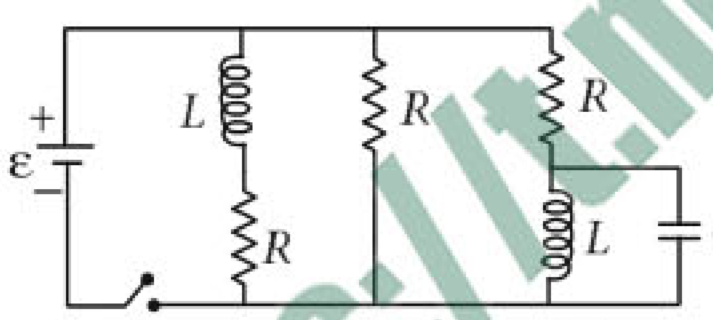
Chapter 16 Electromagnetic Induction and Alternating Current

1. A long solenoid of diameter 0.1 m has 2×10^4 turns per meter. At the centre of the solenoid, a coil of 100 turns and radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to 0 A from 4 A in 0.05 s. If the resistance of the coil is $10\pi^2\ \Omega$, the total charge flowing through the coil during this time is

(a) 16 μC (b) 32 μC
(c) 16π μC (d) 32π μC

(NEET 2017)

2. Figure shows a circuit that contains three identical resistors with resistanace $R = 9.0\ \Omega$ each, two identical inductors with inductance $L = 2.0$ mH each, and an ideal battery with emf $\varepsilon = 18$ V. The current i through the battery just after the switch closed is



(a) 0.2 A (b) 2 A
(c) 0 ampere (d) 2 mA

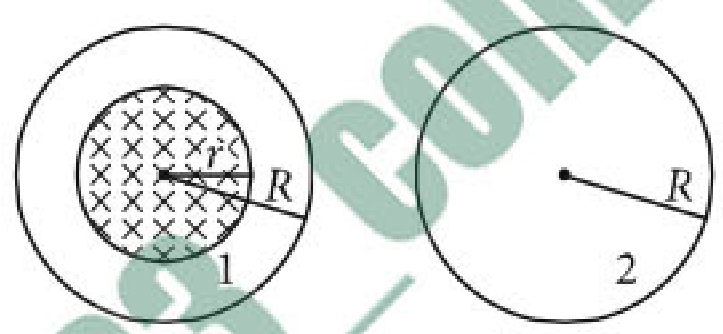
(NEET 2017)

3. Which of the following combinations should be selected for better tuning of an L-C-R circuit used for communication ?

(a) $R = 20\ \Omega$, $L = 1.5$ H, $C = 35$ μF
(b) $R = 25\ \Omega$, $L = 2.5$ H, $C = 45$ μF
(c) $R = 15\ \Omega$, $L = 3.5$ H, $C = 30$ μF
(d) $R = 25\ \Omega$, $L = 1.5$ H, $C = 45$ μF

(NEET-II 2016)

4. A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{d\vec{B}}{dt}$. Loop 1 of radius $R > r$ encloses the region r and loop 2 of radius R is outside the region of magnetic field as shown in the figure. Then the e.m.f. generated is



(a) zero in loop 1 and zero in loop 2

(b) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 2

(c) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2

(d) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and zero in loop 2

(NEET-II 2016)

5. The potential differences across the resistance, capacitance and inductance are 80 V, 40 V and 100 V respectively in an L-C-R circuit. The power factor of this circuit is

(a) 0.4 (b) 0.5
(c) 0.8 (d) 1.0

(NEET-II 2016)

6. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf $V = 10 \sin 340t$. The power loss in A.C. circuit is

(a) 0.76 W (b) 0.89 W
(c) 0.51 W (d) 0.67 W

(NEET-I 2016)

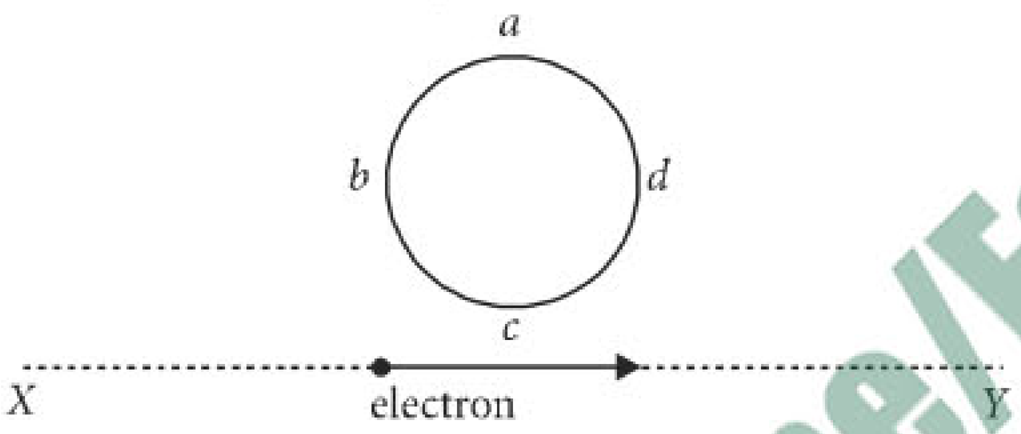
7. A small signal voltage $V(t) = V_0 \sin\omega t$ is applied across an ideal capacitor C

(a) Current $I(t)$ is in phase with voltage $V(t)$.
(b) Current $I(t)$ leads voltage $V(t)$ by 180°.
(c) Current $I(t)$, lags voltage $V(t)$ by 90°.
(d) Over a full cycle the capacitor C does not consume any energy from the voltage source. *(NEET-I 2016)*

8. A long solenoid has 1000 turns. When a current of 4 A flows through it, the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is
(a) 2 H (b) 1 H
(c) 4 H (d) 3 H
(NEET-I 2016)

9. A series *R-C* circuit is connected to an alternating voltage source. Consider two situations :
(*a*) When capacitor is air filled.
(*b*) When capacitor is mica filled.
Current through resistor is i and voltage across capacitor is V then
(a) $i_a > i_b$ (b) $V_a = V_b$
(c) $V_a < V_b$ (d) $V_a > V_b$ *(2015)*

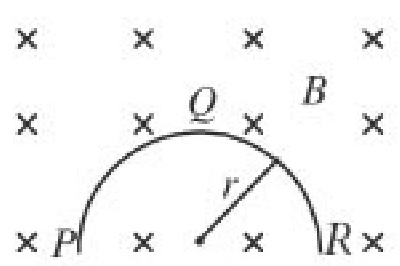
10. An electron moves on a straight line path *XY* as shown. The *abcd* is a coil adjacent to the path of electron. What will be the direction of current, if any, induced in the coil?



(a) The current will reverse its direction as the electron goes past the coil
(b) No current induced
(c) *abcd* (d) *adcb* *(2015)*

11. A resistance '*R*' draws power '*P*' when connected to an AC source. If an inductance is now placed in series with the resistance, such that the impedance of the circuit becomes '*Z*', the power drawn will be
(a) $P\left(\frac{R}{Z}\right)$ (b) P
(c) $P\left(\frac{R}{Z}\right)^2$ (d) $P\sqrt{\frac{R}{Z}}$
(2015 Cancelled)

12. A thin semicircular conducting ring (*PQR*) of radius r is falling with its plane vertical in a horizontal magnetic field B, as shown in the figure.



The potential difference developed across the ring when its speed is v, is
(a) zero
(b) $\frac{Bv\pi r^2}{2}$ and P is at higher potential
(c) πrBv and R is at higher potential
(d) $2rBv$ and R is at higher potential
(2014)

13. A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6 A, the voltage across the secondary coil and the current in the primary coil respectively are
(a) 300 V, 15 A (b) 450 V, 15 A
(c) 450 V, 13.5 A (d) 600 V, 15 A
(2014)

14. A wire loop is rotated in a magnetic field. The frequency of change of direction of the induced e.m.f. is
(a) four times per revolution
(b) six times per revolution
(c) once per revolution
(d) twice per revolution *(NEET 2013)*

15. A coil of self-inductance L is connected in series with a bulb B and an *AC* source. Brightness of the bulb decreases when
(a) a capacitance of reactance $X_C = X_L$ is included in the same circuit.
(b) an iron rod is inserted in the coil.
(c) frequency of the *AC* source is decreased.
(d) number of turns in the coil is reduced.
(NEET 2013)

16. The primary of a transformer when connected to a dc battery of 10 Volt draws a current of 1 mA. The number of turns of the primary and secondary windings are 50 and 100 respectively. The voltage in the secondary and the current drawn by the cricuit in the secondary are respectively
(a) 20 V and 2.0 mA
(b) 10 V and 0.5 mA
(c) Zero volt and therefore no current
(d) 20 V and 0.5 mA
(Karnataka NEET 2013)

17. A current of 2.5 A flows through a coil of inductance 5 H. The magnetic flux linked with the coil is
(a) 0.5 Wb (b) 12.5 Wb
(c) zero (d) 2 Wb
(Karnataka NEET 2013)

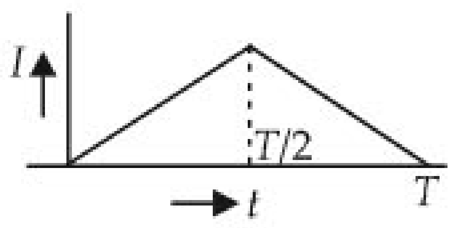
18. A coil of resistance 400 Ω is placed in a magnetic field. If the magnetic flux ϕ (Wb) linked with the coil varies with time t (sec) as $\phi = 50t^2 + 4$.
The current in the coil at $t = 2$ sec is
(a) 0.5 A (b) 0.1 A
(c) 2 A (d) 1 A *(2012)*

19. In an electrical circuit R, L, C and ac voltage source are all connected in series. When L is removed from the circuit, the phase difference between the voltage and the current in the circuit is If instead, C is removed from the circuit, the phase difference is again The power factor of the circuit is

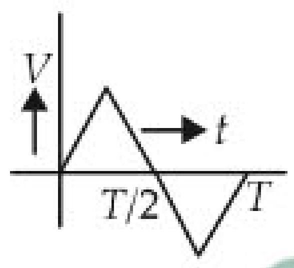
(a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$

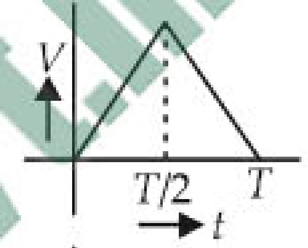
(c) 1 (d) $\frac{\sqrt{3}}{2}$ *(2012)*

20. The current (I) in the inductance is varying with time according to the plot shown in figure.

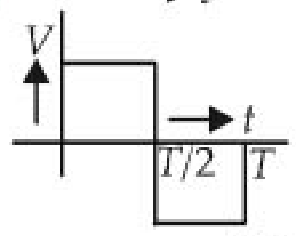


Which one of the following is the correct variation of voltage with time in the coil?

(a) 

(b) 

(c) 

(d) 

(2012)

21. The instantaneous values of alternating current and voltages in a circuit are given as

$$i = \frac{1}{\sqrt{2}} \sin(100\pi t) \text{ ampere}$$

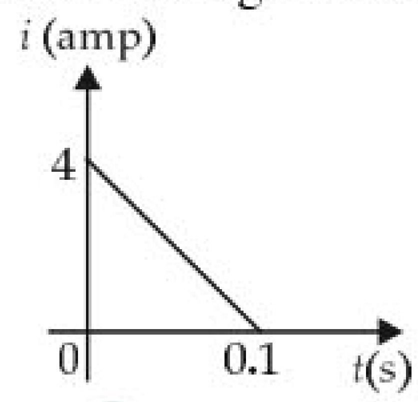
$$e = \frac{1}{\sqrt{2}} \sin(100\pi t + \frac{\pi}{3}) \text{ Volt}$$

The average power in watts consumed in the circuit is

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$

(c) $\frac{1}{2}$ (d) $\frac{1}{8}$ *(Mains 2012)*

22. In a coil of resistance 10 Ω, the induced current developed by changing magnetic flux through it, is shown in figure as a function of time. The magnitude of change in flux through the coil in weber is

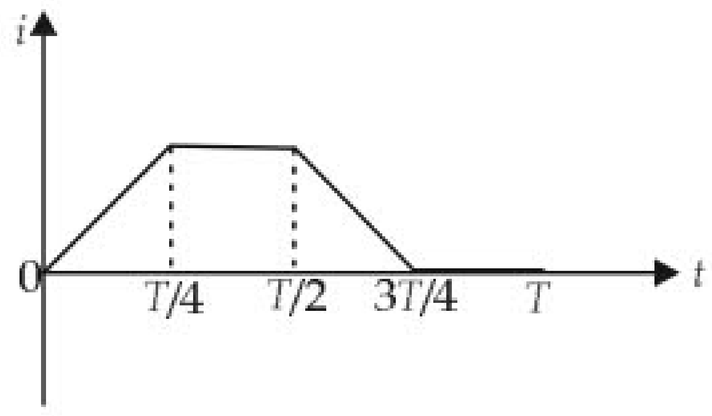


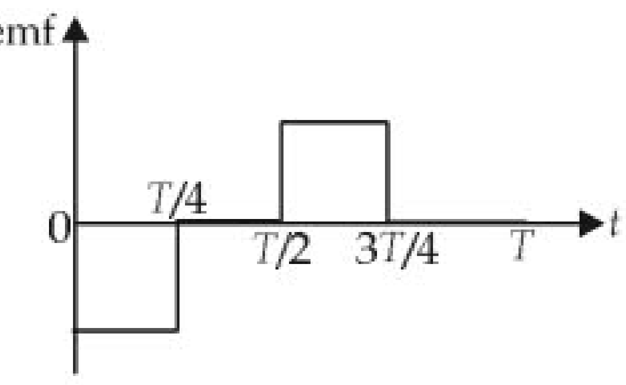
(a) 8
(b) 2
(c) 6
(d) 4 *(Mains 2012)*

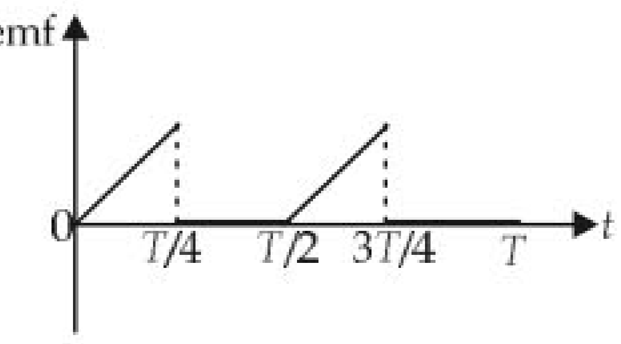
23. An ac voltage is applied to a resistance R and an inductor L in series. If R and the inductive reactance are both equal to 3 Ω, the phase difference between the applied voltage and the current in the circuit is
(a) $\pi/6$ (b) $\pi/4$
(c) $\pi/2$ (d) zero *(2011)*

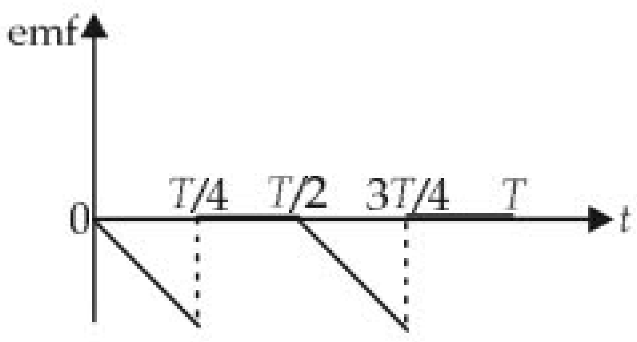
24. In an ac circuit an alternating voltage volts is connected to a capacitor of capacity 1 μF. The r.m.s. value of the current in the circuit is
(a) 10 mA (b) 100 mA
(c) 200 mA (d) 20 mA *(2011)*

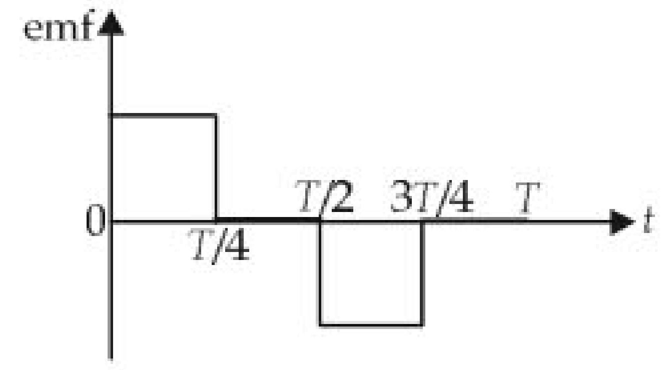
25. The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be



(a) 

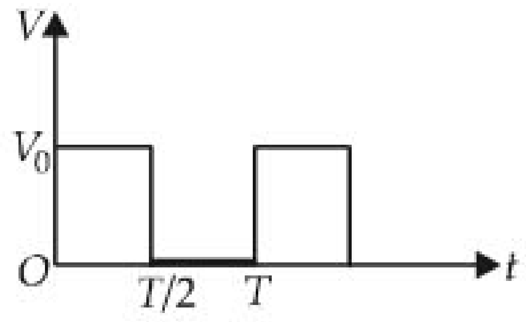
(b) 

(c) 

(d) 

(2011)

26. The r.m.s. value of potential difference V shown in the figure is



(a) $\frac{V_0}{\sqrt{3}}$
(b) V_0
(c) $\frac{V_0}{\sqrt{2}}$
(d) $\frac{V_0}{2}$ *(Mains 2011)*

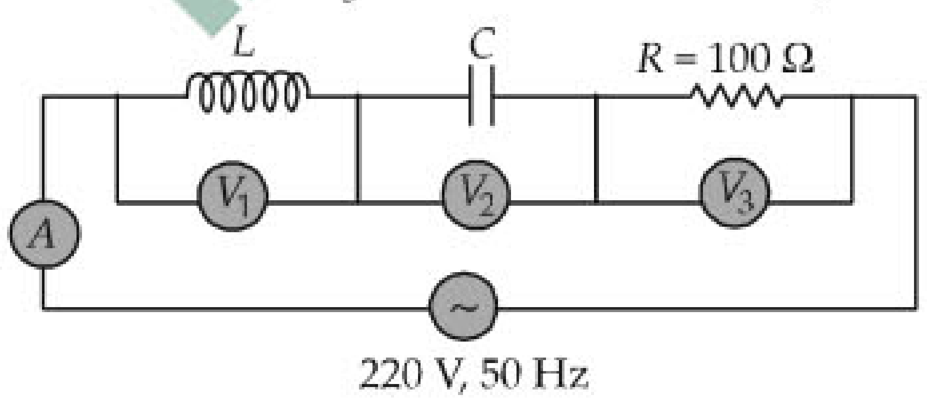
27. A coil has resistance 30 ohm and inductive reactance 20 ohm at 50 Hz frequency. If an ac source, of 200 volt, 100 Hz, is connected across the coil, the current in the coil will be

(a) 2.0 A (b) 4.0 A
(c) 8.0 A (d) $\frac{20}{\sqrt{13}}$ A
(Mains 2011)

28. A conducting circular loop is placed in a uniform magnetic field, B = 0.025 T with its plane perpendicular to the loop. The radius of the loop is made to shrink at a constant rate of 1 mm s^{-1}. The induced emf when the radius is 2 cm, is

(a) $2\pi\,\mu$V (b) $\pi\,\mu$V
(c) $\frac{\pi}{2}\,\mu$V (d) $2\,\mu$V *(2010)*

29. In the given circuit the reading of voltmeter V_1 and V_2 are 300 volts each. The reading of the voltmeter V_3 and ammeter A are respectively



(a) 150 V, 2.2 A (b) 220 V, 2.2 A
(c) 220 V, 2.0 A (d) 100 V, 2.0 A
(2010)

30. A 220 volt input is supplied to a transformer. The output circuit draws a current of 2.0 ampere at 440 volts. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is

(a) 3.6 ampere (b) 2.8 ampere
(c) 2.5 ampere (d) 5.0 ampere
(2010)

31. A condenser of capacity C is charged to a potential difference of V_1. The plates of the condenser are then connected to an ideal inductor of inductance L. The current through the inductor when the potential difference across the condenser reduces to V_2 is

(a) $\left(\frac{C(V_1-V_2)^2}{L}\right)^{\frac{1}{2}}$ (b) $\frac{C(V_1^2-V_2^2)}{L}$

(c) $\frac{C(V_1^2+V_2^2)}{L}$ (d) $\left(\frac{C(V_1^2-V_2^2)}{L}\right)^{\frac{1}{2}}$

(Mains 2010)

32. A rectangular, a square, a circular and an elliptical loop, all in the (x-y) plane, are moving out of a uniform magnetic field with a constant velocity, $\vec{V}=v\hat{i}$. The magnetic field is directed along the negative z axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for

(a) the circular and the elliptical loops
(b) only the elliptical loop
(c) any of the four loops
(d) the rectangular, circular and elliptical loops
(2009)

33. Power dissipated in an LCR series circuit connected to an A.C. source of emf ε is

(a) $\dfrac{\varepsilon^2\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}}{R}$

(b) $\dfrac{\varepsilon^2\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]}{R}$

(c) $\dfrac{\varepsilon^2 R}{\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}}$

(d) $\dfrac{\varepsilon^2 R}{\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]}$ *(2009)*

34. A conducting circular loop is placed in a uniform magnetic field 0.04 T with its plane perpendicular to the magnetic field. The radius of the loop starts shrinking at 2 mm/s. The induced emf in the loop when the radius is 2 cm is
(a) $4.8\pi\,\mu V$ (b) $0.8\pi\,\mu V$
(c) $1.6\pi\,\mu V$ (d) $3.2\pi\,\mu V$ *(2009)*

35. A long solenoid has 500 turns. When a current of 2 ampere is passed through it, the resulting magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is
(a) 1.0 henry (b) 4.0 henry
(c) 2.5 henry (d) 2.0 henry *(2008)*

36. In an a.c. circuit the e.m.f. (ε) and the current (i) at any instant are given respectively by
$\varepsilon = E_0 \sin\omega t$, $i = I_0 \sin(\omega t - \phi)$
The average power in the circuit over one cycle of a.c. is
(a) $\frac{E_0 I_0}{2}\cos\phi$ (b) $E_0 I_0$
(c) $\frac{E_0 I_0}{2}$ (d) $\frac{E_0 I_0}{2}\sin\phi$ *(2008)*

37. A circular disc of radius 0.2 meter is placed in a uniform magnetic field of induction $\frac{1}{\pi}\left(\frac{\text{Wb}}{\text{m}^2}\right)$ in such a way that its axis makes an angle of 60° with $\vec{B}$. The magnetic flux linked with the disc is
(a) 0.08 Wb (b) 0.01 Wb
(c) 0.02 Wb (d) 0.06 Wb *(2008)*

38. The primary and secondary coils of a transformer have 50 and 1500 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$, where ϕ is in webers, t is time in seconds and ϕ_0 is a constant, the output voltage across the secondary coil is
(a) 120 volts (b) 220 volts
(c) 30 volts (d) 90 volts. *(2007)*

39. A transformer is used to light a 100 W and 110 V lamp from a 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is approximately
(a) 50% (b) 90%
(c) 10% (d) 30%. *(2007)*

40. What is the value of inductance L for which the current is maximum in a series LCR circuit with $C = 10\ \mu F$ and $\omega = 1000\ s^{-1}$?
(a) 1 mH
(b) cannot be calculated unless R is known
(c) 10 mH
(d) 100 mH. *(2007)*

41. A coil of inductive reactance 31 Ω has a resistance of 8 Ω. It is placed in series with a condenser of capacitative reactance 25 Ω. The combination is connected to an a.c. source of 110 V. The power factor of the circuit is
(a) 0.33 (b) 0.56
(c) 0.64 (d) 0.80 *(2006)*

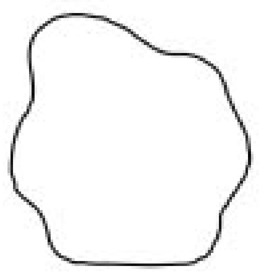
42. Two coils of self inductance 2 mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is
(a) 16 mH (b) 10 mH
(c) 6 mH (d) 4 mH. *(2006)*

43. The core of a transformer is laminated because
(a) ratio of voltage in primary and secondary may be increased
(b) energy losses due to eddy currents may be minimised
(c) the weight of the transformer may be reduced
(d) rusting of the core may be prevented. *(2006)*

44. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produce oscillations of frequency f. If L is doubled and C is changed to $4C$, the frequency will be
(a) $f/2$ (b) $f/4$
(c) $8f$ (d) $f/2\sqrt{2}$ *(2006)*

45. In a circuit L, C and R are connected in series with an alternating voltage source of frequency f. The current leads the voltage by 45°. The value of C is
(a) $\frac{1}{\pi f(2\pi f L - R)}$ (b) $\frac{1}{2\pi f(2\pi f L - R)}$
(c) $\frac{1}{\pi f(2\pi f L + R)}$ (d) $\frac{1}{2\pi f(2\pi f L + R)}$ *(2005)*

46. As a result of change in the magnetic flux linked to the closed loop as shown in the figure, an e.m.f. V volt is induced in the loop. The work done (joule) in taking a charge Q coulomb once along the loop is



(a) QV (b) $2QV$
(c) $QV/2$ (d) zero. *(2005)*

47. A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is
(a) 5 seconds (b) 1/5 seconds
(c) 40 seconds (d) 20 seconds *(2004)*

48. The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in a time Δt. Then the total quantity of electric charge Q that passes any point in the circuit during the time Δt is represented by

(a) $Q = \frac{1}{R} \cdot \frac{\Delta\phi}{\Delta t}$ (b) $Q = \frac{\Delta\phi}{R}$

(c) $Q = \frac{\Delta\phi}{\Delta t}$ (d) $Q = R \cdot \frac{\Delta\phi}{\Delta t}$ *(2004)*

49. For a series LCR circuit the power loss at resonance is

(a) $\frac{V^2}{\left[\omega L - \frac{1}{\omega C}\right]}$ (b) $I^2 L\omega$

(c) $I^2 R$ (d) $\frac{V^2}{C\omega}$. *(2002)*

50. For a coil having $L = 2$ mH, current flow through it is $I = t^2 e^{-t}$ then, the time at which emf become zero
(a) 2 sec (b) 1 sec
(c) 4 sec (d) 3 sec. *(2001)*

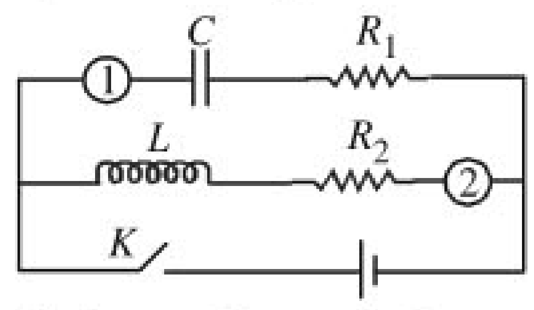
51. A capacitor of capacity C has reactance X. If capacitance and frequency become double then reactance will be
(a) $4X$ (b) $X/2$
(c) $X/4$ (d) $2X$. *(2001)*

52. The value of quality factor is

(a) $\frac{\omega L}{R}$ (b) $\frac{1}{\omega RC}$

(c) $\sqrt{LC}$ (d) L/R. *(2000)*

53. In the circuit given in figure, 1 and 2 are ammeters. Just after key K is pressed to complete the circuit, the reading will be



(a) zero in 1, maximum in 2
(b) maximum in both 1 and 2
(c) zero in both 1 and 2
(d) maximum in 1, zero in 2 *(1999)*

54. A step-up transformer operates on a 230 V line and supplies a load of 2 ampere. The ratio of the primary and secondary windings is 1 : 25. The current in the primary is
(a) 15 A (b) 50 A
(c) 25 A (d) 12.5 A *(1998)*

55. Two coils have a mutual inductance 0.005 H. The current changes in the first coil according to equation $I = I_0 \sin \omega t$, where $I_0 = 10$ A and $\omega = 100\,\pi$ rad/sec. The maximum value of e.m.f. in the second coil is
(a) π (b) 5π
(c) 2π (d) 4π *(1998)*

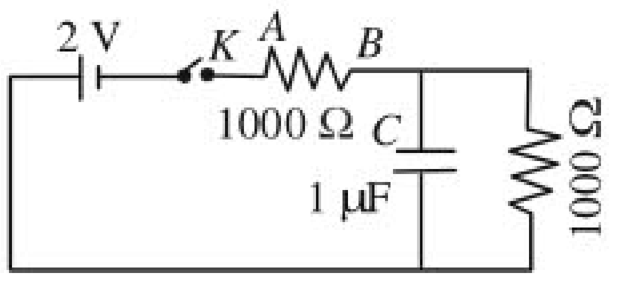
56. The primary winding of a transformer has 500 turns whereas its secondary has 5000 turns. The primary is connected to an A.C. supply 20 V, 50 Hz. The secondary will have an output of
(a) 2 V, 50 Hz (b) 2 V, 5 Hz
(c) 200 V, 50 Hz (d) 200 V, 500 Hz. *(1997)*

57. In an a.c. circuit with phase voltage V and current I, the power dissipated is
(a) $V.I$
(b) depends on phase angle between V and I
(c) $\frac{1}{2} \times V.I$
(d) $\frac{1}{\sqrt{2}} \times V.I$. *(1997)*

58. A metal ring is held horizontally and bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is
(a) more than g (b) equal to g
(c) less than g (d) either (a) or (c). *(1996)*

59. In an A.C. circuit, the current flowing is $I = 5 \sin(100t - \pi/2)$ ampere and the potential difference is $V = 200 \sin(100t)$ volts. The power consumption is equal to
(a) 20 W (b) 0 W
(c) 1000 W (d) 40 W. *(1995)*

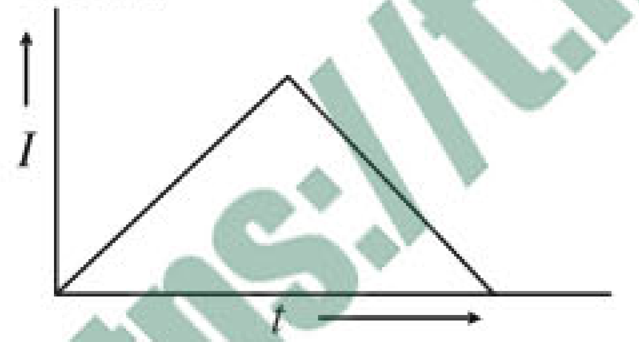
60. When the key K is pressed at time $t = 0$, then which of the following statement about the current I in the resistor AB of the given circuit is true?



