MY HEARTY CONGRATULATIONS TO HSC STUDENTS!

If you want to **get "200" out of "200" in PHYSICS**, you should be answered the compulsory problem as well as possible. The Physics learners are advised to frame their own responses taking ideas from the help – points given for each problem.

Here, All the Public Examination questions **(Up to March 2015)** particularly, fifty nine problems are dealt in a detailed and simple manner, just like your attempts. The students are thus prepared in an effective way to face the compulsory problem confidently and come out with flying colors.

With Best Wishes and Regards,

ALWAYS WITH EDUCATIONAL SERVICE
RAJENDRAN M, M.Sc., B.Ed., C.C.A.,
P.G. ASSISTANT IN PHYSICS,
DEPARTMENT OF PHYSICS,
SRM HIGHER SECONDARY SCHOOL,
KAVERIYAMPOONDI,
THIRUVANNAMALAI – 606603.
murasabiphysics@gmail.com

UNIT - I ELECTROSTATICS

01. A Parallel Plate Capacitor has plates of area $200cm^2$ and separation between the Plates 1mm. Calculate i) The Potential Difference between the plates if 1nc charge is given to the Capacitor ii) with the same charge if the plate separation is increased to 2mm, what is the new Potential difference and iii) Electric field between the Plates.

[March 2006]

Solution: Given Data: d= 1mm = $1x10^{-3}$m; a=$200cm^2$ or $200x10^{-4}m^2$; q=1nc=$1x10^{-9}$C

Formula: The Capacitance of the Capacitor

$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85X10^{-12}X200X10^{-4}}{1X10^{-3}}$$

C= $0.177x10^{-9}$F ; **C= 0.177nF**

i) The Potential Difference between the Plates:

$$V = \frac{q}{C} = \frac{1X10^{-9}}{0.177X10^{-9}};\ \mathbf{V=5.65V}$$

ii) If the Plate separation is increased from 1mm to 2mm, the Capacitance is decreased by 2, the Potential difference increases by the factor 2.

New Potential difference is 5.65x2=11.3V

iii) Electric Field is, $E=\frac{\sigma}{\varepsilon_0} = \frac{q}{A.\varepsilon_0} = \frac{1X10^{-9}}{8.85X10^{-12}X200X10^{-4}}$

E = 5650NC^{-1}

---

02. Three Capacitors each of Capacitance a 9pF are connected in Series i) What is the total Capacitance of the combination? ii) What is the Potential difference across each Capacitor? If the combination is connected to 120V Supply? **[June2006, Sep. 2006, June 2011]**

Solution: Given Data: C_1 = 9µF; C_2 = 9µF; C_3 = 9µF;

i) When the Capacitors are connected in Series, $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$$= \frac{1}{9} + \frac{1}{9} + \frac{1}{9}; = \frac{1+1+1}{9} = \frac{3}{9} = \frac{1}{3}$$

C_S = 3pF Total Capacitance = $3x10^{-12}$F

ii) Voltage V = 120V; Total Capacitance C= $3x10^{-12}$F

Charge q= CV; = $3x10^{-12}$x120 = $360x10^{-12}$

Capacitance of Individual Capacitor C = $9x10^{-12}$F

Potential difference across each Capacitor $V = \frac{q}{C} = \frac{\mathbf{360X10^{-12}}}{\mathbf{9X10^{-12}}}$; **V=40V**

Total Capacitance of the combination = **$3x10^{-12}$F = 3pF**

Potential difference across each Capacitor **V=40V**

---

03. Two Capacitances 0.5 μF and 0.75 μF are connected in Parallel and the combination to a 110V battery. Calculate the Charge from the Source and Charge on each Capacitor? **[June 2007]**

Solution: Given Data: **$C_1 = 0.5\times10^{-6}$F; $C_2 = 0.75\times10^{-6}$F; V=110V**

Formula : Charge Q = CV

Charge on First Capacitor $Q_1 = C_1V$

$Q_1 = 0.5\times10^{-6}\times110 = 55\times10^{-6}$C **$Q_1$ =55** μC

Charge on Second Capacitor $Q_2 = C_2V$

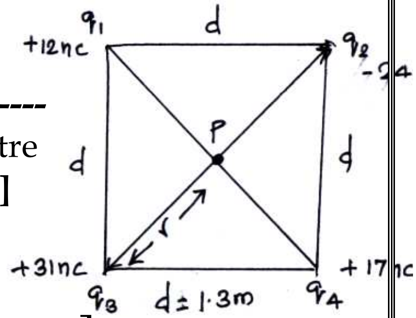
$Q_2 = 0.75\times10^{-6}\times110 = 82.50\times10^{-6}$C **$Q_2$ =82.5** μC

Total Charge Q = $Q_1 + Q_2$ = 55+82.5 = 137.5 μC

Charge from the Source (Q) = 137.5 μC

---

04. Calculate the Electric Potential at a Point P, Located at the Centre of the Square of Point Charge shown in the figure. **[June2007]**



Solution: Given Data: q_1=+12nC; q_2=-24nC; q_3=+31nC; q_4=+17nC; d=1.3m

Formula: Potential at a Point P is $V = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1}{r} + \frac{q_2}{r} + \frac{q_3}{r} + \frac{q_4}{r}\right]$

The distance $r = \frac{d}{\sqrt{2}} = \frac{1.3}{\sqrt{2}}$ **r = 0.919m**

Total Charge (q) = $q_1+q_2+q_3+q_4$ = $(12–24+31+17)\times10^{-9}$ **q = 36×10^{-9}**

Potential at a Point P (V) = $\frac{9X10^9X36X10^{-9}}{0.919}$ **V = 352.6V**

---

05. Two Positive Charges of 12 μC and 8 μC respectively are 10cm apart. Find the Work done in bringing them 4cm closer, so that, they are 6cm apart. **[June 2008]**

Solution: Given Data: The Charges are q_1 = 12C; q_2 = 8C

Distance between the charges $r_B = 10\times10^{-2}$m

Distance between the charges $r_A = 6\times10^{-2}$m

Work = $\frac{q_1q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$ $= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^9 \left(\frac{1}{6X10^{-2}} - \frac{1}{10X10^{-2}}\right)$

$= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^9 \times 10^2 \left(\frac{10-6}{60}\right)$

$= 12 \times 10^{-6} \times 8 \times 10^{-6} \times 9 \times 10^{11} \left(\frac{4}{60}\right)$

$= \frac{96X36}{60} \times 10^{11} \times 10^{-12}$ $= 57.6 \times 10^{11} \times 10^{-12}$; $= 57.6 \times 10^{-1}$;

= 5.76 **Work = 5.76J**

---

06. Two Capacitors of unknown Capacitances are connected in series and parallel if the net Capacitances in the two combinations are 6 μF and 25μF respectively find their Capacitances. **[Sep.2008]**

Solution: Given Data: $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{6}$

$C_p = C_1 + C_2 = 25\ \mu F \quad C_1 + C_2 = 25 - - - - - (1)$

$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{C_1 + C_2}{C_1 C_2} = \frac{1}{6} \therefore 6(C_1 + C_2) = C_1C_2$ - - - - - - - - (2)

From (1) we get $C_2 = 25 - C_1$ - - - - - - - - - - - (3)

Using equation (3), equation (2) can be written as

$6(C_1 + 25 - C_1) = C_1 (25 - C_1)$

$150 = 25C_1 - C_1^2 \qquad C_1^2 - 25C_1 + 150 = 0$

$C_1^2 - 15C_1 - 10C_1 + 150 = 0 \quad ; \quad (C_1 - 15)(C_1 - 10C) = 0$

$\therefore C_1 = 15\ \mu F$ or $10\ \mu F$

When $C_1 = 15\ \mu F$, $C_2 = (25 - 15) = 10\ \mu F$

When $C_1 = 10\ \mu F$, $C_2 = (25 - 10) = 15\ \mu F$

The Capacitances are $C_1 = 15\ \mu F$; $C_2 = 10\ \mu F$

---

07. The Plates of Parallel Plate Capacitor have an area of $90cm^2$ each and are separated by 2.5mm. The Capacitor is charged by connecting it is a 400V supply, how much Electrostatic Energy is stored by the Capacitor? **[June 2009, Sep.2013]**

