Physics II

028

03 Nov. 2011 8.30 am – 11.30 am

REPUBLIC OF RWANDA

RWANDA EDUCATION BOARD (REB)
P .O.BOX 3817 KIGALI. TEL/FAX: 586871

ADVANCED LEVEL NATIONAL EXAMINATION 2011

SUBJECT: PHYSICS II

COMBINATIONS:	**Physics-Chemistry-Mathematics**	**PCM**
:	**Physics –Chemistry- Biology**	**PCB**
	Physics – Economics- Mathematics	**PEM**
	Mathematics –Physics- Geography	**MPG**
	Mathematics- Physics- Computer science	**MPC**

DURATION: 3 HOURS

INSTRUCTIONS:

This paper consists of **two** sections **A** and **B**.
Section A: Attempt **all** questions. **(55 marks)**
Section B: Answer **any three** questions. **(45 marks)**

Non- programmable scientific calculators may be used.

Useful constants:

Acceleration due to gravity:	$g = 9.81 m/s^2$
Magnitude of charge of electron:	$e = 1.6 \times 10^{-19} C$
Heat of combustion of gasoline:	$L_c = 46 \times 10^6 J/kg$
Speed of sound in air:	$v = 340 m/s$
Permittivity of free space:	$\varepsilon_0 = 8.85 \times 10^{-12} F/m$
Molar gas constant:	$R_g = 8.314 J/mol K$
Electron mass:	$m = 9.1 \times 10^{-31} kg$
Gravitational constant:	$G = 6.672 \times 10^{-11} Nm^2/kg^2$
Mass of the earth:	$M = 6 \times 10^{24} kg$
Radius of the earth:	$R = 6.4 \times 10^3 kg$
1atmospheric pressure	$1atm = 1.013 \times 10^5 Pa$:
Resistivity of constantan	$\rho = 47 \times 10^{-8} \Omega m$

Section A: Attempt all questions. (55 marks)

1. The period of the vibration P of a star under its own gravitational attraction is given by $P = \frac{1}{\sqrt{G\sigma}} 2\pi$ where σ is the mean density of the star and G is the gravitational constant. Show that this relation is dimensionally correct. **(4 marks)**

2. The refractive index of the core and cladding of an optical fibre are 1.5 and 1.3 respectively. Calculate the critical angle at the interface. **(3 marks)**

3. A photocell is connected in series with a direct current supply and a micro-ammeter.
   (a) Sketch a labeled circuit using these components and indicate the positive and negative terminals of supply and the meter. **(2 marks)**
   (b) Explain why the arrangement would not work if the supply were connected the wrong way round. **(2 marks)**

4. The thermionic diode and triode have been replaced by semiconductor diode and transistor. State four advantages of using a semiconductor diode and transistor. **(4 marks)**

5. (a) Define capacitance of an insulated conductor. **(1 mark)**
   (b) A parallel plate capacitor is to be made by sandwiching a 0.1 mm thick piece of mica between two metal plates. If mica has a relative permittivity of 7, what area of plates is required to achieve a capacitance of 250 nF? **(3 marks)**

6. (a) What is the principle of superposition as applied to wave motion? **(1 mark)**
   (b) Two loudspeakers emit 340 Hz sounds of equal amplitude 4×10^{-6} m .The speakers are 3m apart and face each other.
   i) What is the wavelength of the sound? **(1.5 marks)**
   ii) Ignoring the reduction of amplitude with distance from each speaker, state the amplitude A_1 of sound half way between the speakers. **(1.5 marks)**

7. (a) State the principle of conservation of angular momentum. **(1 mark)**
   (b) A constant torque of 200 Nm turns a wheel about its centre.

The moment of inertia about this axis is 100 kgm^2.

i) Determine the angular acceleration of the wheel. **(1.5 marks)**

ii) Find the angular velocity gained in 4 seconds. **(1.5 marks)**

8. The capacity of a storage battery, such as those used in automobile electrical systems, is rated in ampere-hours (A.h).

