

THE UNITED REPUBLIC OF TANZANIA
NATIONAL EXAMINATIONS COUNCIL
ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

131/2

PHYSICS 2
(For Both School and Private Candidates)

Time: 2½ Hours

Monday 17 May 2004 a.m.

Instructions

1. This paper consists of sections A, B and C.
2. Answer five (5) questions choosing at least one (1) question from each of the sections A, B and C.
3. All questions carry equal marks.
4. Mathematical tables and unprogramable calculators may be used.
5. Cellular phones are **not** allowed in the examination room.
6. Write your Examination Number on every page of your answer booklet(s).
7. The following information may be useful.
 - (a) Acceleration due to gravity $g = 9.8 \text{ ms}^{-2}$
 - (b) Radius of Earth $R_e = 6.4 \times 10^6 \text{ m}$
 - (c) Young's modulus of copper wire $E_{\text{cu}} = 1.1 \times 10^{11} \text{ Nm}^{-2}$
 - (d) Molar gas constant $R = 8.3 \text{ Jmol}^{-1}\text{K}^{-1}$
 - (e) 1 atmosphere pressure $P = 1.01 \times 10^5 \text{ Nm}^{-2}$
 - (f) Planck's constant $h = 6.63 \times 10^{-34} \text{ Js}$
 - (g) Speed of light in Vacuo $C = 3 \times 10^8 \text{ ms}^{-1}$
 - (h) $1 \text{ eV} = 1.6 \times 10^{-19} \text{ C}$
 - (i) Mass of ${}_{92}\text{U}^{238} = 3.94 \times 10^{-25} \text{ Kg}$
 - (j) Mass of ${}_2\text{He}^4 = 6.63 \times 10^{-27} \text{ Kg}$
 - (k) $1 \text{ \AA} - \text{angstrom unit } \text{\AA} = 10^{-10} \text{ m}$
 - (l) Moment of inertia of disc about centre $I = \frac{1}{2} MR^2$
 - (m) Mass of electron $m_e = 9.1 \times 10^{-31} \text{ Kg}$.

This paper consists of 7 printed pages.

SECTION A

1. (a) What do you understand by the terms:

- (i) Gravitational potential of the earth?
- (ii) Gravitational field strength of the earth?

State the relationship between the two quantities stated in 1.(a)(i) and 1.(a)(ii).

(3 marks)

- (iii) Explain briefly the fact that at one point on the line between the earth and the moon, the gravitational field caused by two bodies is zero. (01 mark)

- (b) (i) Sketch graphs to show how the gravitational force and gravitational potential on a rocket varies as it moves from the earth towards the moon in a straight line. (06 marks)

- (ii) A satellite of mass m kg is moving around the earth with a speed V_{ms}^{-1} in a circular orbit of radius R metres. Develop an expression for its kinetic energy in the orbit in terms of m , mass of the earth M_E and the universal gravitational constant G . (02 marks)

- (iii) Write down the expression for the p.e. and the total energy of the satellite in the orbit. (02 marks)

- (c) If the earth's gravitational field is not uniform over large distances, what is the longest period of a simple pendulum on the earth's surface? (06 marks)

2. (a) (i) Define the moment of inertia of a body. (01 mark)

- (ii) State the parallel axes theorem for moments of inertia. (02 marks)

- (b) (i) What is a torque τ ? (01 mark)

- (ii) A uniform disc of radius R and mass M is mounted on an axle supported in fixed frictionless bearings. A light cord is wrapped around the rim of the wheel and a mass m is attached at the end of the cord. Find the angular acceleration of the disk using the relation $\tau = \frac{dL}{dt}$ and hence the tension in the cord. (06 marks)

- (c) (i) State the principle of conservation of angular momentum. (01 mark)

- (ii) Account for the motion of the top. (02 marks)

- (iii) A boy stands on a platform that can only rotate about a vertical axis holding an axle of a rim - loaded bicycle wheel with its axis vertical. The wheel is spinning about this vertical axis with angular speed ω_0 but the boy and the platform are at rest. The boy tries to change the direction of rotation of the wheel. What will happen? (07 marks)

3. (a) (i) Define tensile stress and tensile strain. (02 marks)

- (ii) Calculate the work done in stretching a copper wire 100 cm long and 0.03 cm^2 cross-sectional area when a load of 120 N is applied. (04 marks)

- (b) (i) Explain how the conservation of energy principle applies to a ball bouncing a wall. (02 marks)

