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SECTION I (One hour)

Answer all questions in this section .

1. The speed of light, C is related to the permeability μ_o and permittivity, ε_o, by the expression

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

(i) Show that this equation is homogenous.

(ii) Calculate the magnitude of ε_o. **(8 marks)**

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2. In figure 1 the currents in the 3 Ω resistor and R are 1.5 A and 0.5A respectively.

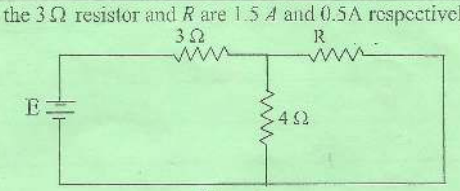

Figure 1

Calculate:

(i) The emf of the battery?

(ii) The resistance of R. **(6 marks)**

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3. (i) Explain why it is preferable to describe elastic behaviour of materials in terms of stress-strain rather than force - extension.

(ii) Figure 2. is a graph of the extension and contraction of a rubber band. Calculate the work done in this process.

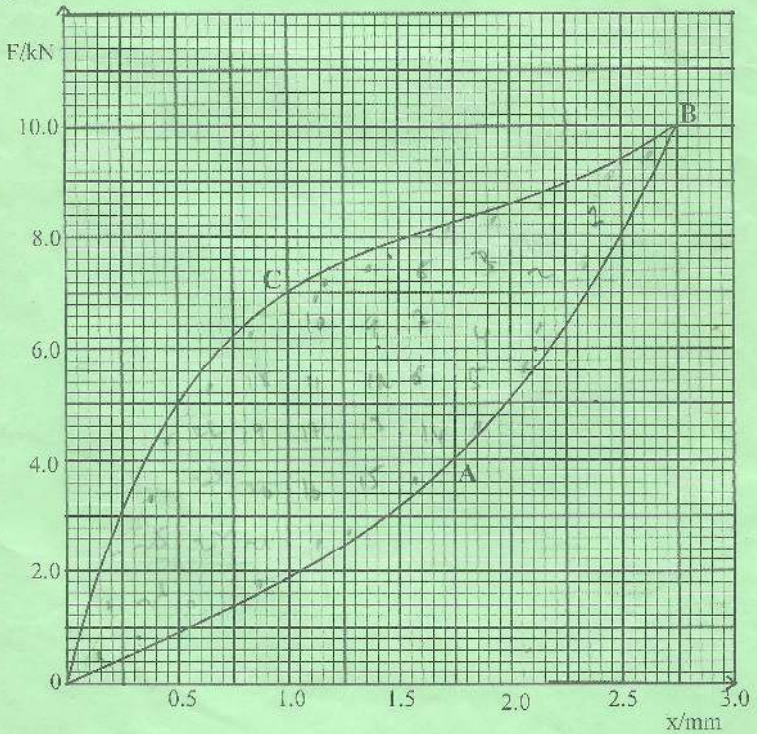

Figure 2.

(6 marks)

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4. A drill using a current of 1.5*A* when connected to a mains supply of 240V makes a round hole in a piece of iron of mass *M*. In one minute 75% of the electrical energy is converted to the internal energy of the iron which causes a rise in temperature of 20° C. If the specific heat capacity of iron is 460J kg^{-1} K^{-1},

(i) Calculate the mass *M* of the piece of iron.
(ii) State any assumptions that you have made.

(5 marks)

5. (a) Sketch
(i) The transfer.
(ii) The input.
(iii) The output.
Characteristics for an n – p – n transistor.
(b) Explain how one of these characteristics may be used to calculate the current gain for the transistor.

(8 marks)

6. Figure 3 shows the path a ray of light would follow in an optical fibre whose core has a refractive index n_1 and cladding n_2.

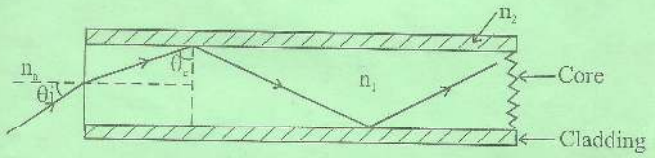

Figure 3

The angle of incidence and the critical angles are θ_i and θ_c respectively.

