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 **Thursday 16 May 2002 a.m.**

Instructions

1. This paper consists of sections A, B and C.
2. Answer any **FIVE (5)** questions choosing at least **ONE (1)** question from each of the sections A, B and C.
3. Marks for each question or part thereof are given beside each question.
4. Mathematical tables and unprogrammable 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.
7. The following information may be useful.
   (a) Acceleration due to gravity, $g = 9.8\ ms^{-2}$
   (b) Radius of the Earth, $R_E = 6.4 \times 10^3$ km
   (c) Density of water, $\rho_{H_2O} = 1000\ kg\ m^{-3}$
   (d) Universal gas constant, $R = 8.31\ Jmol^{-1}K^{-1}$
   (e) Permeability of free space, $\mu_o = 4\pi \times 10^{-7}\ Hm^{-1}$
   (f) Atomic mass of silver, Ag = 108
   (g) Atomic mass of iodine, I = 127
   (h) Electronic charge, $e = 1.6 \times 10^{-19}$ C
   (i) Planck's constant, $h = 6.63 \times 10^{-34}$ Js
   (j) Permittivity of free space, $\varepsilon_o = 8.854 \times 10^{-12}\ Fm^{-1}$
   (k) Mass of electron, $M_e = 9.1 \times 10^{-31}$ kg.

This paper consists of 6 printed pages.

SECTION A

Answer at least **ONE (1)** question from this section.

1. (a) (i) State Newton's law of gravitation. Use the law to derive Kepler's third law. (5 marks)
(ii) Explain why Newton's equation of universal gravitation does not hold for bodies falling near the surface of the earth? (1 mark)

(b) (i) With regard to the Earth - Moon system discuss the formation of tides. (3 marks)
(ii) A satellite of mass 600 kg is in a circular orbit at a height of 2×10^3 km above the earth's surface. Calculate the orbital speed, the kinetic energy and its gravitational potential energy. (6 marks)

(c) Jupiter has a mass 318 times that of the earth, its radius is 11.2 times the earth's radius. Use this information to estimate the escape velocity of a body from Jupiter's surface, if the escape velocity from the earth's surface is 11.2 kms^{-1}. (6 marks)

2. (a) State and write down the equation of continuity as applied to fluid dynamics. (2 marks)

(b) (i) Write down Bernoulli's equation and state the conditions under which it is applicable. (2 marks)
(ii) Air flows over the upper surfaces of the wings of a jet plane at a speed of 340 m/s and past the lower surfaces at 280 m/s. Determine the 'lift' force on the jet plane if it has a total wing area of 50 m^2. The density of air flowing is 1.29 kg/m^3. (6 marks)

(c) What is the difference between

(i) Turbulent flow and laminar flow (2 marks)
(ii) Rotational and irrotational flows? (2 marks)

(d) Water flows steadily along a horizontal pipe which narrows at a constriction; the speed at the narrow part is 12 m/s. If the cross-sectional area at the constriction part is $\frac{1}{4}^{th}$ of the original cross - section area of the pipe calculate the pressure difference between the two parts in Nm^{-2}. (6 marks)

3. (a) (i) Define the angular velocity of a rotating body and give its SI unit. (2 marks)
A car wheel has its angular velocity changing from 2 $rads^{-1}$ to 30 $rads^{-1}$ in 20 seconds. If the radius of the wheel is 400 mm calculate:

(ii) the angular acceleration (2 marks)
(iii) the tangential linear acceleration of a point on the rim of the wheel. (2 marks)

(b) A large wheel of radius 40 cm having 10 spokes on it is made to spin about an axle at 3 rev. per sec. A 25 cm long arrow is shot parallel to the axle but perpendicular to the surface of the rotating wheel without hitting any of the spokes and enters at a point where one of the spokes has just passed.

(i) What minimum speed should the arrow have? (7 marks)
(ii) Does it matter where (between the axle and the rim) you aim? (1 mark)

(c) (i) A recording disc rotates steadily at 45 rev per minute on a turntable. When a small mass of 0.02 kg is dropped gently onto the disc at a distance of 0.04 m from its axis of rotation and sticks the rate of revolution falls to 36 rev min^{-1}. Calculate the moment of inertia of the disc about its centre. (4 marks)
(ii) State and write down the principle used in your calculation in (i) above. (2marks)

4. (a) A cylinder in fig. 1a holds a volume $V_1 = 1000\ cm^3$ of air at an initial pressure of $P_1 = 1.1 \times 10^5$ Pa and temperature $T_1 = 300$ K. Assume the air behaves like an ideal gas.