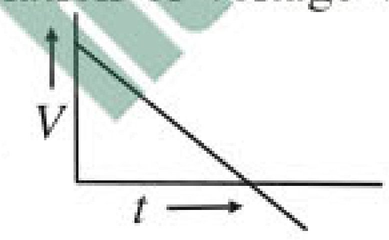
(a) I oscillates between 1 mA and 2 mA
(b) at $t = 0$, $I = 2$ mA and with time it goes to 1 mA
(c) $I = 1$ mA at all t
(d) $I = 2$ mA at all t. *(1995)*

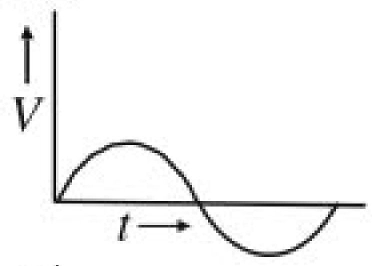
61. A straight line conductor of length 0.4 m is moved with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 Wb/m^2. The induced e.m.f. across the conductor is
(a) 5.04 V (b) 25.2 V
(c) 1.26 V (d) 2.52 V. *(1995)*

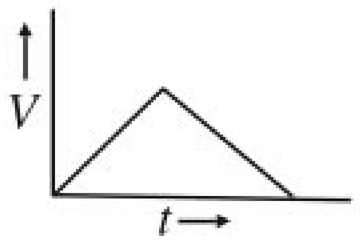
62. The current I in an A.C. circuit with inductance coil varies with time according to the graph given below.

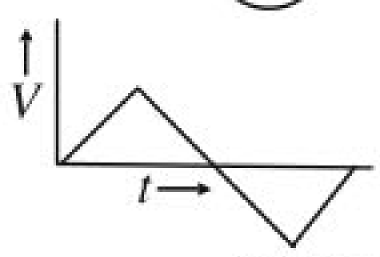


Which one of the following graphs gives the variation of voltage with time?

(a)


(b)


(c)


(d)


(1994)

63. In an A.C. circuit, I_{rms} and I_0 are related as
(a) $I_{rms} = \pi I_0$ (b) $I_{rms} = \sqrt{2}\, I_0$
(c) $I_{rms} = I_0/\pi$ (d) $I_{rms} = I_0/\sqrt{2}$. *(1994)*

64. An series L-C-R circuit is connected to a source of A.C. current. At resonance, the phase difference between the applied voltage and the current in the circuit, is
(a) π (b) zero
(c) $\pi/4$ (d) $\pi/2$. *(1994)*

65. Two cables of copper are of equal lengths. One of them has a single wire of area of cross-section A, while other has 10 wires of cross-sectional area $A/10$ each. Give their suitability for transporting A.C. and D.C.
(a) only multiple strands for A.C., either for D.C.
(b) only multiple strands for A.C., only single strand for D.C.
(c) only single strand for D.C., either for A.C.
(d) only single strand for A.C., either for D.C. *(1994)*

66. If N is the number of turns in a coil, the value of self inductance varies as
(a) N^0 (b) N
(c) N^2 (d) N^{-2} *(1993)*

67. What is the self-inductance of a coil which produces 5 mV when the current changes from 3 ampere to 2 ampere in one millisecond?
(a) 5000 henry (b) 5 mili-henry
(c) 50 henry (d) 5 henry *(1993)*

68. The time constant of C-R circuit is
(a) $1/CR$ (b) C/R
(c) CR (d) R/C *(1992)*

69. The total charge, induced in a conducting loop when it is moved in magnetic field depend on
(a) the rate of change of magnetic flux
(b) initial magnetic flux only
(c) the total change in magnetic flux
(d) final magnetic flux only *(1992)*

70. A rectangular coil of 20 turns and area of cross-section 25 sq. cm has a resistance of 100 Ω. If a magnetic field which is perpendicular to the plane of coil changes at a rate of 1000 tesla per second, the current in the coil is
(a) 1A (b) 50 A
(c) 0.5 A (d) 5 A *(1992)*

71. Faraday's laws are consequence of conservation of
(a) energy
(b) energy and magnetic field
(c) charge
(d) magnetic field *(1991)*

72. If the number of turns per unit length of a coil of solenoid is doubled, the self-inductance of the solenoid will
(a) remain unchanged
(b) be halved
(c) be doubled
(d) become four times *(1991)*

73. A 100 millihenry coil carries a current of 1A. Energy stored in its magnetic field is
(a) 0.5 J (b) 1 A
(c) 0.05 J (d) 0.1 J *(1991)*

74. A magnetic field of 2×10^{-2} T acts at right angles to a coil of area 100 cm^2, with 50 turns. The average e.m.f. induced in the coil is 0.1 V, when it is removed from the field in t sec. The value of t is
(a) 10 s (b) 0.1 s
(c) 0.01 s (d) 1 s *(1991)*

75. The current in self inductance $L = 40$ mH is to be increased uniformly from 1 amp to 11 amp in 4 milliseconds. The e.m.f. induced in inductor during process is
(a) 100 volt (b) 0.4 volt
(c) 4.0 volt (d) 440 volt *(1990)*

76. An inductor may store energy in
(a) its electric field
(b) its coils
(c) its magnetic field
(d) both in electric and magnetic fields *(1990)*

77. In a region of magnetic induction $B = 10^{-2}$ tesla, a circular coil of radius 30 cm and resistance π^2 ohm is rotated about an axis which is perpendicular to the direction of B and which forms a diameter of the coil. If the coil rotates at 200 rpm the amplitude of the alternating current induced in the coil is
(a) $4\pi^2$ mA (b) 30 mA
(c) 6 mA (d) 200 mA *(1988)*

78. Eddy currents are produced when
(a) a metal is kept in varying magnetic field
(b) a metal is kept in steady magnetic field
(c) a circular coil is placed in a magnetic field
(d) through a circular coil, current is passed *(1988)*

Answer Key

1.	(b)	**2.**	(*)	**3.**	(c)	**4.**	(d)	**5.**	(c)	**6.**	(c)	**7.**	(d)	**8.**	(b)	**9.**	(d)	**10.**	(a)
11.	(c)	**12.**	(d)	**13.**	(b)	**14.**	(d)	**15.**	(b)	**16.**	(c)	**17.**	(b)	**18.**	(a)	**19.**	(c)	**20.**	(d)
21.	(d)	**22.**	(b)	**23.**	(b)	**24.**	(d)	**25.**	(a)	**26.**	(c)	**27.**	(b)	**28.**	(b)	**29.**	(b)	**30.**	(d)
31.	(d)	**32.**	(a)	**33.**	(d)	**34.**	(d)	**35.**	(a)	**36.**	(a)	**37.**	(c)	**38.**	(a)	**39.**	(b)	**40.**	(d)
41.	(d)	**42.**	(d)	**43.**	(b)	**44.**	(d)	**45.**	(d)	**46.**	(a)	**47.**	(a)	**48.**	(b)	**49.**	(c)	**50.**	(a)
51.	(c)	**52.**	(a, b)	**53.**	(d)	**54.**	(b)	**55.**	(b)	**56.**	(c)	**57.**	(b)	**58**	(c)	**59.**	(b)	**60.**	(b)
61.	(d)	**62.**	(a)	**63.**	(d)	**64.**	(b)	**65.**	(a)	**66.**	(c)	**67.**	(b)	**68.**	(c)	**69.**	(c)	**70.**	(c)
71.	(d)	**72.**	(d)	**73.**	(c)	**74.**	(b)	**75.**	(a)	**76.**	(c)	**77.**	(c)	**78.**	(a)				

* None is correct.

EXPLANATIONS

1. **(b) :** Given $n = 2 \times 10^4$; $I = 4$ A
Initially $I = 0$ A
$\therefore$ $B_i = 0$ or $\phi_i = 0$
Finally, the magnetic field at the centre of the solenoid is given as

$B_f = \mu_o nI$
$B_f = 4\pi \times 10^{-7} \times 2 \times 10^4 \times 4$
$B_f = 32\pi \times 10^{-3}$ T

Final magnetic flux through the coil is given as

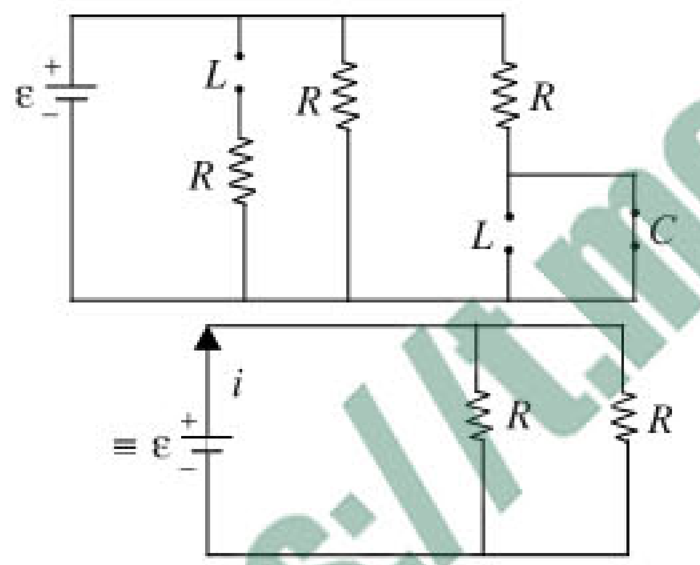
$\phi_f = NBA = 100 \times 32\,\pi \times 10^{-3} \times \pi \times (0.01)^2$
$\phi_f = 32\pi^2 \times 10^{-5}$ T m^2

Induced charge,

$$q = \frac{|\Delta\phi|}{R} = \frac{|\phi_f - \phi_i|}{R} = \frac{32\pi^2 \times 10^{-5}}{10\pi^2}$$

$= 32 \times 10^{-6}$ C $= 32$ μC

2. **(*) :** At time, $t = 0$ *i.e.*, when switch is closed, inductor in the circuit provides very high resistance (open circuit) while capacitor starts charging with maximum current (low resistance).
Equivalent circuit of the given circuit



Current drawn from battery,

$$i = \frac{\varepsilon}{(R/2)} = \frac{2\varepsilon}{R} = \frac{2 \times 18}{9} = 4 \text{ A}$$

*None of the given options is correct.

3. **(c) :** Quality factor of an L-C-R circuit is given by,

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q_1 = \frac{1}{20}\sqrt{\frac{1.5}{35 \times 10^{-6}}} = 50 \times \sqrt{\frac{3}{70}} = 10.35$$

$$Q_2 = \frac{1}{25} \times \sqrt{\frac{2.5}{45 \times 10^{-6}}} = 40 \times \sqrt{\frac{5}{90}} = 9.43$$

$$Q_3 = \frac{1}{15}\sqrt{\frac{3.5}{30 \times 10^{-6}}} = \frac{100}{15}\sqrt{\frac{35}{3}} = 22.77$$

$$Q_4 = \frac{1}{25} \times \sqrt{\frac{1.5}{45 \times 10^{-6}}} = \frac{40}{\sqrt{30}} = 7.30$$

Clearly Q_3 is maximum of Q_1, Q_2, Q_3, and Q_4.
Hence, option (c) should be selected for better tuning of an L-C-R circuit.

4. **(d) :** Emf generated in loop 1,

$$\varepsilon_1 = -\frac{d\phi}{dt} = -\frac{d}{dt}(\vec{B} \cdot \vec{A}) = -\frac{d}{dt}(BA) = -A \times \frac{dB}{dt}$$

$$\varepsilon_1 = -\left(\pi r^2 \frac{dB}{dt}\right)$$

($\because$ $A = \pi r^2$ because $\frac{dB}{dt}$ is restricted upto radius r.)
Emf generated in loop 2,

$$\varepsilon_2 = -\frac{d}{dt}(BA) = -\frac{d}{dt}(0 \times A) = 0$$

5. **(c) :** Here, $V_R = 80$ V, $V_C = 40$ V, $V_L = 100$ V
Power factor, $\cos\phi = \frac{R}{Z}$

$$= \frac{V_R}{V} = \frac{V_R}{\sqrt{V_R^2 + (V_L - V_C)^2}}$$

$$= \frac{80}{\sqrt{(80)^2 + (100 - 40)^2}} = \frac{80}{100} = 0.8$$

6. **(c) :** Here, $L = 20$ mH $= 20 \times 10^{-3}$ H,
$C = 50$ μF $= 50 \times 10^{-6}$ F
$R = 40\ \Omega$, $V = 10 \sin 340t = V_0 \sin\omega t$
$\omega = 340$ rad s^{-1}, $V_0 = 10$ V
$X_L = \omega L = 340 \times 20 \times 10^{-3} = 6.8\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{340 \times 50 \times 10^{-6}} = \frac{10^4}{34 \times 5} = 58.82\ \Omega$$

$$Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{(40)^2 + (58.82 - 6.8)^2}$$

$$= \sqrt{(40)^2 + (52.02)^2} = 65.62\ \Omega$$

The peak current in the circuit is

$$I_0 = \frac{V_0}{Z} = \frac{10}{65.62}\text{ A}, \cos\phi = \frac{R}{Z} = \left(\frac{40}{65.62}\right)$$

Power loss in A.C. circuit,

$$= V_{\text{rms}}\, I_{\text{rms}} \cos\phi = \frac{1}{2} V_0 I_0 \cos\phi$$

$$= \frac{1}{2} \times 10 \times \frac{10}{65.62} \times \frac{40}{65.62} = 0.46 \text{ W}$$

7. **(d) :** When an ideal capacitor is connected with an ac voltage source, current leads voltage by 90°.

Since, energy stored in capacitor during charging is spent in maintaining charge on the capacitor during discharging. Hence over a full cycle the capacitor does not consume any energy from the voltage source.

8. (b) : Here, $N = 1000$, $I = 4$ A, $\phi_0 = 4 \times 10^{-3}$ Wb

Total flux linked with the solenoid, $\phi = N\phi_0$

$= 1000 \times 4 \times 10^{-3}$ Wb $= 4$ Wb

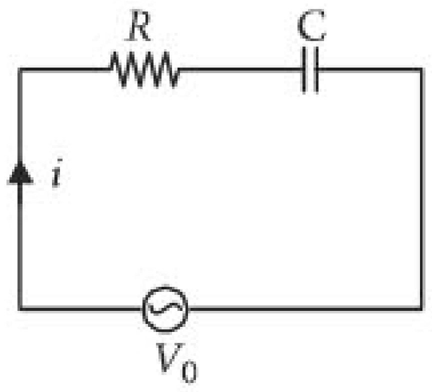
Since, $\phi = LI$

$\therefore$ Self-inductance of solenoid,

$$L = \frac{\phi}{I} = \frac{4\text{ Wb}}{4\text{ A}} = 1\text{ H}$$

9. (d) : Current through resistor, i

= Current in the circuit



$$= \frac{V_0}{\sqrt{R^2 + X_C^2}} = \frac{V_0}{\sqrt{R^2 + (1/\omega C)^2}}$$

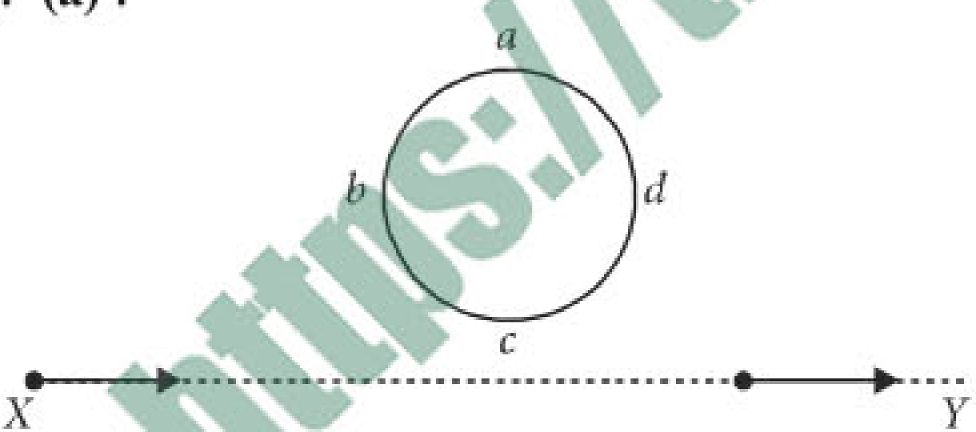
Voltage across capacitor, $V = iX_C$

$$= \frac{V_0}{\sqrt{R^2 + (1/\omega C)^2}} \times \frac{1}{\omega C} = \frac{V_0}{\sqrt{R^2\omega^2C^2 + 1}}$$

As $C_a < C_b$

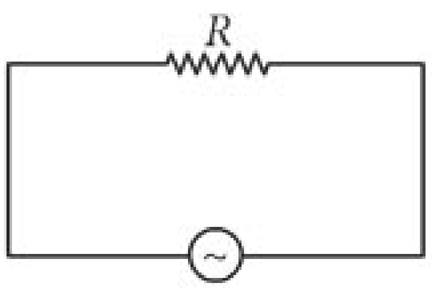
$\therefore$ $i_a < i_b$ and $V_a > V_b$

10. (a) :



When the electron moves from X to Y, the flux linked with the coil *abcd* (which is into the page) will first increase and then decrease as the electron passes by. So the induced current in the coil will be first anticlockwise and will reverse its direction (*i.e.* will become clockwise) as the electron goes past the coil.

11. (c) : Case I : $P = V_{rms}I_{rms}$

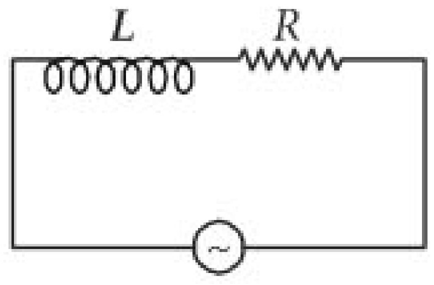


$$= V_{rms} \times \frac{V_{rms}}{R}$$

$$P = \frac{V_{rms}^2}{R} \Rightarrow V_{rms}^2 = PR \qquad \ldots(i)$$

Case II : Power drawn in *LR* circuit

$$P' = V_{rms}I_{rms}\cos\phi = V_{rms} \times \frac{V_{rms}}{Z} \times \frac{R}{Z}$$



$$= V_{rms}^2\frac{R}{Z^2} = PR \times \frac{R}{Z^2}$$

[Using eqn (i)]

$$P' = P\frac{R^2}{Z^2}$$

12. (d) : Motional emf induced in the semicircular ring *PQR* is equivalent to the motional emf induced in the imaginary conductor *PR*.

i.e., $\varepsilon_{PQR} = \varepsilon_{PR} = Bvl = Bv(2r)$ $\qquad (l = PR = 2r)$

Therefore, potential difference developed across the ring is $2rBv$ with R is at higher potential.

13. (b) : Here,

Efficiency of the transformer, $\eta = 90\%$

Input power, $P_{in} = 3$ kW $= 3 \times 10^3$ W $= 3000$ W

Voltage across the primary coil, $V_p = 200$ V

Current in the secondary coil, $I_s = 6$ A

As $P_{in} = I_pV_p$

$\therefore$ Current in the primary coil,

$$I_p = \frac{P_{in}}{V_p} = \frac{3000\text{ W}}{200\text{ V}} = 15\text{ A}$$

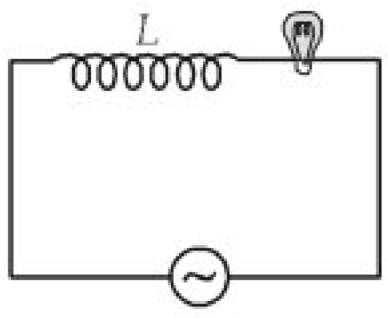
Efficiency of the transformer,

$$\eta = \frac{P_{out}}{P_{in}} = \frac{V_sI_s}{V_pI_p}$$

$$\therefore \frac{90}{100} = \frac{6V_s}{3000} \text{ or } V_s = \frac{90 \times 3000}{100 \times 6} = 450\text{ V}$$

14. (d)

15. (b) : The situation is as shown in the figure.



As the iron rod is inserted, the magnetic field inside the coil magnetizes the iron increasing the magnetic field inside it. Hence, the inductance of the coil increases. Consequently, the inductive reactance of the coil increases. As a result, a larger fraction of the applied AC voltage appears across the inductor, leaving less voltage across the bulb. Therefore, the brightness of the light bulb decreases.

16. (c) : Transformer cannot work on dc.

$\therefore \quad V_s = 0$ and $I_s = 0$

17. (b) : Here, $I = 2.5$ A, $L = 5$ H

Magnetic flux linked with the coil is

$$\phi_B = LI = (5\text{ H})(2.5\text{ A}) = 12.5\text{ Wb}$$

18. (a) : Here, $\phi = 50t^2 + 4$ Wb, $R = 400\ \Omega$

$$\text{Induced emf}, \varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}(50t^2+4) = -100t\text{ V}$$

At $t = 2$ s, $\varepsilon = -200$ V

$$|\varepsilon| = 200\text{ V}$$

Induced current in the coil at $t = 2$ s is

$$I = \frac{|\varepsilon|}{R} = \frac{200\text{ V}}{400\ \Omega} = \frac{1}{2}\text{ A} = 0.5\text{ A}$$

19. (c) : When L is removed, the phase difference between the voltage and current is

$$\tan\phi_1 = \frac{X_C}{R}$$

$$\tan\frac{\pi}{3} = \frac{X_C}{R} \text{ or } X_C = R\tan 60^\circ \text{ or } X_C = \sqrt{3}R$$

When C is removed, the phase difference between the voltage and current is

$$\tan\phi_2 = \frac{X_L}{R}$$

$$\tan\frac{\pi}{3} = \frac{X_L}{R} \text{ or } X_L = R\tan 60^\circ = \sqrt{3}R$$

As $X_L = X_C$, the series LCR circuit is in resonance.

Impedance of the circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = R \quad (\because X_L = X_C)$$

$$\text{Power factor}, \cos\phi = \frac{R}{Z} = \frac{R}{R} = 1$$

20. (d) : $V = -L\dfrac{dI}{dt}$

$V \propto$ slope of I-t graph

21. (d) : Given : $i = \dfrac{1}{\sqrt{2}}\sin(100\pi t)$ ampere

Compare it with $i = i_0 \sin(\omega t)$, we get

$$i_0 = \frac{1}{\sqrt{2}}\text{ A}$$

$$\text{Given : } e = \frac{1}{\sqrt{2}}\sin\left(100\pi t + \frac{\pi}{3}\right)\text{ volt}$$

Compare it with , we get

$$e_0 = \frac{1}{\sqrt{2}}\text{V}, \ \phi = \frac{\pi}{3}$$

$$\therefore \quad i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}}\text{ A} = \frac{1}{2}\text{ A}$$

$$e_{rms} = \frac{e_0}{\sqrt{2}} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}}\text{ V} = \frac{1}{2}\text{ V}$$

Average power consumed in the circuit,

$$P = i_{rms}\, e_{rms} \cos\phi$$

$$= \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\cos\frac{\pi}{3} = \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{8}\text{ W}$$

22. (b) : q = Area under i-t graph

$$= \frac{1}{2} \times 4 \times 0.1 = 0.2\text{ C}$$

As $q = \dfrac{\Delta\phi}{R}$

$\therefore \quad \Delta\phi = qR = (0.2\text{ C})\,(10\ \Omega) = 2$ weber

23. (b) : Here, $R = 3\ \Omega$

Inductive reactance, $X_L = 3\ \Omega$

The phase difference between the applied voltage and the current in the circuit is

$$\tan\phi = \frac{X_L}{R} = \frac{3\ \Omega}{3\ \Omega} = 1$$

$$\phi = \tan^{-1}(1) \quad \text{or} \quad \phi = \frac{\pi}{4}$$

24. (d) : The given equation of alternating voltage is

$$e = 200\sqrt{2}\sin 100t \qquad \text{...(i)}$$

The standard equation of alternating voltage is

$$e = e_0 \sin\omega t \qquad \text{...(ii)}$$

Comparing (i) and (ii), we get

$$e_0 = 200\sqrt{2}\text{ V}, \omega = 100\text{ rad s}^{-1}$$

The capacitive reactance is

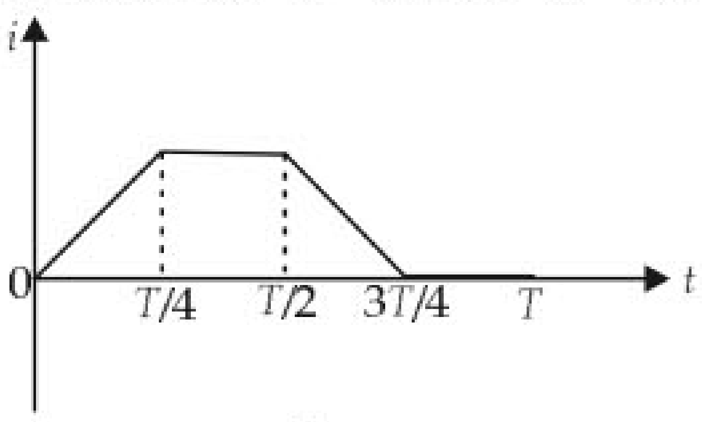
$$X_C = \frac{1}{\omega C} = \frac{1}{100 \times 1 \times 10^{-6}}\ \Omega$$

The r.m.s. value of the current in the circuit is

$$i_{r.m.s.} = \frac{v_{r.m.s.}}{X_C} = \frac{e_0/\sqrt{2}}{1/\omega C} = \frac{(200\sqrt{2}/\sqrt{2})}{(1/100 \times 10^{-6})}$$

$= 200 \times 100 \times 10^{-6}$ A $= 2 \times 10^{-2}$ A $= 20$ mA

25. (a) :



$$\text{Induced emf, } e = -L\frac{di}{dt}$$

For $0 \le t \le \dfrac{T}{4}$,

i-t graph is a straight line with positive constant slope.