(i) What is meant by the critical angle?
(ii) State and explain whether n_1 is less than or greater than n_2.
(iii) The refractive index for glass is 1.5. Calculate θ_c

(6 marks)

7. The mercury-in-glass thermometer and the constant volume gas thermometer can be used to measure temperatures.
(i) Explain why the constant volume gas thermometer could give readings in degree Celsius and the mercury –in- glass thermometer gives readings in degrees Celsius too.
(ii) The two thermometers may give different readings when immersed in a volume of liquid. Explain why?

(6 marks)

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SECTION II (one and a half hours)

Answer all questions

Answer either 8 (a), (b) and (c) or 8 (d) ,and (e).

EITHER 8 (a), (b) and (c)

8. (a) Describe an experiment to show that for a constant force, the mass of a body is inversely proportional to its acceleration. State clearly how you would minimise errors in measurements and how you would arrive at the required result from your measurements. **(8 marks)**

(b) A ball X of mass 400 g travelling at 2.5 m s^{-1} makes an elastic and head-on collision with a second identical, stationary ball Y. They remain in physical contact for 60 μs.

(i) What does elastic collision mean?

(ii) Calculate the velocity of X and Y after the collision.

(iii) Find the average force exerted by X during the collision. **(9 marks)**

(c) Figure 4 shows a ball propelled from a point A. The ball moves with constant velocity, hits a wall B and moves back to A with the same velocity. The ball is in physical contact with the wall for a time interval Δt. Sketch a graph of the momentum of the ball against time for the movement of the ball.

(3 marks)

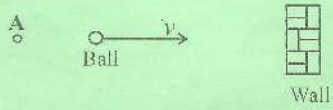

Figure 4

(Total = 20 marks)

OR 8 (d), and (e)

(d) Describe how you would measure the specific heat capacity of a liquid. Describe the procedure you would use to make allowance for heat losses, and how you would derive the specific heat capacity from your measurements.

(10 marks)

(e) The kinetic theory of ideal gases leads to the equation:

$$P = \frac{1}{3}\rho\,\overline{C^2}$$

where P is the pressure, ρ is the density and $\overline{C^2}$ is the mean square speed of the molecules. State the assumptions used to derive this result. **(6 marks)**

(ii) Hence, derive the equation. **(4 marks)**

(Total = 20 marks)

Answer either 9 (a) (b) and(c) or 9(d) (e) and (f)

EITHER 9 (a),(b) and (c)

9. (a) A radioactive source emits both alpha and beta radiations.

(i) What does it mean for a substance to be radioactive.

(ii) State and explain how you would distinguish between the two types of radiations. **(6 marks)**

(b) Figure 5 shows a graph of the natural logarithm of the activity of a radioactive element plotted against time in minutes.

Sketch the set-up from which such results could have been obtained. **(4 marks)**