(a) What total energy in joule can be supplied by a (12 V, 60 Ah) battery if its internal resistance is negligible? **(2 marks)**

(b) What mass of gasoline has total heat of combustion equal to energy obtained in part (a) above? **(2 marks)**

9. (a) Define the linear magnification of a lens. **(1 mark)**

(b) A slide of dimensions 2 cm by 2 cm produces a clear image of dimensions 80 cm by 80 cm on a projector screen.

i) Determine the linear magnification of the lens. **(1 mark)**

ii) Calculate the focal length of the projector lens if the screen is 82 cm from the slide. **(2 marks)**

10. (a) Define resistivity of a material **(1 mark)**

(b) Calculate the resistance per metre length of constantan wire of diameter 0.4 mm. **(2 marks)**

11. (a) What is meant by velocity ? **(1 mark)**

(b) A resultant force of 12 N acts for 5 s on a mass of 6 kg.

i) What is the change in momentum of the mass? **(1 mark)**

ii) Determine the final velocity of the mass. **(1 mark)**

12. An empty cylindrical canister 1.5 m long and 90 cm in diameter is to be filled with pure oxygen at 22 °C to store in space station. To hold as much gas as possible, the absolute pressure of the oxygen will be 21 atm. The molar mass of oxygen is 32g/mol.

(a) Calculate the volume of the cylinder. **(1 mark)**

(b) How many moles of oxygen does this canister hold? **(1 mark)**

(c) For someone lifting this canister, by how many kilograms does this gas increase the mass to be lifted? **(1 mark)**

13. A particle with initial velocity $\vec{v} = (5 \times 10^3 \text{ m/s})\ \vec{j}$ enters a region of uniform electric and magnetic fields. The magnetic field in the region is $\vec{B} = -(1\text{T})\vec{k}$. Calculate the magnitude and direction of the

electric field in the region if the particle is to pass through undeflected (the resultant force is zero), for a particle of positive charge. You can ignore the weight of the particle. **(4 marks)**

14. A beam of light is incident on a liquid of 1.4 refractive index. The reflected rays are completely linearly polarized.
    (a) What is polarization? **(1 mark)**
    (b) What is the angle of refraction of the beam? **(3 marks)**

15. In a truck- loading station at a post office, a small 0.2 kg package is released from rest at point A on a track that is one –quarter of a circle with radius 1.6 m (figure 1) .The size of the package is much less than 1.6 m, so the package can be treated as a particle. It slides down the track and reaches point B with a speed of 4.8 m/s. From point B, it slides on a horizontal surface a distance of 3 m to point C, where it comes to rest.

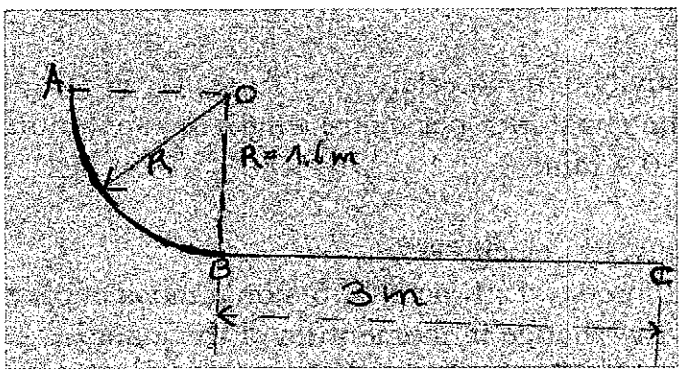

Figure1

(a) What is the coefficient of kinetic friction on the horizontal surface? **(1.5marks)**
(b) How much work is done on the package by friction as it slides down the circular arc from A to B? **(1.5marks)**

SECTION B: Answer any three questions. (45 marks)

16. (a) i) Show that if a free electron moves at right angle to a magnetic field the path is a circle. **(5 marks)**

ii) Show also that the electron suffers no force if it moves parallel to the magnetic field. **(3 marks)**

(b) An electron starts from rest and is accelerated through a potential difference of 200 V.

i) What is the electron's kinetic energy at the end of the acceleration? **(1.5marks)**

ii) At what speed will it be moving after the acceleration? **(1 mark)**

(c) The electron now enters a region in which the magnetic field strength is 0.2 T and at 90° to the electron's path.

i) What is the force on the electron? **(1 mark)**

ii) What is the radius of curvature of the path followed? **(1.5marks)**

iii) How long would the electron have to remain in the magnetic field for it to end up travelling at 90° to its initial direction? **(2 marks)**