$\therefore \quad \frac{di}{dt} = \text{constant}$

$\Rightarrow \quad e = -\text{ve and constant} \qquad \text{For } 0 \le t \le \frac{T}{4}$

For $\frac{T}{4} \le t \le \frac{T}{2}$

i is constant $\therefore \frac{di}{dt} = 0$

$\Rightarrow \quad e = 0 \qquad \text{For } \frac{T}{4} \le t \le \frac{T}{2}$

For $\frac{T}{2} \le t \le \frac{3T}{4}$

i-t graph is a straight line with negative constant slope.

$\therefore \quad \frac{di}{dt} = \text{constant}$

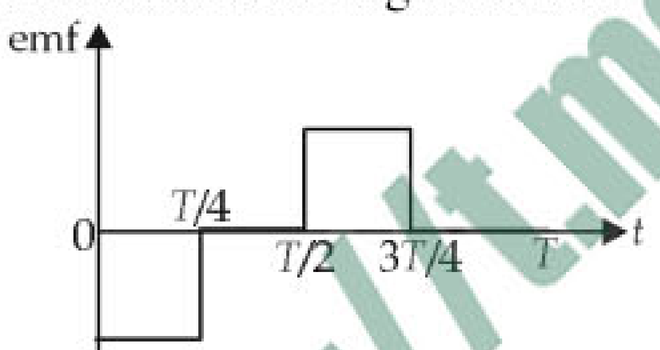
$\Rightarrow \quad e = +\text{ve and constant} \qquad \text{For } \frac{T}{2} \le t \le \frac{3T}{4}$

For $\frac{3T}{4} \le t \le T$,

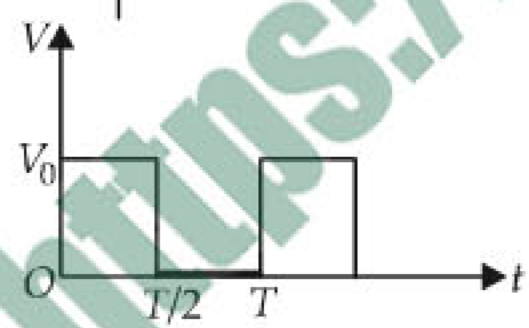
i is zero $\therefore \frac{di}{dt} = 0$

$\Rightarrow \quad e = 0 \qquad \text{For } \frac{3T}{4} \le t \le T$

From this analysis, the variation of induced emf with time as shown in the figure below.



26. (c) :



$V = V_0$ for $0 \le t \le \frac{T}{2}$

$V = 0$ for $\frac{T}{2} \le t \le T$

$$V_{\text{rms}} = \left[\frac{\int_0^T V^2\,dt}{\int_0^T dt}\right]^{1/2} = \left[\frac{\int_0^{T/2} V_0^2\,dt + \int_{T/2}^{T} (0)\,dt}{\int_0^T dt}\right]^{1/2}$$

$$= \left[\frac{V_0^2}{T}[t]_0^{T/2}\right]^{1/2} = \left[\frac{V_0^2}{T}\left(\frac{T}{2}\right)\right]^{1/2} = \left[\frac{V_0^2}{2}\right]^{1/2}$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

27. (b) : Here, Resistance, $R = 30\ \Omega$

Inductive reactance, $X_L = 20\ \Omega$ at 50 Hz

$\because \quad X_L = 2\pi\upsilon L$

$\therefore \quad \frac{X_L}{X_L'} = \frac{\upsilon}{\upsilon'}$

$$X_L' = \frac{\upsilon'}{\upsilon} \times X_L = \left(\frac{100}{50}\right) \times 20\ \Omega = 40\ \Omega$$

Impedance, $Z = \sqrt{R^2 + (X_L')^2} = \sqrt{(30)^2 + (40)^2}$

$= 50\ \Omega$

Current in the coil, $I = \frac{V}{Z} = \frac{200\text{ V}}{50\ \Omega} = 4\text{ A}$

28. (b) : Here,

Magnetic field, $B = 0.025$ T

Radius of the loop, $r = 2$ cm $= 2 \times 10^{-2}$ m

Constant rate at which radius of the loop shrinks,

$$\frac{dr}{dt} = 1 \times 10^{-3}\text{ m s}^{-1}$$

Magnetic flux linked with the loop is

$\phi = BA\cos\theta = B(\pi r^2)\cos 0° = B\pi r^2$

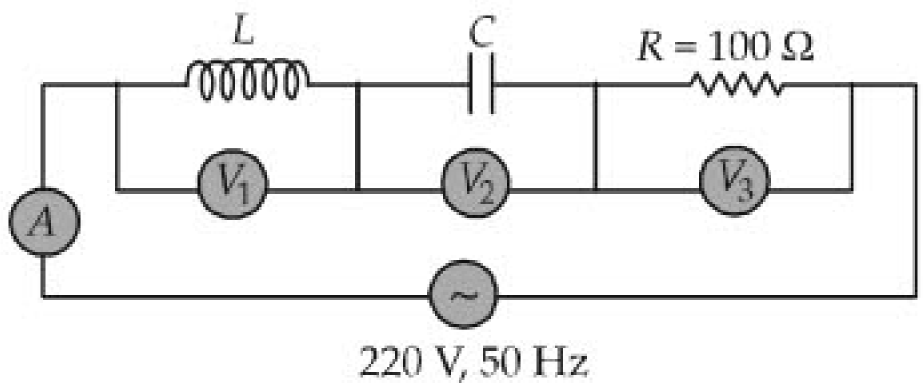
The magnitude of the induced emf is

$$|\varepsilon| = \frac{d\phi}{dt} = \frac{d}{dt}(B\pi r^2) = B\pi 2r\frac{dr}{dt}$$

$= 0.025 \times \pi \times 2 \times 2 \times 10^{-2} \times 1 \times 10^{-3}$

$= \pi \times 10^{-6}\text{ V} = \pi\ \mu\text{V}$

29. (b) :



As $V_L = V_C = 300$ V, therefore the given series LCR circuit is in resonance.

$\therefore \quad V_R = V = 220\text{ V}, Z = R = 100\ \Omega$

Current, $I = \frac{V}{Z} = \frac{220\text{ V}}{100\ \Omega} = 2.2\text{ A}$

Hence, the reading of the voltmeter V_3 is 220 V and the reading of ammeter A is 2.2 A.

30. (d) : Here, Input voltage, $V_p = 220$ V

Output voltage, $V_s = 440$ V

Input current, $I_p = ?$

Output current, $I_s = 2$ A

Efficiency of the transformer, $\eta = 80\%$

Efficiency of the transformer, $\eta = \frac{\text{Output power}}{\text{Input power}}$

$$\eta = \frac{V_s I_s}{V_p I_p} \quad \text{or} \quad I_p = \frac{V_s I_s}{\eta V_p} = \frac{(440\text{ V})(2\text{ A})}{\left(\frac{80}{100}\right)(220\text{ V})}$$

$$= \frac{(440\text{ V})(2\text{ A})(100)}{(80)(220\text{ V})} = 5\text{ A}$$

31. (d) : In case of oscillatory discharge of a capacitor through an inductor, charge at instant t is given by

$q = q_0 \cos\omega t$

where, $\omega = \frac{1}{\sqrt{LC}}$ ...(i)

$$\therefore \cos\omega t = \frac{q}{q_0} = \frac{CV_2}{CV_1} = \frac{V_2}{V_1} \quad (\because q = CV)$$

Current through the inductor

$$I = \frac{dq}{dt} = \frac{d}{dt}(q_0 \cos\omega t) = -q_0 \omega \sin\omega t$$

$$|I| = CV_1 \frac{1}{\sqrt{LC}}[1 - \cos^2 \omega t]^{1/2}$$

$$= V_1 \sqrt{\frac{C}{L}}\left[1 - \left(\frac{V_2}{V_1}\right)^2\right]^{1/2} = \left[\frac{C(V_1^2 - V_2^2)}{L}\right]^{1/2}$$

(using (i))

32. (a) : Once a rectangular loop or a square loop is being drawn out of the field, the rate of cutting the lines of field will be a constant for a square and rectangle, but not for circular or elliptical areas.

33. (d) : Average power, $P = E_{\text{r.m.s}} I_{\text{r.m.s}} \cos\phi$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}, \quad \cos\phi = \frac{R}{Z}$$

But $I_{\text{r.m.s}} = \frac{E_{\text{r.m.s}}}{Z}$. $\therefore P = E_{\text{r.m.s}}^2 \cdot \frac{R}{Z^2}$

$$\therefore P = E_{\text{r.m.s}}^2 \frac{R}{\{R^2 + (X_L - X_C)^2\}}.$$

$$= \frac{\varepsilon^2 R}{\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]}$$

34. (d) : Rate of decrease in the radius of the loop is 2 mm/s.

Final radius = 2 cm = 0.02 m

Initial radius = 2.2 cm = 0.022 m, $B = 0.04$ T

$$\varepsilon = -\frac{d\phi}{dt} = -B\frac{dA}{dt}$$

$\varepsilon = -\pi(0.022^2 - 0.02^2) \times 0.04 = -\pi \times 3.36 \times 10^{-6}$ V

$|\varepsilon| = \pi \times 3.36 \times 10^{-6}$ V $= 3.4\pi\ \mu$V

35. (a) : For a long solenoid, $B = \mu_0 ni = \mu_0 \frac{N}{l} \cdot i$

Flux $= \mu_0 \frac{N}{l} \cdot i \cdot A$

given flux per turn $= 4 \times 10^{-3}$, $i = 2$ A

$\therefore$ Total flux $= 4 \times 10^{-3}$

$$L = \left(\mu_0 \frac{N}{l} \cdot NA\right) = \frac{4 \times 10^{-3} \times 500}{2} = 1 \text{ henry}$$

36. (a) : Average power $= \frac{E_0 I_0}{2}\cos\phi$

37. (c) : $\vec{B} = \frac{1}{\pi}\left(\frac{\text{Wb}}{\text{m}^2}\right)$

Area of the disc normal to B is $\pi R^2 \cos 60°$.

Flux = B × Area normal

$\therefore$ Flux $= \frac{1}{2} \times 0.04 = 0.02$ Wb

38. (a) : Given : No. of turns across primary $N_p = 50$

Number of turns across secondary $N_s = 1500$

Magnetic flux linked with primary, $\phi = \phi_0 + 4t$

$\therefore$ Voltage across the primary,

$$V_p = \frac{d\phi}{dt} = \frac{d}{dt}(\phi_0 + 4t) = 4 \text{ volt.}$$

Also, $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$$\therefore V_s = \left(\frac{1500}{50}\right) \times 4 = 120 \text{ V.}$$

39. (b) : Given : Output power $P = 100$ W

Voltage across primary $V_p = 220$ V

Current in the primary $I_p = 0.5$ A

Efficiency of a transformer $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

$$= \frac{P}{V_p I_p} \times 100 = \frac{100}{220 \times 0.5} \times 100 = 90\%.$$

40. (d) : In series LCR, current is maximum at resonance.

$\therefore$ Resonant frequency $\omega = \frac{1}{\sqrt{LC}}$

$\therefore \omega^2 = \frac{1}{LC}$ or, $L = \frac{1}{\omega^2 C}$

Given $\omega = 1000$ s^{-1} and $C = 10\ \mu$F

$$\therefore L = \frac{1}{1000 \times 1000 \times 10 \times 10^{-6}} = 0.1 \text{ H} = 100 \text{ mH.}$$

41. (d) : $X_L = 31\ \Omega$, $X_C = 25\ \Omega$, $R = 8\ \Omega$
Impedence of series LCR is

$$Z = \sqrt{(R^2) + (X_L - X_C)^2}$$
$$= \sqrt{(8)^2 + (31-25)^2} = \sqrt{64+36} = 10\ \Omega.$$

Power factor, $\cos\phi = \frac{R}{Z} = \frac{8}{10} = 0.8$

42. (d) : Mutual inductance between coils is

$$M = K\sqrt{L_1 L_2}$$

or, $M = 1\sqrt{2\times10^{-3}\times8\times10^{-3}}$ $(\because K = 1)$
$= 4 \times 10^{-3} = 4$ mH.

43. (b) : The core of a transformer is laminated to minimise the energy losses due to eddy currents.

44. (d) : Frequency of LC oscillation $= \frac{1}{2\pi\sqrt{LC}}$

or, $\frac{f_1}{f_2} = \left(\frac{L_2 C_2}{L_1 C_1}\right)^{1/2} = \left(\frac{2L\times4C}{L\times C}\right)^{1/2} = (8)^{1/2}$

$\therefore$ $\frac{f_1}{f_2} = 2\sqrt{2} \Rightarrow f_2 = \frac{f_1}{2\sqrt{2}}$ or, $f_2 = \frac{f}{2\sqrt{2}}$.
$(\because f_1 = f)$

45. (d) : $\tan\phi = \frac{X_C - X_L}{R}$

$$\tan\left(\frac{\pi}{4}\right) = \frac{\frac{1}{\omega C} - \omega L}{R}$$

$$R = \frac{1}{\omega C} - \omega L$$

$$(R + 2\pi f L) = \frac{1}{2\pi f C} \text{ or } C = \frac{1}{2\pi f(R + 2\pi f L)}$$

46. (a) : Work done due to a charge $W = QV$

47. (a) : Time constant of LR circuit is $\tau = L/R$.
$\therefore$ $\tau = 5$ sec.

48. (b) : Induced emf is given by $\Rightarrow V = \frac{\Delta\phi}{\Delta t}$

$\Rightarrow$ current$(i) = \frac{Q}{\Delta t} = \frac{\Delta\phi}{\Delta t}\times\frac{1}{R}$
[where Q is total charge in time Δt]

$\Rightarrow Q = \frac{\Delta\phi}{R}$

49. (c) : The impedence Z of a series LCR circuit is given by, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

where $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$, ω is angular frequency.
At resonance, $X_L = X_C$, hence $Z = R$.
$\therefore$ $V_R = V$ (supply voltage)
$\therefore$ R.M.S. current, $I = \frac{V_R}{R} = \frac{V}{R}$
$\therefore$ Power loss $= I^2 R = V^2/R$.

50. (a) : $I = t^2 e^{-t}$

$|\varepsilon| = L\frac{dI}{dt}$ here emf is zero when $\frac{dI}{dt} = 0$

$\frac{dI}{dt} = 2te^{-t} - t^2 e^{-t} = 0$; $2te^{-t} = t^2 e^{-t}$

i.e. $te^{-t}(t-2) = 0 \Rightarrow t \neq \infty$ $t \neq 0$, $t = 2$ sec.

51. (c) : $X = \frac{1}{C\omega}$ $X' = \frac{1}{4C\omega}$ $\therefore$ $X' = \frac{X}{4}$

52. (a, b) : Quality factor $Q = \frac{\omega L}{R}$

Since $\omega^2 = \frac{1}{LC}$

$\therefore$ Quality factor $Q = \frac{1}{\omega RC}$

53. (d) : At $t = 0$
(i) capacitor offers negligible resistance.
(ii) inductor offers large resistance to current flow.

54. (b) : $\frac{E_P}{E_S} = \frac{N_P}{N_S} = \frac{1}{25}$; $E_S = 5750$ V

$I_S = 2$ amp, $P_S = 2 \times 5750$

$$I_P = \frac{P_P}{V_P} = \frac{P_S}{V_P} = \frac{2\times5750}{230} = 50 \text{ A}.$$

55. (b) : As

$$|\varepsilon| = M\frac{dI}{dt} = M\frac{d}{dt}(I_0 \sin\omega t) = MI_0\omega\cos\omega t$$

$\therefore$ $\varepsilon_{max} = 0.005 \times 10 \times 100\pi \times 1 = 5\pi$.

56. (c) : Turns on primary winding = 500; Turns on secondary winding = 5000; Primary winding voltage $(E_p) = 20$ V and frequency = 50 Hz.

$$\frac{N_s}{N_p} = \frac{E_s}{E_p} \text{ or } \frac{5000}{500} = \frac{E_s}{20}$$

or $E_s = \frac{5000\times20}{500} = 200$ V and frequency remains the same. Therefore secondary winding will have an output of 200 V, 50 Hz.

57. (b) : The dissipation of power in an a.c. circuit is $(P) = V \times I \times \cos\theta$. Therefore current flowing in the circuit depends upon the phase voltage (V) and current (I) of the a.c. circuit.

58. (c) : When the magnet is dropped through the ring an induced current is developed into the ring in the direction opposing the motion of magnet (Lenz's law). Therefore this induced current decreases the acceleration of bar magnet.

59. (b) : Current $(I) = 5\sin(100t - \pi/2)$ and voltage $(V) = 200\sin(100t)$. Comparing the given equation, with the standard equation, we find that between current and voltage is $\phi = \frac{\pi}{2} = 90^\circ$.

Power consumption $P = I_{rms}V_{rms}\cos\phi$

$= I_{rms}V_{rms}\cos 90^\circ = 0$

60. (b) : Initially, the current will pass through the capacitor (and not through the resistance which is parallel to capacitor). So effective resistance in the circuit is R_{AB}. Therefore the current in the resistor is 2 mA. After some time, the capacitor will become fully charged and will be in its steady state. Now no current will pass through the capacitor and the effective resistance of the circuit will be (1000 + 1000) = 2000 Ω. Therefore current in the resistor

$$= \frac{V}{R} = \frac{2}{2000} = 1 \times 10^{-3}\text{ A} = 1\text{ mA}.$$

61. (d) : Length of conductor (l) = 0.4 m;
Speed = 7 m/s and magnetic field (B) = 0.9 Wb/m^2.
Induced e.m.f. (ε) = Blv = 0.9 × 0.4 × 7 = 2.52 V.

62. (a) : In an A.C. circuit with inductance coil, the voltage V leads the current I by a phase difference of 90°. Or the current I lags behind the voltage V by a phase difference of 90°. Thus the voltage goes on decreasing with the increase in time as shown in the graph (a).

63. (d) : $I_{rms} = \frac{I_0}{\sqrt{2}}$

64. (b) : For resonance condition, the impedance will be minimum and the current be maximum. This is only possible when $X_L = X_C$.

Therefore $\tan\theta = \frac{X_L + X_C}{R} = 0$ or $\theta = 0$.

65. (a) : The major portion of the A.C. flows on the surface of the wire. So where a thick wire is required, a number of thin wires are joined together to give an equivalent effect of a thick wire. Therefore multiple strands are suitable for transporting A.C. Similarly multiple strands can also be used for D.C.

66. (c) : $L = \frac{N\phi}{i}$; $\phi = BA$; $B = \mu_0 ni = \frac{\mu_0 Ni}{l}$

$$L = \frac{\mu_0 N^2}{l}A = \mu_0 n^2\, A\, l$$

where n is the number of turns/unit length $L \propto N^2$

67. (b) : $\varepsilon = -L\frac{di}{dt}$

$$L = \frac{-\varepsilon}{\frac{di}{dt}} = \frac{-5\times10^{-3}}{(2-3)}\text{ H} = 5\text{ mH}$$

68. (c) : The time constant for resonance circuit, $\tau = CR$

Growth of charge in a circuit containing capacitance and resistance is given by the formula, $q = q_0(1 - e^{-\tau/CR})$

CR is known as time constant in this formula.

69. (c) : $q = \int i dt = \frac{1}{R}\int \varepsilon dt = \left(\frac{-d\phi}{dt}\right)\frac{1}{R}\int dt = \frac{1}{R}\int d\phi$

Hence total charge induced in the conducting loop depend upon the total change in magnetic flux.
As the emf or iR depends on rate of change of ϕ, charge induced depends on change of flux.

70. (c) : $i = \frac{\varepsilon}{R} = \frac{\frac{NAdB}{dt}}{R}$

$$= \frac{20\times(25\times10^{-4})\times1000}{100} = 0.5\text{ A}$$

71. (d) : According to Faraday's laws, it is the conservation of energy.

72. (d) : Self inductance of a solenoid = $\mu_0 n^2 Al$ where n is the number of turns/length.
So self induction $\propto n^2$
So inductance becomes 4 times when n is doubled.

73. (c) : $E = \frac{1}{2}Li^2 = \frac{1}{2}\times(100\times10^{-3})\times1^2 = 0.05$ J

74. (b) : $\varepsilon = \frac{-(\phi_2 - \phi_1)}{t} = \frac{-(0 - NBA)}{t} = \frac{NBA}{t}$

$$t = \frac{NBA}{\varepsilon} = \frac{50\times2\times10^{-2}\times10^{-2}}{0.1} = 0.1\text{ s}$$

75. (a) : $|\varepsilon| = L\frac{di}{dt}$

Given that, $L = 40 \times 10^{-3}$ H,
di = 11 A − 1 A = 10 A
and $dt = 4 \times 10^{-3}$ s

$\therefore |\varepsilon| = 40\times10^{-3}\times\left(\frac{10}{4\times10^{-3}}\right) = 100$ V

76. (c)

77. (c) : $I_0 = \frac{E_0}{R} = N\frac{BA\omega}{R}$

Given, $N = 1$, $B = 10^{-2}$ T,
$A = \pi(0.3)^2$ m^2, $R = \pi^2$
$f = (200/60)$ and $\omega = 2\pi(200/60)$

Substituting these values and solving, we get
$I_0 = 6 \times 10^{-3}$ A = 6 mA

78. (a) : Eddy currents are produced when a metal is kept in a varying magnetic field.

Chapter 17 Electromagnetic Waves

1. In an electromagnetic wave in free space the root mean square value of the electric field is $E_{rms} = 6\ V\ m^{-1}$. The peak value of the magnetic field is
(a) 2.83×10^{-8} T (b) 0.70×10^{-8} T
(c) 4.23×10^{-8} T (d) 1.41×10^{-8} T
(NEET 2017)

2. A 100 Ω resistance and a capacitor of 100 Ω reactance are connected in series across a 220 V source. When the capacitor is 50% charged, the peak value of the displacement current is
(a) 2.2 A (b) 11 A
(c) 4.4 A (d) $11\sqrt{2}$ A
(NEET-II 2016)

3. Out of the following options which one can be used to produce a propagating electromagnetic wave?
(a) A chargeless particle
(b) An accelerating charge
(c) A charge moving at constant velocity
(d) A stationary charge
(NEET-I 2016)

4. The energy of the em waves is of the order of 15 keV. To which part of the spectrum does it belong?
(a) Ultraviolet rays (b) γ-rays
(c) X-rays (d) Infra-red rays
(2015)

5. A radiation of energy 'E' falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (C = Velocity of light)
(a) $\frac{2E}{C^2}$ (b) $\frac{E}{C^2}$
(c) $\frac{E}{C}$ (d) $\frac{2E}{C}$
(2015 Cancelled)

6. Light with an energy flux of $25 \times 10^4\ W\ m^{-2}$ falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm², the average force exerted on the surface is
(a) 1.25×10^{-6} N
(b) 2.50×10^{-6} N
(c) 1.20×10^{-6} N
(d) 3.0×10^{-6} N
(2014)

7. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is
(a) Microwaves are heat waves, so always produce heating.
(b) Infra-red waves produce heating in a microwave oven.
(c) The frequency of the microwaves must match the resonant frequency of the water molecules.
(d) The frequency of the microwaves has no relation with natural frequency of water molecules.
(NEET 2013)

8. An electromagnetic wave of frequency $\upsilon = 3.0$ MHz passes from vacuum into a dielectric medium with relative permittivity $\in = 4.0$. Then
(a) Wavelength is doubled and frequency becomes half.
(b) Wavelength is halved and frequency remains unchanged.
(c) Wavelength and frequency both remain unchanged.
(d) Wavelength is doubled and frequency unchanged.
(Karnataka NEET 2013)

9. The electric field associated with an em wave in vacuum is given by $E = \hat{i}\, 40 \cos (kz - 6 \times 10^8 t)$ where E, z and t are in volt/m, meter and seconds respectively. The value of wave vector k is
(a) $2\ m^{-1}$ (b) $0.5\ m^{-1}$
(c) $6\ m^{-1}$ (d) $3\ m^{-1}$
(2012)

10. The ratio of amplitude of magnetic field to the amplitude of electric field for an electromagnetic wave propagating in vacuum is equal to
(a) the speed of light in vacuum
(b) reciprocal of speed of light in vacuum
(c) the ratio of magnetic permeability to the electric susceptibility of vacuum
(d) unity *(Mains 2012)*

11. The electric and the magnetic field, associated with an e.m. wave, propagating along the +z-axis, can be represented by

(a) $\left[\vec{E}=E_0\hat{i},\ \vec{B}=B_0\hat{j}\right]$

(b) $\left[\vec{E}=E_0\hat{k},\ \vec{B}=B_0\hat{i}\right]$

(c) $\left[\vec{E}=E_0\hat{j},\ \vec{B}=B_0\hat{i}\right]$

(d) $\left[\vec{E}=E_0\hat{j},\ \vec{B}=B_0\hat{k}\right]$ *(2011)*

12. The decreasing order of wavelength of infrared, microwave, ultraviolet and gamma rays is
(a) microwave, infrared, ultraviolet, gamma rays
(b) gamma rays, ultraviolet, infrared, microwaves
(c) microwaves, gamma rays, infrared, ultraviolet
(d) infrared, microwave, ultraviolet, gamma rays *(2011)*

13. Which of the following statement is false for the properties of electromagnetic waves?
(a) Both electric and magnetic field vectors attain the maxima and minima at the same place and same time.
(b) The energy in electromagnetic wave is divided equally between electric and magnetic vectors.
(c) Both electric and magnetic field vectors are parallel to each other and perpendicular to the direction of propagation of wave.
(d) These waves do not require any material medium for propagation. *(2010)*

14. The electric field of an electromagnetic wave in free space is given by $\vec{E}=10\cos(10^7 t+kx)\hat{j}$ V/m, where t and x are in seconds and metres respectively. It can be inferred that
(1) the wavelength λ is 188.4 m.
(2) the wave number k is 0.33 rad/m.
(3) the wave amplitude is 10 V/m.
(4) the wave is propagating along +x direction.
Which one of the following pairs of statements is correct?
(a) (3) and (4) (b) (1) and (2)
(c) (2) and (3) (d) (1) and (3)
(Mains 2010)

15. The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$;

$$E_y = 2.5\,\frac{\text{N}}{\text{C}}\cos\left[\left(2\pi\times10^6\,\frac{\text{rad}}{\text{m}}\right)t-\left(\pi\times10^{-2}\,\frac{\text{rad}}{\text{s}}\right)x\right];$$

$E_z = 0$. The wave is
(a) moving along x direction with frequency 10^6 Hz and wavelength 100 m.
(b) moving along x direction with frequency 10^6 Hz and wavelength 200 m.
(c) moving along $-x$ direction with frequency 10^6 Hz and wavelength 200 m.
(d) moving along y direction with frequency $2\pi\times10^6$ Hz and wavelength 200 m.
(2009)