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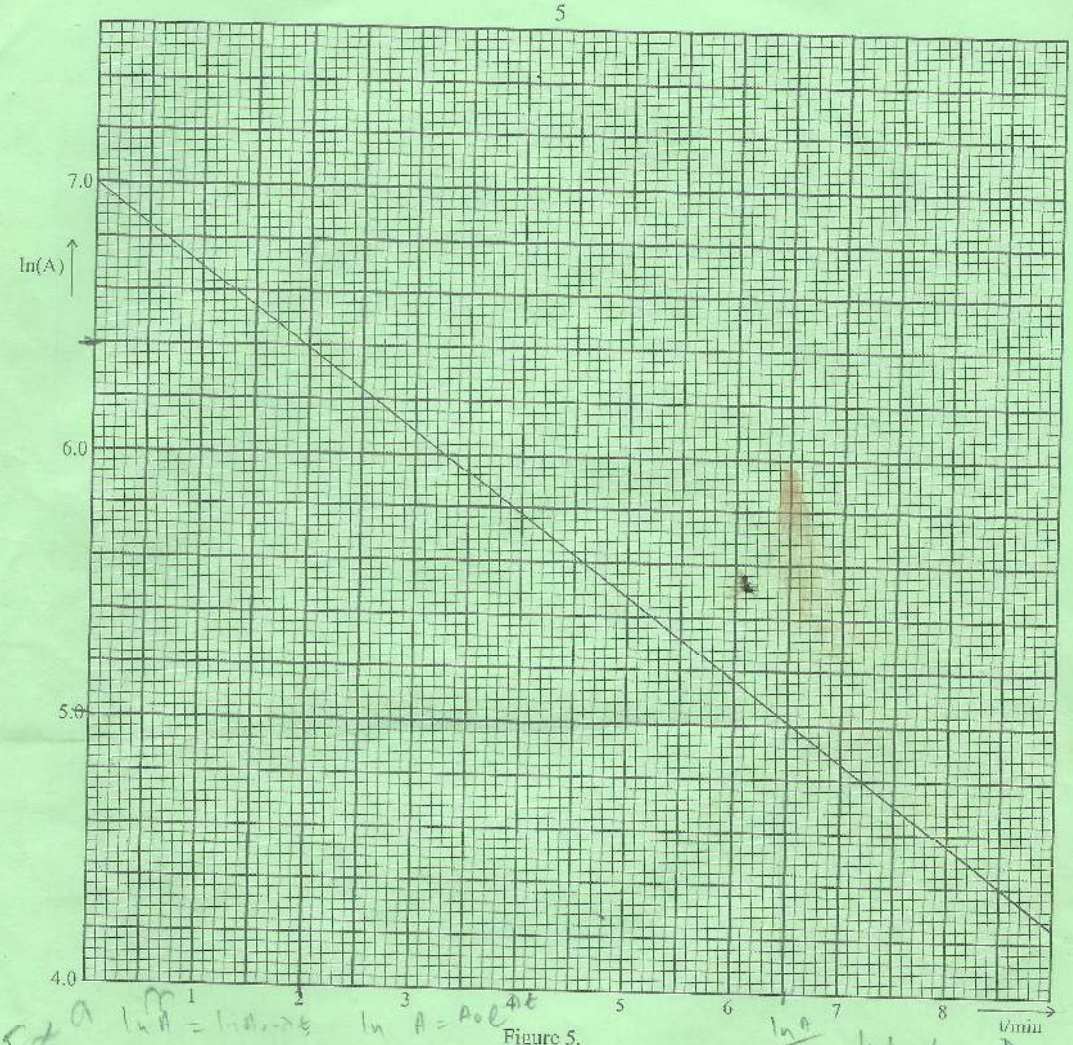

Figure 5.

(c) (i) Use the graph to obtain a value for the half-life of the sample.
(ii) Use the graph to calculate the initial activity of the sample.

(10 marks)

OR 9 (d) (e) and (f)

(Total = 20 marks)

(d) (i) What is a capacitor?
(ii) In what ways is a capacitor
(a) similar to
(b) different from a diode?

(5 marks)

(e) A capacitor, charged fully with a battery of 10 V is discharged through a resistor. Figure 6. shows how the current varies with the time.
(i) Sketch an electric circuit from which such results would have been obtained.

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(ii) Use the graph to estimate the initial charge on the capacitor and hence, or otherwise, estimate its capacitance.

(iii) Calculate the time constant for the capacitor. **(13 marks)**

(f) How will the graph be affected if the resistance R in the circuit is doubled? Explain your answer.

