KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.Ed. (SCIENCE)

COURSE CODE: SPH 221

COURSE TITLE: ELECTRICITY AND MAGNETISM II

DURATION: 2 HOURS

DATE: 17/05/2022 **TIME: 9:00AM-11:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- The following constants might be used: $K_e=8.99\times10^{9}$ N.m^2/C^2; $M_e=9.1\times10^{-31}$ kg; $M_p=1.6\times10^{-27}$ kg; $e=1.60\times10^{-19}$ C; $\varepsilon_0=8.85\times10^{-12}$ C^2/N.M^2

QUESTION ONE [30 Marks]

a) State Coulombs law. [2]

b) Estimate the speed of an electron in a hydrogen atom with radius about 0.53×10^{-10} m. [4]

c) Consider three point charges located at the corners of right triangle as shown in figure 1, where q1=q2=5.0μC, q3=-2.0 μC and a=0.10m. Find the resultant force exerted on q3. [4]

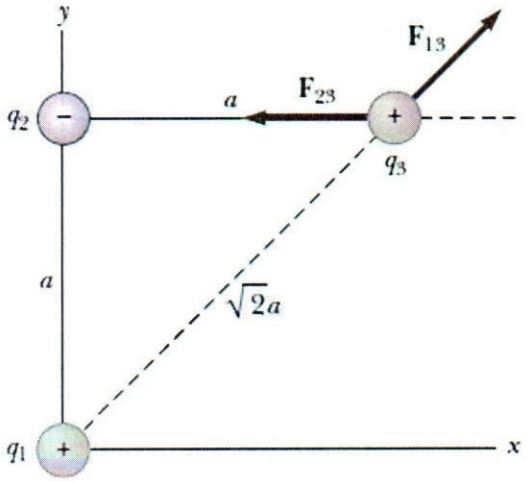

figure 1

d) Give the definition and units of electric field. [2]

e) Show that for a parallel-plate capacitor, the capacitance is given by $C=Q/\Delta V=\varepsilon_0/d$ [4]

f) Show that for two capacitors in series, the equivalent capacitance is given by $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$ [3]

g) Show that for an insulating sphere of radius a with uniform charge density ρ and carries a positive charge Q, the electric field in region r<a is given by $E=\frac{\rho}{3\varepsilon_0}r$ [4]

h) A parallel plate capacitor has an area of $A=2.0 \times 10^{-4}$ m^2 and plate separation=1.0 mm. Find its capacitance. [3]

i) Show that the work done in charging a capacitor to a charge Q equals the electrical potential energy U stored in the capacitor i.e. $U=\frac{Q^2}{2C}=\frac{1}{2}Q\Delta V=\frac{1}{2}C(\Delta V)^2$ [4]

QUESTION TWO [20 Marks]

a) Utilizing the electric field due to a point charge, show that the electric flux Φ is given by $\Phi=\frac{q}{\varepsilon_0}$ [3]

b) A spherical shell with R=5 m has a net charge of Q=1μC uniformly distributed over the surface. What is the magnitude of the electric field at (a) a distance r=1m from the *center* of the sphere and (b) a distance d=1 m from the *surface* of the sphere? [4]

c) Show that the capacitance of a parallel plate capacitor is given by $C=\frac{\varepsilon_0 A}{d}$ where ε_0=permittivity of free space; A= area of the plates and d=plate separation. [4]

d) Joule's heating in a resistor R is given as $P=i^2R=\frac{\varepsilon^2 R}{(R+r)^2}$ where ε=e.m.f of the cell and r is the internal resistance. What is the value of R to obtain maximum Joule's heating? [3]

e) What is the force on 0.1μC charge moving at velocity **v**= (10**j**-20**k**) m/s in a magnetic field **B**= (-3**i**+4**k**) x 10-4 T? [3]

f) Consider a capacitor of capacitance C that is being discharged through a resistor of resistance R. After how many time constants is the charge on the capacitor one-fourth its initial value? [3]

QUESTION THREE [20 Marks]

a) State the Kirchhoff's laws, as applied in complex circuit analysis [2]

b) Find the currents I_1, I_2 and I_3 in the circuit shown in figure 2. [8]

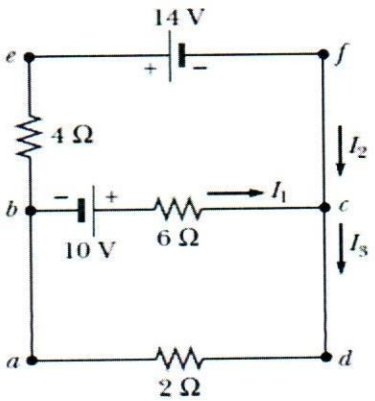

Figure 2

c) Show that if a capacitor is charged with a battery through a resistor of resistance R, the charge on the capacitor vary in time according to the expression $q(t)=Q(1-e^{-t/RC})$. What does the product RC represent? [10]

QUESTION FOUR [20 Marks]

a) A proton is moving in a circular orbit of radius 14 cm in a uniform 0.35T magnetic field perpendicular to the velocity of the proton. Find the linear speed of the proton. [3]

b) Give a mathematical expression of the Biot-Savart law? [2]

c) Explain the origin of magnetic field that can be determined by the Biot-Savart law. [1]

d) For a straight, long thin wire carrying a constant current i, determine the magnitude of magnetic field at a point P due to this current. [use figure 3] [8]

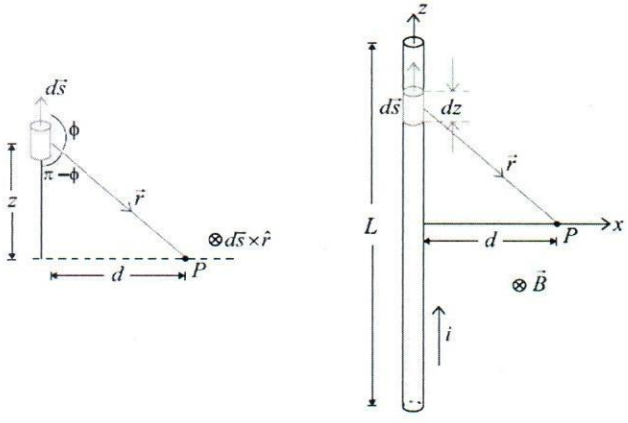

Figure 3

e) Charge q and –q are at a distance b from each other, as shown in figure 4. What is the electric field at a point P, which lies at a third corner of the square? [6]

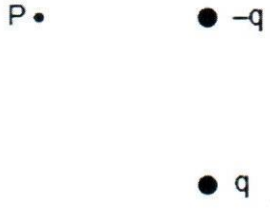

Figure 4

QUESTION FIVE [20 Marks]

a) A parallel plate capacitor of capacitance 1 pF has dimensions 5 cm by 10 cm separated by a paper of thickness d millimeters. Find the thickness of this dielectric. (k=2). [4]

b) What is maximum charge that can be placed on this capacitor? (dielectric strength of paper is $16\text{x}10^6$ V/m) [4]

c) Find the electric field due to a non-conducting, infinite plane of positive charge with uniform surface charge density σ. [6]

d) Find an expression for the electric potential at a point p located on the perpendicular central axis of a uniformly charged ring of radius a and total charge Q. [6]

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