- (ii) A weighing pan of mass 200 g when empty stretches a coil spring by 10 cm. When a lump of putty of mass 250 g is now dropped from rest into the pan from a height of 30 cm, what maximum distance will the pan move downwards? (04 marks)
- (c) (i) State Bernoulli's principle and the equation of continuity. (02 marks)
- (ii) Distinguish between "dynamic lift" and 'upthrust'. (02 marks)
- (iii) A bat of mass 1100 g hovers upwards by beating its wings of effective area 0.4 m^2 . Estimate the velocity imparted to the air by the beatings of the wings. Assume the air to be at s.t.p. weather conditions. (04 marks)
4. (a) (i) Define the bulk modulus of a gas. (01 mark)
- (ii) Find the ratio of the adiabatic bulk modulus of a gas to that of its isothermal bulk modulus in terms of the specific heat capacities of the gas. (02 marks)
- (b) (i) State the assumptions that are made for the kinetic theory. (03 marks)
- (ii) Given a hollow cube of side 10 cm containing 10^{22} oxygen molecules at constant pressure having a translational speed of 500 m/s, calculate the pressure of the gas in mm Hg if each molecule has a mass of $5 \times 10^{-26} \text{ kg}$. (05 marks)
- (c) (i) A gas expands adiabatically and its temperature falls while the same gas when compressed adiabatically its temperature rises. Explain giving reasons why this happens. (02 marks)
- (ii) A mole of oxygen at 280 K is insulated in an infinitely flexible container. The atmospheric pressure outside the container is $5 \times 10^5 \text{ Nm}^{-2}$. When 580 J of heat is supplied to the oxygen the temperature increases to 300 K and the volume of the container increases by $3.32 \times 10^{-4} \text{ m}^3$. Calculate the values of the principal molar heat capacities and the specific universal gas constant. (07 marks)
- [Molar mass of oxygen = $32 \times 10^{-3} \text{ kg}$]

SECTION B

5. (a) Distinguish between diffraction and interference. (02 marks)
- (b) A monochromatic beam of light is directed normally on a slit and an image of the slit is focused on a screen by a lens.
- (i) Sketch a diagram of the intensity pattern that is produced on the screen. (02 marks)
- (ii) How will the pattern appear if two identical slits are used? Explain. (02 marks)
- (c) In a Young's double slit experiment, the distance between the centre of the interference pattern and the 10th bright fringe on either side is 3.44 cm and the distance between the slits and the screen is 2.0 m. If the wavelength of the light used is $5.89 \times 10^{-7} \text{ m}$, determine the slit separation. (04 marks)
- (d) A parallel beam of light of wavelength 589 nm was directed normally on to a plane diffraction grating. Measurements showed that the angle between the 1st order spectra on either side of the normal was 34.2° .

- (i) Calculate the number of lines per millimetre on the grating. (04 marks)
- (ii) How many diffraction orders will be visible? (01 mark)
6. (a) State Faraday's law of electromagnetic induction. (02 marks)
- (b) Explain the following:
- (i) A moving coil galvanometer has its coil wound on a light metal frame. (03 marks)
- (ii) The core of the armature of a dynamo is laminated. (03 marks)
- (c) (i) Derive an expression for the emf induced in a disc of radius r rotating in a uniform magnetic field of flux density B at a constant angular velocity ω . (03 marks)
- (ii) Find the rate of rotation of a wheel if the wheel with metal spokes 1.2 m long is rotated in a magnetic field of flux density 5×10^{-5} T normal to the plane of the wheel has an emf of 10^{-2} V induced between its rim and the axle. (03 marks)
- (d) (i) In measuring the magnetic flux density inside the gap of a large electromagnet, a search coil connected to a ballistic galvanometer was placed with its plane normal to the flux and then withdrawn to a position where the flux density is negligible. If A , N and R are the area, number of turns of the coil and the total resistance of the circuit respectively, determine the charge flowing through the circuit in terms of A , N , R and the flux density B . (05 marks)
- (ii) A coil of 50 turns having an area of $5 \times 10^{-5} \text{ m}^2$ and a resistance of 20Ω gives the same throw of the galvanometer as that when a $1 \mu\text{F}$ capacitor charged to 110V discharged through it. What is the flux density in the coil? (03 marks)
7. (a) (i) Define the reactance of a capacitor. (01 mark)
- A constant a.c. supply is connected to a series circuit consisting of a resistance of 300Ω and a $6.67 \mu\text{F}$ capacitor having a $\frac{3000}{2\pi}$ Hz frequency supply.
- (ii) Derive an expression for the current flowing in the circuit. (03 marks)
- (iii) It is desired to reduce the current in the circuit to half its value by connecting an additional resistance in series. Calculate the magnitude of this extra component. (06 marks)
- (b) (i) Explain the term capacitance. (01 mark)
- (ii) Derive the expression for the energy stored in a capacitor of capacitance C (F) carrying a charge Q (C). (02 marks)
- (c) A parallel plate capacitor with air as the dielectric has a capacitance of $3.0 \mu\text{F}$. If the space between the plates is filled with an insulating material of dielectric constant 2, what is the change in the energy stored if:
- (i) The p.d. between the plates is kept constant at 150 V. (04 marks)
- (ii) The charge on the plates is kept constant at $5 \times 10^{-7} \text{ C}$. (03 marks)

SECTION C

8. (a) (i) Write down Eienstein's photoelectric equation and explain the symbols used. (02 marks)
- (ii) The frequency of incident radiation on a metal surface is 5×10^{14} Hz and electrons with maximum energy of 2.3×10^{-19} J are emitted. What wavelength of incident radiation is required to liberate electrons with maximum energy of 5.6×10^{-19} J? (04 marks)

- (b) Some energy levels of a mercury atom are shown below.