16. The velocity of electromagnetic radiation in a medium of permittivity ε_0 and permeability μ_0 is given by

(a) $\dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$ (b) $\sqrt{\dfrac{\mu_0}{\varepsilon_0}}$

(c) $\sqrt{\dfrac{\varepsilon_0}{\mu_0}}$ (d) $\sqrt{\mu_0\varepsilon_0}$

(2008)

17. The electric and magnetic field of an electromagnetic wave are
(a) in opposite phase and perpendicular to each other
(b) in opposite phase and parallel to each other
(c) in phase and perpendicular to each other
(d) in phase and parallel to each other.
(2007, 1994)

18. If λ_v, λ_x and λ_m represent the wavelengths of visible light, X-rays and microwaves respectively, then
(a) $\lambda_m > \lambda_x > \lambda_v$ (b) $\lambda_m > \lambda_v > \lambda_x$
(c) $\lambda_v > \lambda_x > \lambda_m$ (d) $\lambda_v > \lambda_m > \lambda_x$.
(2005)

19. We consider the radiation emitted by the human body. Which one of the following statements is true?
(a) The radiation emitted is in the infra-red region
(b) The radiation is emitted only during the day
(c) The radiation is emitted during the summers and absorbed during the winters
(d) The radiation emitted lies in the ultraviolet region and hence is not visible *(2003)*

20. Which of the following rays are not electromagnetic waves ?
(a) X-rays (b) γ-rays
(c) β-rays (d) heat rays *(2003)*

21. The velocity of electromagnetic wave is parallel to
(a) $\vec{B}\times\vec{E}$ (b) $\vec{E}\times\vec{B}$
(c) $\vec{E}$ (d) $\vec{B}$. *(2002)*

22. What is the cause of Green house effect?
(a) infra-red rays (b) ultra violet rays
(c) X-rays (d) radio waves. *(2002)*

23. Biological importance of ozone layer is
(a) it stops ultraviolet rays
(b) ozone layer reduces green house effect
(c) ozone layer reflects radio waves
(d) ozone layer controls O_2/H_2 ratio in atmosphere. *(2001)*

24. The frequency order for γ-rays (B), X-rays (A), UV rays (C) is
(a) $B > A > C$ (b) $A > B > C$
(c) $C > B > A$ (d) $A > C > B$. *(2000)*

25. Ozone layer blocks the radiations of wavelength
(a) more than 3×10^{-7} m
(b) equal to 3×10^{-7} m
(c) less than 3×10^{-7} m
(d) all of these *(1999)*

26. Wavelength of light of frequency 100 Hz
(a) 4×10^6 m (b) 3×10^6 m
(c) 2×10^6 m (d) 5×10^{-5} m *(1999)*

27. If ε_0 and μ_0 are the electric permittivity and magnetic permeability in a free space, ε and μ are the corresponding quantities in medium, the index and refraction of the medium is
(a) $\sqrt{\dfrac{\varepsilon_0\mu_0}{\varepsilon\,\mu}}$ (b) $\sqrt{\dfrac{\varepsilon\mu}{\varepsilon_0\mu_0}}$
(c) $\sqrt{\dfrac{\varepsilon_0\mu}{\varepsilon\,\mu_0}}$ (d) $\sqrt{\dfrac{\varepsilon}{\varepsilon_0}}$. *(1997)*

28. Which of the following electromagnetic radiations have the smaller wavelength?
(a) X-rays (b) γ-rays
(c) UV waves (d) microwaves. *(1994)*

29. A signal emitted by an antenna from a certain point can be received at another point of the surface in the form of
(a) sky wave (b) ground wave
(c) sea wave (d) both (a) and (b) *(1993)*

30. The structure of solids is investigated by using
(a) cosmic rays
(b) X-rays
(c) γ-rays
(d) infra-red radiations *(1992)*

31. The frequency of electromagnetic wave, which best suited to observe a particle of radius 3×10^{-4} cm is of the order of
(a) 10^{15} (b) 10^{14}
(c) 10^{13} (d) 10^{12} *(1991)*

32. In which of the following, emission of electrons does not take place
(a) thermionic emission
(b) X-rays emission
(c) photoelectric emission
(d) secondary emission *(1990)*

33. Which of the following electromagnetic radiations have the longest wavelength ?
(a) X-rays (b) γ-rays
(c) Microwaves (d) Radiowaves *(1989)*

Answer Key

1. (a)	**2.** (a)	**3.** (b)	**4.** (c)	**5.** (d)	**6.** (b)	**7.** (c)	**8.** (b)	**9.** (a)	**10.** (b)
11. (a)	**12.** (a)	**13.** (c)	**14.** (d)	**15.** (b)	**16.** (a)	**17.** (c)	**18.** (b)	**19.** (a)	**20.** (c)
21. (b)	**22.** (a)	**23.** (a)	**24.** (a)	**25.** (d)	**26.** (b)	**27.** (b)	**28.** (b)	**29.** (d)	**30.** (b)
31. (b)	**32.** (b)	**33.** (d)							

EXPLANATIONS

1. (a) : Given: $E_{rms} = 6 \text{ V m}^{-1}$

$$\frac{E_{rms}}{B_{rms}} = c \text{ or } B_{rms} = \frac{E_{rms}}{c}$$

$$B_{rms} = \frac{6}{3\times10^8} = 2\times10^{-8}\text{ T}$$

Since, $B_{rms} = \frac{B_0}{\sqrt{2}}$

where B_o is the peak value of magnetic field.

$\therefore\ B_0 = B_{rms}\sqrt{2} = 2\times10^{-8}\times\sqrt{2}T$

$B_o \approx 2.83 \times 10^{-8}$ T

2. (a) : Here, $R = 100\ \Omega$, $X_c = 100\ \Omega$

Net impedance, $Z = \sqrt{R^2 + X_L^2} = 100\sqrt{2}\ \Omega$

Peak value of displacement current

= Maximum conduction current in the circuit

$$= \frac{\varepsilon_0}{Z} = \frac{220\sqrt{2}}{100\sqrt{2}} = 2.2 \text{ A}$$

3. (b) : An accelerating charge is used to produce oscillating electric and magnetic fields, hence the electromagnetic wave.

4. (c) : As $\lambda = \frac{hc}{E}$

where the symbols have their usual meanings.

Here, $E = 15$ keV $= 15 \times 10^3$ V

and $hc = 1240$ eV nm

$$\therefore\ \lambda = \frac{1240\text{ eV nm}}{15\times10^3\text{ eV}} = 0.083\text{ nm}$$

As the wavelength range of X-rays is from 1 nm to 10^{-3} nm, so this wavelength belongs to X-rays.

5. (d) : Energy of radiation, $E = h\upsilon = \frac{hC}{\lambda}$

Also, its momentum $p = \frac{h}{\lambda} = \frac{E}{C} = p_i$

$$p_r = -p_i = -\frac{E}{C}$$

So, momentum transferred to the surface

$$= p_i - p_r = \frac{E}{C} - \left(-\frac{E}{C}\right) = \frac{2E}{C}$$

6. (b) : Here, Energy flux, $I = 25 \times 10^4 \text{ W m}^{-2}$

Area, $A = 15 \text{ cm}^2 = 15 \times 10^{-4} \text{ m}^2$

Speed of light, $c = 3 \times 10^8 \text{ m s}^{-1}$

For a perfectly reflecting surface, the average force exerted on the surface is

$$F = \frac{2IA}{c} = \frac{2\times25\times10^4\text{ W m}^{-2}\times15\times10^{-4}\text{ m}^2}{3\times10^8\text{ m s}^{-1}}$$

$= 250 \times 10^{-8}$ N $= 2.50 \times 10^{-6}$ N

7. (c) : In microwave oven the frequency of the microwaves must match the resonant frequency of water molecules so that energy from the waves is transferred efficiently to the kinetic energy of the molecules.

8. (b) : Frequency of electromagnetic wave does not change with change in medium but wavelength and velocity of wave changes with change in medium.

Velocity of electromagnetic wave in vacuum

$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}} = \upsilon\lambda_{vacuum} \quad ...(i)$$

Velocity of electromagnetic wave in the medium

$$v_{medium} = \frac{1}{\sqrt{\mu_0\mu_r\epsilon_0\epsilon_r}} = \frac{c}{\sqrt{\mu_r\epsilon_r}}$$

where μ_r and ϵ_r be relative permeability and relative permittivity of the medium.

For dielectric medium, $\mu_r = 1$

$$\therefore\ v_{medium} = \frac{c}{\sqrt{\epsilon_r}}$$

Here, $\epsilon_r = 4.0$

$$\therefore\ v_{medium} = \frac{c}{\sqrt{4}} = \frac{c}{2} \quad ...(ii)$$

Wavelength of the wave in medium

$$\lambda_{medium} = \frac{v_{medium}}{\upsilon} = \frac{c}{2\upsilon} = \frac{\lambda_{vacuum}}{2} \quad \text{(Using (i) and (ii))}$$

9. (a) : Compare the given equation with

$E = E_0\cos(kz - \omega t)$

we get, $\omega = 6 \times 10^8 \text{ s}^{-1}$

Wave vector, $k = \frac{\omega}{c} = \frac{6\times10^8\text{ s}^{-1}}{3\times10^8\text{ m s}^{-1}} = 2\text{ m}^{-1}$

10. (b) : The amplitude of magnetic field and electric field for an electromagnetic wave propagating in vacuum are related as

$E_0 = B_0 c$

where c is the speed of light in vacuum.

$\therefore \frac{B_0}{E_0} = \frac{1}{c}$

11. (a) : The electromagnetic wave is propagating along the $+z$ axis.

Since the electric and magnetic fields are perpendicular to each other and also perpendicular to the direction of propagation of wave.

Also, $\vec{E} \times \vec{B}$ gives the direction of wave propagation.

$\therefore \vec{E} = E_0 \hat{i},\ B = B_0 \hat{j} \qquad (\because \hat{i} \times \hat{j} = \hat{k})$

12. (a) : The decreasing order of wavelength of the given electromagnetic waves is as follows :

$$\lambda_{\text{Microwave}} > \lambda_{\text{Infrared}} > \lambda_{\text{Ultraviolet}} > \lambda_{\text{Gamma rays}}$$

13. (c) : In an electromagnetic wave both electric and magnetic vectors are perpendicular to each other as well as perpendicular to the direction of propagation of wave.

14. (d) : As given

$$E = 10\cos(10^7 t + kx) \qquad \text{...(i)}$$

Comparing it with standard equation of e.m. wave,

$$E = E_0\cos(\omega t + kx) \qquad \text{...(ii)}$$

Amplitude $E_0 = 10$ V/m and $\omega = 10^7$ rad/s

$\because\ c = \upsilon\lambda = \frac{\omega\lambda}{2\pi}$

or $\lambda = \frac{2\pi c}{\omega} = \frac{2\pi \times 3 \times 10^8}{10^7} = 188.4$ m

Also, $c = \frac{\omega}{k}$ or $k = \frac{\omega}{c} = \frac{10^7}{3 \times 10^8} = 0.033$

The wave is propagating along y direction.

15. (b) :

$$E_y = 2.5\frac{\text{N}}{\text{C}}\left[\left(2\pi \times 10^6 \frac{\text{rad}}{\text{m}}\right)t - \left(\pi \times 10^{-2}\frac{\text{rad}}{\text{s}}\right)x\right]$$

$$E_z = 0$$

The wave is moving in the positive direction of x.

This is the form $E_y = E_0(\omega t - kx)$

$\omega = 2\pi \times 10^6$

$2\pi\upsilon = 2\pi \times 10^6 \Rightarrow \upsilon = 10^6$ Hz

$\frac{2\pi}{\lambda} = k \Rightarrow \frac{2\pi}{\lambda} = \pi \times 10^{-2}$

$\Rightarrow \lambda = \frac{2\pi}{\pi \times 10^{-2}} = 2 \times 10^2 = 200$ m.

16. (a) : The velocity of electromagnetic radiation in vacuum is $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$, where μ_0 and ε_0 are the permeability and permittivity of vacuum.

17. (c) : In electromagnetic wave, electric and magnetic field are in phase and perpendicular to each other and also perpendicular to the direction of the propagation of the wave.

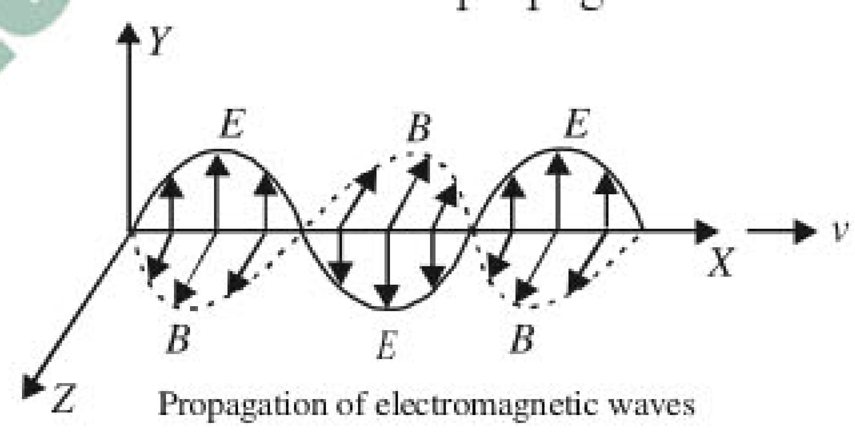
18. (b) : $\lambda_m > \lambda_v > \lambda_x$.

In spectrum X-rays has minimum wavelength and microwave has maximum wavelength.

19. (a) : Every body at all time, at all temperatures emit radiation (except at $T = 0$), which fall in the infrared region.

20. (c)

21. (b) : According to Maxwell, the electromagnetic waves are those waves in which there are sinusoidal variation of electric and magnetic field vectors at right angles to each other as well as at right angles to the direction of wave propagation.



Propagation of electromagnetic waves

If the electric field $(\vec{E})$ and magnetic field $(\vec{B})$ are vibrating along Y and Z direction, propagation of electromagnetic wave will be along the X-axis. Therefore, the velocity of electromagnetic wave is parallel to $\vec{E} \times \vec{B}$.

22. (a) : As the electro-magnetic radiations from Sun pass through the atmosphere, some of them are absorbed by it while other reach the surface of earth. The range of wavelength which reaches earth lies in infrared region. This part of the radiation from the sun has shorter wavelength and can penetrate through the layer of gases like CO_2 and reach earth surface. But the radiation from the earth being of longer wavelength can escape through this layer. As a result the earth surface gets warm. This is known as green house effect.

23. (a) : The ozone layer absorbs the harmful ultraviolet rays coming from sun.

24. (a)

25. (d) : The range is from 380 nm to even 200 nm to 120 nm

26. (b) : $\lambda = \frac{3\times10^8}{100\text{ Hz}} = 3\times10^6$ m

27. (b) : $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ (free space)

$v = \frac{1}{\sqrt{\mu\varepsilon}}$ (medium)

$\therefore \quad \mu = \frac{c}{v} = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

28. (b)

29. (d)

30. (b) : X-rays are used for the investigation of structure of solids.

31. (b) : The wave length of radiation used should be less than the size of the particle

Size of particle = $\lambda = \frac{c}{\upsilon}$

$3\times10^{-4} = \frac{3\times10^{10}}{\upsilon}$ or $\upsilon = 10^{14}$ hertz

However, when frequency is higher than this, wavelength is still smaller. Resolution becomes better.

32. (b) : Thermionic emission : When a metal is heated to a high temperature, the free electron gain kinetic energy and escape from the surface of the metal.

Secondary emission : When an electron strikes the surface of a metallic plate, it emits other electrons from the surface.

Photoelectric emission : Emission of electrons from the metal surface on irradiation with radiation of suitable frequency.

X-rays emission : They are due to transitions in the inner energy levels of the atom.

33. (d) :

Radiations	Wavelength [Range in m]
X-rays	1×10^{-11} to 3×10^{-8}
γ-rays	6×10^{-14} to 1×10^{-11}
Microwaves	10^{-3} to 0.3
Radiowaves	10 to 10^4

Chapter 18

Optics

1. The ratio of resolving powers of an optical microscope for two wavelengths $\lambda_1 = 4000$ Å and $\lambda_2 = 6000$ Å is
(a) 9 : 4 (b) 3 : 2
(c) 16 : 81 (d) 8 : 27
(NEET 2017)

2. Young's double slit experiment is first performed in air and then in a medium other than air. It is found that 8^{th} bright fringe in the medium lies where 5^{th} dark fringe lies in air. The refractive index of the medium is nearly
(a) 1.59 (b) 1.69
(c) 1.78 (d) 1.25 *(NEET 2017)*

3. A beam of light from a source L is incident normally on a plane mirror fixed at a certain distance x from the source. The beam is reflected back as a spot on a scale placed just above the source L. When the mirror is rotated through a small angle θ, the spot of the light is found to move through a distance y on the scale. The angle θ is given by
(a) $\frac{y}{x}$ (b) $\frac{x}{2y}$
(c) $\frac{x}{y}$ (d) $\frac{y}{2x}$ *(NEET 2017)*

4. A thin prism having refracting angle 10° is made of glass of refractive index 1.42. This prism is combined with another thin prism of glass of refractive index 1.7. This combination produces dispersion without deviation. The refracting angle of second prism should be
(a) 6° (b) 8°
(c) 10° (d) 4° *(NEET 2017)*

5. Two polaroids P_1 and P_2 are placed with their axis perpendicular to each other. Unpolarised light I_0 is incident on P_1. A third polaroid P_3 is kept in between P_1 and P_2 such that its axis makes an angle 45° with that of P_1. The intensity of transmitted light through P_2 is
(a) $\frac{I_0}{4}$ (b) $\frac{I_0}{8}$
(c) $\frac{I_0}{16}$ (d) $\frac{I_0}{2}$ *(NEET 2017)*

6. Two identical glass ($\mu_g = 3/2$) equiconvex lenses of focal length f each are kept in contact. The space between the two lenses is filled with water ($\mu_w = 4/3$). The focal length of the combination is
(a) $f/3$ (b) f
(c) $4f/3$ (d) $3f/4$
(NEET-II 2016)

7. An air bubble in a glass slab with refractive index 1.5 (near normal incidence) is 5 cm deep when viewed from one surface and 3 cm deep when viewed from the opposite face. The thickness (in cm) of the slab is
(a) 8 (b) 10
(c) 12 (d) 16
(NEET-II 2016)

8. The interference pattern is obtained with two coherent light sources of intensity ratio n. In the interference pattern, the ratio $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ will be
(a) $\frac{\sqrt{n}}{n+1}$ (b) $\frac{2\sqrt{n}}{n+1}$
(c) $\frac{\sqrt{n}}{(n+1)^2}$ (d) $\frac{2\sqrt{n}}{(n+1)^2}$
(NEET-II 2016)

9. A person can see clearly objects only when they lie between 50 cm and 400 cm from his eyes. In order to increase the maximum distance of distinct vision to infinity, the type and power of the correcting lens, the person has to use, will be
(a) convex, +2.25 diopter
(b) concave, –0.25 diopter
(c) concave, –0.2 diopter
(d) convex, +0.15 diopter *(NEET-II 2016)*

10. A linear aperture whose width is 0.02 cm is placed immediately in front of a lens of focal length 60 cm. The aperture is illuminated normally by a parallel beam of wavelength 5×10^{-5} cm. The distance of the first dark band of the diffraction pattern from the centre of the screen is
(a) 0.10 cm (b) 0.25 cm
(c) 0.20 cm (d) 0.15 cm
(NEET-II 2016)

11. Match the corresponding entries of **column 1** with **column 2**. [Where m is the magnification produced by the mirror]

Column 1	Column 2
(A) $m = -2$	(p) Convex mirror
(B) $m = -\frac{1}{2}$	(q) Concave mirror
(C) $m = +2$	(r) Real image
(D) $m = +\frac{1}{2}$	(s) Virtual image

(a) A → p and s; B → q and r; C → q and s; D → q and r
(b) A → r and s; B → q and s; C → q and r; D → p and s
(c) A → q and r; B → q and r; C → q and s; D → p and s
(d) A → p and r; B → p and s; C → p and q; D → r and s
(NEET-I 2016)

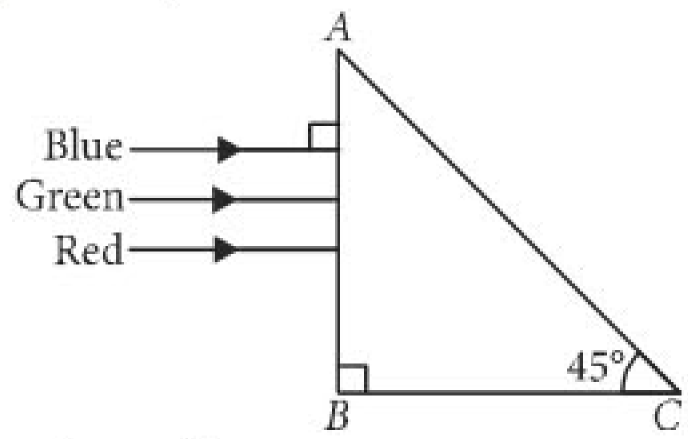
12. In a diffraction pattern due to a single slit of width a, the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident on the slit. The first secondary maximum is observed at an angle of
(a) $\sin^{-1}\left(\frac{1}{2}\right)$ (b) $\sin^{-1}\left(\frac{3}{4}\right)$
(c) $\sin^{-1}\left(\frac{1}{4}\right)$ (d) $\sin^{-1}\left(\frac{2}{3}\right)$
(NEET-I 2016)

13. The intensity at the maximum in a Young's double slit experiment is I_0. Distance between two slits is $d = 5\lambda$, where λ is the wavelength of light used in the experiment. What will be the intensity in front of one of the slits on the screen placed at a distance $D = 10d$?
(a) $\frac{3}{4}I_0$ (b) $\frac{I_0}{2}$
(c) I_0 (d) $\frac{I_0}{4}$
(NEET-I 2016)

14. A astronomical telescope has objective and eyepiece of focal lengths 40 cm and 4 cm respectively. To view an object 200 cm away from the objective, the lenses must be separated by a distance
(a) 50.0 cm (b) 54.0 cm
(c) 37.3 cm (d) 46.0 cm
(NEET-I 2016)

15. The angle of incidence for a ray of light at a refracting surface of a prism is 45°. The angle of prism is 60°. If the ray suffers minimum deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are
(a) 45°; $\sqrt{2}$ (b) 30°; $\frac{1}{\sqrt{2}}$
(c) 45°; $\frac{1}{\sqrt{2}}$ (d) 30°; $\sqrt{2}$
(NEET-I 2016)

16. A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively.



The prism will
(a) not separate the three colours at all
(b) separate the red colour part from the green and blue colours
(c) separate the blue colour part from the red and green colours
(d) separate all the three colours from one another
(2015)

17. At the first minimum adjacent to the central maximum of a single-slit diffraction pattern, the phase difference between the Huygen's wavelet from the edge of the slit and the wavelet from the midpoint of the slit is
(a) π radian (b) $\frac{\pi}{8}$ radian
(c) $\frac{\pi}{4}$ radian (d) $\frac{\pi}{2}$ radian *(2015)*

18. In an astronomical telescope in normal adjustment a straight black line of length L is drawn on inside part of objective lens. The eye-piece forms a real image of this line. The length of this image is I. The magnification of the telescope is

(a) $\frac{L+I}{L-I}$ (b) $\frac{L}{I}$

(c) $\frac{L}{I}+1$ (d) $\frac{L}{I}-1$ *(2015)*

19. Two slits in Young's experiment have widths in the ratio 1 : 25. The ratio of intensity at the maxima and minima in the interference pattern, $\frac{I_{max}}{I_{min}}$ is

(a) $\frac{49}{121}$ (b) $\frac{4}{9}$

(c) $\frac{9}{4}$ (d) $\frac{121}{49}$ *(2015)*

20. For a parallel beam of monochromatic light of wavelength 'λ', diffraction is produced by a single slit whose width 'a' is of the order of the wavelength of the light. If 'D' is the distance of the screen from the slit, the width of the central maxima will be

(a) $\frac{Da}{\lambda}$ (b) $\frac{2Da}{\lambda}$

(c) $\frac{2D\lambda}{a}$ (d) $\frac{D\lambda}{a}$

(2015 Cancelled)

21. Two identical thin plano-convex glass lenses (refractive index 1.5) each having radius of curvature of 20 cm are placed with their convex surfaces in contact at the centre. The intervening space is filled with oil of refractive index 1.7. The focal length of the combination is

(a) –50 cm (b) 50 cm
(c) –20 cm (d) –25 cm

(2015 Cancelled)

22. The refracting angle of a prism is A, and refractive index of the material of the prism is cot (A/2). The angle of minimum deviation is

(a) $90° - A$ (b) $180° + 2A$
(c) $180° - 3A$ (d) $180° - 2A$

(2015 Cancelled)

23. In a double slit experiment, the two slits are 1 mm apart and the screen is placed 1 m away. A monochromatic light of wavelength 500 nm is used. What will be the width of each slit for obtaining ten maxima of double slit within the central maxima of single slit pattern?