Fig. 1b shows a sequence of operations imposed on the air in the cylinder.

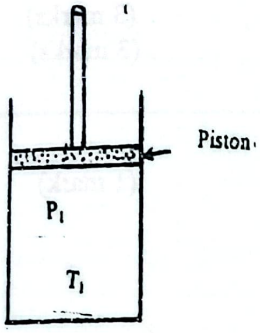

Fig. 1a

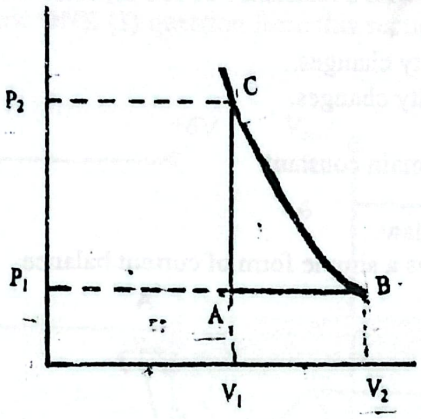

Fig. 1b

(i) AB – the air is heated to 375 K at constant pressure. Calculate the new volume. (3 marks)
(ii) BC – the air is compressed isothermally to volume V_1. Calculate the new pressure P_2. (3 marks)
(iii) Calculate the root mean square speed of nitrogen molecules at a temperature of 27 °C. (3 marks)

(b) State 1st law of thermodynamics and write down its equation. What does the law express? (2 marks)

(c) A litre of air initially at 25 °C and 760 mmHg is heated at constant pressure until the volume is doubled. Determine:

(i) the final temperature. (3 marks)
(ii) the external work done by the air in expanding it. (3 marks)
(iii) the quantity of heat supplied. (3 marks)

SECTION B

Answer at least **ONE (1)** question from this section.

5. (a) What are the necessary conditions for interference of light to be observable? (2 marks)

(b) Why does a small oil patch on the tarmac road often show almost circular coloured rings? (2 marks)

(c) In a Young's double slit experiment the distance between the centre of the interference pattern and the tenth bright fringe on either side is 3.44 cm and the distance between the slits and the screen is 2 m. If the wavelength of the light used was 5.89×10^{-7} m, determine:

(i) the slit separation. (3 marks)
(ii) the path difference. (2 marks)

(d) (i) Explain what is meant by diffraction. (1 mark)
(ii) Derive the width of the diffraction pattern for the case of a single slit. (2 marks)
(iii) A radar speed trap is placed 15 m from the side of a road, its beam making an angle of 15° with the road. If the transmitting aerial has a horizontal width of 20 cm and the wavelength used is 3 cm, over what distance along the road can vehicles be detected? (8 marks)

6. (a) (i) Define "Self inductance" of a coil. (1 mark)
(ii) A current of 1.5 A flows in a circuit in which there is a coil of 2.1 H. The electric energy in the inductor is wholly stored in a capacitor whose terminals are maintained at 350 V. Determine the capacitance of the capacitor. (2 marks)

(b) (i) Briefly explain the factors upon which the 'throw' of a ballistic galvanometer depends. (4 marks)

SECTION C

Answer at least ONE (1) question from this section.

8.

