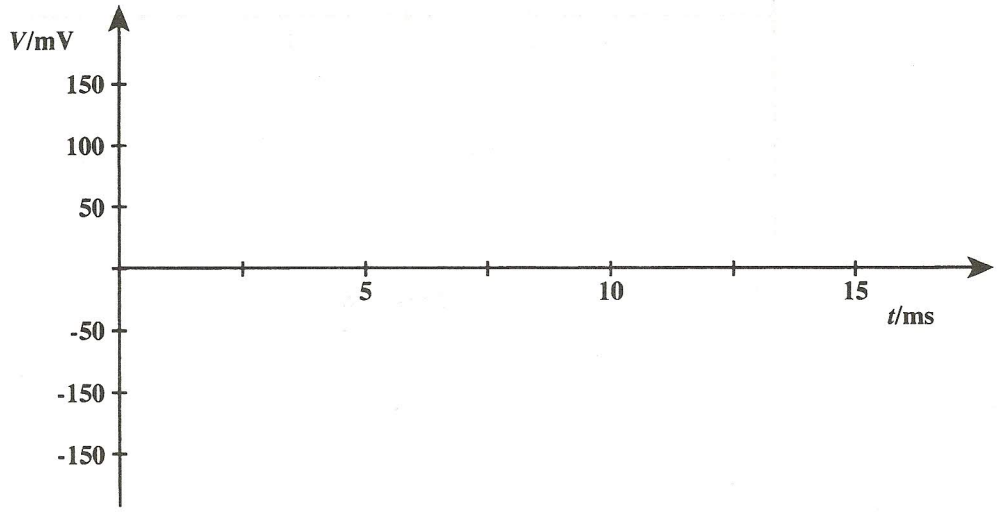

Figure 6

[3 marks]

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(b)

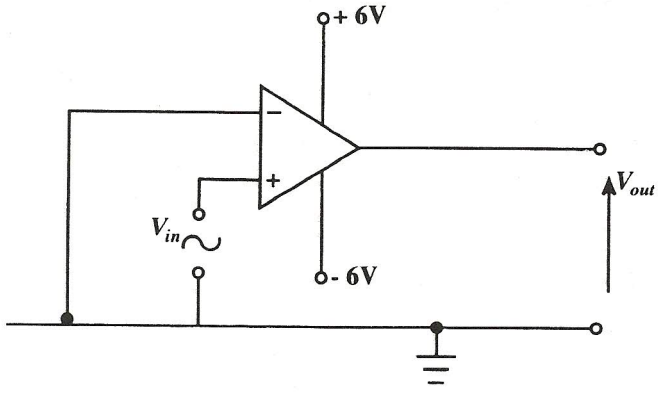

Figure 7

The signal in (a) is applied to the non-inverting terminal of an operational amplifier as shown in Figure 7.

Using the axes below, draw a graph to show how the output varies with time. Show clearly the scale on the vertical axis.

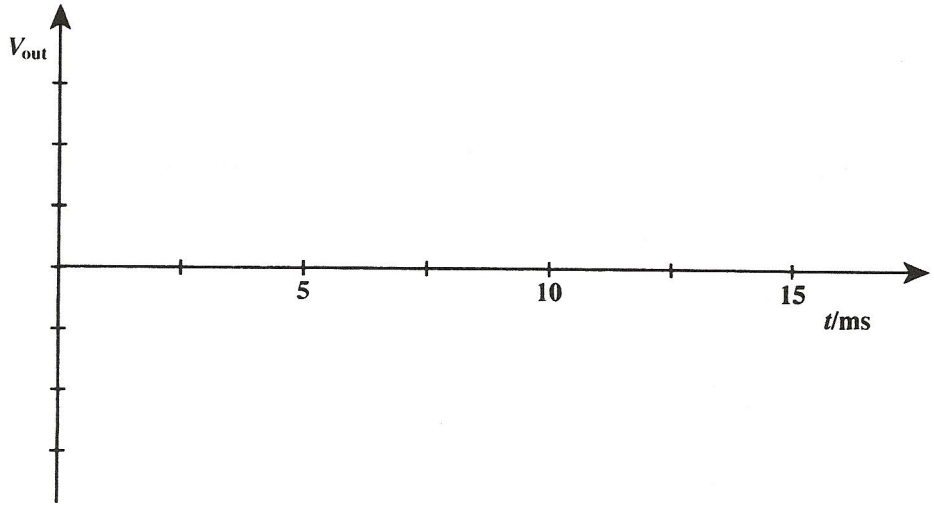

Figure 8

[3 marks]

Total 10 marks

7. (a) Thorium-232 is radioactive and emits α-particles. The daughter product Radium-228 is also radioactive but it decays by β -particle emission. Complete the following equations for these decays:

$$^{232}_{90}Th \rightarrow ^{228}_{88}Ra +$$

$$^{228}_{88}Ra \rightarrow \qquad Ac +$$

[3 marks]

(b) (i) Derive an equation for the radius R of the circular path of a particle with mass, m, and charge, q, moving with a velocity, v, at right angles to a uniform magnetic field, strength B. **[3 marks]**

(ii) An α-particle and a β-particle move with the same velocity through the same perpendicular magnetic field. If the radius of the α-particle's path is 0.40 m what will that of the β-particle be?