(a) 0.5 mm (b) 0.02 mm
(c) 0.2 mm (d) 0.1 mm

(2015 Cancelled)

24. A beam of light of λ = 600 nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is

(a) 1.2 cm (b) 1.2 mm
(c) 2.4 cm (d) 2.4 mm *(2014)*

25. In the Young's double slit experiment, the intensity of light at a point on the screen where the path difference λ is K, (λ being the wavelength of light used). The intensity at a point where the path difference is $\lambda/4$ will be

(a) K (b) $K/4$
(c) $K/2$ (d) zero *(2014)*

26. If the focal length of objective lens is increased then magnifying power of

(a) microscope will increase but that of telescope decrease.
(b) microscope and telescope both will increase.
(c) microscope and telescope both will decrease.
(d) microscope will decrease but that of telescope will increase. *(2014)*

27. The angle of a prism is A. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence $2A$ on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ, of the prism is

(a) $2\sin A$ (b) $2\cos A$

(c) $\frac{1}{2}\cos A$ (d) $\tan A$ *(2014)*

28. A plano convex lens fits exactly into a plano concave lens. Their plane surfaces are parallel to each other. If lenses are made of different materials of refractive indices μ_1 and μ_2 and R is the radius of curvature of the curved surface of the lenses, then the focal length of the combination is

(a) $\frac{R}{(\mu_1-\mu_2)}$ (b) $\frac{2R}{(\mu_2-\mu_1)}$

(c) $\frac{R}{2(\mu_1+\mu_2)}$ (d) $\frac{R}{2(\mu_1-\mu_2)}$

(NEET 2013)

29. In Young's double slit experiment, the slits are 2 mm apart and are illuminated by photons of two wavelengths λ_1 = 12000 Å and λ_2 = 10000 Å. At what minimum distance from the common central bright fringe on the screen 2 m from the slit will a bright fringe from one interference pattern coincide with a bright fringe from the other?
(a) 4 mm (b) 3 m
(c) 8 mm (d) 6 mm
(NEET 2013)

30. For a normal eye, the cornea of eye provides a converging power of 40 D and the least converging power of the eye lens behind the cornea is 20 D. Using this information, the distance between the retina and the cornea-eye lens can be estimated to be
(a) 1.67 cm (b) 1.5 cm
(c) 5 cm (d) 2.5 cm
(NEET 2013)

31. A parallel beam of fast moving electrons is incident normally on a narrow slit. A fluorescent screen is placed at a large distance from the slit. If the speed of the electrons is increased, which of the following statements is correct?
(a) The angular width of the central maximum will decrease.
(b) The angular width of the central maximum will be unaffected.
(c) Diffraction pattern is not observed on the screen in the case of electrons.
(d) The angular width of the central maximum of the diffraction pattern will increase.
(NEET 2013)

32. In Young's double slit experiment the distance between the slits and the screen is doubled. The separation between the slits is reduced to half. As a result the fringe width
(a) is halved
(b) becomes four times
(c) remains unchanged
(d) is doubled *(Karnataka NEET 2013)*

33. A parallel beam of light of wavelength λ is incident normally on a narrow slit. A diffraction pattern formed on a screen placed perpendicular to the direction of the incident beam. At the second minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of slit is
(a) 2π (b) 3π
(c) 4π (d) $\pi\lambda$
(Karnataka NEET 2013)

34. The reddish appearance of the sun at sunrise and sunset is due to
(a) the scattering of light
(b) the polarisation of light
(c) the colour of the sun
(d) the colour of the sky
(Karnataka NEET 2013)

35. Two plane mirrors are inclined at 70°. A ray incident on one mirror at angle, θ after reflection falls on second mirror and is reflected from there parallel to first mirror. The value of θ is
(a) 45° (b) 30°
(c) 55° (d) 50°
(Karnataka NEET 2013)

36. When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index
(a) equal to that of glass
(b) less than one
(c) greater than that of glass
(d) less than that of glass *(2012)*

37. A ray of light is incident at an angle of incidence i, on one face of a prism of angle A (assumed to be small) and emerges normally from the opposite face. If the refractive index of the prism is μ, the angle of incidence i, is nearly equal to
(a) μA (b) $\frac{\mu A}{2}$
(c) $\frac{A}{\mu}$ (d) $\frac{A}{2\mu}$ *(2012, 1989)*

38. A concave mirror of focal length f_1 is placed at a distance of d from a convex lens of focal length f_2. A beam of light coming from infinity and falling on this convex lens – concave mirror combination returns to infinity. The distance d must equal
(a) $f_1 + f_2$ (b) $-f_1 + f_2$
(c) $2f_1 + f_2$ (d) $-2f_1 + f_2$ *(2012)*

39. The magnifying power of a telescope is 9. When it is adjusted for parallel rays the distance between the objective and eyepiece is 20 cm. The focal length of lenses are
(a) 10 cm, 10 cm (b) 15 cm, 5 cm
(c) 18 cm, 2 cm (d) 11 cm, 9 cm
(2012)

40. For the angle of minimum deviation of a prism to be equal to its refracting angle, the prism must be made of a material whose refractive index
(a) lies between $\sqrt{2}$ and 1
(b) lies between 2 and $\sqrt{2}$
(c) is less than 1
(d) is greater than 2 *(Mains 2012)*

41. A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is
(a) 10 cm (b) 15 cm
(c) 2.5 cm (d) 5 cm
(Mains 2012)

42. Which of the following is not due to total internal reflection?
(a) Working of optical fibre
(b) Difference between apparent and real depth of a pond
(c) Mirage on hot summer days
(d) Brilliance of diamond *(2011)*

43. A biconvex lens has a radius of curvature of magnitude 20 cm. Which one of the following options describe best the image formed of an object of height 2 cm placed 30 cm from the lens?
(a) Virtual, upright, height = 1 cm
(b) Virtual, upright, height = 0.5 cm
(c) Real, inverted, height = 4 cm
(d) Real, inverted, height = 1 cm *(2011)*

44. A thin prism of angle 15° made of glass of refractive index $\mu_1 = 1.5$ is combined with another prism of glass of refractive index $\mu_2 = 1.75$. The combination of the prisms produces dispersion without deviation. The angle of the second prism should be
(a) 5° (b) 7°
(c) 10° (d) 12°
(Mains 2011)

45. A converging beam of rays is incident on a diverging lens. Having passed through the lens the rays intersect at a point 15 cm from the lens on the opposite side. If the lens is removed the point where the rays meet will move 5 cm closer to the lens. The focal length of the lens is
(a) 5 cm (b) –10 cm
(c) 20 cm (d) –30 cm
(Mains 2011)

46. A ray of light travelling in a transparent medium of refractive index μ, falls on a surface separating the medium from air at an angle of incidence of 45°. For which of the following value of μ the ray can undergo total internal reflection?
(a) $\mu = 1.33$ (b) $\mu = 1.40$
(c) $\mu = 1.50$ (d) $\mu = 1.25$
(2010)

47. A lens having focal length f and aperture of diameter d forms an image of intensity I. Aperture of diameter $\frac{d}{2}$ in central region of lens is covered by a black paper. Focal length of lens and intensity of image now will be respectively
(a) f and $\frac{I}{4}$ (b) $\frac{3f}{4}$ and $\frac{I}{2}$
(c) f and $\frac{3I}{4}$ (d) $\frac{f}{2}$ and $\frac{I}{2}$
(2010)

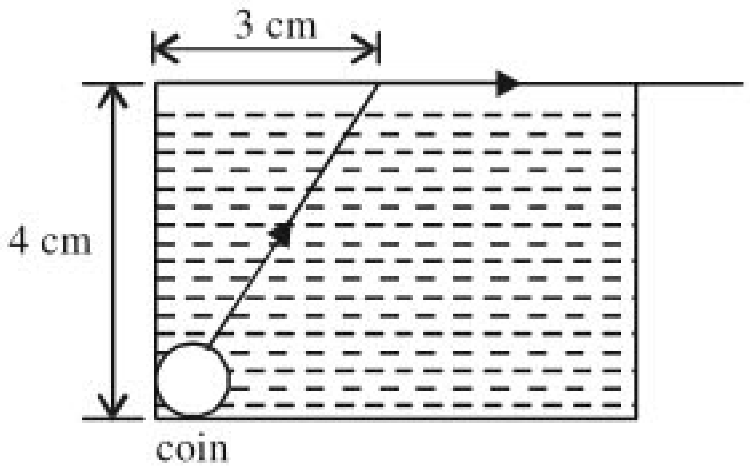
48. The speed of light in media M_1 and M_2 are 1.5×10^8 m/s and 2.0×10^8 m/s respectively. A ray of light enters from medium M_1 to M_2 at an incidence angle i. If the ray suffers total internal reflection, the value of i is
(a) Equal to $\sin^{-1}\left(\frac{2}{3}\right)$
(b) Equal to or less than $\sin^{-1}\left(\frac{3}{5}\right)$
(c) Equal to or greater than $\sin^{-1}\left(\frac{3}{4}\right)$
(d) Less than $\sin^{-1}\left(\frac{2}{3}\right)$ *(Mains 2010)*

49. A ray of light is incident on a 60° prism at the minimum deviation position. The angle of refraction at the first face (*i.e.*, incident face) of the prism is
(a) zero (b) 30°
(c) 45° (d) 60°
(Mains 2010)

50. Two thin lenses of focal lengths f_1 and f_2 are in contact and coaxial. The power of the combination is
(a) $\frac{f_1 + f_2}{2}$ (b) $\frac{f_1 + f_2}{f_1 f_2}$
(c) $\sqrt{\frac{f_1}{f_2}}$ (d) $\sqrt{\frac{f_2}{f_1}}$ *(2008)*

51. A boy is trying to start a fire by focusing sunlight on a piece of paper using an equiconvex lens of focal length 10 cm. The diameter of the sun is 1.39×10^9 m and its mean distance from the earth is 1.5×10^{11} m. What is the diameter of the sun's image on the paper?
(a) 6.5×10^{-5} m (b) 12.4×10^{-4} m
(c) 9.2×10^{-4} m (d) 6.5×10^{-4} m
(2008)

52. A small coin is resting on the bottom of a beaker filled with liquid. A ray of light from the coin travels upto the surface of the liquid and moves along its surface. How fast is the light travelling in the liquid?



(a) 2.4×10^8 m/s (b) 3.0×10^8 m/s
(c) 1.2×10^8 m/s (d) 1.8×10^8 m/s. *(2007)*

53. The frequency of a light wave in a material is 2×10^{14} Hz and wavelength is 5000 Å. The refractive index of material will be
(a) 1.50 (b) 3.00
(c) 1.33 (d) 1.40 *(2007)*

54. A microscope is focussed on a mark on a piece of paper and then a slab of glass of thickness 3 cm and refractive index 1.5 is placed over the mark. How should the microscope be moved to get the mark in focus again?
(a) 2 cm upward (b) 1 cm upward
(c) 4.5 cm downward
(d) 1 cm downward. *(2006)*

55. A convex lens and a concave lens, each having same focal length of 25 cm, are put in contact to form a combination of lenses. The power in diopters of the combination is
(a) zero (b) 25
(c) 50 (d) infinite. *(2006)*

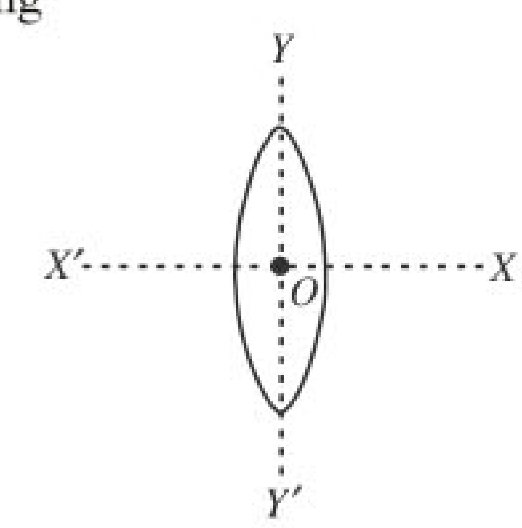
56. The angular resolution of a 10 cm diameter telescope at a wavelength of 5000 Å is of the order of
(a) 10^6 rad (b) 10^{-2} rad
(c) 10^{-4} rad (d) 10^{-6} rad. *(2005)*

57. A telescope has an objective lens of 10 cm diameter and is situated at a distance of one kilometre from two objects. The minimum distance between these two objects, which can be resolved by the telescope, when the mean wavelength of light is 5000 Å, is of the order of
(a) 0.5 m (b) 5 m
(c) 5 mm (d) 5 cm *(2004)*

58. The refractive index of the material of a prism is $\sqrt{2}$ and its refracting angle is 30°. One of the refracting surfaces of the prism is made a mirror inwards. A beam of monochromatic light entering the prism from the other face will retrace its path after reflection from the mirrored surface if its angle of incidence on the prism is
(a) 45° (b) 60°
(c) 0 (d) 30° *(2004)*

59. A beam of light composed of red and green ray is incident obliquely at a point on the face of rectangular glass slab. When coming out on the opposite parallel face, the red and green ray emerge from
(a) Two points propagating in two different non parallel directions
(b) Two points propagating in two different parallel directions.
(c) One point propagating in two different directions.
(d) One point propagating in the same directions. *(2004)*

60. An equiconvex lens is cut into two halves along (i) XOX' and (ii) YOY' as shown in the figure. Let f, f', f'' be the focal lengths of the complete lens, of each half in case (i), and of each half in case (ii), respectively.
Choose the correct statement from the following



(a) $f' = f, f'' = 2f$ (b) $f' = 2f, f'' = f$
(c) $f' = f, f'' = f$ (d) $f' = 2f, f'' = 2f$ *(2003)*

61. A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will
(a) become zero (b) become infinite
(c) become small, but non-zero
(d) remain unchanged *(2003)*

62. A bulb is located on a wall. Its image is to be obtained on a parallel wall with the help of convex lens. The lens is placed at a distance d ahead of second wall, then required focal length will be
(a) only $\frac{d}{4}$ (b) only $\frac{d}{2}$

(c) more than $\frac{d}{4}$ but less than $\frac{d}{2}$

(d) less than $\frac{d}{4}$. *(2002)*

63. Diameter of human eye lens is 2 mm. What will be the minimum distance between two points to resolve them, which are situated at a distance of 50 meter from eye. The wavelength of light is 5000 Å

(a) 2.32 m (b) 4.28 mm
(c) 1.25 cm (d) 12.48 cm. *(2002)*

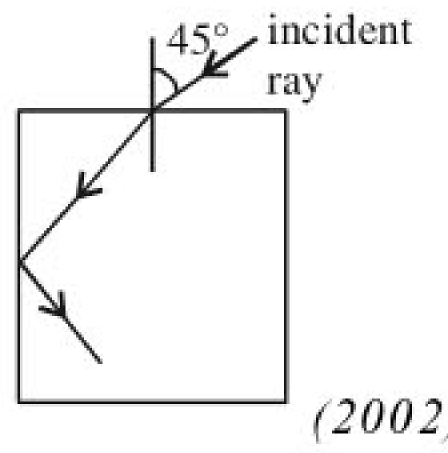
64. For the given incident ray as shown in figure, the condition of total internal refraction of this ray the required refractive index of prism will be

(a) $\frac{\sqrt{3}+1}{2}$

(b) $\frac{\sqrt{2}+1}{2}$

(c) $\sqrt{\frac{3}{2}}$

(d) $\sqrt{\frac{7}{6}}$.



(2002)

65. Optical fibre are based on

(a) total internal reflection
(b) less scattering (c) refraction
(d) less absorption coefficient. *(2001)*

66. A ray of light travelling in air have wavelength λ, frequency n, velocity v and intensity I. If this ray enters into water then these parameters are λ', n', v' and I' respectively. Which relation is correct from following?

(a) $\lambda = \lambda'$ (b) $n = n'$
(c) $v = v'$ (d) $I = I'$. *(2001)*

67. A disc is placed on a surface of pond which has refractive index 5/3. A source of light is placed 4 m below the surface of liquid. The minimum radius of disc needed so that light is not coming out is,

(a) ∞ (b) 3 m
(c) 6 m (d) 4 m. *(2001)*

68. A bubble in glass slab (μ = 1.5) when viewed from one side appears at 5 cm and 2 cm from other side, then thickness of slab is

(a) 3.75 cm (b) 3 cm
(c) 10.5 cm (d) 2.5 cm. *(2000)*

69. A tall man of height 6 feet, want to see his full image. Then required minimum length of the mirror will be

(a) 12 feet (b) 3 feet
(c) 6 feet (d) any length. *(2000)*

70. For a plano convex lens (μ = 1.5) has radius of curvature 10 cm. It is silvered on its plane surface. Find focal length after silvering

(a) 10 cm (b) 20 cm
(c) 15 cm (d) 25 cm. *(2000)*

71. Rainbow is formed due to

(a) scattering and refraction
(b) internal reflection and dispersion
(c) reflection only
(d) diffraction and dispersion. *(2000)*

72. A plano convex lens is made of refractive index 1.6. The radius of curvature of the curved surface is 60 cm. The focal length of the lens is

(a) 200 cm (b) 100 cm
(c) 50 cm (d) 400 cm *(1999)*

73. Colours appear on a thin soap film and on soap bubbles due to the phenomenon of

(a) interference (b) dispersion
(c) refraction (d) diffraction *(1999)*

74. If the refractive index of a material of equilateral prism is $\sqrt{3}$, then angle of minimum deviation of the prism is

(a) 60° (b) 45°
(c) 30° (d) 75° *(1999)*

75. A luminous object is placed at a distance of 30 cm from the convex lens of focal length 20 cm. On the other side of the lens, at what distance from the lens a convex mirror of radius of curvature 10 cm be placed in order to have an upright image of the object coincident with it?

(a) 50 cm (b) 30 cm
(c) 12 cm (d) 60 cm *(1998)*

76. Light enters at an angle of incidence in a transparent rod of refractive index n. For what value of the refractive index of the material of the rod the light once entered into it will not leave it through its lateral face whatsoever be the value of angle of incidence?

(a) $n = 1.1$ (b) $n = 1$
(c) $n > \sqrt{2}$ (d) $n = 1.3$ *(1998)*

77. An astronomical telescope of tenfold angular magnification has a length of 44 cm. The focal length of the objective is

(a) 44 cm (b) 440 cm
(c) 4 cm (d) 40 cm. *(1997)*

78. The focal length of converging lens is measured for violet, green and red colours. It is respectively f_v, f_g, f_r. We will get

(a) $f_v < f_r$ (b) $f_g > f_r$
(c) $f_v = f_g$ (d) $f_g > f_r$. *(1997)*

79. An electromagnetic radiation of frequency n, wavelength λ, travelling with velocity v in air, enters a glass slab of refractive index μ. The frequency, wavelength and velocity of light in the glass slab will be respectively

(a) n, 2λ and $\frac{v}{\mu}$ (b) $\frac{2n}{\mu}$, $\frac{\lambda}{\mu}$ and v

(c) $\frac{n}{\mu}$, $\frac{\lambda}{\mu}$ and $\frac{v}{\mu}$ (d) n, $\frac{\lambda}{\mu}$ and $\frac{v}{\mu}$. *(1997)*

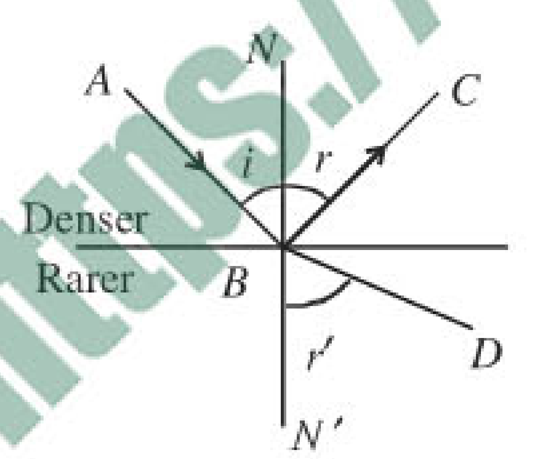
80. If a convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined together, what will be their resulting power?

(a) + 7.5 D (b) – 0.75 D
(c) + 6.5 D (d) – 6.5 D. *(1996)*

81. The refractive index of water is 1.33. What will be the speed of light in water?

(a) 4×10^8 m/s (b) 1.33×10^8 m/s
(c) 3×10^8 m/s (d) 2.25×10^8 m/s. *(1996)*

82. A ray of light from a denser medium strikes a rare medium as shown in figure. The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are r and r'. The critical angle would be



(a) $\sin^{-1}(\tan r)$ (b) $\sin^{-1}(\sin r)$
(c) $\cos^{-1}(\tan r)$ (d) $\tan^{-1}(\sin r)$ *(1996)*

83. If f_V and f_R are the focal lengths of a convex lens for violet and red light respectively and F_V and F_R are the focal lengths of a concave lens for violet and red light respectively, then we must have

(a) $f_V > f_R$ and $F_V > F_R$
(b) $f_V < f_R$ and $F_V > F_R$
(c) $f_V > f_R$ and $F_V < F_R$
(d) $f_V < f_R$ and $F_V < F_R$. *(1996)*

84. Light travels through a glass plate of thickness t and having a refractive index μ. If c is the velocity of light in vacuum, the time taken by light to travel this thickness of glass is

(a) $\frac{t}{\mu c}$ (b) $\frac{\mu t}{c}$

(c) $t\mu c$ (d) $\frac{tc}{\mu}$. *(1996)*

85. A lens is placed between a source of light and a wall. It forms images of area A_1 and A_2 on the wall, for its two different positions. The area of the source of light is

(a) $\frac{A_1 - A_2}{2}$ (b) $\frac{1}{A_1} + \frac{1}{A_2}$

(c) $\sqrt{A_1 A_2}$ (d) $\frac{A_1 + A_2}{2}$. *(1995)*

86. Exposure time of camera lens at $f/2.8$ setting is 1/200 second. The correct time of exposure at $f/5.6$ is

(a) 0.20 second (b) 0.40 second
(c) 0.02 second (d) 0.04 second. *(1995)*

87. In a Fresnel biprism experiment, the two positions of lens give separation between the slits as 16 cm and 9 cm respectively. What is the actual distance of separation?

(a) 13 cm (b) 14 cm
(c) 12.5 cm (d) 12 cm. *(1995)*

88. Four lenses of focal length ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be

(a) + 15 cm (b) + 150 cm
(c) – 150 cm (d) – 15 cm. *(1994)*

89. The blue colour of the sky is due to the phenomenon of

(a) scattering (b) dispersion
(c) reflection (d) refraction. *(1994)*

90. Ray optics is valid, when characteristic dimensions are
(a) much smaller than the wavelength of light
(b) of the same order as the wavelength of light
(c) of the order of one millimetre
(d) much larger than the wavelength of light. *(1994, 1989)*

91. A small source of light is 4 m below the surface of water of refractive index 5/3. In order to cut off all the light, coming out of water surface, minimum diameter of the disc placed on the surface of water is
(a) 6 m (b) ∞
(c) 3 m (d) 4 m. *(1994)*

92. A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 mm. The light is focussed by a convex lens on a screen placed in focal plane. The first minimum will be formed for the angle of diffraction equal to
(a) 0° (b) 15°
(c) 30° (d) 50° *(1993)*

93. Interference was observed in interference chamber where air was present, now the chamber is evacuated, and if the same light is used, a careful observer will see
(a) no interference
(b) interference with brighter bands
(c) interference with dark bands
(d) interference with larger width *(1993)*

94. Time taken by sunlight to pass through a window of thickness 4 mm whose refractive index is $\frac{3}{2}$ is
(a) 2×10^{-4} s (b) 2×10^{8} s
(c) 2×10^{-11} s (d) 2×10^{11} s *(1993)*

95. There is a prism with refractive index equal to $\sqrt{2}$ and the refractive angle equal to 30°. One of the refractive surface of the prism is polished. A beam of monochromatic light will be retrace its path if its angle of indence over the refracting surface of the prism is
(a) 0° (b) 30°
(c) 45° (d) 60° *(1992)*

96. If yellow light emitted by sodium lamp in Young's double slit expt is replaced by monochromatic blue of light of the same intensity
(a) fringe width will decrease
(b) fringe width will increase
(c) fringe width will remain unchanged
(d) fringes will becomes less intense *(1992)*

97. In Young's double slit experiment carried out with light of wavelength (λ) = 5000 Å, the distance between the slits is 0.2 mm and the screen is at 200 cm from the slits. The central maximum is at $x = 0$. The third maximum (taking the central maximum as zeroth maximum) will be at x equal to
(a) 1.67 cm (b) 1.5 cm
(c) 0.5 cm (d) 5.0 cm *(1992)*

98. A beam of monochromatic light is refracted from vacuum into a medium of refractive index 1.5. The wavelength of refracted light will be
(a) depend on intensity of refracted light
(b) same
(c) smaller
(d) larger *(1992, 1991)*

99. Green light wavelength 5460 Å is incident on an air-glass interface. If the refractive index of glass is 1.5, the wavelength of light in glass would be ($c = 3 \times 10^8$ ms^{-1})
(a) 3640 Å (b) 5460 Å
(c) 4861 Å (d) none of these *(1991)*

100. Ratio of intensities of two waves are given by 4 : 1. Then ratio of the amplitudes of the two waves is
(a) 2 : 1 (b) 1 : 2
(c) 4 : 1 (d) 1 : 4 *(1991)*

101. In Young's experiment, two coherent sources are placed 0.90 mm apart and fringe are observed one metre away. If it produces second dark fringe at a distance of 1 mm from central fringe, the wavelength of monochromatic light is used would be
(a) 60×10^{-4} cm (b) 10×10^{-4} cm
(c) 10×10^{-5} cm (d) 6×10^{-5} cm *(1991)*

102. In Young's double slit experiment, the fringe width is found to be 0.4 mm. If the whole apparatus is immersed in water of refractive index $\frac{4}{3}$, without disturbing the geometrical arrangement, the new fringe width will be

(a) 0.30 mm (b) 0.40 mm
(c) 0.53 mm (d) 450 microns *(1990)*

103. The Young's double slit experiment is performed with blue and with green light of wavelengths 4360 Å and 5460 Å respectively. If x is the distance of 4^{th} maxima from the central one, then

(a) x(blue) = x(green)
(b) x(blue) > x(green)
(c) x(blue) < x(green)
(d) $\dfrac{x(\text{blue})}{x(\text{green})} = \dfrac{5460}{4360}$ *(1990)*

104. Interference is possible in
(a) light waves only
(b) sound waves only
(c) both light and sound waves
(d) neither light nor sound waves *(1989)*

105. Which of the phenomenon is not common to sound and light waves ?
(a) Interference (b) Diffraction
(c) Coherence (d) Polarisation *(1988)*

106. Which one of the following phenomena is not explained by Huygen's construction of wavefront ?
(a) Refraction (b) Reflection
(c) Diffraction (d) Origin of spectra *(1988)*

107. Focal length of a convex lens of refractive index 1.5 is 2 cm. Focal length of lens when immersed in a liquid of refractive index of 1.25 will be
(a) 10 cm (b) 2.5 cm
(c) 5 cm (d) 7.5 cm *(1988)*

Answer Key

1. (b)	**2.** (c)	**3.** (d)	**4.** (a)	**5.** (b)	**6.** (d)	**7.** (c)	**8.** (b)	**9.** (b)	**10.** (d)
11. (c)	**12.** (b)	**13.** (b)	**14.** (b)	**15.** (d)	**16.** (b)	**17.** (a)	**18.** (b)	**19.** (c)	**20.** (c)
21. (a)	**22.** (d)	**23.** (c)	**24.** (d)	**25.** (c)	**26.** (d)	**27.** (b)	**28.** (a)	**29.** (d)	**30.** (a)
31. (a)	**32.** (b)	**33.** (c)	**34.** (a)	**35.** (d)	**36.** (a)	**37.** (a)	**38.** (c)	**39.** (c)	**40.** (b)
41. (d)	**42.** (b)	**43.** (c)	**44.** (c)	**45.** (d)	**46.** (c)	**47.** (c)	**48.** (c)	**49.** (b)	**50.** (b)
51. (c)	**52.** (d)	**53.** (b)	**54.** (b)	**55.** (a)	**56.** (c)	**57.** (c)	**58.** (a)	**59.** (b)	**60.** (a)
61. (b)	**62.** (b)	**63.** (c)	**64.** (c)	**65.** (a)	**66.** (b)	**67.** (b)	**68.** (c)	**69.** (b)	**70.** (a)
71. (b)	**72.** (b)	**73.** (a)	**74.** (a)	**75.** (a)	**76.** (c)	**77.** (d)	**78.** (a)	**79.** (d)	**80.** (b)
81. (d)	**82.** (a)	**83.** (b)	**84.** (b)	**85.** (c)	**86.** (c)	**87.** (d)	**88.** (a)	**89.** (a)	**90.** (d)
91. (a)	**92.** (c)	**93.** (d)	**94.** (c)	**95.** (c)	**96.** (a)	**97.** (b)	**98.** (c)	**99.** (a)	**100.** (a)
101. (d)	**102.** (a)	**103.** (c)	**104.** (c)	**105.** (d)	**106.** (d)	**107.** (c)			

EXPLANATIONS

1. (b) : The resolving power of an optical microscope,

$$RP = \frac{2\mu \sin\theta}{\lambda}$$

For wavelength $\lambda_1 = 4000$ Å, resolving power will be

$$RP_1 = \frac{2\mu \sin\theta}{4000} \quad \text{...(i)}$$

For wavelength $\lambda_2 = 6000$ Å, resolving power will be

$$RP_2 = \frac{2\mu \sin\theta}{6000} \quad \text{...(ii)}$$

On dividing eqn. (i) by eqn. (ii)

$$= \frac{RP_1}{RP_2} = \frac{6000}{4000} = \frac{3}{2}$$

2. (c) : Position of 8th bright fringe in medium,

$$x = \frac{8\lambda_m D}{d}$$

Position of 5th dark fringe in air,

$$x' = \frac{\left(5 - \frac{1}{2}\right)\lambda_{air} D}{d}$$

$$x' = \frac{4.5\,\lambda_{air} D}{d}$$

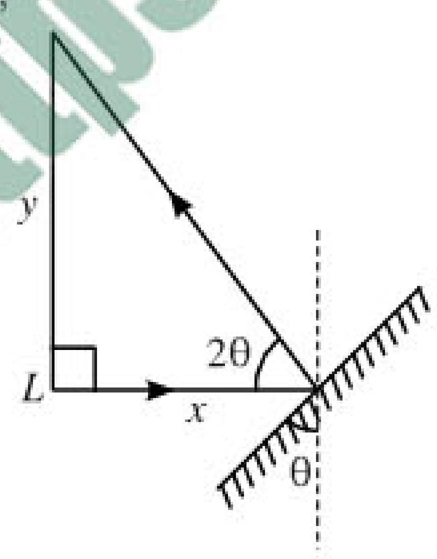
Given $x = x'$

$$\therefore \frac{8\lambda_m D}{d} = \frac{4.5\lambda_{air} D}{d}$$

$$\mu_m = \frac{\lambda_{air}}{\lambda_m} = \frac{8}{4.5} = 1.78$$

3. (d) : When mirror is rotated by θ angle reflected ray will be rotated by 2θ.