Level	energy in eV
	0
4	-1.6
3	-3.7
2	-5.5
1	-10.4

Calculate:

- (i) The ionisation energy of a mercury atom in Joules. (02½ marks)
- (ii) The wavelength of radiation emitted when an electron moves from level 4 to level 2. (02½ marks)
- (c) Explain what is meant by the wave-particle duality. How are the two aspects related? (02 marks)
- (d) Calculate the de Broglie wavelength of:
- (i) an electron with ke of 54 eV. (04 marks)
- (ii) a 45 g golf ball travelling with a speed of 25 m/s. (03 marks)
9. (a) (i) What do you understand by the term mass difference? State the relationship between mass difference and binding energy of a nucleus. (03 marks)
- (ii) A nucleus of uranium – 238 disintegrates with the emission of an alpha particle according to the reaction
- $${}_{92}\text{U}^{238} \longrightarrow {}_{90}\text{Th}^{234} + {}_2\text{He}^4 + 6.768 \times 10^{-13} \text{ J}$$
- Calculate the mass of ${}_{90}\text{Th}^{234}$ (03 marks)
- (b) Distinguish between an LED and a photodiode. (02 marks)

- (c) For the circuit shown in the figure below (fig. 1), the potentiometer is adjusted until the LED just begins to glow. At this stage the voltmeter registers 1.5 V and a current of $24 \mu\text{A}$ is also registered by the microammeter.

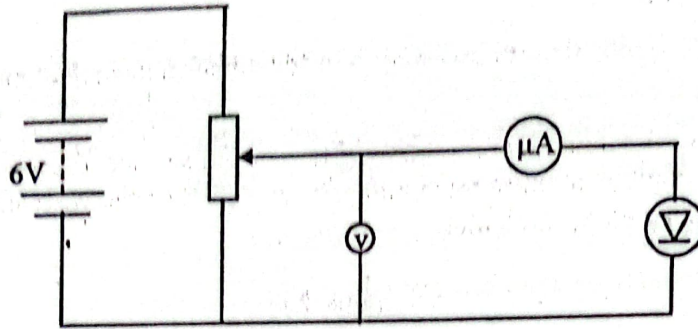


Fig. 1

- (i) Calculate the power transferred in the LED when it just begins to glow. (02 marks)
- (ii) Show that, when the current is $24 \mu\text{A}$, the rate at which electrons are passing through the LED is $1.5 \times 10^{14} \text{ s}^{-1}$. (02 marks)
- (iii) Hence find the average energy transferred by each electron as it passes through the LED. (02 marks)
- (d) Compute the potential difference between the collector and the emitter V_{CE} given that $R = 150 \text{ K}$, $R_L = 750 \Omega$ and a current gain of 80 in fig. 2. (06 marks)

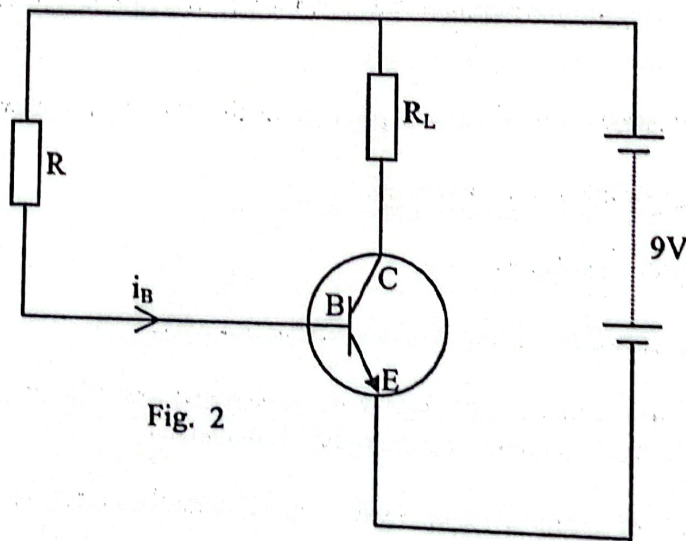


Fig. 2

10. (a) What do you understand by the following terms:

- (i) Laser light.
- (ii) Mean life time of excited atom.
- (iii) Metastable state.

(01 mark)

(01 mark)

(02 marks)

- (b) List down four characteristics of laser light that makes it advantageous over light from other sources. (06 marks)
- (c) (i) What is an isotope? (01 mark)
- (ii) Explain how x-ray powder photography is used to determine crystalline structure. (03 marks)
- (d) When light of wavelength $4046 \text{ \AA}$ shines onto a certain metal surface, the most energetic photoelectrons are stopped by a retarding potential of 1.6 V , when the wavelength is $5769 \text{ \AA}$ the stopping potential is 0.45 V . Calculate:
- (i) The value of the Planck's constant from this data. (04 marks)
- (ii) The work function of the photoemitter used. (02 marks)