Solution: Given Data: $A = 90cm^2 = 90x10^{-4}m^2$, $d = 2.5mm = 2.5x10^{-3}$; $V = 400V$

Capacitance of a Parallel Plate Capacitor (C) = $\frac{\varepsilon_0 A}{d}$

$= \frac{8.85X10^{-12}X90X^{10-4}}{2.5X^{10-3}}$

$C = 3.186x10^{-11}F$

Energy of the Capacitor = $\left(\frac{1}{2}\right)CV^2$

$= \left(\frac{1}{2}\right) x\ 3.186\ x\ 10^{-11}\ x\ (400)^2$

Energy = $2.55x10^{-6}J$

---

08. Three Charges -2×10^{-9}C, 3×10^{-9}C, -4×10^{-9}C are placed at the vertices of an equilateral triangle ABC of side 20cm Calculate the workdone in shifting the charges A, B and C to A_1, B_1, and C_1 respectively which are mid points of the sides of the triangle.

Solution: Given Data: $q_1 = -2\times10^{-9}C$, $q_2 = 3\times10^{-9}C$, $q_3 = -4\times10^{-9}C$

AB = BC = CA = 20cm = 0.20m

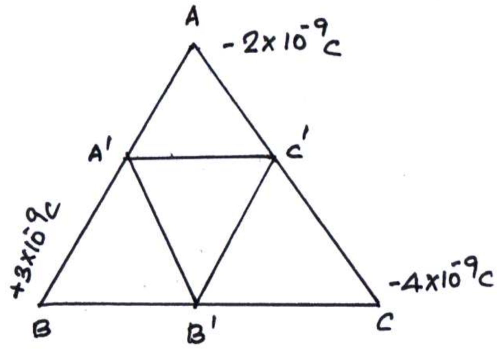
The Potential Energy of the System of Charges,

$$U = \frac{1}{4\pi\epsilon_0}\left[\frac{q_1q_2}{r} + \frac{q_2q_3}{r} + \frac{q_3q_1}{r}\right]$$

Work done in displacing the charges from A, B and C to A_1, B_1 and C_1 respectively

$W = U_f - U_i$

U_i and U_f are the initial and final potential energy of the system



$U_i = \frac{9X10^9}{0.20}[-6 \times 10^{-18} - 12 \times 10^{-18} + 8 \times 10^{-18}]$

$= -4.5 \times 10^{-7}J$

$U_f = \frac{9X10^9}{0.10}[-6 \times 10^{-18} - 12 \times 10^{-18} + 8 \times 10^{-18}]$

$= -9 \times 10^{-7}J$

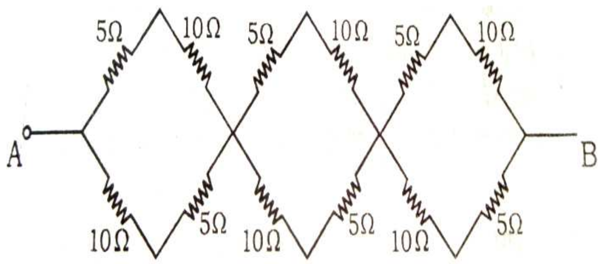
Work done = $-9 \times 10^{-7} - (-4.5 \times 10^{-7})$; **$W = -4.5 \times 10^{-7}$ J**

UNIT - II CURRENT ELECTRICITY

09. In the given network, calculate the effective resistance between points A and B. Find the effective resistance one unit **[March 2007]**

∴ The network has three identical units. The simplified form of one unit is given below.

Figure



The equivalent resistance of one unit is

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{15} + \frac{1}{15}$ or $R_P = 7.5\Omega$

The combined resistance between points A and B is

$R = R^I + R^I + R^I$ $(\because R_s = R_1 + R_2 + R_3)$

$R = 7.5 + 7.5 + 7.5 = 22.5\ \Omega$

Effective Resistance R = 22.5 Ω

---

10. The effective resistances are10 Ω, 2.4 Ω when two resistors are connected in series and parallel. What are the resistances of individual resistors

[Mar.2007, Mar.2010,Oct.2011, Mar. 2015]

Solution: Given Data: $R_s = R_1 + R_2 = 10\ \Omega$ - - - - - - - (1)

$$R_P = \frac{R_1R_2}{R_1+R_2} = 2.4\ \Omega \text{ - - - - - - - - -(2)}$$

From eqn.(1) we get $R_2 = 10 - R_1$

From eqn.(2) we get $R_1R_2 = 2.4\ (R_1+R_2)$

$2.4(R_1+10 - R_1) = R_1R_2$; $24 = R_1R_2$

$(R_1 - R_2)^2 = (R_1 + R_2)^2 - 4R_1R_2$; $= (10)^2 - 4(24)$; $= 100 - 96$; $= 4$

$R_1 - R_2 = 2$; $\therefore R_1 - R_2 = 2$; $R_1 + R_2 = 10$

(1) + (3) $\therefore 2R_1 = 12$; $\therefore R_1 = 6$

Substitute eqn. (1) $\therefore R_2 = 10 - R_1$; $= 10 - 6$; $R_2 = 4$

Resistance of $R_1 = 6\ \Omega$; Resistance of $R_2 = 4\ \Omega$

---

11. A copper wire of 10^{-6} m^2 area of cross section carries a current of 2A, if the number of electron per cubic meter is 8×10^{28}, Calculate the Current density and Average drift velocity. **[March 2009]**

Solution: Given Data: Area = 10^{-6}m^2; Current = 2A; Number of electrons /m^3 = 8×10^{28}

Current density (J) $= \frac{I}{A}$; $J = \frac{2}{10^{-6}}$; **$J = 2 \times 10^6$ A/m^2** **J =** neV_d

$$V_d = \frac{J}{ne};\ = \frac{2X10^{6}}{8X10^{28}X1.6X10^{-19}}\ ;= 15.6 \times 10^{-5} ms^{-1}$$

Average Drift Velocity = 15.6×10^{-5} ms^{-1}

---

12. What is the drift velocity of an electron in a copper conductor having area 10×10^{-6}m^2 carrying a current of 2A. Assume that there are 10×10^{28} electrons / m^3 **[March 2011]**

Solution: Given Data: Area = 10×10^{-6}m^2; Current = 2A; Number of electrons /m^3 = 10×10^{28}

Drift Velocity (V_d) $= \frac{I}{nAe}$

$$V_d = \frac{2}{10X10^{28}X10X10^{-6}X1.6X10^{-19}}$$

$$= \frac{2}{1.6X10^{5}} = 1.25 \times 10^{-4} ms^{-1};$$

Drift Velocity = 1.25×10^{-5} ms^{-1}

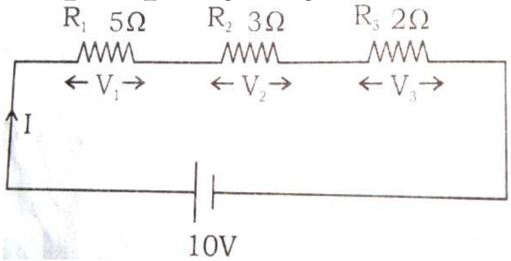
---

13. Three resistors are connected in series with 10V supply as shown in the figure. Find the voltage drop across each resistor **[June 2010, March 2012]**

Solution: Given Data: $R_1 = 5\ \Omega$, $R_2 = 3\ \Omega$, $R_3 = 2\ \Omega$, V = 10 Volt