For small angle θ,



$$\tan 2\theta \approx 2\theta = \frac{y}{x}$$

$$\therefore \theta = \frac{y}{2x}$$

4. (a) : The condition for dispersion without deviation is given as $(\mu - 1)A = (\mu' - 1)A'$

Given $\mu = 1.42$, $A = 10°$, $\mu' = 1.7$, $A' = ?$

$\therefore \quad (1.42 - 1) \times 10 = (1.7 - 1)A'$

$(0.42) \times 10 = 0.7 \times A'$

or $\quad A' = \dfrac{0.42 \times 10}{0.7} = 6°$

5. (b) : The intensity of transmitted light through P_1,

$$I_1 = \frac{I_0}{2}$$

The intensity of transmitted light through P_3,

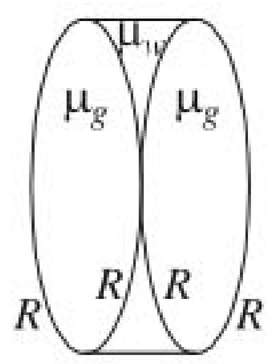
$$I_2 = I_1 \cos^2 45° = \frac{I_o}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_o}{2} \cdot \frac{1}{2} = \frac{I_o}{4}$$

Angle between polaroids P_3 and $P_2 = (90° - 45°) = 45°$

$\therefore$ Intensity of transmitted light through P_2,

$$I_3 = I_2 \cos^2 45° = \frac{I_o}{4}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_o}{8}$$

6. (d) : Here, $\mu_g = \frac{3}{2}$, $\mu_w = \frac{4}{3}$



Focal length (f) of glass convex lens is given by

$$\frac{1}{f} = (\mu_g - 1)\left(\frac{2}{R}\right)$$

or $\quad \dfrac{1}{f} = \left(\dfrac{3}{2} - 1\right)\dfrac{2}{R} = \dfrac{1}{R}$ or $f = R \quad$ ...(i)

Focal length (f') of water filled concave lens is given by

$$\frac{1}{f'} = (\mu_w - 1)\left(-\frac{2}{R}\right) \text{ or } \frac{1}{f'} = \left(\frac{4}{3} - 1\right)\left(-\frac{2}{R}\right)$$

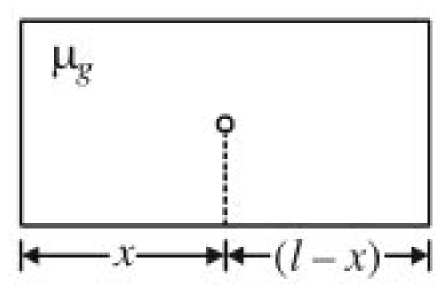
$$= -\frac{2}{3R} = -\frac{2}{3f} \qquad \text{[Using eqn. (i)]}$$

Equivalent focal length (f_{eq}) of lens system

$$\frac{1}{f_{eq}} = \frac{1}{f} - \frac{2}{3f} + \frac{1}{f} = \frac{3 - 2 + 3}{3f} = \frac{4}{3f}$$

$$\therefore f_{eq} = \frac{3f}{4}$$

7. (c): Here $\mu = 1.5$



l = length of the slab

x = position of air bubble from one side

As per question, total apparent length of slab = 5 + 3

or $\frac{x}{\mu}+\frac{(l-x)}{\mu}=8$ or $\frac{l}{\mu}=8$ $\therefore$ $l=8\mu=8\times 15=12$ cm

8. (b) : Here, $\frac{I_1}{I_2}=n$

$$\frac{I_{max}}{I_{min}}=\left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2=\left(\frac{\sqrt{I_1/I_2}+1}{\sqrt{I_1/I_2}-1}\right)^2=\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2$$

$$\frac{I_{max}-I_{min}}{I_{max}+I_{min}}=\frac{\frac{I_{max}}{I_{min}}-1}{\frac{I_{max}}{I_{min}}+1}$$

$$=\frac{\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2-1}{\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2+1}=\frac{(\sqrt{n}+1)^2-(\sqrt{n}-1)^2}{(\sqrt{n}+1)^2+(\sqrt{n}-1)^2}$$

$$=\frac{4\sqrt{n}}{2(n+1)}=\frac{2\sqrt{n}}{n+1}$$

9. (b) : Here, u = 400 cm = 4 m, $v=\infty$, f = ?

Using lens formula, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

or $\frac{1}{\infty}-\frac{1}{4}=\frac{1}{f}$ or $f=-4$ m

Lens should be concave.

Power of lens $=\frac{1}{f}=\frac{1}{-4}=-0.25$ D

10. (d) : Here, a = 0.02 cm = 2×10^{-4} m

$\lambda = 5\times 10^{-5}$ cm = 5×10^{-7} m

D = 60 cm = 0.6 m

Position of first minima on the diffraction pattern,

$$y_1=\frac{D\lambda}{a}=\frac{0.6\times 5\times 10^{-7}}{2\times 10^{-4}}=15\times 10^{-4}\text{ m}=0.15\text{ cm}$$

11. (c) : Magnification in the mirror, $m=-\frac{v}{u}$

$m=-2\Rightarrow v=2u$

As v and u have same signs so the mirror is concave and image formed is real.

$m=-\frac{1}{2}\Rightarrow v=\frac{u}{2}\Rightarrow$ Concave mirror and real image.

$m=+2\Rightarrow v=-2u$

As v and u have different signs but magnification is 2 so the mirror is concave and image formed is virtual.

$m=+\frac{1}{2}\Rightarrow v=-\frac{u}{2}$

As v and u have different signs with magnification $\left(\frac{1}{2}\right)$ so the mirror is convex and image formed is virtual.

12. (b) : For first minimum,

the path difference between extreme waves,

$a\sin\theta=\lambda$

Here $\theta=30°$ $\Rightarrow$ $\sin\theta=\frac{1}{2}$

$\therefore$ $a=2\lambda$ ...(i)

For first secondary maximum, the path difference between extreme waves

$a\sin\theta'=\frac{3}{2}\lambda$ or $(2\lambda)\sin\theta'=\frac{3}{2}\lambda$ [Using eqn (i)]

or $\sin\theta'=\frac{3}{4}$ $\therefore$ $\theta'=\sin^{-1}\left(\frac{3}{4}\right)$

13. (b) : Here, $d=5\lambda$, $D=10d$, $y=\frac{d}{2}$.

Resultant Intensity at $y=\frac{d}{2}$, I_y = ?

The path difference between two waves at $y=\frac{d}{2}$

$$\Delta x=d\tan\theta=d\times\frac{y}{D}=\frac{d\times\frac{d}{2}}{10d}=\frac{d}{20}=\frac{5\lambda}{20}=\frac{\lambda}{4}$$

Corresponding phase difference, $\phi=\frac{2\pi}{\lambda}\Delta x=\frac{\pi}{2}$.

Now, maximum intensity in Young's double slit experiment,

$I_{max}=I_1+I_2+2I_1I_2$

$I_0=4I$ $(\because\ I_1=I_1=I)$

$\therefore$ $I=\frac{I_0}{4}$.

Required intensity,

$$I_y=I_1+I_2+2I_1I_2\cos\frac{\pi}{2}=2I=\frac{I_0}{2}$$

14. (b) : Here f_o = 40 cm, f_e = 4 cm

Tube length(l) = Distance between lenses = v_o+f_e

For objective lens,

u_o = –200 cm, v_o = ?

$$\frac{1}{v_o}-\frac{1}{u_o}=\frac{1}{f_o}\text{ or }\frac{1}{v_o}-\frac{1}{-200}=\frac{1}{40}$$

or $\frac{1}{v_o}=\frac{1}{40}-\frac{1}{200}=\frac{4}{200}$ $\therefore$ $v_0=50$ cm

$\therefore$ $l=50+4=54$ cm

15. (d) : Given, $i = 45°, A = 60°$

Since the ray undergoes minimum deviation, therefore, angle of emergence from second face, $e = i = 45°$

$\therefore \quad \delta_m = i + e - A = 45° + 45° - 60° = 30°$

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60°+30°}{2}\right)}{\sin\left(\frac{60°}{2}\right)}$$

$$= \frac{\sin 45°}{\sin 30°} = \frac{1}{\sqrt{2}} \times \frac{2}{1} = \sqrt{2}$$

16. (b) : As beam of light is incident normally on the face AB of the right angled prism ABC, so no refraction occurs at face AB and it passes straight and strikes the face AC at an angle of incidence , $i = 45°$.

For total reflection to take place at face AC,

$i > i_c$ or $\sin i > \sin i_c$

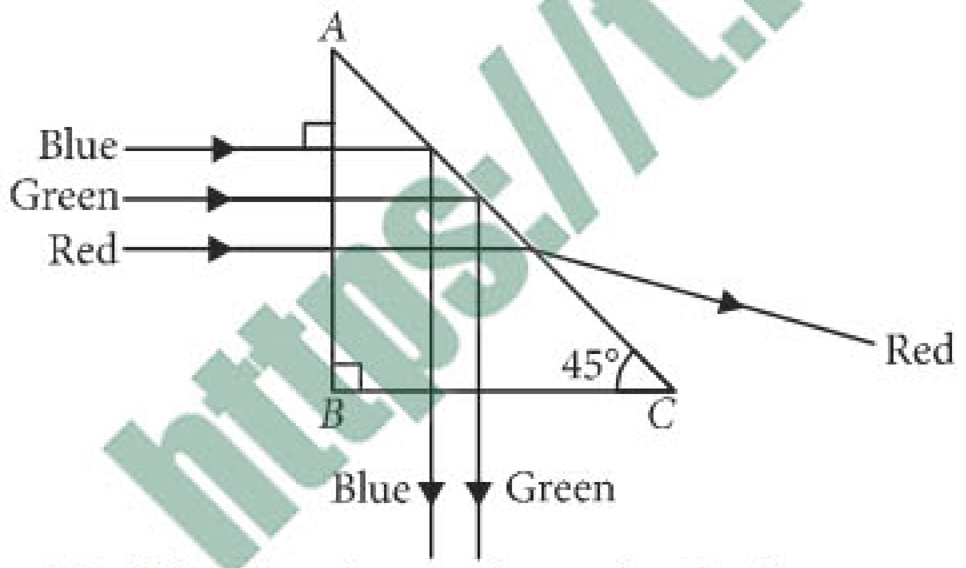
where i_c is the critical angle.

But as here $i = 45°$ and $\sin i_c = \frac{1}{\mu}$

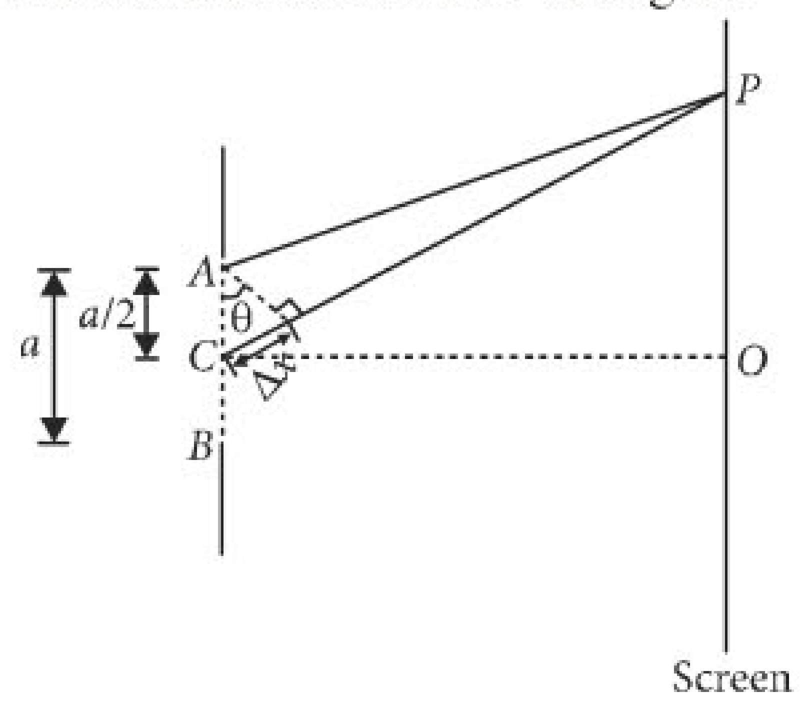
$\therefore \quad \sin 45° > \frac{1}{\mu}$ or $\frac{1}{\sqrt{2}} > \frac{1}{\mu}$ or $\mu > \sqrt{2} = 1.414$

As $\mu_{red} (= 1.39) < \mu (= 1.414)$ while $\mu_{green} (= 1.44)$ and $\mu_{blue} (= 1.47) > \mu\ (= 1.414)$, so only red colour will be transmitted through face AC while green and blue colours will suffer total internal reflection.

So the prism will separate red colour from the green and blue colours as shown in the following figure.



17. (a) : The situation is shown in the figure.



In figure A and B represent the edges of the slit AB of width a and C represents the midpoint of the slit.

For the first minimum at P,

$a \sin\theta = \lambda$ ...(i)

where λ is the wavelength of light.

The path difference between the wavelets from A to C is

$$\Delta x = \frac{a}{2}\sin\theta = \frac{1}{2}(a\sin\theta) = \frac{\lambda}{2} \quad \text{(using (i))}$$

The corresponding phase difference $\Delta\phi$ is

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta x = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} = \pi$$

18. (b)

19. (c) : As, intensity $I \propto$ width of slit W

Also, intensity $I \propto$ square of amplitude A

$$\therefore \quad \frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{A_1^2}{A_2^2}$$

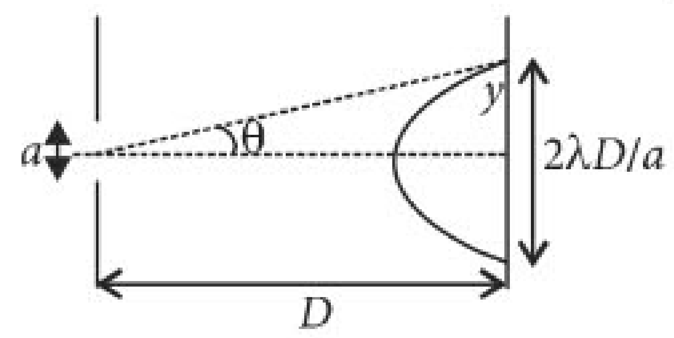
But $\frac{W_1}{W_2} = \frac{1}{25}$ (given)

$$\therefore \quad \frac{A_1^2}{A_2^2} = \frac{1}{25} \quad \text{or} \quad \frac{A_1}{A_2} = \sqrt{\frac{1}{25}} = \frac{1}{5}$$

$$\therefore \quad \frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{\left(\frac{A_1}{A_2} + 1\right)^2}{\left(\frac{A_1}{A_2} - 1\right)^2}$$

$$= \frac{\left(\frac{1}{5} + 1\right)^2}{\left(\frac{1}{5} - 1\right)^2} = \frac{\left(\frac{6}{5}\right)^2}{\left(-\frac{4}{5}\right)^2} = \frac{36}{16} = \frac{9}{4}$$

20. (c) : Given situation is shown in the figure.



For central maxima, $\sin\theta = \frac{\lambda}{a}$

Also, θ is very-very small so

$$\sin\theta \approx \tan\theta = \frac{y}{D}$$

$$\therefore \quad \frac{y}{D} = \frac{\lambda}{a}, \qquad y = \frac{\lambda D}{a}$$

Width of central maxima $= 2y = \frac{2\lambda D}{a}$.

21. (a)

22. (d): As $\mu = \dfrac{\sin\left(\dfrac{A+\delta}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$

$$\cot\frac{A}{2} = \frac{\sin\left(\dfrac{A+\delta}{2}\right)}{\sin\left(\dfrac{A}{2}\right)} \qquad \left[\because \ \mu = \cot\frac{A}{2}\right]$$

$$\frac{\cos\left(\dfrac{A}{2}\right)}{\sin\left(\dfrac{A}{2}\right)} = \frac{\sin\left(\dfrac{A+\delta}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$$

$$\sin\left(\frac{\pi}{2}-\frac{A}{2}\right) = \sin\left(\frac{A}{2}+\frac{\delta}{2}\right); \frac{\pi}{2}-\frac{A}{2} = \frac{A}{2}+\frac{\delta}{2}$$

$\therefore \quad \delta = \pi - 2A = 180° - 2A$

23. (c) : For double slit experiment,

$d = 1$ mm $= 1 \times 10^{-3}$ m, $D = 1$ m, $\lambda = 500 \times 10^{-9}$ m

Fringe width $\beta = \dfrac{D\lambda}{d}$

Width of central maxima in a single slit

As per question, width of central maxima of single slit pattern = width of 10 maxima of double slit pattern

$$\frac{2\lambda D}{a} = 10\left(\frac{\lambda D}{d}\right)$$

$$a = \frac{2d}{10} = \frac{2\times10^{-3}}{10} = 0.2\times10^{-3}\text{ m} = 0.2\text{ mm}$$

24. (d) : Here, $\lambda = 600$ nm $= 600 \times 10^{-9}$ m

$a = 1$ mm $= 10^{-3}$ m, $D = 2$ m

Distance between the first dark fringes on either side of the central bright fringe is also the width of central maximum.

Width of central maximum $= \dfrac{2\lambda D}{a}$

$$= \frac{2\times600\times10^{-9}\text{ m}\times2\text{ m}}{10^{-3}\text{ m}}$$

$= 24 \times 10^{-4}$ m $= 2.4 \times 10^{-3}$ m $= 2.4$ mm

25. (c) : Intensity at any point on the screen is

$$I = 4I_0\cos^2\frac{\phi}{2}$$

where I_0 is the intensity of either wave and ϕ is the phase difference between two waves.

Phase difference, $\phi = \dfrac{2\pi}{\lambda} \times$ Path difference

When path difference is λ, then

$$\phi = \frac{2\pi}{\lambda}\times\lambda = 2\pi$$

$$\therefore \quad I = 4I_0\cos^2\left(\frac{2\pi}{2}\right) = 4I_0\cos^2(\pi) = 4I_0 = K \ \text{...(i)}$$

When path difference is $\dfrac{\lambda}{4}$, then

$$\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{4} = \frac{\pi}{2}$$

$$\therefore \quad I = 4I_0\cos^2\left(\frac{\pi}{4}\right) = 2I_0 = \frac{K}{2} \qquad \text{[Using (i)]}$$

26. (d) : Magnifying power of a microscope,

$$m = \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$$

where f_o and f_e are the focal lengths of the objective and eyepiece respectively and L is the distance between their focal points and D is the least distance of distinct vision.

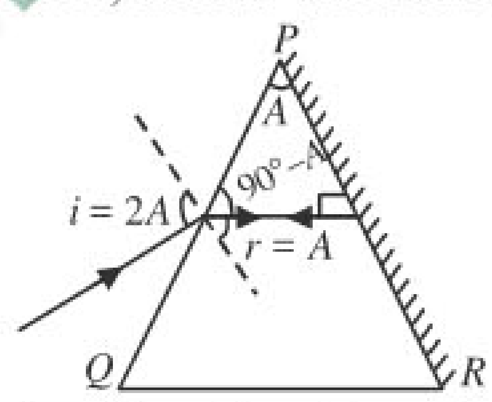
If f_o increases, then m will decrease.

Magnifying power of a telescope, $m = \dfrac{f_o}{f_e}$

where f_o and f_e are the focal lengths of the objective and eyepiece respectively.

If f_o increases, then m will increase.

27. (b) :



On reflection from the silvered surface, the incident ray will retrace its path, if it falls normally on the surface.

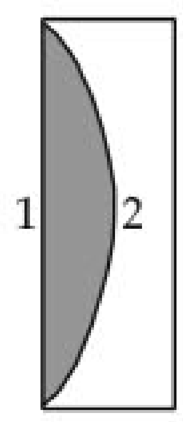
By geometry, $r = A$

Applying Snell's law at surface PQ,

$1\sin i = \mu\sin r$

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin A} = 2\cos A$$

28. (a) : The combination of two lenses 1 and 2 is as shown in figure.



$$\therefore \quad \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

According to lens maker's formula

$$\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right) = \frac{(\mu_1 - 1)}{R}$$

$$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right)$$

$$= (\mu_2 - 1)\left(-\frac{1}{R}\right) = -\frac{(\mu_2 - 1)}{R}$$

$\therefore \dfrac{1}{f} = \dfrac{(\mu_1 - 1)}{R} - \dfrac{(\mu_2 - 1)}{R}$

$\dfrac{1}{f} = \dfrac{(\mu_1 - \mu_2)}{R}$; $f = \dfrac{R}{(\mu_1 - \mu_2)}$

29. **(d) :** Let n_1 bright fringe of λ_1 coincides with n_2 bright fringe of λ_2. Then

$$\frac{n_1\lambda_1 D}{d} = \frac{n_2\lambda_2 D}{d} \quad \text{or} \quad n_1\lambda_1 = n_2\lambda_2$$

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{10000}{12000} = \frac{5}{6}$$

Let x be given distance.

$$\therefore \quad x = \frac{n_1\lambda_1 D}{d}$$

Here, $n_1 = 5$, $D = 2$ m, $d = 2$ mm $= 2 \times 10^{-3}$ m

$\lambda_1 = 12000$ Å $= 12000 \times 10^{-10}$ m $= 12 \times 10^{-7}$ m

$$x = \frac{5 \times 12 \times 10^{-7}\text{ m} \times 2\text{ m}}{2 \times 10^{-3}\text{ m}} = 6 \times 10^{-3}\text{ m} = 6\text{ mm}$$

30. **(a) :** Converging power of cornea, $P_c = +40$ D

Least converging power of eye lens, $P_e = +20$ D

Power of the eye-lens, $P = P_c + P_e$

$= 40$ D $+ 20$ D $= 60$ D

Power of the eye lens

$$P = \frac{1}{\text{Focal length of the eye lens } (f)}$$

$$f = \frac{1}{P} = \frac{1}{60\text{ D}} = \frac{1}{60}\text{ m} = \frac{100}{60}\text{ cm} = \frac{5}{3}\text{ cm}$$

Distance between the retina and cornea-eye lens

= Focal length of the eye lens

$= \dfrac{5}{3}$ cm $= 1.67$ cm

31. **(a)**

32. **(b) :** Fringe width, $\beta = \dfrac{\lambda D}{d}$

where D is the distance between slits and screen and d is the distance between the slits.

When D is doubled and d is reduced to half, then fringe width becomes

$$\beta' = \frac{\lambda(2D)}{(d/2)} = \frac{4\lambda D}{d} = 4\beta$$

33. **(c) :** For the second minimum,

Path difference $= 2\lambda$

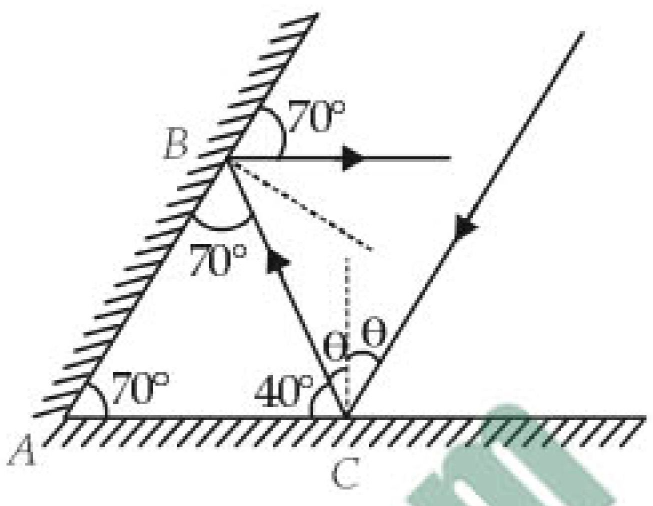
Therefore, corresponding value of phase difference is

$$\Delta\phi = \frac{2\pi}{\lambda} \times \text{Path difference}$$

$$\therefore \quad \Delta\phi = \frac{2\pi}{\lambda} \times 2\lambda = 4\pi$$

34. **(a) :** The reddish appearance of the sun at sunrise and sunset is due to the scattering of light.

35. **(d) :** Different angles as shown in the figure.



$\theta + 40° = 90°$

$\therefore \quad \theta = 90° - 40° = 50°$

36. **(a) :** According to lens maker's formula

$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_L} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

where μ_g is the refractive index of the material of the lens and μ_L is the refractive index of the liquid in which lens is dipped.

As the biconvex lens dipped in a liquid acts as a plane sheet of glass, therefore

$$f = \infty \Rightarrow \frac{1}{f} = 0$$

$$\therefore \quad \frac{\mu_g}{\mu_L} - 1 = 0 \quad \text{or} \quad \mu_g = \mu_L$$

37. **(a) :** As the emergent ray emerges normally from the opposite face,

$\therefore \quad e = 0, r_2 = 0$ As $r_1 + r_2 = A$

$\therefore \quad r_1 = A$

Applying Snell's law for incident ray

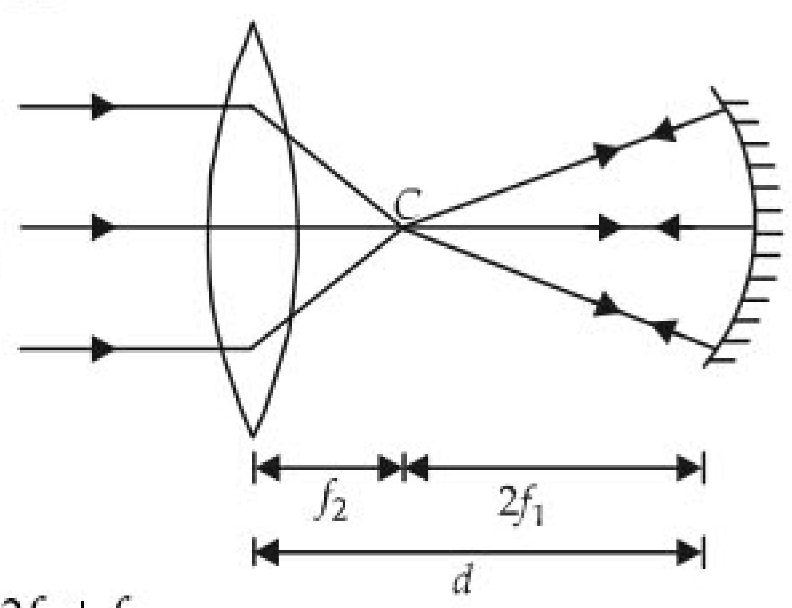
$1 \sin i = \mu \sin r_1 = \mu \sin A$

or $\quad \mu = \dfrac{\sin i}{\sin A}$

For small angle, $\sin i \approx i$, $\sin A \approx A$

$\therefore \quad \mu = \dfrac{i}{A}$ or $i = \mu A$

38. **(c) :**



$\therefore \quad d = 2f_1 + f_2$

39. (c) : Magnifying power, $m = \frac{f_o}{f_e} = 9$ ...(i)

where f_o and f_e are the focal lengths of the objective and eyepiece respectively

Also, $f_o + f_e = 20$ cm ...(ii)

On solving (i) and (ii), we get

$f_o = 18$ cm, $f_e = 2$ cm

40. (b) : As $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$$\mu = \frac{\sin\left(\frac{A+A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin A}{\sin\left(\frac{A}{2}\right)} \quad (\because \delta_m = A(\text{Given}))$$

$$= \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = 2\cos\left(\frac{A}{2}\right)$$

As $\delta = i + e - A$

At minimum deviation, $\delta = \delta_m$, $i = e$

$\therefore \quad \delta_m = 2i - A$

$2i = \delta_m + A$

$$i = \frac{\delta_m + A}{2} = \frac{A+A}{2} = A \quad (\because \delta_m = A(\text{given}))$$

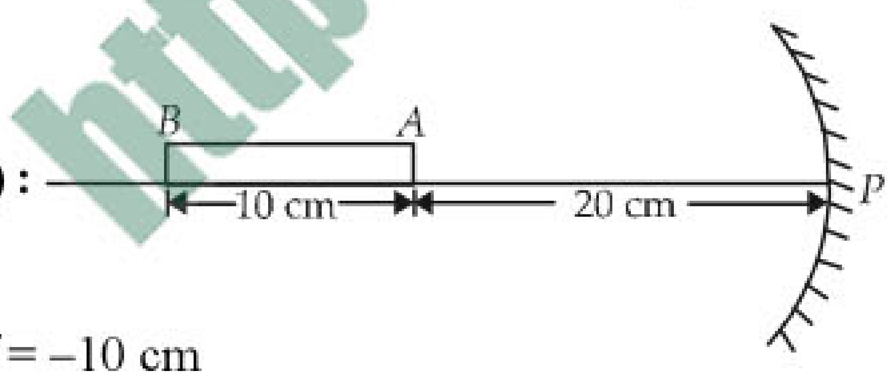
$i_{\min} = 0° \Rightarrow A_{\min} = 0°$

Then, $\mu_{\max} = 2\cos 0° = 2$

$\because \quad i_{\max} = \frac{\pi}{2} \Rightarrow A_{\max} = \frac{\pi}{2}$

Then, $\mu_{\min} = 2\cos 45° = 2 \times \frac{1}{\sqrt{2}} = \sqrt{2}$

So refractive index lies between 2 and $\sqrt{2}$.