17. (a) Describe a semiconductor diode. **(2 marks)**

(b) Draw a labelled circuit which can be used to produce a full wave rectification including the source of alternating current, a bridge connected diodes and a load. Explain its functioning. **(8 marks)**

(c) In the junction transistor voltage amplifier circuit of figure2:
R_1=100kΩ, R_2= 1kΩ, V_{CC} = 6V, V_{BE} = 0.6V, current gain h_{FE} = 60

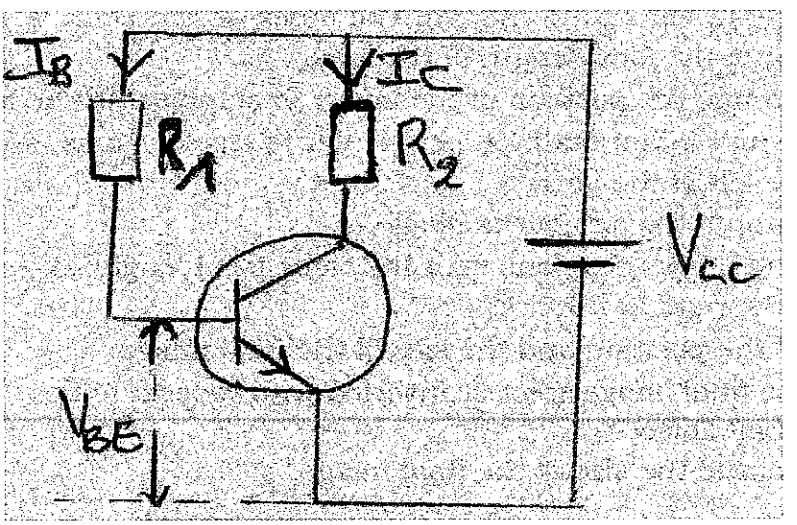

Figure2.

Calculate :

i) the voltage across R_1. **(1 mark)**

ii) I_B **(1 mark)**

iii) I_C **(1 mark)**

iv) The voltage across R_2. **(1 mark)**

v) The voltage across the collector –emitter. **(1mark)**

18. (a) i) State the law of universal gravitation. **(2 marks)**

ii) Define the gravitational field. **(2 marks)**

iii) Use your answers i) and ii) to show that the magnitude of the gravitational field strength at the earth's surface is $\frac{GM}{R^2}$ where M is the mass of the earth, R is the radius of the earth and G is the gravitational constant. **(2 marks)**

(b)What is meant by gravitational potential? Use the data below to show that its value at the earth's surface is -62.55 MJ/kg? **(4 marks)**

(c) A communication satellite occupies an orbit such that its period of revolution about the earth is 24 h. Explain the significance of this period and show that the radius R_0 of the orbit is given by

$R_0 = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ where T is the period of revolution. **(5 marks)**

19. The radii of curvature of the surfaces of a thin converging meniscus lens are R_1=12 cm and R_2=28 cm. The index of refraction is 1.6.

(a) i Compute the focal length of the lens. **(3 marks)**

ii) Determine the position of the image of an object in the form of an arrow 5mm tall, perpendicular to the lens axis, 45 cm to the left of the lens. **(2 marks)**

iii) Compute the size of the image. **(3 marks)**

(b) A second converging lens with the same focal length is placed 3m to the right of the first.

i) Find the position and the size of the final image. **(3 marks)**

ii) Is the final image erect or inverted with respect to the original object? **(2 marks)**

iii) Compute the size of the final image. **(2 marks)**

20. A wheel changes its angular velocity with a constant acceleration while rotating about a fixed axis through its centre.

(a) Show that the change in the magnitude of the radial acceleration during any time interval of the point on the wheel is twice the product of the angular acceleration, the angular displacement, and the perpendicular distance of the point from the axis. **(5 marks)**

(b) The radial acceleration of a point on the wheel that is 0.25 m from the axis changes from 25 m/s^2 to 85 m/s^2 as the wheel rotates through 15 rad. Calculate the tangential acceleration of this point. **(4 marks)**

(c) Show that the change in the wheel's kinetic energy during any time interval is the product of the moment of inertia about the axis, the angular acceleration and the angular displacement. **(4 marks)**

(d) During the 15 rad angular displacement of part (b) above, the kinetic energy of the wheel increases from 20 J to 45 J. What is the moment of inertia of the wheel about the rotation axis? **(2 marks)**