Effective Resistance of Series combination $R_s = R_1 + R_2 + R_3 = R_s$ - 10 Ω

Current in Circuit $I = \frac{V}{R_S}$; $= \frac{10}{10}$; **I = 1A**



Voltage drop across R_1, $V_1 = IR_1$ = 1x5=5V

Voltage drop across R_2, $V_2 = IR_2$ = 1x3=3V

Voltage drop across R_3, $V_3 = IR_3$ = 1x2=2V

Voltage drop across each resistors are **V_1 = 5V; V_2 = 3V; V_3 = 2V**

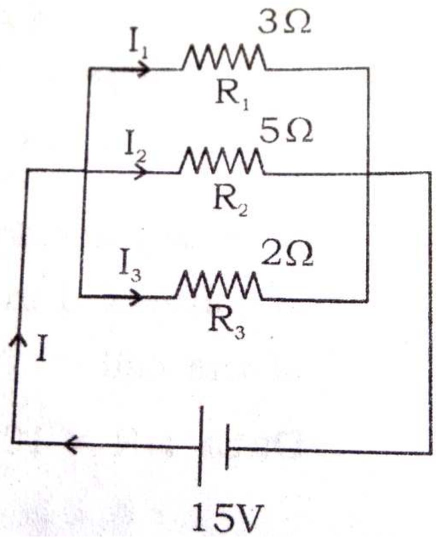
---

14. Find the current flowing across the resistors 3 Ω , 5 Ω and 2 Ω connected in Parallel to a 15V supply; also find the effective resistance and Total Current drawn from the supply. **[Oct.2010, Mar. 2015]**

Solution: Given Data: $R_1 = 3\ \Omega$, $R_2 = 5\ \Omega$, $R_3 = 2\ \Omega$, V = 15 Volt

Effective Resistance of Series combination $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$= \frac{1}{3} + \frac{1}{5} + \frac{1}{2}$ $\mathbf{R_P} = 0.9677\ \Omega$



Current through R_1, $I_1 = \frac{V}{R_1} = \frac{15}{3} = 5A$

Current through R_2, $I_2 = \frac{V}{R_2} = \frac{15}{5} = 3A$

Current through R_3, $I_3 = \frac{V}{R_3} = \frac{15}{2} = 7.5A$

Total Current $I = \frac{V}{R_P} = \frac{15}{0.9677}$ **I = 15.5A**

Effective Resistance R_P = 0.9677 Ω

Total Current drawn from supply I = 15.5A

---

15. In a metre bridge, the balancing length for a 10 Ω resistance in left gap is 51.8cm. Find the unknown resistance and specific resistance of a wire of length 108cm and radius 0.2mm. **[Oct.2010, June 2010]**

Solution: Given Data: Resistance in left gap of a metre bridge P = 10 Ω

Balancing length ℓ_1 = 51.8cm; ℓ_2 = 100 – ℓ_1 = 100 – 51.8

= 48.2cm = 48.2×10^{-2}m

Length of a wire = 108×10^{-2}m = 1.08m; Radius of the wire = 0.2×10^{-3}m

Unknown Resistance Q = $\frac{P X \ell_2}{\ell_1}$; Specific Resistance ρ = $\frac{Q X \pi r^2}{\ell}$

Unknown Resistance Q = $\frac{10X48.2}{51.8} = \frac{482}{51.8}$ **Q = 9.305ohm.**

Specific Resistance ρ = $\frac{9.305X3.14X(0.2X10^{-3})^2}{1.08}$

$= \frac{9.305X3.14X0.04X10^{-6}}{1.08} = \frac{1.1687}{1.08}$ **ρ = 1.082×10^{-6} ohm metre**

Unknown Resistance Q= 9.305ohm.

Specific Resistance ρ = 1.082×10^{-6} ohm metre

---

16. An iron box of 400W power is used daily for 30 minutes. If the cost per unit is 75 paise, find the weekly expense on using the iron box. **[June 2012]**

Solution: Given Data: Power of an iron box P = 400W; Rate / Unit = 75p;

Consumption time t = 30minutes / Day; Cost / Week =?

Energy consumed in 30 minutes = Power x time in hours

= 400 x ½ = 200Wh

Energy consumed in one week = 200x7=1400Wh = 1.4Unit

Cost / Week = Total units consumed x Rate / Unit

= 1.4x0.75 = **₹.1.05**

---

17. The resistance of a field coil measures 50 Ω at 20^0C and 65 Ω at 70^0C. Find the temperature coefficient of resistance. **[June 2013]**

Solution: Given Data: R_{20} = 50 Ω ; R_{70} = 65 Ω ; α =?

$R_t = R_0 (1+ \alpha t)$; $R_{20} = R_0 (1+ \alpha 20)$; $50 = R_0 (1+ \alpha 20)$ - - - - - - - - (1)

$R_{70} = R_0 (1+ \alpha 70)$; $65 = R_0 (1+ \alpha 70)$ - - - - - - - - (2)

Dividing (2) by (1)

$\frac{65}{50} = \frac{1+70\alpha}{1+20\alpha}$; 65 + 1300α = 50 + 3500 α

2200 α = 15 ; $\alpha = \frac{0.0068}{0^C}$

---

18. A circular coil of radius 20cm has 100 turns wire and it carries a current of 5A. Find the magnetic induction at a point along its axis at a distance of 20cm from the centre of the coil. **[March 2006, Oct. 2006, March 2009]**

Solution: Given Data: Number of Turns n = 100; Current I = 5A

Distance of the Coil d = 20x10^{-2}m

Magnetic Induction B = $\dfrac{\mu_0 n I a^2}{2(a^2+x^2)^{\frac{3}{2}}}$

Magnetic Induction B = $\dfrac{4X3.14X10^{-7}X100X5X(2X10^{-1})^2}{2\{(2X10^{-1})^2+(2X10^{-1})^2\}^{\frac{3}{2}}}$

$= \dfrac{12.56X500X10^{-7}X4X10^{-2}}{2X\{4X10^{-2}+4X10^{-2}\}^{\frac{3}{2}}}$

$= \dfrac{12.56X500X10^{-9}X2}{(8X10^{-2})^{\frac{3}{2}}}$; $= \dfrac{12.56X10^{-6}}{(\sqrt{8}X10^{-1})^3}$

$= \dfrac{12.56X10^{-6}}{8\sqrt{8}X10^{-3}}$; $= \dfrac{12.56X10^{-6}}{8X2\sqrt{2}X10^{-3}}$; B = $\dfrac{6.28}{8X1.414}$x10^{-3} = 0.555162X10^{-3}

= 5.5516x10^{-4} = 5.552x10^{-4}T

Magnetic Induction = 5.552x10^{-4}T

----

19. A rectangular coil of 500 turns and area 6X10^{-4} m^2 is suspended inside a radial magnetic field of induction 10^{-4}T by a suspension wire of torsional constant 5x10^{-10} Nm/degree. Calculate the current required to produce a deflection of 10^0

[June 2006, Oct.2009, March 2013]

Solution: Given Data: Number of turns of the coil n = 500

Area of the coil A = 6x10-^{4}m^2 ; Magnetic field B = 10^{-4}T

Torsional Constant C = 5x10^{-10}Nm per degree

Angle of deflection θ = 10^0

Formula: nBIA = C **θ** **; Current I =** $\dfrac{C\theta}{nBA}$

Current I = $\dfrac{C\theta}{nBA} = \dfrac{5X10^{-10}X10}{500X10^{-4}X6X10^{-4}} = \dfrac{50X10^{-10}}{3000X10^{-8}}$

= 0.01666x10^{-10+8}

= 0.01666x10^{-2}

= 0.1666x10^{-3} ; = 0.1666mÅ

Current Required = 0.1666mÅ

----

20. A moving coil Galvanometer of resistance 20 **Ω** produces full scale deflection for a current of 50mA. How you will convert the Galvanometer into (i) An ammeter of range 20A and (ii) A voltmeter of range 120V. **[March 2007, March 2009, June 2013]**

Solution: Given Data: G = 20 ; $I_g = 50x10^{-3}$A; I = 20A ; S = ?
V = 120V ; R = ?

i) $S = G\frac{I_g}{I-I_g}$; $\frac{20X50X10^{-3}}{20-50X10^{-3}}$; $\frac{1}{20-0.05}$; **S = 0.05 Ω**

A shunt of 0.05 Ω should be connected in parallel

ii) $R = \frac{V}{I_g} - G$; $\frac{120}{50X10^{-3}}$ - 20 ; 2400 – 20 = 2380 **Ω**

R = 2380 Ω

---

21. A long straight wire carrying current produces a Magnetic Induction of $4x10^{-6}$T at a point. 15 cm from the wire, Calculate the current through the wire. **[Oct.2007]**

Solution: Given Data: B = $4x10^{-6}$T ; a = $15x10^{-2}$m; I = ?

