PHYSICS II

030

03 /11/ 2014 8.30 AM – 11.30 AM

Rwanda Education Board

ADVANCED LEVEL NATIONAL EXAMINATIONS, 2014

SUBJECT: PHYSICS

PAPER II: THEORY

COMBINATIONS :

PHYSICS - CHEMISTRY - MATHEMATICS	**(PCM)**
MATHEMATICS - PHYSICS - COMPUTER SCIENCE	**(MPC)**
PHYSICS – CHEMISTRY - BIOLOGY	**(PCB)**
MATHEMATICS – PHYSICS - GEOGRAPHY	**(MPG)**
PHYSICS - ECONOMICS - MATHEMATICS	**(PEM)**

DURATION: 3 HOURS

INSTRUCTIONS :

1. Write your names and index number on the answer booklet as written on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2. Do not open this question paper until you are told to do so.
3. This paper consists of **two** sections **A** and **B**.
   Section A: Attempt **all** questions. **(55 marks)**
   Section B: Answer **only any three** questions. **(45 marks)**
4. Non- programmable scientific calculator may be used.
5. **Useful constants:**

Magnitude of charge of electron	$: e = 1.6 \times 10^{-19}\ C$
Speed of light in vacuum or in air	$: c = 3 \times 10^{8}\ m/s$
Permittivity of free space	$: \varepsilon_0 = 8.85 \times 10^{-12}\ F/m$
Electron mass	$: m_e = 9.1 \times 10^{-31}\ \text{kg}$
Planck's constant	$: h = 6.626 \times 10^{-34}\ J.s$
Boltzmann's constant	$: k = 1.38 \times 10^{-23}\ J/K$
Permeability of free space	$: \mu_0 = 4\pi \times 10^{-7}\ H/m$
Density of the water	$: \rho = 1000 \text{kg}/m^3$

SECTION A: ATTEMPT ALL QUESTIONS. (55 MARKS)

1. A compound microscope is an optical instrument for forming magnified images of small objects, consisting of two converging lenses at opposite ends both mounted in the same tube.

   (a) Name two lenses in a compound microscope. **(2marks)**

   (b) Which lens in the compound microscope forms an enlarged real image of the specimen? **(1mark)**

   (c) Which lens in the compound microscope produces an enlarged virtual image of an intermediate image? **(1mark)**

2. A junction transistor is one of the components of the following circuit (figure 1).

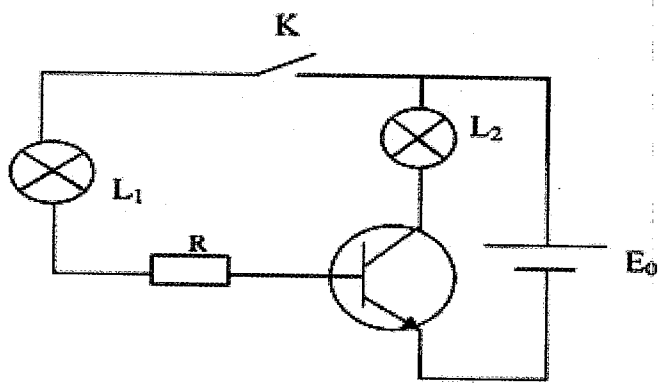

Figure 1

   (a) What is the type of this transistor? **(1mark)**

   (b) Name three important parts of a transistor. **(3marks)**

3. State the fundamental physical quantities that are used to derive the following derived physical quantities :

   (a) density **(2marks)**

   (b) acceleration **(2marks)**

4. (a) Two batteries are arranged in a circuit. One battery has a voltage of 9V and the other has a voltage of 3V. They are placed such that the positive terminal of one battery faces the positive terminal of the other in the pathway. What is the net voltage of the circuit? **(1 mark)**

   (b) What is the resistance of a lamp which draws 120mA when connected to a 6V battery? **(2marks)**

5. (a) For what range of object positions does a concave mirror form a real image? **(1mark)**

   (b) A spherical concave mirror has a focal length of 16cm. An object is at 12cm from this mirror. Where is its image? **(2marks)**

6. (a) An object is moving in a circle with constant speed. What is the direction of the net force acting on this object? **(1mark)**

   (b) What is the net force required to make an object of 40kg accelerate at a rate of 2 m/s^2 ? **(3marks)**

7. (a) Determine the factors on which the time period of a simple pendulum depends. **(2marks)**

   (b) A 4kg mass attached to a spring is observed to oscillate with a period of 2 seconds. What is the spring constant of this spring? **(2marks)**

8. (a) A cyclotron is a device for accelerating charged particles to high speeds in circular orbits of ever-increasing radius. The charged particles are subjected to both an electric field and a magnetic field. One of these fields increases the speed of the particles, and the other field holds them in a circular path. Which field performs which function? **(2marks)**

   (b) An electric charge of 4μC, travelling with a speed of $1x10^6$ m/s in a direction perpendicular to a magnetic field, experiences a magnetic force of 8×10^{-3} N.