[3 marks]

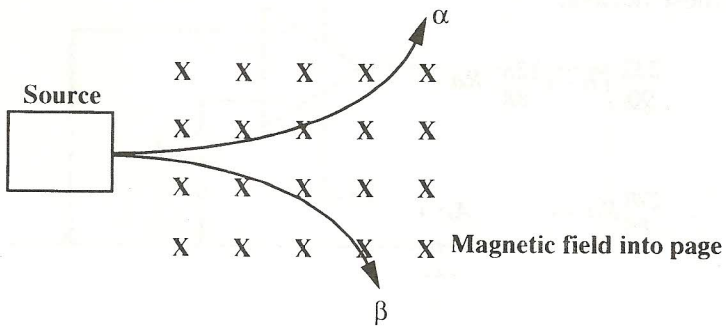

Figure 9

(c) Diagrams similar to the one above are often seen in textbooks. Explain why the diagram is unrealistic.

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_____

_____

[1 mark]

Total 10 marks

8. Figure 10 illustrates an electron beam tube used for observing electron diffraction.

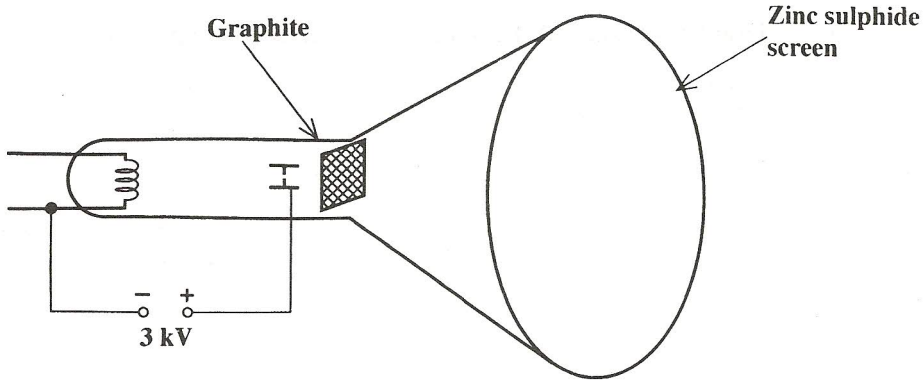

Figure 10

(a) The accelerated electrons are diffracted by the sheet of graphite. Show on the diagram in Figure 10 what you would expect to see on the screen. **[2 marks]**

(b) How fast are the electrons travelling when they have been accelerated through a p.d. of 3000 V ? **[3 marks]**

(c) Calculate the wavelength of the electrons which are emitted from the anode. **[3 marks]**

(d) What changes to the image on the screen would be observed if the accelerating voltage were reduced? **[2 marks]**

Total 10 marks

9. In the Rutherford scattering experiment, which established the concept of the nuclear atom, alpha particles were fired at very thin pieces of gold foil.

(a) (i) Draw a diagram of the apparatus used in this experiment.

(ii) Suggest a reason why the experiment was conducted in a vacuum.

_____

_____

_____

[3 marks]

(b) Complete the table below by adding the conclusions which may be drawn from the observations made in the experiment.

Observation	Conclusion
The vast majority of the alpha particles passed through the gold foil without being deflected.	
Some alpha particles were deflected through large angles as they passed through the gold foil.	
A very small number of alpha particles did not penetrate the foil and were detected on the same side of the foil as the α-particle source.	

[3 marks]

(c) The electrons around the nucleus may have only certain allowed energies as shown in the diagram below for a mercury atom. When an electron is in one of the higher, excited, energy states it eventually moves to a lower level and emits a photon of light. Find the wavelength of the light emitted when an electron jumps from Level 3 down to Level 2.

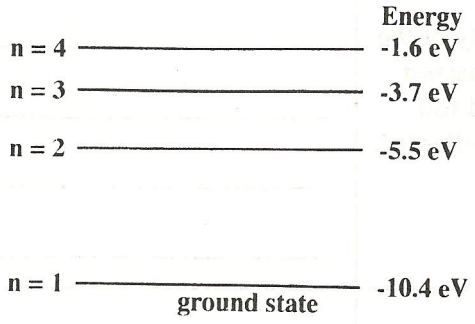

Figure 11

[4 marks]

Total 10 marks

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