$B = \frac{\mu_0 I}{2\pi a}$; $I = \frac{BX2\pi a}{\mu_0}$;

$= \frac{4X10^{-6}X2\pi X15X10^{-2}}{4\pi X10^{-7}}$; **I = 3A**

---

22. In a Hydrogen atom electron moves in an orbit of radius 0.5Å making 10^{16} revolutions per second. Determine the Magnetic moment associated with orbital motion of the electron. **[June 2008]**

Solution: Given Data: r= 0.5Å = $0.5x10^{-10}$m; n = $10^{16}s^{-1}$

Orbital Magnetic Moment μ_l= i.A ----------------(1)

$i = \frac{e}{T}$; e.n ----------------(2)

$A = \pi r^2$ -----------------(3)

Substituting equation (2), (3) in (1) μ_l= e.n. πr^2

$= 1.6x10^{-19}x10^{16}x3.14(0.5x10^{-10})^2$;

$= 1.256x10^{-23}$

∴ $\mu_l = 1.256x10^{-23}Am^2$

---

23. A Galvanometer has a resistance of 40 Ω. It shows full scale deflection for a current of 2mA. How you will convert the Galvanometer into a Voltmeter or range 0 to 20V?

[Oct.2010]

Solution: Given Data: Resistance of Galvanometer G = 40 Ω.

Current flowing through Galvanometer Ig = $2x10^{-3}$A; Voltage V = 20V

Resistance R = $\frac{V}{I_g} - G$; $\frac{20}{2X10^{-3}}$ - 40 ; = $10x10^3$ – 40 ; = 10000 – 40 = 9960 **Ω**

A resistance of 9960 Ω is to be connected in series.

---

24. Two parallel wires each of length 5cm are placed at a distance of 10cm apart in air. They carry equal currents along the same direction and experience a mutually attractive force of $3.6x10^{-4}$ N. Find the current through the conductors.

[Oct.2009, June 2010, March 2013]

Solution: Given Data: $I_1 = I_2 = I$ ℓ = 5m, a =10^{-1}m, F = $3.6x10^{-4}$N, I =?

$F = \frac{\mu_0 I_1 I_2 \ell}{2\pi a}$; $= \frac{2X10^{-7} I^2 \ell}{a}$;

$I^2 = \frac{F.a}{2X10^{-7}\ell} = \frac{3.6X10^{-4}X10^{-1}}{2X10^{-7}X5}$

$I^2 = 36$; **I = 6A**

---

25. Two straight infinitely long parallel wires carrying equal currents and parallel at a distance of 20cm apart in air experience a mutually attractive force of $4.9x10^{-5}$N per unit length of wire, calculate the current. **[Oct.2011]**

Solution: Given Data: Distance of separation a = $20x10^{-2}$m

Attractive force F = $4.9x10^{-5}$ per unit length

Strength of currents is same i.e., $I_1 = I_2 = I$

$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi a}$; $\frac{F}{\ell} = \frac{\mu_0 I^2}{2\pi a}$ [∵ $I_1 = I_2 = I$] ;

$\frac{F}{\ell} = \frac{4\pi X10^{-7} X I^2}{2\pi X 20 X10^{-2}}$; $\frac{F}{\ell} = 4.9x10^{-5}$

$\frac{2I^2}{20}x10^{-5} = 4.9x10^{-5}$; $= I^2 = 49$

∴Current = I = $\sqrt{49}$; = 7A ∴Current = I = 7A

---

26. The deflection in a Galvanometer falls from 50 divisions to 10 divisions when 12 Ω resistance is connected across the Galvanometer. Calculate the Galvanometer resistance.

[Sep.2012]

Solution: Given Data: θ_1 = 50 Division, θ_g = 10 Division, S = 12 Ω; G = ?

$I \propto \theta_1$; $I_g \propto \theta_g$

In a parallel circuit potential is common.

$\therefore G I_g = S(I - I_g)$

$\therefore G = \frac{S(I-I_g)}{I_g}$; $\frac{12(50-10)}{10}$; **G = 48** Ω

UNIT – IV ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENT

27. An A.C Generator consists of a coil 10000 turns and of area $100cm^2$. The coil rotates at an Angular speed of 140rpm in a uniform magnetic field of $3.6x10^{-2}$T. Find the maximum value of the emf induced. **[June 2009]**

Solution: Given Data: N = 10000; A = $10^2cm^2 = 10^{-2}m^2$;

ω = 140rpm = $\frac{140}{60}$ rps ; B = $3.6x10^{-2}$T E_o = ?

Formula : E_o = NAB ω = NAB2πv

Maximum value of the Induced emf = $10^4x10^{-2}x3.6x10^{-2}x2\pi x\frac{7}{3}$

E_o = 52.75V **Maximum value of the emf induced is 52.75V.**

UNIT – V ELECTROMAGNETIC WAVES AND WAVE OPTICS

28. A soap film of refractive index 1.33 is illuminated by white light incident at an angle 300. The reflected light is examined by spectroscope in which dark band corresponding to the wave length 6000Å is found. Calculate the smallest thickness of the film.

[Oct.2007, Sep.2013]

Solution: Given Data: μ = 1.33; I = 30^0; λ = 6000Å = $6x10^{-7}$m;

n = 1 (Smallest thickness) ; t = ?

$\mu = \frac{\text{Sin i}}{\text{Sin r}}$; $\text{Sin r} = \frac{\text{Sin i}}{\mu}$; $\frac{\text{Sin } 30^0}{1.33}$; $\frac{0.5}{1.33}$; **Sin r = 0.3759**

$\therefore$ Cos r = $\sqrt{1-(0.3759)^2}$; = 0.9267

$2\mu t\cos r = \lambda$; $t = \frac{\lambda}{2\mu \text{Cos r}}$; $= \frac{6X10^{-7}}{2X1.33X0.9267}$

t = $\frac{6X10^{-7}}{2.465}$; **t = $2.434x10^{-7}$m**

Smallest thickness of the film t = $2.434x10^{-7}$m ------------------------------------

29. In Young's Experiment of a light of frequency $6x10^{14}$Hz is used distance between the centre of adjacent fringes is 0.75mm. Calculate this distance between the slits, if the screen is 1.5m away. **[Oct.2007]**

Solution: Given Data: Frequency of light v = $6x10^{14}$Hz

Bandwidth $\beta = 0.75x10^{-3}m = 75x10^{-5}m$

Let the distance between the slits = d; Distance of the screen D = 1.5m

$\beta = \frac{\lambda D}{d}$;

$\therefore \lambda = \frac{\beta d}{D}$;

$\therefore d = \frac{\lambda D}{\beta}$; $\lambda = \frac{C}{V}$

Wave length $\lambda = \frac{C}{V}$;

$= \frac{3X10^{8}}{6X10^{14}}$; $= 0.5x10^{8-14}$; $= 0.5x10^{-6}$; $= 5000x10^{-10}m$

We know that for Young's double slit experiment $\beta = \frac{\lambda D}{d}$

Distance between two slits, d = $\frac{\lambda D}{\beta}$;

$= \frac{5000X10^{-10}X1.5}{75X10^{-5}}$

$= \frac{5X10^{-7}X15X10^{-1}}{75X10^{-5}}$; **$= 10^{-7-1+5} = 10^{-3}m$; d= 1mm**

Distance between two slits = 1mm

---

30. A parallel beam of monochromatic light is allowed to incident normally on a plane transmission grating having 5000 lines per centrimetre. A second order spectral line is found to be diffracted at an angle 30^0. Find the wave length of the light.