41. (d) : 

Here, $f = -10$ cm

For end A, $u_A = -20$ cm

Image position of end A,

$$\frac{1}{v_A} + \frac{1}{u_A} = \frac{1}{f}$$

$$\frac{1}{v_A} + \frac{1}{(-20)} = \frac{1}{(-10)} \text{ or } \frac{1}{v_A} = \frac{1}{-10} + \frac{1}{20} = -\frac{1}{20}$$

$v_A = -20$ cm

For end B, $u_B = -30$ cm

Image position of end B,

$$\frac{1}{v_B} + \frac{1}{u_B} = \frac{1}{f}$$

$$\frac{1}{v_B} + \frac{1}{(-30)} = \frac{1}{(-10)} \text{ or } \frac{1}{v_B} = \frac{1}{-10} + \frac{1}{30} = -\frac{2}{30}$$

$v_B = -15$ cm

Length of the image

$= |v_A| - |v_B| = 20\text{ cm} - 15\text{ cm} = 5\text{ cm}$

42. (b) : Difference between apparent and real depth of a pond is due to refraction. Other three are due to total internal reflection.

43. (c)

44. (c) : For dispersion without deviation

$\delta_1 + \delta_2 = 0$

$(\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$

$$A_2 = -\frac{(\mu_1 - 1)A_1}{(\mu_2 - 1)}$$

Substituting the given values, we get

$$A_2 = -\frac{(1.5-1)15°}{(1.75-1)} = -10°$$

–ve sign shows that two prisms must be joined in opposition.

45. (d) : Here, $v = +15$ cm, $u = +(15 - 5) = +10$ cm

According to lens formula

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{15} - \frac{1}{10} = \frac{1}{f} \quad \Rightarrow f = -30\text{ cm}$$

46. (c) : For total internal reflection, $\sin i > \sin C$

where, i = angle of incidence, C = critical angle

But, $\sin C = \frac{1}{\mu} \quad \therefore \quad \sin i > \frac{1}{\mu}$ or $\mu > \frac{1}{\sin i}$

$$\mu > \frac{1}{\sin 45°} \qquad (i = 45°\text{ (Given)})$$

$\mu > \sqrt{2}$

Hence, option (c) is correct.

47. (c) : Focal length of the lens remains same. Intensity of image formed by lens is proportional to area exposed to incident light from object.

i.e. Intensity $\propto$ area

or $\frac{I_2}{I_1} = \frac{A_2}{A_1}$

Initial area, $A_1 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$

After blocking, exposed area,

$$A_2 = \frac{\pi d^2}{4} - \frac{\pi(d/2)^2}{4} = \frac{\pi d^2}{4} - \frac{\pi d^2}{16} = \frac{3\pi d^2}{16}$$

$$\therefore \quad \frac{I_2}{I_1} = \frac{A_2}{A_1} = \frac{\frac{3\pi d^2}{16}}{\frac{\pi d^2}{4}} = \frac{3}{4}$$

or $\quad I_2 = \frac{3}{4} I_1 = \frac{3}{4} I \qquad (\because I_1 = I)$

Hence, focal length of a lens $= f$, intensity of the image $= \frac{3I}{4}$

48. (c) : Refractive index for medium M_1 is

$$\mu_1 = \frac{c}{v_1} = \frac{3\times10^8}{1.5\times10^8} = 2$$

Refractive index for medium M_2 is

$$\mu_2 = \frac{c}{v_2} = \frac{3\times10^8}{2.0\times10^8} = \frac{3}{2}$$

For total internal reflection, $\sin i \geq \sin C$

where i = angle of incidence, C = critical angle

But $\sin C = \frac{\mu_2}{\mu_1}$

$$\sin i \geq \frac{\mu_2}{\mu_1} \geq \frac{3/2}{2} \Rightarrow i \geq \sin^{-1}\left(\frac{3}{4}\right)$$

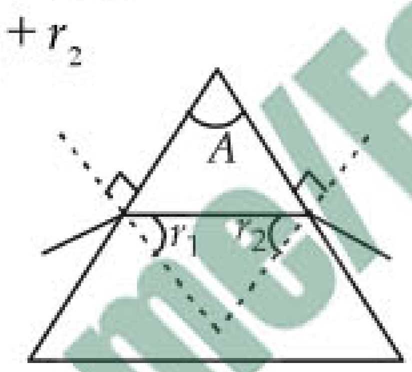
49. (b) : Angle of prism, $A = r_1 + r_2$

For minimum deviation

$r_1 = r_2 = r \quad \therefore \quad A = 2r$

Given, $A = 60°$

Hence, $r = \frac{A}{2} = \frac{60°}{2} = 30°$



50. (b) : $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$; $\quad \therefore$ Power $P = \frac{f_1 + f_2}{f_1 f_2}$

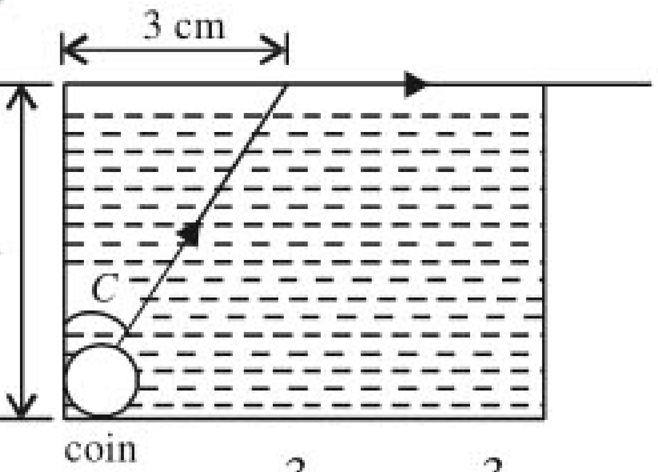
51. (c) : $\frac{\text{size of image}}{\text{size of object}} = \left|\frac{v}{u}\right|$

$$\Rightarrow \text{size of the image} = \frac{1.39\times10^9\times10^{-1}}{1.5\times10^{11}} = 0.92\times10^{-3}\text{ m}$$

$= 0.92 \times 10^{-3}$ m.

size of the image $= 9.2 \times 10^{-4}$ m

52. (d) :



From figure, $\sin C = \frac{3}{\sqrt{(4)^2+(3)^2}} = \frac{3}{5}$

where C is the critical angle.

Also, $\sin C = {}^l\mu_a$

$\sin C = \frac{1}{{}^a\mu_l} \quad \left[\text{since } {}^l\mu_a = \frac{1}{{}^a\mu_l}\right]$

Also $\;{}^a\mu_l = \frac{\text{velocity of light in air } (c)}{\text{velocity of light in liquid } (v)}$

$$\therefore \quad \sin C = \frac{v}{c} = \frac{v}{3\times10^8}$$

or, $\quad v = 3\times10^8\times\frac{3}{5} = 1.8\times10^8 \text{ ms}^{-1}$.

53. (b) : $\mu = \frac{\text{velocity of light in vacuum } (c)}{\text{velocity of light in medium } (v)}$

$\therefore \quad v = \upsilon\lambda = 2 \times 10^{14} \times 5000 \times 10^{-10}$

In the medium, $v = 10^8$ m/s

$$\therefore \quad \mu = \frac{v_{vac}}{v_{med}} = \frac{3\times10^8}{10^8} = 3.$$

54. (b) : Apparent depth $= \frac{\text{real depth}}{\mu} = \frac{3}{1.5} = 2$ cm

As image appears to be raised by 1 cm, therefore, microscope must be moved upwards by 1 cm.

55. (a) : Focal length of convex lens $f_1 = 25$ cm

Focal length of concave lens $f_2 = -25$ cm

Power of combination in dioptres,

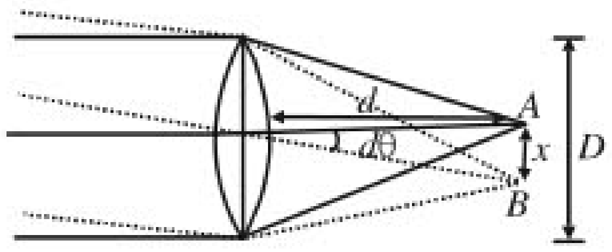
$$P = P_1 + P_2 = \frac{100}{f_1} + \frac{100}{f_2} = \frac{100}{25} - \frac{100}{25} = 0.$$

56. (c) : R.P. $= 1/\Delta\theta$

The angular resolution, $\Delta\theta = \frac{1.22\lambda}{D}$

$$= \frac{1.22\times5000\times10^{-8}}{0.1} = 6.1\times10^{-4} \simeq 10^{-4}.$$

57. (c) : Resolution of telescope



$$d\theta = 1.22\frac{\lambda}{D} = 1.22\times\frac{5000\times10^{-8}}{10} \quad \tan\theta \simeq d\theta$$

$x = d\theta \times d$

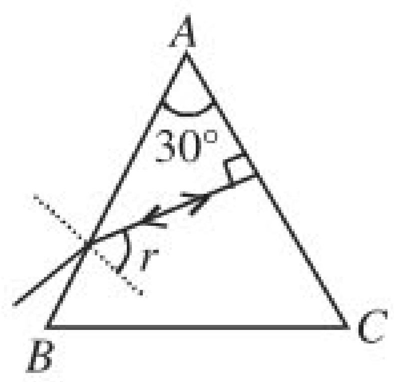
$$= \frac{1.22\times5000\times10^{-8}\times10^5}{10} \; [d = 10^5 \text{ cm}] \simeq 5 \text{ mm}$$

58. (a) : $\angle r = 30°$ (using law of triangle)

$\Rightarrow \mu = \frac{\sin i}{\sin r}$

$\Rightarrow \sqrt{2} \times \sin 30 = \sin i$

$\Rightarrow \sin i = \frac{1}{\sqrt{2}} \Rightarrow i = 45°$

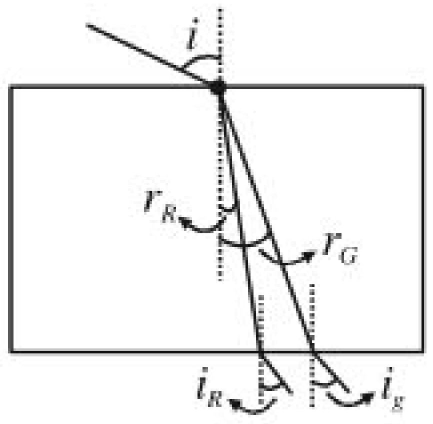


59. (b) : The velocities of different colours is different in a given medium. Red and green are refracted at different angle of refraction.

$$\frac{\sin i}{\sin r_R} = \mu \quad \text{...(i)}$$

$$\frac{\sin i}{\sin r_G} = \mu \quad \text{...(ii)}$$

$$\frac{\sin r_p}{\sin i_p} = \mu \quad \text{...(iii)}$$



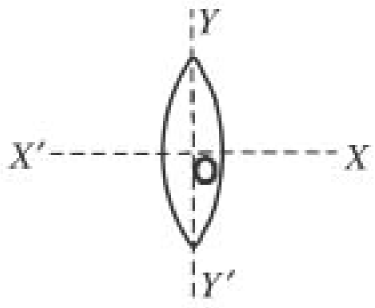
From equation (i), (ii) and (iii)

$\Rightarrow i = i_R = i_G$

Thus two point propagation in two different parallel direction.

60. (a) : Since the lens is equiconvex, the radius of curvature of each half is same, say R. We know from Lens maker's formula

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$



(considering the lens to be placed in air). Here $R_1 = R$

$R_2 = -R$ by convection

$$\therefore \frac{1}{f} = (\mu - 1)\frac{2}{R} \Rightarrow (\mu - 1)\frac{1}{R} = \frac{1}{2f} \quad \text{...(i)}$$

If we cut the lens along XOX' then the two halves of the lens will be having the same radii of curvature and so, focal length $f' = f$

But when we cut it along YOY' then, we will have

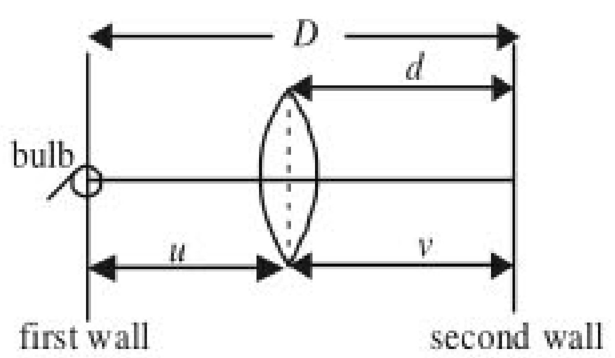
$R_1 = R$ but $R_2 = \infty$

$$\therefore \frac{1}{f''} = (\mu - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) = (\mu - 1)\frac{1}{R} = \frac{1}{2f}$$

$\Rightarrow f'' = 2f.$

61. (b) : When refractive index of lens is equal to the refractive index of liquid, the lens behave like a plane surface with focal length infinity.

62. (b) : A real image is to be formed on the 2nd wall of the bulb placed on the first wall by the convex lens. The lens is placed at a distance of d from the 2nd wall.



Now, we know that to form a real image of an object on a screen by a convex lens, the distance between the source and the screen (D) should be equal to $4f$, where f is the focal length of the lens.

In that case, $u = v = D/2 = d$.

$\therefore \; f = D/4 = d/2$.

63. (c) : Resolving power of eyelens

$$= \frac{d}{\lambda} = \frac{2\times10^{-1}}{5000\times10^{-8}} = \frac{1}{d\theta}$$

[Given d = diameter of lens = 2 mm = 2×10^{-1} cm,
λ = 5000 Å = 5000×10^{-8} cm].

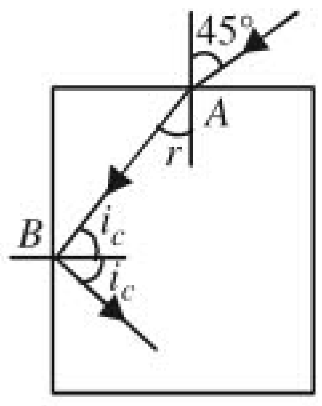
Let S be the minimum distance between two points so that it may be resolved.

$\therefore \; S = r d\theta$. Here r = 50 m = 5000 cm.

$$\therefore \; S = 5000\times\frac{5000\times10^{-8}}{2\times10^{-1}} = 1.25 \text{ cm}.$$

64. (c) : Applying Snell's law of refraction at A, we get

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin 45°}{\sin r}$$



$\therefore \; \sin r = 1/\sqrt{2}\mu$

$$\therefore \; r = \sin^{-1}\left(\frac{1}{\sqrt{2}\mu}\right) \quad \text{... (i)}$$

Applying the condition of total internal reflection at B, we get

$$i_c = \sin^{-1}(1/\mu) \quad \text{... (ii)}$$

where i_c is the critical angle.

Now, $r + i_c = 90° = \pi/2$.

$$\therefore \; \sin^{-1}\frac{1}{\sqrt{2}\mu} = \frac{\pi}{2} - \sin^{-1}\frac{1}{\mu}$$

or, $\sin^{-1}\dfrac{1}{\sqrt{2}\mu} = \cos^{-1}\dfrac{1}{\mu}$

$$\therefore \; \frac{1}{\sqrt{2}\mu} = \frac{\sqrt{\mu^2-1}}{\mu} \text{ or } \frac{1}{2} = \mu^2 - 1. \; \therefore \; \mu = \sqrt{3/2}.$$

65. (a)

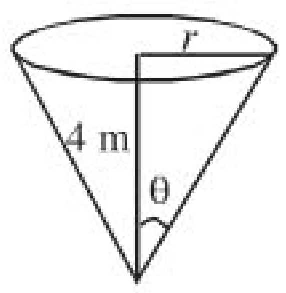
66. (b) : Frequency remains same.

67. (b) : θ is the critical angle.

$\therefore \; \theta = \sin^{-1}(1/\mu) = \sin^{-1}(3/5)$

or, $\sin\theta = 3/5$.

$\therefore \; \tan\theta = 3/4 = r/4$ or, r = 3 m.



68. (c) : Total apparent depth,

$y = y_1 + y_2 = 5 + 2 = 7$ cm.

If x is real depth = thickness of slab, then as

$$\mu = \frac{\text{real depth}}{\text{apparent depth}} = \frac{x}{y}$$

or, $x = \mu y = 1.5 \times 7 = 10.5$ cm.

69. (b) : The minimum mirror length should be half of the height of man.

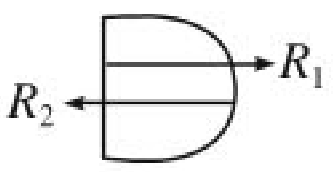
70. (a) : $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$$= (1.5 - 1)\left[\frac{1}{\infty} - \frac{1}{(-10)}\right] = 0.5\left[\frac{1}{10}\right] \Rightarrow f = 20 \text{ cm}$$

When plane surface is silvered, $F = \frac{f}{2} = \frac{20}{2} = 10$ cm.

71. (b) : The rainbow is an example of the dispersion of sunlight by the water drops in the atmosphere. This is a phenomenon due to a combination of the refraction of sunlight by spherical water droplets and of internal (not total) reflection.

72. (b) : $R_1 = +\infty$
$R_2 = -60$ cm



$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.6 - 1)\left(\frac{1}{\infty} - \frac{1}{-60}\right) \text{ or } \quad f = 100 \text{ cm.}$$

73. (a)

74. (a) : $A = 60°,\ \mu = \sqrt{3}, \delta_m = ?$

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\frac{A}{2}} \qquad \therefore \delta_m = 60°$$

75. (a) : For lens, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$u = -30,\ f = 20,\ v = 60$ cm

To have an upright image of the object, coincide with it, image should tend to form at centre of curvature of convex mirror. Therefore, the distance of convex mirror from the lens = 60 – 10 = 50 cm.

76. (c) : $n > \frac{\sin r}{\sin i}$

i.e., $n > \frac{\sin 90°}{\sin 45°} \Rightarrow n > \sqrt{2}$

77. (d) : Length of astronomical telescope $(f_o + f_e) = 44$ cm and ratio of focal length of the objective lens to that of the eye piece $\frac{f_o}{f_e} = 10$.

From the given ratio, we find that $f_o = 10 f_e$.
Therefore $10f_e + f_e = 44$ or $f_e = 4$ cm
and focal length of the objective (f_o)
$= 44 - f_e = 44 - 4 = 40$ cm.

78. (a) : $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Since the refractive index of violet colour (μ_v) is greater than the refractive index of red colour (μ_r), therefore focal length of violet colour is less than the focal length of red colour or in other words, $f_v < f_r$.

79. (d) : Frequency = n; Wavelength = λ; Velocity of air = v and refractive index of glass slab = μ.
Frequency of light remains the same, when it changes the medium. Refractive index is the ratio of wavelengths in vacuum and in the given medium. Similarly refractive index is also the ratio of velocities in vacuum and in the given medium.

80. (b) : Focal length $(f_1) = 80$ cm and $(f_2) = -50$ cm
(Minus sign due to concave lens)
Power of the combination (P)

$$= P_1 + P_2 = \frac{100}{f_1} + \frac{100}{f_2} = \frac{100}{80} - \frac{100}{50} = -0.75 \text{ D.}$$

81. (d) : Refractive index of water $(\mu_2) = 1.33$.

$$\frac{v_2}{v_1} = \frac{\mu_1}{\mu_2} = \frac{1}{1.33}$$

Therefore $v_2 = \frac{v_1}{1.33} = \frac{3 \times 10^8}{1.33} = 2.25 \times 10^8$ m/s.

82. (a) : According to Snell's law,

$$\mu = \frac{\sin i}{\sin r'} = \frac{\sin i}{\sin(90° - r)} = \frac{\sin i}{\cos r}$$

From law of reflection, $i = r$.

$$\therefore \quad \mu = \frac{\sin r}{\cos r} = \tan r$$

Critical angle = $\sin^{-1}(\mu) = \sin^{-1}(\tan r)$.

83. (b) : For a convex lens, $f_R > f_V$ or $f_V < f_R$. For a concave lens, focal length is negative.
$\therefore$ $|F_V| < |F_R|$ or $F_V > F_R$ as the smaller negative value is bigger.

84. (b) : Time = $\frac{\text{distance}}{\text{velocity}} = \frac{t}{v} = \frac{t}{c/\mu} = \frac{\mu t}{c}$

85. (c) : By displacement method, size of object $(O) = \sqrt{I_1 \times I_2}$.

Therefore area of source of light $(A) = \sqrt{A_1 A_2}$.

86. (c) : Time of exposure $t \propto (f\text{-number})^2$

$$\therefore \quad \frac{t}{\left(\frac{1}{200}\right)} = \left(\frac{5.6}{2.8}\right)^2 = 4 \text{ or } t = 0.02 \text{ s}$$

87. (d) : Separations between the slits $(d_1) = 16$ cm and $(d_2) = 9$ cm.
Actual distance of separation

$$(d) = \sqrt{d_1 d_2} = \sqrt{16 \times 9} = 12 \text{ cm}.$$

88. (a) : Magnifying power of telescope, $M = f_o/f_e$
To produce largest magnifications $f_o > f_e$ and f_o and

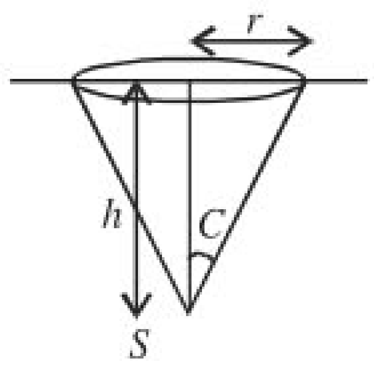
f_e both should be positive (convex lens).
Therefore $f_e = +15$ cm.

89. (a) : According to Rayleigh, the amount of scattering is inversely proportional to the fourth power of the wavelength.

90. (d)

91. (a) : In order to cut off all the light coming out of water surface, angle C should be equal to critical angle.

i.e. $\sin C = \frac{1}{\mu} = \frac{1}{5/3} = \frac{3}{5}$.



$\therefore \quad \tan C = 3/4$.

Now, $\tan C = \frac{r}{h}$;

$r = h\tan C = 4 \times \frac{3}{4} = 3$ m

Diameter of disc $= 2r = 6$ m.

92. (c) : For first minimum, $a\sin\theta = n\lambda = 1\lambda$

$$\sin\theta = \frac{\lambda}{a} = \frac{5000 \times 10^{-10}}{0.001 \times 10^{-3}} = 0.5$$

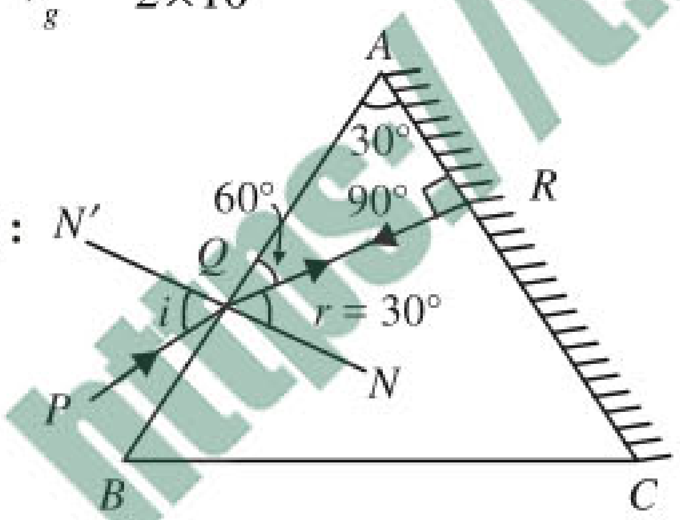
$\theta = 30°$.

93. (d) : In vacuum, λ increases very slightly compared to that in air. As $\beta \propto \lambda$, therefore, width of interference fringe increases slightly.

94. (c) : $v_g = \frac{c}{\mu} = \frac{3 \times 10^8}{\frac{3}{2}} = 2 \times 10^8$ m/s

$$t = \frac{x}{v_g} = \frac{4 \times 10^{-3}}{2 \times 10^8} = 2 \times 10^{-11} \text{ s}$$

95. (c) :



The ray will retrace the path when the refracted ray QR is incident normally on the polished surface AC. Thus angle of refraction $r = 30°$

$$\mu = \frac{\sin i}{\sin r}$$

$\therefore \quad \sin i = \mu \times \sin r = \sqrt{2} \times \sin 30°$

$$\sin i = \sqrt{2} \times \frac{1}{2} = \frac{1}{\sqrt{2}} \text{ or } i = \sin^{-1}\frac{1}{\sqrt{2}} = 45°$$

96. (a) : As $\beta = \frac{\lambda D}{d}$ and $\lambda_b < \lambda_y$,

$\therefore$ Fringe width β will decrease

97. (b) : $x = (n)\lambda\frac{D}{d} = 3 \times 5000 \times 10^{-10} \times \frac{2}{0.2 \times 10^{-3}}$

$= 1.5 \times 10^{-2}$ m $= 1.5$ cm

98. (c) : λ' of refracted light is smaller, because $\lambda' = \frac{\lambda}{\mu}$

99. (a) : $\lambda_g = \frac{\lambda_a}{\mu} = \frac{5460}{1.5} = 3640$ Å

100. (a) : $\frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{4}{1} \quad \therefore \frac{a}{b} = \frac{2}{1}$

101. (d) : For dark fringe $x = (2n-1)\frac{\lambda D}{2d}$

$$\therefore \quad \lambda = \frac{2xd}{(2n-1)D} = \frac{2 \times 10^{-3} \times 0.9 \times 10^{-3}}{(2 \times 2 - 1) \times 1}$$

$\lambda = 0.6 \times 10^{-6}$ m $= 6 \times 10^{-5}$ cm

102. (a) : $\beta' = \frac{\beta}{\mu} = \frac{0.4}{\frac{4}{3}} = 0.3$ mm

103. (c) : Distance of n^{th} maxima $x = n\lambda\frac{D}{d} \propto \lambda$

As $\lambda_b = \lambda_g$

$\therefore \quad x$(blue) < x(green).

