UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006/07

TITLE O F PAPER: INTRODUCTORY PHYSICS II

COURSE NUMBER: P102

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR OUT OF FIVE QUESTIONS

EACH QUESTION CARRIES 25 MARKS

MARKS FOR EACH SECTION ARE IN THE RIGHT HAND MARGIN

GIVE CLEAR EXPLANATIONS AND USE CLEAR DIAGRAMS IN YOUR SOLUTIONS. MARKS WILL BE LOST WHERE IT IS NOT CLEAR HOW THE EQUATIONS USED WERE OBTAINED

THIS PAPER HAS SEVEN PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS DATA THAT MAY BE USEFUL IN SOME QUESTIONS

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE CHIEF INVIGILATOR

QUESTION 1

(a) A wave is described by the following equation:

$x = 15\sin(2\pi t + \pi/2)$ m.

(i) What is the angular velocity? **(2 marks)**

(ii) What is the phase angle? **(2 marks)**

(iii) Convert the wave into a cosine function. **(3 marks)**

(b) Calculate the velocity of sound in water? **(2 marks)**

(c) A sound output in a music concert puts out 100 watts of acoustic power.

(i) At what distance is the sound level 120 dB? **(4 marks)**

(ii) What is the significance of this sound level? **(2 marks)**

(d) A motor bike producing a sound of 1500 Hz, moving at a speed of 220 km/h moves towards a stationary observer and goes past him. Calculate the frequency of the sound heard by the observer when

(i) the bike is moving towards **(2 marks)**

and (ii) away from the observer. **(2 marks)**

(e) A light ray enters flint glass of refractive index 1.66 from air at an angle θ. The light ray is refracted at an angle of 37° in the glass. The glass floats on water of refractive index 1.33. Upon reaching the glass-water interface, the light ray is refracted by an angle θ'. Refer to Figure 1.

(i) Find the angle θ. **(3 marks)**

(ii) find the angle θ'. **(3 marks)**

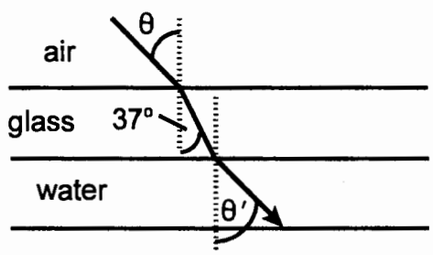

Figure 1.

QUESTION 2

(a) Two small spheres each of mass m = 70 g are suspended from strings of length l = 60 cm. One sphere has a charge 2Q the other one has a charge 3Q. The strings make an angle θ = 15° with the vertical. Find the magnitude of the charge Q. Start with a force diagram to obtain the required equations. **(8 marks)**

(b) Three charges are arranged at the vertices of a triangle as shown in Figure 2. The inclined sides of the triangle make an angle of 45° with the horizontal and are 50 cm long.

(i) What are the x- and y-components of the force on q_1 due to the other two charges? **(6 marks)**

(ii) What are the x- and y-components of the electric field at the origin due to only the two charges q_2 and q_3? **(4 marks)**

(iii) Using the electric field from (ii) find the force on q_1 due to the other two charges. **(2 marks)**

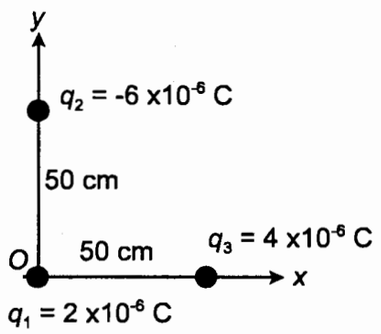

Figure 2.

(c) Briefly discuss what an *emf* source is and give an example of it. **(5 marks)**

QUESTION 3

(a) Consider the circuit shown in Figure 3.

(i) What is the effective resistance of the network as experienced by the battery? **(5 marks)**

(ii) What is the total current through the circuit? **(1 mark)**

(iii) What is the potential drop between points *a* and *b*? **(2 marks)**

(iv) What is the current through resistor R_3? **(2 marks)**

(b) For the network shown in Figure 4, use Kirchhoff's laws to find the currents i_1, i_2, and i_3. **(10 marks)**

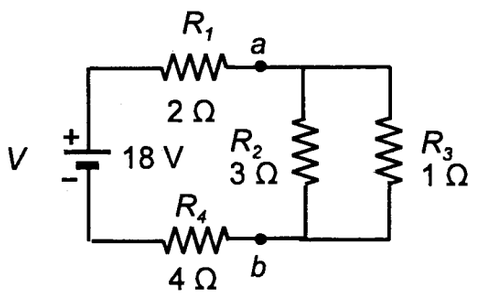

Figure 3.

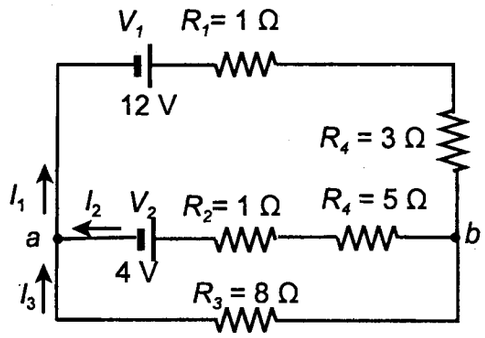

Figure 4.