[March2008, March 2010, June 2012]

Solution: Given Data: N = 5000lines /cm = $5000x10^2$lines /m;

m = 2; $\theta = 30^0$; λ = ?

Formula: Sin **θ = Nm ; $\lambda = \frac{\sin\theta}{Nm}$**

$\lambda = \frac{\sin 30^0}{5X10^5X2}$; $\frac{0.5}{5X10^5X2}$; Wavelength $\lambda = 5x10^{-7}m$ **λ = 5000Å**

---

31. A monochromatic light wavelength 589nm is incident on a water surface having refractive index 1.33. Find the velocity frequency and wavelength of light in water.

[Oct.2008, March 2011]

Solution: Given Data: Wavelength λ = 589×10^{-9}m; Refractive Index μ = 1.33

$\mu = \frac{C_{Air}}{C_{Water}}$ $\therefore C_{Water} = \frac{C_{Air}}{\mu}$ **; Frequency** $v = \frac{C_{Water}}{\lambda}$

Velocity of light in water $C_{Water} = \frac{C_{Air}}{\mu}$

$= \frac{3X10^8}{1.33}$; = 2.2556×10^8 C_{Water} = 2.26×10^8 **m/s**

Frequency $v = \frac{C_{Water}}{\lambda} \times \mu$; $= \frac{2.26X10^8}{589X10^{-9}} \times 1.33$

$= \frac{2.26}{589} \times 10^{8+9} \times 1.33$; $= \frac{2.26}{589} \times 10^{17} \times 1.33$

$= \frac{2.26X10^3}{589} \times 10^{14} \times 1.33$; $= \frac{2260}{589} \times 10^{14} \times 1.33$; $= 3.837 \times 10^{14} \times 1.33$

$= 3.84 \times 10^{14} \times 1.33$; **v = 5.103×10^{14}Hz**

Wavelength $\lambda = \frac{C}{V}$ $= \frac{2.26X10^8}{5.103X10^{14}}$ **; =0.442876 x 10^{-6}**

$= 4428.76 \times 10^{-10}$; $= 4429 \times 10^{-10}$m **λ = 4429Å**

Velocity of light in water = 2.26×10^8m/s

Frequency of light in water = 5.103×10^{14}Hz

Wavelength of light in water = 4429Å

---

32. In a Newton's rings experiment the diameter of the 20th dark ring was found to be 5.82mm and that of the 10th ring 3.36mm, if the radius of the Plano convex lens is 1m. Calculate the wavelength of light used. **[March 2010, March 2014]**

Solution: Given Data: Diameter of the 20th dark ring D_{20} = 5.82×10^{-3}m

Diameter of the 10th dark ring D_{10} = 3.36×10^{-3}m

Radius of the Plano Convex lens R = 1m ; Difference of the order m = 10

Formula: $\lambda = \frac{D^2{}_{n+m} - D^2{}_n}{4mR}$ **; Wavelength** $\lambda = \frac{D^2{}_{20} - D^2{}_{10}}{4X10XR}$

$= \frac{(5.82X10^{-3})^2 - (3.36X10^{-3})^2}{4X10X1}$; $= \frac{(5.82+3.36)X10^{-3}\ (5.82-3.36)X10^{-3}}{40}$

$= \frac{9.18X2.46X10^{-6}}{40}$

Wavelength = 5645 x 10^{-10}m ; = 5645Å Wavelength = 5645Å

---

33. A Plano – convex lens of radius 3m is placed on an optically flat glass plate and is illuminated by monochromatic light. The radius of the 8th dark ring is 3.6mm. Calculate the wavelength of light used. **[March 2011]**

Solution: Given Data: R = 3m ; n = 8 ; r_8 = 3.6mm = 3.6x10^{-3}m ; λ = ?

Formula: rn = $\sqrt{nR\lambda}$ r_n^2 = nR $\boldsymbol{\lambda}$

$\boldsymbol{\lambda} = \dfrac{r_{n2}}{nR}$; $= \dfrac{(3.6X10^{-3})^2}{8X3}$; **= 5400x10^{-10}m (or) 5400** Å

The wavelength of light used is 5400Å

---

34. A Plane transmission grating has 5000 lines / cm. Calculate the Angular separation in second order spectrum of red line 7070Å and blue line 5000Å **[June 2013]**

Solution: Given Data: Number of lines of a grating = $\dfrac{5000}{10^{-2}}$; = 5x10^5

Wavelength of Red line λ_R = 7070Å; Wavelength of Blue line λ_B = 5000Å

Order m = 2

Formula: Sinθ = Nmλ ; For Red line, Sinθ_R = Nmλ_R

Sinθ_R = 5x10^5 x 2 x 7070 x 10^{-10}; = 70700 x 10^{-5}; = 0.707

θ_R = Sin^{-1} (0.707) ; **θ_R = 45^0**

For Blue line, Sinθ_B = Nmλ_B

Sinθ_B = 5x10^5 x 2 x 5000 x 10^{-10}; = 5000 x 10^{-5}; = 0.5

θ_B = Sin^{-1} (0.5) ; **θ_B = 30^0**

Angular Separation **θ_R - θ_B ; 45^0 - 30^0 Angular Separation = 15^0**

---

35. A 300mm long tube containing 60cc of Sugar solution produces a rotation of 9^0 when placed in a polarimeter, if the specific rotation is 60^0. Calculate the quantity of Sugar contained in the solution. **[June 2013]**

Solution: Given Data: ℓ = 300mm = 30cm = 3 decimeter

θ = 9^0 ; S = 60^0; v = 60cc; m = ?

Formula S = $\dfrac{\theta}{\ell XC}$; $= \dfrac{\theta}{\ell X(m/v)}$

m = $\dfrac{\theta.v}{\ell XS}$; $= \dfrac{9X60}{3X60}$

Quantity of Sugar m = 3g.

---

36. Wavelength of Balmer second line is 4861Å. Calculate the wave length of first line. **[March 2007]**

Solution: Given Data: For Balmer second line $n_1 = 2$, $n_2 = 4$, $\lambda_2 = 4861$Å

For Balmer First line $n_1 = 2$, $n_2 = 3$, $\lambda_1 = ?$

For Balmer second line $\bar{\nu} = \frac{1}{\lambda_2}$; $= R\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$

$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$; $= R\frac{3}{16}$ -------------**(1)**

For Balmer first line $\bar{\nu} = \frac{1}{\lambda_1}$; $= R\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$

$\frac{1}{\lambda_1} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$; $= R\frac{5}{36}$ -------------**(2)**

Dividing (1) by (2) $\frac{\lambda_1}{\lambda_2} = \frac{R\frac{3}{16}}{R\frac{5}{36}}$; $= \frac{3}{16} X \frac{36}{5} = \frac{27}{20}$

$\boldsymbol{\lambda_1 = \lambda_2 \times \frac{27}{20}}$; $= 4861 \times \frac{27}{20}$; $\boldsymbol{\lambda_1 =}$ **6563**Å

---

37. In Bragg's Spectrometer the glancing angle for first order spectrum was observed to be 8^0. Calculate the wave length of x– ray. If d = $2.82 x 10^{-10}$m. At what angle will the second maximum occur? **[June 2007]**

Solution: Given Data: For n = 1; $\theta_1 = 8^0$; d = 2.82×10^{-10}m; λ =?

For n = 2; θ_2 =?