   Calculate the magnitude of the magnetic field. **(2marks)**

9. (a) An electric current flows through a plane circular coil as shown below (figure 2).

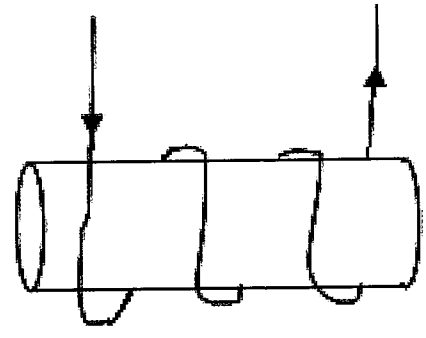

Figure 2

   What is the direction of the magnetic field inside the coil? **(1mark)**

   (b) A solenoid is designed to produce a magnetic field of 0.0314T at its centre. The wire of this solenoid can carry a maximum current of 10A. What minimum number of turns per unit of length must the solenoid have? **(2marks)**

10. (a) What is the importance of Lenz's law of electromagnetic induction? **(1mark)**

(b) What is the induced electromotive force in a circuit if a magnetic flux of one weber is reduced to zero in one second ? **(2marks)**

11. (a) Determine the direction of propagation of a plane progressive wave represented by the equation $y = 0.5\sin(100\pi\, t - \frac{20\,\pi\, x}{17})$ where y is the displacement in millimeters, t is in seconds and x is the distance from a fixed origin 0 in metres. **(1mark)**

(b) Find the frequency of this wave. **(3marks)**

12. (a) A charged comb attracts small bits of dry paper which fly away when they touch the comb. Explain this phenomenon. **(1mark)**

(b) An electron is placed in a uniform electric field of $2.5\times10^{3}\, N/C$. What is the magnitude of the electric force felt by the electron? **(2marks)**

13. (a) Define the specific heat capacity of a substance. **(1mark)**

(b) The energy of 1600 J is needed to increase the temperature of 500 g of lead from 20°C to 45°C.What is the specific heat capacity of lead? **(3marks)**

14. Water flows along a horizontal pipe of cross-sectional area 48cm^2 (section 1) which has a constriction of cross-sectional area 12cm^2 (section 2) (figure 3).

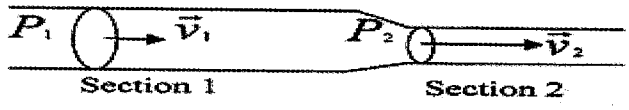

Figure 3

If the speed of the water at the constriction is 4m/s,

(a) calculate the speed in the wider section. **(2marks)**

(b) the pressure in the wider section is $P_1 = 10^5$ Pa, calculate the pressure P_2 at the constriction. **(2marks)**

15. (a) Determine the work done by an expanding gas when its volume changes from 50cm^3 to 100cm^3 while the pressure remains constant at 10^5 Pa. **(2marks)**

(b) What is the change in internal energy of a thermodynamic system if 500J of heat are added to a system and 125J of work are done on the system? **(2marks)**

SECTION B: ANSWER ONLY ANY THREE QUESTIONS. (45 MARKS)

16. (a)(i)State and explain three types of mechanical equilibrium. **(6marks)**

(ii) What does zero net torque mean in rotational motion? **(2marks)**

(iii) What is the SI unit of torque? **(1mark)**

(b) A wheel has a kinetic energy of 24400J when rotating at 602 revolutions per minute.

(i) Find the angular speed ω of the wheel in rad/s. **2marks)**

(ii) Calculate the rotational inertia (moment of inertia) of that wheel. **(2marks)**

(c) A disc of moment of inertia $10\,\text{kg}\,m^2$ about its centre rotates steadily about the centre with an angular velocity of $20\,rad/s$.

Calculate its angular momentum about the centre. **(2marks)**

17. (a) State two assumptions of the kinetic theory of gas. **(2marks)**

(b) Use the kinetic theory of matter known as kinetic molecular theory to answer the following.

