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 $g = 9.8\ ms^{-2}$
   (b) Radius of Earth $R_e = 6.4 \times 10^6 m$
   (c) Young's modulus of copper wire $E_{cu} = 1.1 \times 10^{11} Nm^{-2}$
   (d) Molar gas constant $R = 8.3\ Jmol^{-1}K^{-1}$
   (e) 1 atmosphere pressure $P = 1.01 \times 10^5 Nm^{-2}$
   (f) Planck's constant $h = 6.63 \times 10^{-34} Js$
   (g) Speed of light in Vacuo $C = 3 \times 10^8 ms^{-1}$
   (h) 1 eV $= 1.6 \times 10^{-19} C$
   (i) Mass of $_{92}U^{238} = 3.94 \times 10^{-25} Kg$
   (j) Mass of $_2He^4 = 6.63 \times 10^{-27} Kg$
   (k) 1 $\mathring{A}$ - angstrom unit $\mathring{A} = 10^{-10} m$
   (l) Moment of inertia of disc about centre $I = \frac{1}{2}MR^2$
   (m) Mass of electron $m_e = 9.1 \times 10^{-31} Kg$.

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 Vms^{-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_o 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 5×10^{-26} 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 5×10^5 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 3.32×10^{-4} m^3. Calculate the values of the principal molar heat capacities and the specific universal gas constant. **(07 marks)**

[Molar mass of oxygen = 32×10^{-3} 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 10^{th} 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 5.89×10^{-7} 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 1^{st} 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.

(b) Explain the following:

(i) A moving coil galvanometer has its coil wound on a light metal frame. **(02 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 5×10^{-5} m^2 and a resistance of 20 Ω gives the same throw of the galvanometer as that when a 1 μF 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 300 Ω and a 6.67 μF 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 μF. 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 5×10^{-7} 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

$$_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}H_{e}^{4} + 6.768 \times 10^{-13}\,J$$

Calculate the mass of $_{90}Th^{234}$ **(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 μA is also registered by the microammeter.

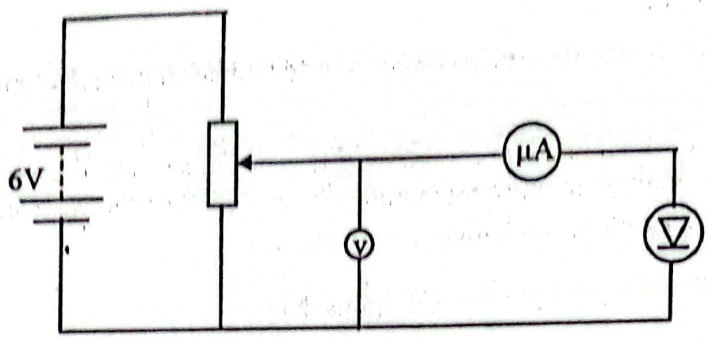

Fig. 1

(i) Calculate the power transferred in the LED when it just begins to glow. **(02 marks)**

(ii) Show that, when the current is 24 μA, the rate at which electrons are passing through the LED is $1.5 \times 10^{14}\ s^{-1}$. **(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 $R = 150\ K$, $R_L = 750\ \Omega$ and a current gain of 80 in fig. 2. **(06 marks)**

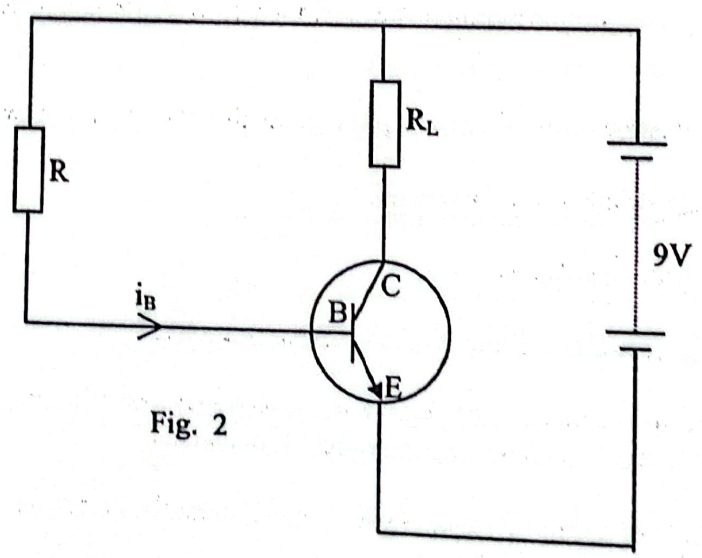

Fig. 2

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

(i) Laser light. **(01 mark)**

(ii) Mean life time of excited atom. **(01 mark)**

(iii) Metastable state. **(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 A 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 A° 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)**