When n = 1, 2dsin $\boldsymbol{\theta_1}$ = (1) λ or $\boldsymbol{\lambda}$ = 2 x 2.82 x 10^{-10} x sin 8^0; = 0.7849 Å

When n = 2; 2dsin $\boldsymbol{\theta_2}$ = (2) λ

sin $\boldsymbol{\theta_2} = \frac{\lambda}{d}$; $= \frac{0.7849 X 10^{-10}}{2.82 X 10^{-10}}$; = 0.2783 ; = Sin^{-1} (0.2783) ; $\boldsymbol{\theta_2}$**= 16^0 9′**

---

38. An α particle is projected with an energy on 4MeV directly towards a gold nucleus, calculate this distance of its closest approach (Given atomic number of Gold 79 and atomic number of a α particle = 2) **[March 2008]**

Solution: Given Data: Energy of the α particle = 4MeV = $4x10^6$ev = $4x10^6x1.6x10^{-10}$J $E_K = 6.4x10^{-13}$J ; Z = 79, r_0=?

Formula: $r_0 = \frac{2Ze^2}{4\pi\varepsilon_{0E_K}}$; $= \frac{2X79X(1.6X10^{-19})^2X9X10^9}{6.4X10^{-13}}$

$r_0 = 5.688 \times 10^{-14}$m.

---

39. An electron beam passes through a transverse magnetic field of 2 x 10^{-3} T and an electric field E of 3.4 x 10^4 V/m, acting simultaneously, If the path of the electrons remain un-deviated calculate the speed of electrons. If the electric field is removed what will be the radius of the electron path? **[Oct.2011]**

Solution: Given Data: Magnetic field B = 2X10^{-3}T ;
Electric field E = 3.4x10^4V/m.
Formula: Speed of Electrons v $= \frac{E}{B}$; Radius of the electron path r = $\frac{\text{mv}}{\text{Be}}$
Speed of electrons v = $\frac{\mathbf{E}}{\mathbf{B}}$; $= \frac{3.4X10^4}{2X10^{-3}}$;
v = 1.7x 10^7m/s
Radius of the electron path r = $\frac{\mathbf{mv}}{\mathbf{Be}}$ **;**

$$= \frac{9.1X10^{-31}X1.7X10^7}{2X10^{-3}X1.6X10^{-19}}$$

$$= \frac{15.47X10^{-24}}{3.2X10^{-22}} ; = 4.834 \times 10^{-2}\text{m}$$

Speed of electrons v =1.7x 10^7m/s
Radius of the electron path r =4.834 x 10^{-2}m

UNIT – VII DUAL NATURE OF RADIATION OF MATTER AND RELATIVITY

40. How fast would a rocket have to go relative to an observer for its length to be corrected to 99% of its length at rest? **[Oct.2007, Oct.2011, March 2012]**

Solution: Given Data: $\frac{\ell}{\ell_0}$ = 99%; $= \frac{99}{100}$; v = ?

Formula: $= \ell_0\sqrt{1 - \frac{v^2}{c^2}}$; $\ell = \frac{99}{100}\ell_0$

$$\frac{\ell}{\ell_0} = \frac{99}{100} ; \quad \therefore \frac{99}{100} = \sqrt{1 - \frac{v^2}{c^2}}$$

$\therefore$ **v = 0.141c**
v = 0.141 x 3 x 10^8
v = 0.423 x 10^8 ms^{-1}

---

41. At what speed is a particle moving if the mass is equal to three times its rest mass? **[Oct.2008]**

Solution: Given Data: m = 3 m_0; v =?

Formula: $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$; $3m_0 = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$; $\therefore 3 = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

$\sqrt{1-\frac{v^2}{c^2}} = \frac{1}{3}$; $1 - \frac{v^2}{c^2} = \frac{1}{9}$; $-\frac{v^2}{c^2} = \frac{1}{9} - 1$; $= -\frac{8}{9}$

$\frac{v^2}{c^2} = \frac{8}{9}$; $v^2 = \frac{8}{9}c^2$ v = 0.943c ; = 0.943 x 3 x 10^8

V = 2.829 x 10^8ms^{-1}

---

42. The time interval measured by an observer at rest is 2.5 x 10^{-8} s. What is the time interval as measured by an observer moving with a velocity v = 0.73c. **[June 2009]**

Solution: Given Data: Time interval measured by an observer t=2.5 x 10^{-8}s

Formula: Time as measured by an observer $t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

Time interval measured by an observer $t = \frac{2.5 \text{ X } 10^{-8}}{\sqrt{1-\left(\frac{0.73c}{C}\right)^2}}$; $= \frac{2.5 \text{ X } 10^{-8}}{\sqrt{1-0.5329}}$

$= \frac{2.5 \, X \, 10^{-8}}{0.6834}$; = 3.658 x 10^{-8} ; **t =** 3.658 x 10^{-8}

Time interval measured by an observer t =3.658 x 10^{-8}

---

43. A metallic surface when illuminated with light of wavelength 3333Å emits electrons with energies up to 0.6eV. Calculate the work function of the metal. **[Oct.2009, June 2012, March 2013]**

Solution: Given Data: λ = 3333Å ; KE = 0.6eV ; W = ?

Work function, W = hν – Kinetic Energy (or)

Formula: $W = \frac{hc}{\lambda} - KE$; $= \left(\frac{6.626 X 10^{-34} X 3 X 10^{8}}{3333 X 10^{-10}}\right)$ - (0.6 x 1.6 x 10^{-19})

= (5.96 x 10^{-19}) – (0.96 x 10^{-19})

W = 5 x10^{-19} J

$W = \frac{5 \text{ X} 10-19}{1.6 \text{ X} 10-19}$ eV

W = 3.125eV

-

44. The work function of Iron is 4.7eV; calculate the cut off frequency and the corresponding cut off wavelength for this metal. **[June 2009, March 2012]**

Solution: Given Data: Work function of Iron W = 4.7eV

$= 4.7 \times 1.6 \times 10^{-19}$ W = 7.52×10^{-19}

Formula: Cut off frequency $\nu_o = \frac{W}{h}$

$= \frac{7.52 \text{ X } 10^{-19}}{6.625 \text{ X } 10^{-34}}$; **$\nu_o = 1.135 \times 10^{15}$Hz**

Cut off Wavelength $\lambda_0 = \frac{c}{\nu_o}$; = $\frac{3 \text{ X } 10^{8}}{1.135 \text{ X } 10^{15}}$; $= 2.643 \times 10^{-7}$m

$= 2.643 \times 10^{2} \times 10^{-9}$ m ; 2.643×10^{2}nm

Cut off frequency $\nu_o = 1.135 \times 10^{15}$Hz

Cut off Wavelength $\lambda_0 = 2.643 \times 10^{2}$nm

---

45. A proton is moving at a speed of 0.900 times the velocity of light. Find the Kinetic Energy in joules and MeV. **[March 2011]**

Solution: Given Data: Relativistic KE = $mc^2 - m_oc^2$

$E_K = (m - m_o)\, c^2$

Speed of Proton V = 0.9 times C ; = 0.9x C

Mass of Proton m = 1.6726×10^{-27} kg ; C = 3×10^{8}

Relativistic KE = $(m - m_o)\, c^2$; m = ?

$$m = \frac{\mathbf{m_0}}{\sqrt{\mathbf{1-\frac{v^2}{c^2}}}}\ ; = \frac{m_o}{\sqrt{1-\left(\frac{0.9C}{C^2}\right)^2}}\ ; = \frac{m_o}{\sqrt{1-0.81}}$$

$$= \frac{m_o}{\sqrt{0.19}}\ ; = \frac{1}{0.435}\, m_o$$

$m = 2.299\, m_o$

$E_K = (2.299\, m_o - m_o)C^2$

$= m_o C^2(2.299 - 1)$; $= m_o C^2 \times 1.299$

$= 1.6726 \times 10^{-27} \times (3 \times 10^{8}) \times 1.299$

$= \frac{19.55 \text{ X } 10^{-11}}{1.6 \text{ X } 10^{-19}}$ J ; $= \frac{19.55 \text{ X } 10^{-11}}{1.6 \text{ X } 10^{-19}}$ eV

$= 12.218 \times 10^{8}$; $= 1221.8 \times 10^{6}$

E_K = 1221.8MeV

---

46. What is the de – Braglie wave length of an electron of Kinetic Energy 120eV?

[Oct.2012]

Solution: Given Data: KE = 120eV; = 120 x 1.6 x 10^{-19}J; λ = ?