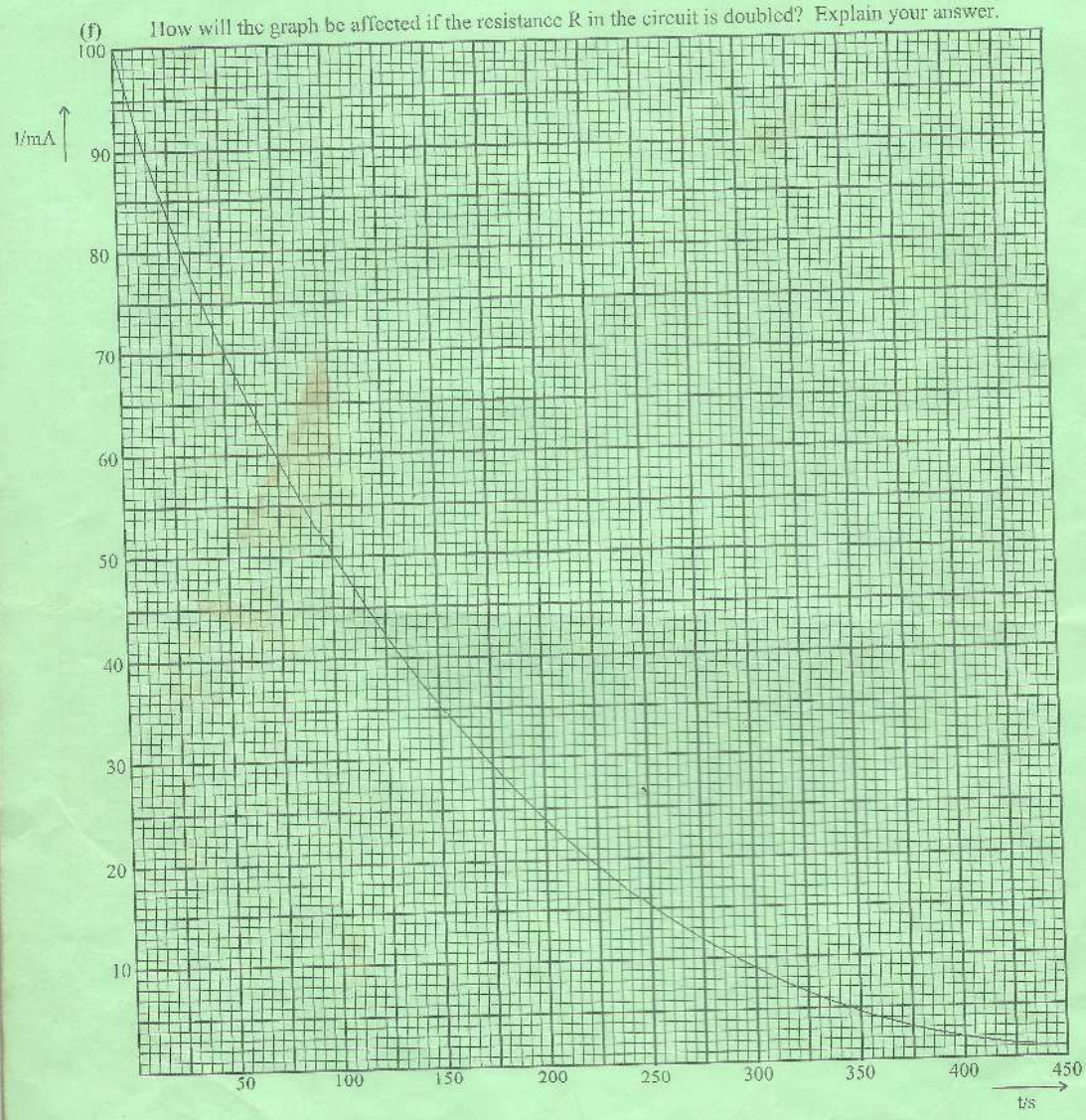

Figure 6.

(2 marks)

(Total = 20 marks)

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Answer Either 10 (a), (b) and (c) or 10 (d) , (e), and (f)

EITHER 10 (a), (b) and (c)

10. (a) Explain what is meant by the terms:
   (i) Displacement,
   (ii) Wave Speed,
   for a mechanical wave. **(2 marks)**

(b) Distinguish clearly between stationary waves and progressive waves with references to the following characteristics of waves:
   (i) Amplitude
   (ii) Frequency
   (iii) Wavelength
   (iv) Phase
   (v) Wave form
   (vi) Energy transmitted. **(12 marks)**

Diffraction and Interference are phenomena exhibited by waves. State clearly the differences between these two phenomena. **(3 marks)**

(c) A laser is used to produce young fringes with slits separated by 0.50 mm. The screen is 1.0 m from the slits and 10 fringe separations occupy 12.5 mm. What is the wavelength of the laser light? **(3 marks)**

(Total = 20 marks)

OR 10 (d),(e) and (f)

10 (d) Electrons can be emitted from the surface of zinc by ultraviolet light but not by visible light. On the other hand, electrons can be emitted from potassium even by visible light.
   (i) Explain why visible light cannot cause electrons to be emitted from the surface of zinc whereas ultraviolet light does?
   (ii) If both metals were illuminated with ultraviolet light of the same frequency, how will the energies of electrons emitted from the zinc and potassium surfaces differ. **(4 marks)**

(e) Explain each of the following:

   (iii) If the intensity of the ultraviolet light directed at a piece of zinc is doubled, the number of electrons leaving the surface per second also doubles but the maximum kinetic energy is uncharged.
   (iv) The maximum kinetic energy of photoelectrons is directly proportional to the difference between the frequency of light falling on the surface and the threshold frequency for that metal.
   (v) Gamma photons are more harmful to people than infrared photons.

(11 marks)

(f) Calculate the wavelength of the photon emitted when an electron makes a quantum jump from the n=3 state to the ground state of the hydrogen atom. The energy at the state n = 3 is –1.51eV and that at the ground state is -13.6 eV.

(5 marks)

(Total = 20 marks)