(i) State two important characteristic properties of solids. **(2marks)**

(ii) State two important characteristic properties of liquids. **(2marks)**

(iii) State two important characteristic properties of gases. **(2marks)**

(iv) The pressure exerted by an ideal gas due to molecular bombardment on the walls of a container is given by $p=\frac{1}{3}\rho\overline{v}^2$. For each of the symbols ρ and $\overline{v}$, state the physical quantity and the SI unit. **(4marks)**

(c) Determine the translational kinetic energy of an oxygen molecule at a temperature of 27°C.

Use absolute temperature (thermodynamic temperature). **(3marks)**

18. (a) In a photoelectric effect experiment, which of the following factors will increase, decrease or will not affect the maximum kinetic energy of the photoelectrons? In each case justify your answer on the basis of Einstein's photoelectric equation :

$$\frac{mv_m^2}{2}=hf-\phi$$

(i)Use light of greater intensity. **(2marks)**

(ii) Use light of higher frequency. **(2marks)**

(iii) Use light of longer wavelength. **(2marks)**

(iv)Use a metal surface with a larger work function. **(2marks)**

(b)The photoelectric work function of potassium is 2.3 eV . The light having the wavelength of 250 nm falls on potassium.

(i) Convert 2.3 eV in joules. **(2marks)**

(ii) Find the frequency of this light. **(3marks)**

(iii) Calculate the maximum kinetic energy of the photoelectrons. **(2marks)**

19. (a) (i) When is an object said to be in motion? **(2marks)**

(ii) Differentiate between speed and acceleration. **(2marks)**

(b) A ball is thrown vertically upwards from ground level with a velocity of 29.43 m/s . Air resistance may be ignored. The positive direction is that of motion.

(i) What is the direction of acceleration during the upward motion of the ball? **(1mark)**

(ii) Determine the magnitudes of the velocity and acceleration of the ball at the highest point(maximum height) of its motion. **(2marks)**

(iii) What is the total time it takes to return to the ground level? **(4marks)**

(c) A car moving along a straight road with a velocity of 108km/h is brought to a stop within a distance of 200m.

(i) What is the initial velocity of the car in m/s? **(1mark)**

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

(iii) Calculate the uniform retardation (negative acceleration) of the car. **(2marks)**

20. (a) What condition is required for resonance to occur in series RLC circuit? **(2marks)**

(b) A series resonance network consisting of a resistor of 30 Ω, a capacitor of 2 μF and an inductor of 20 mH is connected across a sinusoidal supply voltage which has a constant output of 9 volts at all frequencies (figure 4).

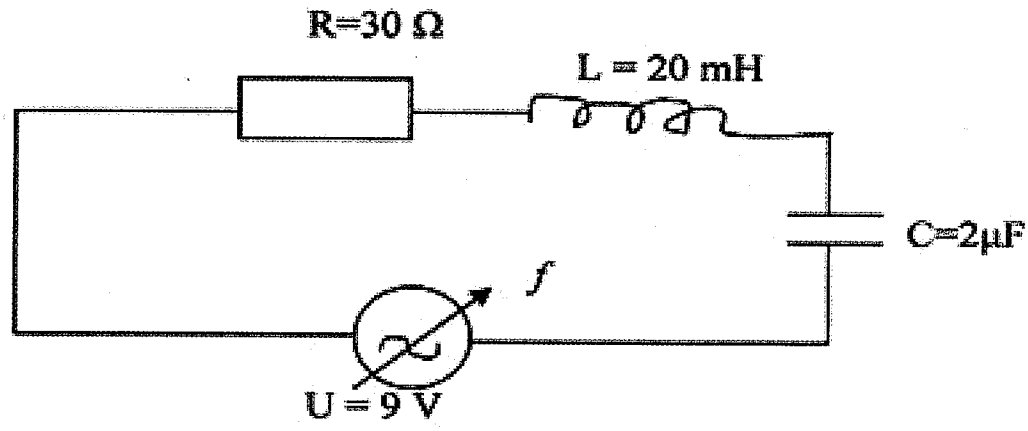

Figure 4

Calculate :

(i) the resonant frequency. **(3marks)**

(ii) the current at resonance. **(3marks)**

(iii) the inductive reactance at resonance. **(3marks)**

(iv) the voltages across the inductor at resonance. **(3marks)**

(v) the voltage across capacitor at resonance. **(1mark)**