(c) A capacitor of capacitance C = 5 μF is connected in series with a resistor of resistance R = 1 MΩ. It is charged by a battery of emf ε = 30 V.

(i) What is the charge in the capacitor when fully charged? **(1 mark)**

(ii) What is the charge in the capacitor after one time constant of charging? **(2 marks)**

(iii) What is the charge after 1.5 time constants of discharging? **(2 marks)**

QUESTION 4

(a) A gas contains hydrogen, deuteron, and helium which are then singly ionised (one electron removed). They are then directed to a mass spectrometer for their separation. In the velocity selector the magnitude of the electric field ***E*** is equal to 2 500 V/m. Particles of velocity equal to $v = 6.20 \times 10^6$ m/s go through undeflected.

(i) What is the magnitude of the magnetic field ***B*** in the velocity selector? Show how you obtain the equation used. **(6 marks)**

(ii) Show that the radius of curvature for a particle of mass m and charge q, in a perpendicular magnetic field **B′** is given by

$$r = \frac{mv}{qB'}.$$ **(5 marks)**

(iii) In the electric field free region of the mass spectrometer, the magnetic field ***B′*** has a magnitude of 0.035 T. Find the radius of curvature of the motion of each type of particle as given in this problem. **(6 marks)**

(b) The rectangular wire loop shown in Figure 5 carries a current *I* in the anticlockwise direction. It is placed in a magnetic field ***B*** at an angle $\theta = 45°$ downward with the vertical. Use the cross product to determine how the wire will move if it will move at all. **(8 marks)**

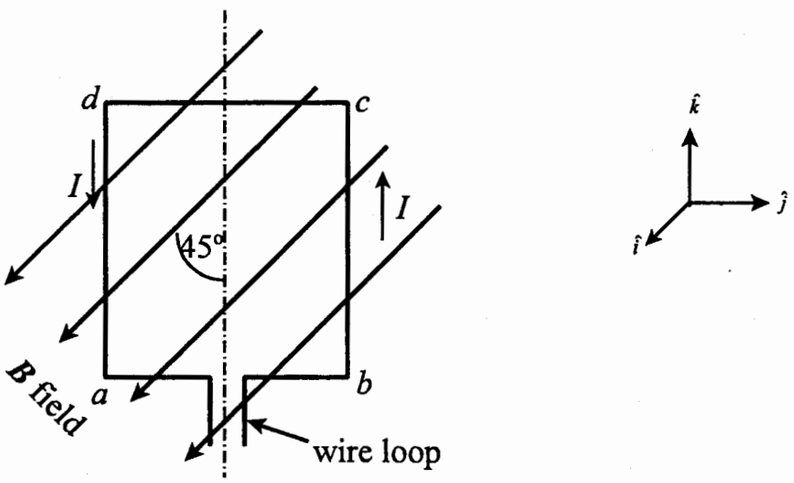

Figure 5.

QUESTION 5

(a) A step-down transformer is used in a circuit for charging a battery system. The 220 V mains supply is dropped to 16 V by a transformer. The primary current is 1.5 A.

(i) What is the ratio of the secondary to the primary turns of the transformer? **(2 marks)**

(ii) What is the secondary current? **(2 marks)**

(iii) What is the power delivered to the battery system? **(2 marks)**

(b) What are two things that support the wave nature of light? **(4 marks)**

(c) Explain the origin of discrete spectra from atoms. **(5 marks)**

(d) In denoting a particular nucleus a symbol like ${}^{A}_{Z}X$ is used. What is its meaning? **(3 marks)**

(e) Describe the particles released in natural radioactivity? **(7 marks)**

GENERAL DATA SHEET

Speed of light in vacuum $c = 2.9978 \times 10^8$ m/s
Speed of sound in air = 334 m/s
Gravitational acceleration = 9.80 m/s^2
Universal gravitational constant $G = 6.67 \times 10^{-11}$ N m^2/kg^2
Density of mercury = 1.36×10^4 kg/m^3
Density of water = 1000 kg/m^3
Bulk modulus for water B = 2.1×10^9 N/m^2
Standard atmospheric pressure = 1.013×10^5 Pa
Gas constant R = 8.314 J/(K mol)
Avogadro's number $N_A = 6.022 \times 10^{23}$ mol^{-1}
$I_0 = 10^{-12}$ W/m^2
1 calorie = 1 c = 4.186 J
1 food calorie = 1 Calorie = 1C = 10^3 calories = 4.186×10^3 J

c(*water*) = 4186 J/(kg K) c(*ice*) = 2090 J/(kg K) c(*steam*) = 2079 J/(kg K)
L_f(*ice*) = 3.33×10^5 J/kg L_v(*water*) = 2.260×10^6 J/kg

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$$

Charge of an electron = -1.6×10^{-19} C
Charge of a proton = $+1.6 \times 10^{-19}$ C
1 atomic mass unit = 1 amu = 1 u = 1.66×10^{-27} kg
Electron mass, $m_e = 9.109 \times 10^{-31}$ kg
Proton mass, $m_p = 1.673 \times 10^{-27}$ kg
Neutron mass $m_n = 1.675 \times 10^{-27}$ kg