Formula: $\boldsymbol{\lambda} = \frac{\mathbf{h}}{\sqrt{\mathbf{2mE}}}$; $\boldsymbol{\lambda} = \frac{6.626 \text{ X } 10^{-34}}{\sqrt{2\text{X}9.1\text{X}10^{-31}\text{X}120\text{X}1.6\text{X}10^{-19}}}$

λ = 1.121 x 10^{-10}m

UNIT – VIII NUCLEAR PHYSICS

47. A piece of bone from an archaeological site is found to give a count rate of 15 counts per minutes. A similar sample of fresh bone gives a count rate of 19 counts per minute. Calculate the age of the specimen (Given T½ = 5570 Years)

[Mar. 2006, Oct.2011, Sep.2013, March 2014]

Solution: Given Data: Count Rate of fresh sample,
N_o = 19 counts per minute; Count Rate of bone N = 15 counts per minute;
T½ = 5570 Years; Age of the sample, t = ?

Formula: N = $N_o e^{-\lambda t}$; **$\lambda = \frac{0.6931}{5570}$**; 15 = 19$e^{-\lambda t}$ (or) $e^{\lambda t} = \frac{19}{15}$

$\log_e \frac{19}{15} = \lambda t$ (or) $t = \log_e \frac{19}{15} \times \frac{1}{\lambda}$

$t = \frac{5570}{0.6931} \times 2.3026 \times \log_{10} \frac{19}{15}$; $= \frac{5570}{0.6931} \times 2.3026 \times 0.1026$

t = 1899 Years

---

48. Calculate the energy released when 1kg of $_{92}U^{235}$ undergoes nuclear fission. Assume, energy fission is 200MeV, Avogadro = 6.023x10^{23} Express your answer in Kilowatt hour also.

[March 2006, Sep.2011, Sep.2013]

Solution: Given Data: Avogadro Number N = 6.023 x 10^{23}

i.e.235kg of U^{235} contains 6.023 x 10^{23} atoms

1kg of U^{235} contains n = $\frac{6.023\text{X}10^{23}}{235}$ atoms ; = 2.56 x 10^{24} atoms

Energy released per fission of each nuclide = 200MeV

∴Energy released due to fission of n nuclides = E = 200 x 2.56 x 10^{24}MeV

= 5.12 x 10^{23} MeV ; = 5.12 x 10^{23} x 10^{6} eV

= 5.12 x 1029 x 1.6 x 10-19;

= 8.19 x 10^{10} J

1 kilowatt hour = 3600 x 10^{3}J

$E = \frac{8.19 \text{ X}10^{10}}{3600\text{X}10^{3}}$

E = 2.28 x 10^{7}kwh

---

49. Find the energy released when two $_1H^2$ nuclei fuse together to form a single $_2He^4$ nucleus. Given the binding energy per nucleon of $_1H^2$ a single $_2He^4$ nucleus, given the binding energy per nucleon of $_1H^2$ and $_2He^4$ are 1.1 MeV and 7.0 MeV respectively.

[June 2006, Oct. 2012]

Solution: Given Data: Binding energy per nucleon of $_1H^2$ = 1.1MeV

Binding energy per nucleon of $_2H^4$ = 7.0MeV

Total binding energy of $_1H^2$ = 2 x 1.1 = 2.2MeV

Total binding energy of $_2H^4$ = 4 x 7 = 28MeV

The reaction is , $\mathbf{2\ {}_1H^2 \longrightarrow {}_2H^4 + Q}$

Total binding energy of the reactants = 2 x 2.2 = 4.4MeV

Total binding energy of the products = 4 x 7 = 28MeV

Energy Released = Total binding energy of products - Total binding energy of reactants

= 28 – 4.4 ; = 23.6MeV **Energy Released = 23.6MeV**

---

50. A reactor is developing energy at the rate of 32 MW. Calculate the required number of fissions per second of $_{92}U^{235}$. Assume that energy per fission is 200MeV.

[June 2006, June 2008, June 2011, March 2014]

Solution: Given Data: Energy of a reactor = 32MW = 32 x 10^6W

Energy released per fission = 200MeV = 200 x 10^6eV

Energy released per fission = 200 x 10^6 x1.6 x 10^{-19} J = 320 x 10^{-13}J

Required Number of fission per second

$$\mathbf{N = \frac{\text{Total Energy released per second}}{\text{Energy per fission}} = \frac{32X10^{6\ J/S}}{320X10^{-13\ J}}}$$

= 0.1 x 10^{6+13} ; = 0.1 x 10^{19} ; = 1 x 10^{18}

Required Number of fissions per second = 1 x 10^{18}

---

51. Show that the mass of radium ($_{88}Ra^{226}$) with an activity of 1 curie is almost a gram.

[June 2006, March 2008, March 2012]

Solution: Given Data: Half – Life T½ = 1600 Years

1 Curie = 3.7 x 1010 disintegrations / second

Decay Constant $\lambda = \frac{0.6931}{T½}$; $= \frac{0.6931}{1600 \text{ X } 365 \text{ X } 24 \text{ X } 60 \text{ X } 60}$; $= \frac{0.6931}{504576X10^5}$

$\boldsymbol{\lambda}$ **= 0.1373 x 10^{-10}**

From the law of disintegration, we get $\frac{dN}{dt} = \boldsymbol{\lambda}N$

$N = \frac{dN}{dt} \times \frac{1}{\lambda}$

But $\frac{dN}{dt} = 3.7 \times 10^{10}$ disintegrations / second

$\therefore N = 3.7 \times 10^{10} \times \frac{1}{0.1373 \times 10^{-10}}$; **N = 26.948 x 10^{20} atoms.**

According to Avogadro's Hypothesis

6.023 x 10^{23} atoms contribute 226 g of radium.

$\therefore$ 26.948 x 10^{20} atoms contribute

$$= \frac{226 \times 26.948 \times 10^{20}}{6.023 \times 10^{23}} ; = 1011.16 \times 10^{-3} \text{ gm} ; = 1.011 \text{gm}$$

$\therefore$ **26.948 x 10^{20} atoms contribute one gram of radium.**

The mass of radium with an activity of 1 curie is almost a gram.

---

52. Calculate the mass of coal required to produce the same energy as that produced by the fission of 1 kg of $_{92}U^{235}$. **[Oct.2006]**

Solution: Given Data: Energy per fission = 200 MeV ; 1eV = 1.6 x 10^{-19}J

Avogadro Number N= 6.023 x 10^{23}

Heat of combustion of coal = 33.6 x 10^{6} J /kg ; Mass of coal = ?

Energy per fission of U^{235} = 200 MeV ; = 200 x 10^{6} eV

= 200 x 10^{6} eV x 1.6 x 10^{-19}J

Number of atoms in 235 g of U^{235} = 6.023 x 10^{23}

$\therefore$**Number of atoms in 1 kg (1000g) =** $\frac{6.023}{235} \times 10^{23} \times 1000$**;** **=** $\frac{6.023 \times 10^{26}}{235}$

$\therefore$ Energy produced by the fission of 1kg of U^{235}

$$= \frac{6.023 \times 10^{26}}{235} ; = 200 \times 10^{6} \times 1.6 \times 10^{-19} \text{J} ; = 8.2016 \times 10^{13} \text{J}$$

Heat of combustion of coal = 33.6 x 10^{6}J/kg

Let M be the mass in kg of the coal required to produce equivalent energy produced by 1 kg of U^{235}

$\therefore$ 33.6 x 10^{6} x M = 8.2016 x 10^{13}J

$\therefore M = \frac{8.2016 \times 10^{13}}{33.6 \times 10^{6}}$; = 0.2441 x 10^{7} kg

= 2.441 x 10^{6} kg ; **1000 kg = 1 ton**

$\therefore$ 2.441 x 10^{6} kg = 2441 x 10^{3} kg ; = 2441 ton.