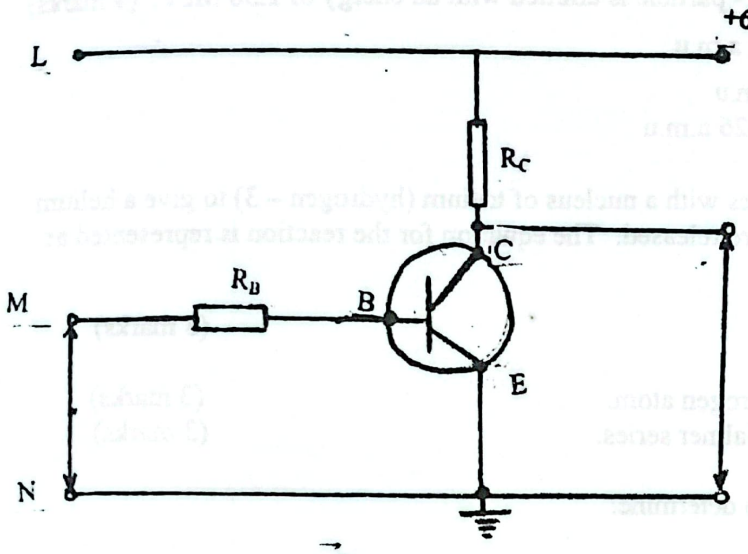

Fig. a

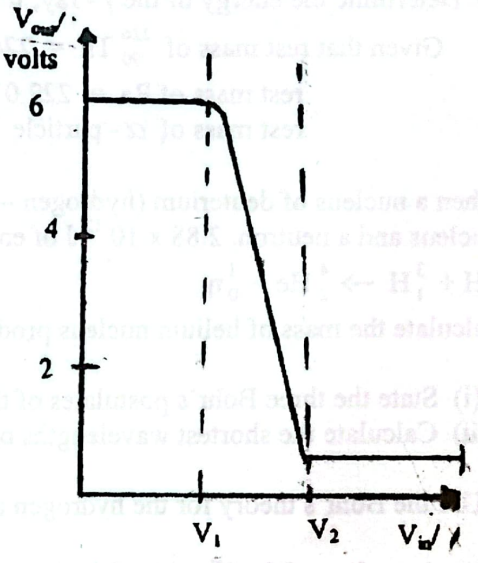

Fig. b

The above figures show a transistor circuit and the relationship between the input p.d. V_{in} and the output p.d:

(a) What are the outputs when

(i) L is connected to M
(ii) M is connected to N? (4 marks)

(b) (i) How can this circuit be used as a switching circuit? Explain. (4 marks)
(ii) Through what range of input voltage could this circuit be used as an amplifier? (2 marks)
(iii) Mention and discuss one application of the transistor as a switch. (2 marks).

(c) Suppose L (in fig a) is connected to M and the transistor operates with a collector current of 5 mA while its power supply is 6 V. Find the values of

(i) the base bias resister R_B (4 marks)
(ii) the load resistor R_C. (4 marks)

Note: $V_{CE} = \frac{1}{2} V_{CC}$, d.c current gain $\frac{I_C}{I_B} = 100$ and $V_{BE} = 0.6$ V

9. (a) What is meant by the following terms?

(i) Atomic mass unit (a.m.u)
(ii) Binding energy
(iii) Mass defect (3 marks)

Calculate the binding energy per nucleon for phosphorus $^{31}_{15}P$ given that $^{31}_{15}P = 30.97376$ a.m.u, $^{1}_{0}\eta = 1.00865$ a.m.u and $^{1}_{1}H = 1.00782$ a.m.u (4 marks)

(b) It is observed that thorium nucleus $^{226}_{90}Th$ originally at rest decays to form a radium nucleus Ra, an α – particle and a γ - ray.

(i) Write down the equation for the disintegration. (1 mark)

(ii) Determine the energy of the γ - ray, if the α - particle is emitted with an energy of 2.38 MeV. (9 marks)

Given that rest mass of $^{226}_{90}Th$ = 226.0249 a.m.u

rest mass of Ra = 222.0154 a.m.u

rest mass of α - particle = 4.0026 a.m.u

(c) When a nucleus of deuterium (hydrogen – 2) fuses with a nucleus of tritium (hydrogen – 3) to give a helium nucleus and a neutron, 2.88×10^{-12} J of energy are released. The equation for the reaction is represented as

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}\eta$$

Calculate the mass of helium nucleus produced. (3 marks)

10. (a) (i) State the three Bohr's postulates of the hydrogen atom. (3 marks)

(ii) Calculate the shortest wavelengths of the Balmer series. (3 marks)

(b) Use the Bohr's theory for the hydrogen atom to determine:

(i) the radius of the 1st orbit of the hydrogen atom in Angstrom units (Å). (3 marks)

(ii) the velocity of the electron in this 1st orbit. (3 marks)

(c) (i) What is ionization potential of an atom? (1 mark)

(ii) Show that the ionization potential of hydrogen atom is 13.6 eV. (5 marks)

How can you account for the chemical behaviour of atoms on the basis of the atomic electrons and shells? (2 marks)