2441 ton of coal is required to produce the same energy as that produced by fission 1 kg of U^{235}

---

53. Mass defect of $_6C^{12}$ is 0.098 amu . Calculate the binding energy per nucleon.

[June 2007]

Mass defect (Δm) of the nucleus $_6C^{12}$ = 0.0989 amu

1amu = 931 MeV

$\therefore$ Binding energy of the nucleus = 0.0989 x 931; = 92.076 meV

There are 12 neucleus in the $_6C^{12}$ nucleus.

$\therefore$ Binding energy per nucleon = $\frac{92.076}{12}$; = 7.672

Binding energy per nucleon = 7.7 MeV

---

54. Calculate the time required for 60% of a sample of radon to undergo decay. Given **T½** of radon = 3.8 Days. **[March 2007]**

Solution: Given Data: Half – Life of radon (T½) = 3.8 Days

Amount of sample disintegrated = 60%; Time required =?

Formula: $\boldsymbol{\lambda = \frac{0.6931}{3.8}}$ **per day ;** Amount of sample disintegrated = 60%

Amount of sample present = 40%

Let N_o be the original amount of the sample present.

From law of disintegration, $\mathbf{N = N_o e^{-\lambda t}}$

Substituting for N = 40% of N_e, ; $\frac{40}{100} N_o = N_o e^{-\lambda t}$

$\therefore e^{\lambda t} = \frac{10}{4}$; $= \log_e 2.5 = \lambda \times t$; $t = \frac{3.8}{0.6931} \times \log_{10} 2.5 \times 2.3026$; = 5.022 days

t =5.022 days

---

55. The binding energy per nucleon for $_6C^{12}$ nucleus is 7.68 MeV and that for $_6C^{13}$ is 7.47 MeV. Calculate the energy required to remove a neutron from $_6C^{13}$ nucleus.

[March 2009]

Solution: Given Data: Binding energy per nucleon of $_6C^{12}$ = 7.68 MeV

Binding Energy of neutron =?

We can write the reaction as $_6C^{13} \longrightarrow {}_6C^{12} + {}_0n^1$

Total binding energy of $_6C^{13}$ = 7.47 x 13; = 97.11 MeV

Total binding energy of $_6C^{12}$ = 7.68 x 12; = 92.16 MeV

Total binding energy of the reactant = Total binding energy of the product

$\therefore$ 97.11 MeV = 92.16 MeV + Binding Energy of a neutron

Binding Energy of a neutron = 97.11 – 92.16

Binding Energy of a neutron = 4.95 MeV

---

56. Calculate the energy released in the following reaction

$_3Li^6 + {_0n^1} \longrightarrow {_2He^4} + {_1H^3}$

Solution: Given Data: Mass of $_3Li^6$ nucleus = 6.015126amu

Mass of $_1H^3$ nucleus = 3.016049amu; Mass of $_2H^4$ nucleus = 4.002604amu

Mass of $_0n^1$ = 1.008665amu

Formula: Energy released = Mass defect x 931; = Δm x 931

$_3Li^6 + {_0n^1} \longrightarrow {_2He^4} + {_1H^3}$

Total mass of reactants = mass of $_3Li^6$+ mass of $_0n^1$

= (6.015126 + 1.008665) amu

Total mass of reactants = 7.023791amu

Total mass of products = mass of $_2He^4$+ mass of $_1H^3$

= (4.002604 + 3.016049) amu

Total mass of products = 7.018653amu

Mass difference **Δm** = (7.023791 – 7.018653) amu

Mass difference Δm = 0.005238 amu

Energy released = **Δm x 931 MeV**

= 0.005238 x 931

Energy released = 4.783 MeV

---

57. Calculate the energy released in the following reaction

$_{13}Al^{27} + {_1H^2} \longrightarrow {_{12}Mg^{25}} + {_2He^4}$

Solution: Given Data: Mass of $_{13}Al^{27}$ = 26.981535 amu

Mass of $_1H^2$ = 2.014102 amu ; Mass of $_{12}Mg^{25}$ = 24.98584amu

Mass of $_2He^4$ = 4.002604amu **Energy released = ?**

Total mass of reactants = mass of $_{13}Al^{27}$+ mass of $_1H^2$

= (26.981535 + 2.014102) amu

Total mass of reactants = 28.995637amu

Total mass of products = mass of $_{12}Mg^{25}$+ mass of $_2He^4$

= (24.98584+ 4.002604) amu

Total mass of products = 28.988444amu

∴ Difference in mass in the reaction = 28.995637 – 28.988444; = 0.007193 amu

1 amu = 931 MeV

∴ Energy released in the reaction = 0.007193 x 931

Energy released in the reaction = 6.697 MeV

UNIT – IX SEMICONDUCTOR DEVICES AND THEIR APPLICATIONS

58. A transistor is connected in CE configuration. The voltage drop across the load resistance (Rc) 3kΩ is 6V. Find the basic current. The current gain α of the transistor is 0.97 **[June 2010]**

Solution: Given Data: Voltage across the collector load resistance (Rc) = 6V

α = 0.97; Rc = 3kΩ

The voltage across the collector resistance is , Rc = IcRc = 6V

Hence, Ic = $\frac{6}{R_C}$; = $\frac{6}{3X10^3}$; **Ic = 2mA**

Current Gain β = $\frac{\alpha}{1-\alpha} = \frac{0.97}{1-0.97}$ **β = 32.33**

$\therefore I_B = \frac{I_C}{\beta} = \frac{2X10^{-3}}{32.33}$; **$I_B$ =61.86μA**

UNIT – X COMMUNICATION SYSTEMS

59. A 10MHz sinusoidal carrier wave of amplitude 10 mv is modulated by 5 Kz sinusoidal audio signal of amplitude 6mV. Find this frequency components of the resultant modulated wave and their amplitude **[March 2011]**

Solution: Given Data: Frequency of the carrier f_c = 10MHz

Frequency of the signal f_s = 5 KHz = 0.005 MHz

Amplitude of the carrier signal = E_c = 10mV

Amplitude of the audio signal = E_s = 6mV

Frequency components of modulated wave =?

Amplitude of the components in the modulated wave =?

The modulated carrier wave contains the following frequencies.

i) Original carrier wave of frequency = f_c = 10 MHz

ii) Upper side band frequency, $f_c + f_s$ = 10 + 0.005 = 10.005MHz

iii) Lower side band frequency, $f_c - f_s$ = 10 – 0.005 = 9.995 MHz

The modulation factor is

m = $\frac{E_S}{E_C}$; = $\frac{6}{10}$; m = 0.6

Amplitude of USB = Amplitude of LSB = $\frac{mE_C}{2}$

= $\frac{0.6 X10}{2}$; Amplitude of LSB = 3mV

“நேர்மையான முயற்சியில் கிடைத்த வெற்றியின் மூலமாகக் கிடைக்கும் மகிழ்ச்சியின் சிகரத்தை யாரும் அளக்கவே முடியாது”

@@@@@@@@@@

இலட்சம் கனவு கண்ணோடு
இலட்சியங்கள் நெஞ்சோடு
உன்னை வெல்ல யாருமில்லை
உறுதியோடு போராடு !

@@@@@@@@@@

“உலகில் பிறந்த ஒவ்வொருவரும், மற்றவர் செய்ய முடியாத ஒன்றைச் செய்து முடிக்கும் தனிச்சிறப்பு மிக்க ஆற்றலைப் பெற்றிருக்கிறார்கள். அந்தச்செயல் எது எனக் கண்டு கொள்ளுங்கள். அதை மட்டுமே வளர்த்துக் கொண்டு வந்தால், உங்கள் வழியில் நீங்களும் சாதனை படைத்து வெற்றி காண இயலும்.”