104. (c) : Interference is a wave phenomenon shown by both the light waves and sound waves.

105. (d) : Sound waves can not be polarised as they are longitudinal. Light waves can be polarised as they are transverse.

106. (d) : Huygen's construction of wavefront does not apply to origin of spectra which is explained by quantum theory.

107. (c) : $$\frac{f_a}{f_e} = \frac{\left(\frac{\mu_g}{\mu_l} - 1\right)}{(\mu_g - 1)} = \frac{\left(\frac{1.5}{1.25} - 1\right)}{1.5 - 1} = \frac{\frac{1}{5}}{\frac{1}{2}} = \frac{2}{5}$$

$$f_e = \frac{5}{2}f_a = \frac{5}{2} \times 2 = 5 \text{ cm}$$

Chapter 19 Dual Nature of Radiation and Matter

1. The de-Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature T (kelvin) and mass m, is
   (a) $\frac{h}{\sqrt{3mkT}}$ (b) $\frac{2h}{\sqrt{3mkT}}$
   (c) $\frac{2h}{\sqrt{mkT}}$ (d) $\frac{h}{\sqrt{mkT}}$
   (NEET 2017)

2. The photoelectric threshold wavelength of silver is 3250×10^{-10} m. The velocity of the electron ejected from a silver surface by ultraviolet light of wavelength 2536×10^{-10} m is
   [Given $h = 4.14 \times 10^{-15}$ eV s and $c = 3 \times 10^8$ m s^{-1}]
   (a) $\approx 0.6 \times 10^6$ m s^{-1} (b) $\approx 61 \times 10^3$ m s^{-1}
   (c) $\approx 0.3 \times 10^6$ m s^{-1} (d) $\approx 6 \times 10^5$ m s^{-1}
   (NEET 2017)

3. Electrons of mass m with de-Broglie wavelength λ fall on the target in an X-ray tube. The cutoff wavelength (λ_0) of the emitted X-ray is
   (a) $\lambda_0 = \frac{2mc\lambda^2}{h}$ (b) $\lambda_0 = \frac{2h}{mc}$
   (c) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ (d) $\lambda_0 = \lambda$
   (NEET-II 2016)

4. Photons with energy 5 eV are incident on a cathode C in a photoelectric cell. The maximum energy of emitted photoelectrons is 2 eV. When photons of energy 6 eV are incident on C, no photoelectrons will reach the anode A, if the stopping potential of A relative to C is
   (a) +3 V (b) +4 V
   (c) −1 V (d) −3 V
   (NEET-II 2016)

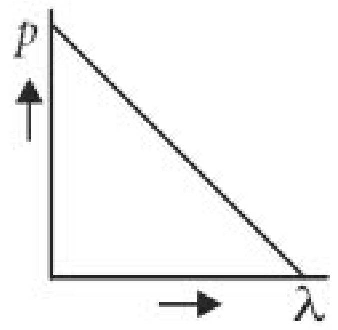
5. An electron of mass m and a photon have same energy E. The ratio of de-Broglie wavelengths associated with them is
   (a) $c(2mE)^{\frac{1}{2}}$ (b) $\frac{1}{c}\left(\frac{2m}{E}\right)^{\frac{1}{2}}$
   (c) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$ (d) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$
   (c being velocity of light) *(NEET-I 2016)*

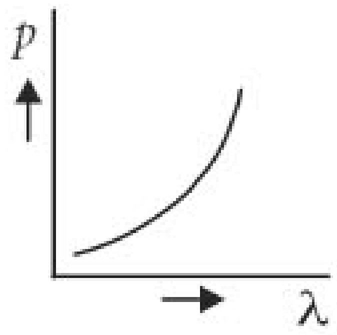
6. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is
   (a) $\frac{5}{2}\lambda$ (b) 3λ
   (c) 4λ (d) 5λ
   (NEET-I 2016)

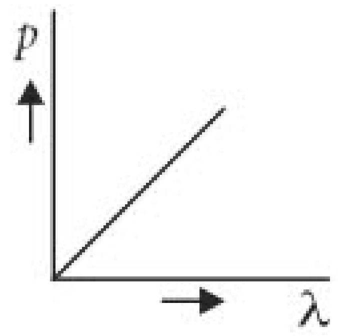
7. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface of the material is
   (h = Planck's constant, c = speed of light)
   (a) $\frac{2hc}{\lambda}$ (b) $\frac{hc}{3\lambda}$
   (c) $\frac{hc}{2\lambda}$ (d) $\frac{hc}{\lambda}$ *(2015)*

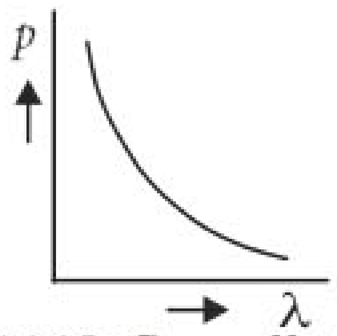
8. Light of wavelength 500 nm is incident on a metal with work function 2.28 eV. The de Broglie wavelength of the emitted electron is
   (a) $\geq 2.8 \times 10^{-9}$ m (b) $\leq 2.8 \times 10^{-12}$ m
   (c) $< 2.8 \times 10^{-10}$ m (d) $< 2.8 \times 10^{-9}$ m
   (2015)

9. Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?

(a) 

(b) 

(c) 

(d) 

(2015 Cancelled)

10. A certain metallic surface is illuminated with monochromatic light of wavelength, λ. The stopping potential for photo-electric current for this light is $3V_0$. If the same surface is illuminated with light of wavelength 2λ, the stopping potential is V_0. The threshold wavelength for this surface for photo-electric effect is

(a) $\frac{\pi}{4}$ (b) $\frac{\lambda}{6}$ (c) 6λ (d) 4λ

(2015 Cancelled)

11. When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is

(a) 0.65 eV (b) 1.0 eV
(c) 1.3 eV (d) 1.5 eV *(2014)*

12. If the kinetic energy of the particle is increased to 16 times its previous value, the percentage change in the de Broglie wavelength of the particle is

(a) 25 (b) 75
(c) 60 (d) 50 *(2014)*

13. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by

(a) $\lambda_p \propto \sqrt{\lambda_e}$ (b) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$
(c) $\lambda_p \propto \lambda_e^2$ (d) $\lambda_p \propto \lambda_e$

(NEET 2013)

14. For photoelectric emission from certain metal the cutoff frequency is υ. If radiation of frequency 2υ impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass)

(a) $\sqrt{\frac{2h\upsilon}{m}}$ (b) $2\sqrt{\frac{h\upsilon}{m}}$
(c) $\sqrt{\frac{h\upsilon}{(2m)}}$ (d) $\sqrt{\frac{h\upsilon}{m}}$

(NEET 2013)

15. A source of light is placed at a distance of 50 cm from a photo cell and the stopping potential is found to be V_0. If the distance between the light source and photo cell is made 25 cm, the new stopping potential will be :

(a) $V_0/2$ (b) V_0 (c) $4V_0$ (d) $2V_0$

(Karnataka NEET 2013)

16. The de-Broglie wavelength of neutrons in thermal equilibrium at temperature T is

(a) $\frac{3.08}{\sqrt{T}}$ Å (b) $\frac{0.308}{\sqrt{T}}$ Å
(c) $\frac{0.0308}{\sqrt{T}}$ Å (d) $\frac{30.8}{\sqrt{T}}$ Å

(Karnataka NEET 2013)

17. A 200 W sodium street lamp emits yellow light of wavelength 0.6 μm. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is

(a) 1.5×10^{20} (b) 6×10^{18}
(c) 62×10^{20} (d) 3×10^{19} *(2012)*

18. Monochromatic radiation emitted when electron on hydrogen atom jumps from first excited to the ground state irradiates a photosensitive material. The stopping potential is measured to be 3.57 V. The threshold frequency of the material is

(a) 4×10^{15} Hz (b) 5×10^{15} Hz
(c) 1.6×10^{15} Hz (d) 2.5×10^{15} Hz

(2012)

19. An α-particle moves in a circular path of radius 0.83 cm in the presence of a magnetic field of 0.25 Wb/m². The de Broglie wavelength associated with the particle will be

(a) 1 Å (b) 0.1 Å
(c) 10 Å (d) 0.01 Å *(2012)*

20. If the momentum of an electron is changed by P, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be

(a) $200P$ (b) $400P$ (c) $\frac{P}{200}$ (d) $100P$

(Mains 2012)

21. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is

(a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5

(Mains 2012)

22. Photoelectric emission occurs only when the incident light has more than a certain minimum

(a) power (b) wavelength
(c) intensity (d) frequency

(2011)

23. In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by

(a) increasing the potential difference between the anode and filament
(b) increasing the filament current
(c) decreasing the filament current
(d) decreasing the potential difference between the anode and filament *(2011)*

24. Light of two different frequencies whose photons have energies 1 eV and 2.5 eV respectively illuminate a metallic surface whose work function is 0.5 eV successively. Ratio of maximum speeds of emitted electrons will be

(a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5

(2011)

25. Electrons used in an electron microscope are accelerated by a voltage of 25 kV. If the voltage is increased to 100 kV then the de-Broglie wavelength associated with the electrons would

(a) increase by 2 times
(b) decrease by 2 times
(c) decrease by 4 times
(d) increase by 4 times *(2011)*

26. In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is

(a) 1.8 V (b) 1.3 V
(c) 0.5 V (d) 2.3 V *(2011)*

27. The threshold frequency for a photosensitive metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on this metal, the cut-off voltage for the photoelectron emission is nearly

(a) 1 V (b) 2 V (c) 3 V (d) 5 V

(Mains 2011)

28. A beam of cathode rays is subjected to crossed electric (E) and magnetic fields (B). The fields are adjusted such that the beam is not deflected. The specific charge of the cathode rays is given by

(a) $\frac{B^2}{2VE^2}$ (b) $\frac{2VB^2}{E^2}$
(c) $\frac{2VE^2}{B^2}$ (d) $\frac{E^2}{2VB^2}$ *(2010)*

(Where V is the potential difference between cathode and anode)

29. A source S_1 is producing, 10^{15} photons per second of wavelength 5000 Å. Another source S_2 is producing 1.02×10^{15} photons per second of wavelength 5100 Å. Then, (power of S_2)/(power of S_1) is equal to

(a) 1.00 (b) 1.02
(c) 1.04 (d) 0.98 *(2010)*

30. The potential difference that must be applied to stop the fastest photoelectrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of 200 nm falls on it, must be

(a) 2.4 V (b) –1.2 V
(c) –2.4 V (d) 1.2 V *(2010)*

31. When monochromatic radiation of intensity I falls on a metal surface, the number of photoelectrons and their maximum kinetic energy are N and T respectively. If the intensity of radiation is $2I$, the number of emitted electrons and their maximum kinetic energy are respectively

(a) N and $2T$ (b) $2N$ and T
(c) $2N$ and $2T$ (d) N and T

(Mains 2010)

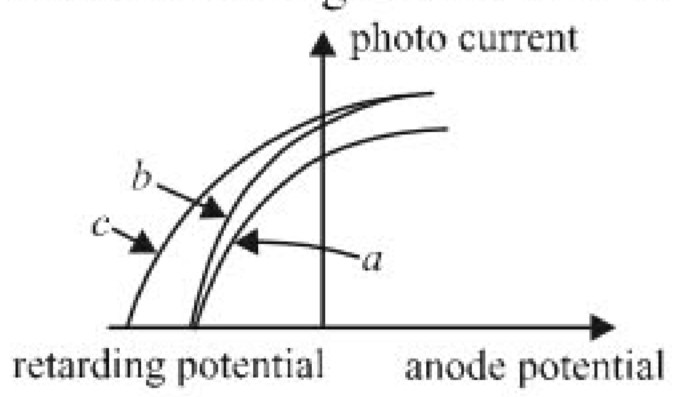
32. The electron in the hydrogen atom jumps from excited state (n = 3) to its ground state (n = 1) and the photons thus emitted irradiate a photosensitive material. If the work function of the material is 5.1 eV, the stopping potential is estimated to be (the energy of the electron in n^{th} state $E_n = \frac{-13.6}{n^2}$eV)

(a) 5.1 V (b) 12.1 V (c) 17.2 V (d) 7 V *(Mains 2010)*

33. The number of photo electrons emitted for light of a frequency υ (higher than the threshold frequency υ_0) is proportional to

(a) threshold frequency (υ_0)
(b) intensity of light
(c) frequency of light (υ)
(d) $\upsilon - \upsilon_0$ *(2009)*

34. The figure shows a plot of photo current versus anode potential for a photo sensitive surface for three different radiations. Which one of the following is a correct statement?



(a) Curves (a) and (b) represent incident radiations of same frequency but of different intensities.
(b) Curves (b) and (c) represent incident radiations of different frequencies and different intensities.
(c) Curves (b) and (c) represent incident radiations of same frequency having same intensity.
(d) Curves (a) and (b) represent incident radiations of different frequencies and different intensities *(2009)*

35. Monochromatic light of wavelength 667 nm is produced by a helium neon laser. The power emitted is 9 mW. The number of photons arriving per sec. on the average at a target irradiated by this beam is

(a) 3×10^{16} (b) 9×10^{15}
(c) 3×10^{19} (d) 9×10^{17} *(2009)*

36. The work function of a surface of a photosensitive material is 6.2 eV. The wavelength of the incident radiation for which the stopping potential is 5 V lies in the

(a) Infrared region (b) X-ray region
(c) Ultraviolet region (d) Visible region *(2008)*

37. A particle of mass 1 mg has the same wavelength as an electron moving with a velocity of 3×10^6 m s^{-1}. The velocity of the particle is

(a) 3×10^{-31} ms^{-1} (b) 2.7×10^{-21} ms^{-1}
(c) 2.7×10^{-18} ms^{-1} (d) 9×10^{-2} ms^{-1}
(mass of electron = 9.1×10^{-31} kg) *(2008)*

38. In the phenomenon of electric discharge through gases at low pressure, the coloured glow in the tube appears as a result of

(a) collisions between the charged particles emitted from the cathode and the atoms of the gas
(b) collision between different electrons of the atoms of the gas
(c) excitation of electrons in the atoms
(d) collision between the atoms of the gas *(2008)*

39. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons move

(a) in a circular orbit
(b) along a parabolic path
(c) along a straight line
(d) in an elliptical orbit. *(2007)*

40. Monochromatic light of frequency 6.0×10^{14} Hz is produced by a laser. The power emitted is 2×10^{-3} W. The number of photons emitted, on the average, by the source per second is

(a) 5×10^{16} (b) 5×10^{17}
(c) 5×10^{14} (d) 5×10^{15}. *(2007)*

41. A 5 watt source emits monochromatic light of wavelength 5000 Å. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0 m, the number of photoelectrons liberated will be reduced by a factor of

(a) 8 (b) 16
(c) 2 (d) 4. *(2007)*

42. A photocell employs photoelectric effect to convert

(a) change in the frequency of light into a change in the electric current
(b) change in the frequency of light into a change in electric voltage

(c) change in the intensity of illumination into a change in photoelectric current
(d) change in the intensity of illumination into a change in the work function of the photocathode. *(2006)*

43. When photons of energy $h\upsilon$ fall on an aluminium plate (of work function E_0), photoelectrons of maximum kinetic energy K are ejected. If the frequency of radiation is doubled, the maximum kinetic energy of the ejected photoelectrons will be
(a) $K + h\upsilon$ (b) $K + E_0$
(c) $2K$ (d) K. *(2006)*

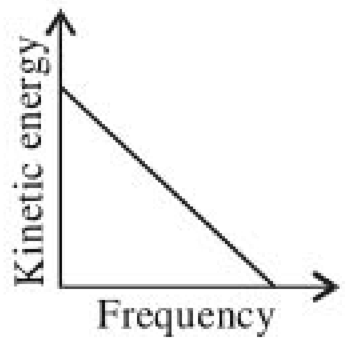
44. In a discharge tube ionization of enclosed gas is produced due to collisions between
(a) neutral gas atoms/molecules
(b) positive ions and neutral atoms/molecules
(c) negative electrons and neutral atoms/molecules
(d) photons and neutral atoms/molecules. *(2006)*

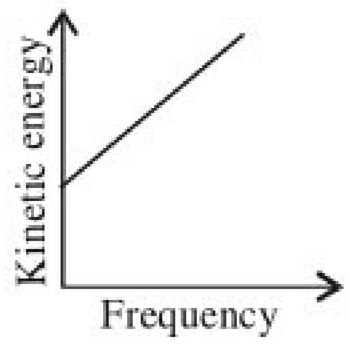
45. The momentum of a photon of energy 1 MeV in kg m/s will be
(a) 5×10^{-22} (b) 0.33×10^{6}
(c) 7×10^{-24} (d) 10^{-22}. *(2006)*

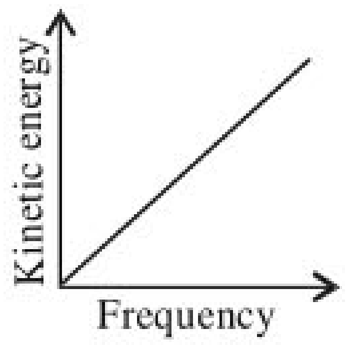
46. The work functions for metals A, B and C are respectively 1.92 eV, 2.0 eV and 5 eV. According to Einstein's equation the metals which will emit photoelectrons for a radiation of wavelength 4100 Å is/are
(a) A only
(b) A and B only
(c) all the three metals
(d) none. *(2005)*

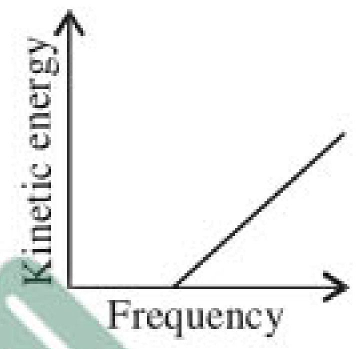
47. A photosensitive metallic surface has work function, $h\upsilon_0$. If photons of energy $2h\upsilon_0$ fall on this surface, the electrons come out with a maximum velocity of 4×10^6 m/s. When the photon energy is increased to $5h\upsilon_0$, then maximum velocity of photoelectrons will be
(a) 2×10^7 m/s (b) 2×10^6 m/s
(c) 8×10^6 m/s (d) 8×10^5 m/s. *(2005)*

48. According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is

(a) 

(b) 

(c) 

(d) 

(2004, 1996)

49. A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2 m then
(a) each emitted electron carries one quarter of the initial energy
(b) number of electrons emitted is half the initial number
(c) each emitted electron carries half the initial energy
(d) number of electrons emitted is a quarter of the initial number *(2003)*

50. J.J. Thomson's cathode-ray tube experiment demonstrated that
(a) cathode rays are streams of negatively charged ions
(b) all the mass of an atom is essentially in the nucleus
(c) the e/m of electrons is much greater than thee $/m$ of protons
(d) the e/m ratio of the cathode-ray particles changes when a different gas is placed in the discharge tube *(2003)*

51. The value of Planck's constant is
(a) 6.63×10^{-34} J/sec.
(b) 6.63×10^{-34} kg-m^2/sec
(c) 6.63×10^{-34} kg-m^2
(d) 6.63×10^{-34} J-sec. *(2002)*

52. If particles are moving with same velocity, then which has maximum de Broglie wavelength?
(a) proton (b) α-particle
(c) neutron (d) β-particle. *(2002)*

53. When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occurs by incidence of
(a) infrared rays (b) X-rays
(c) radio wave (d) micro wave. *(2002)*

54. Which of the following is not the property of cathode rays?
(a) It produces heating effect
(b) It does not deflect in electric field
(c) It casts shadow
(d) It produces fluorescence. *(2002)*

55. Which one among the following shows particle nature of light?
(a) photo electric effect (b) interference
(b) refraction (d) polarization. *(2001)*

56. In Thomson mass spectrograph $\vec{E} \perp \vec{B}$ then the velocity of electron beam will be
(a) $\frac{|\vec{E}|}{|\vec{B}|}$ (b) $\vec{E}\times\vec{B}$
(c) $\frac{|\vec{B}|}{|\vec{E}|}$ (d) $\frac{\vec{E}^2}{\vec{B}^2}$. *(2001)*

57. A photo-cell is illuminated by a source of light, which is placed at a distance d from the cell. If the distance become $d/2$, then number of electrons emitted per second will be
(a) remain same (b) four times
(c) two times (d) one-fourth. *(2001)*

58. By photoelectric effect, Einstein proved
(a) $E = h\upsilon$ (b) $K.E. = \frac{1}{2}mv^2$
(c) $E = mc^2$ (d) $E = \frac{-Rhc^2}{n^2}$. *(2000)*

59. Who evaluated the mass of electron indirectly with help of charge
(a) Thomson (b) Millikan
(c) Rutherford (d) Newton. *(2000)*

60. When a proton is accelerated through 1 V, then its kinetic energy will be
(a) 1 eV (b) 13.6 eV
(c) 1840 eV (d) 0.54 eV *(1999)*

61. The photoelectric work function for a metal surface is 4.125 eV. The cut-off wavelength for this surface is
(a) 3000 Å (b) 2062.5 Å
(c) 4125 Å (d) 6000 Å *(1999)*

62. As the intensity of incident light increases
(a) kinetic energy of emitted photoelectrons increases
(b) photoelectric current decreases
(c) photoelectric current increases
(d) kinetic energy of emitted photoelectrons decreases *(1999)*

63. In a photo-emissive cell, with exciting wavelength λ, the fastest electron has speed v. If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be
(a) less than $v(4/3)^{1/2}$
(b) $v(4/3)^{1/2}$
(c) $v(3/4)^{1/2}$
(d) greater than $v(4/3)^{1/2}$ *(1998)*

64. Which of the following statement is correct?
(a) The photocurrent increases with intensity of light
(b) The stopping potential increases with increase of incident light
(c) The current in photocell increases with increasing frequency
(d) The photocurrent is proportional to the applied voltage. *(1997)*

65. The kinetic energy of an electron, which is accelerated in the potential difference of 100 volts, is
(a) 416.6 cal (b) 6.636 cal
(c) 1.602×10^{-17} J (d) 1.6×10^4 J. *(1997)*

66. An electron beam has a kinetic energy equal to 100 eV. Find its wavelength associated with a beam, if mass of electron = 9.1×10^{-31} kg and 1 eV = 1.6×10^{-19} J/eV.
(Planck's constant = 6.6×10^{-34} Js)
(a) 24.6 Å (b) 0.12 Å
(c) 1.2 Å (d) 6.3 Å. *(1996)*

67. In a discharge tube at 0.02 mm, there is formation of
(a) Crooke's dark space
(b) Faraday's dark space
(c) both space partly
(d) none of these. *(1996)*

68. An electron of mass m and charge e is accelerated from rest through a potential difference V in vacuum. Its final velocity will be

(a) $\sqrt{\dfrac{2eV}{m}}$ (b) $\sqrt{\dfrac{eV}{m}}$

(c) $\dfrac{eV}{2m}$ (d) $\dfrac{eV}{m}$. *(1996)*

69. If a photon has velocity c and frequency υ, then which of the following represents its wavelength?

(a) $\dfrac{h\upsilon}{c^2}$ (b) $h\upsilon$ (c) $\dfrac{hc}{E}$ (d) $\dfrac{h\upsilon}{c}$

(1996)

70. The velocity of photons is proportional to (where υ = frequency)

(a) $1/\sqrt{\upsilon}$ (b) υ^2

(c) υ (d) $\sqrt{\upsilon}$. *(1996)*

71. An electron of mass m, when accelerated through a potential difference V, has de Broglie wavelength λ. The de Broglie wavelength associated with a proton of mass M accelerated through the same potential difference, will be

(a) $\lambda \dfrac{M}{m}$ (b) $\lambda \dfrac{m}{M}$

(c) $\lambda \sqrt{\dfrac{M}{m}}$ (d) $\lambda \sqrt{\dfrac{m}{M}}$ *(1995)*

72. If we consider electrons and photons of same wavelength, then they will have same

(a) momentum
(b) angular momentum
(c) energy
(d) velocity. *(1995)*

73. When light of wavelength 300 nm (nanometer) falls on a photoelectric emitter, photoelectrons are liberated. For another emitter, however, light of 600 nm wavelength is sufficient for creating photoemission. What is the ratio of the work functions of the two emitters?

(a) 1 : 2 (b) 2 : 1

(c) 4 : 1 (d) 1 : 4 *(1993)*

74. Number of ejected photoelectrons increases with increase

(a) in intensity of light
(b) in wavelegth of light
(c) in frequency of light
(d) never *(1993)*

75. Momentum of photon wavelength λ is

(a) $\dfrac{h\upsilon}{c}$ (b) zero (c) $\dfrac{h\lambda}{c^2}$ (d) $\dfrac{h\lambda}{c}$

(1993)

76. The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the current before and after changes are I_1 and I_2, all other conditions remaining unchanged, then (assuming $h\upsilon > W_2$)

(a) $I_1 = I_2$ (b) $I_1 < I_2$

(c) $I_1 > I_2$ (d) $I_1 < I_2 < 2I_1$

(1992)

77. Photoelectric work function of a metal is 1 eV. Light of wavelength λ =3000 Å falls on it. The photo electrons come out with a maximum velocity

(a) 10 metres/sec (b) 10^2 metres/ sec
(c) 10^4 metres/sec (d) 10^6 metres/sec

(1991)

78. The wavelength of a 1 keV photon is 1.24×10^{-9} m. What is the frequency of 1 MeV photon?

(a) 1.24×10^{15} (b) 2.4×10^{20}
(c) 1.24×10^{18} (d) 2.4×10^{23}

(1991)

79. An electron with (rest mass m_0) moves with a speed of 0.8 c. Its mass when it moves with this speed is

(a) m_0 (b) $\dfrac{m_0}{6}$

(c) $\dfrac{5m_0}{3}$ (d) $\dfrac{3m_0}{5}$ *(1991)*

80. A radio transmitter operates at a frequency 880 kHz and a power of 10 kW. The number of photons emitted per second is

(a) 1.72×10^{31} (b) 1.327×10^{25}
(c) 1.327×10^{37} (d) 1.327×10^{45}

(1990)

81. The momentum of a photon of an electromagnetic radiation is 3.3×10^{-29} kg ms^{-1}. What is the frequency of the associated waves?
[$h = 6.6 \times 10^{-34}$ Js ; $c = 3 \times 10^8$ ms^{-1}]

(a) 1.5×10^{13} Hz (b) 7.5×10^{12} Hz
(c) 6×10^3 Hz (d) 3×10^3 Hz

(1990)

82. Ultraviolet radiations of 6.2 eV falls on an aluminium surface. Kinetic energy of fastest electron emitted is (work function = 4.2 eV)

(a) 3.2×10^{-21} J (b) 3.2×10^{-19} J
(c) 7×10^{-25} J (d) 9×10^{-32} J *(1989)*

83. The de Broglie wave corresponding to a particle of mass m and velocity v has a wavelength associated with it

(a) $\frac{h}{mv}$ (b) hmv
(c) $\frac{mh}{v}$ (d) $\frac{m}{hv}$ *(1989)*

84. The energy of a photon of wavelength λ is

(a) $hc\lambda$ (b) $\frac{hc}{\lambda}$
(c) $\frac{\lambda}{hc}$ (d) $\frac{\lambda h}{c}$ *(1988)*

85. Thermions are

(a) protons (b) electrons
(c) photons (d) positrons *(1988)*

86. The threshold frequency for photoelectric effect on sodium corresponds to a wavelength of 5000 Å. Its work function is

(a) 4×10^{-19} J (b) 1 J
(c) 2×10^{-19} J (d) 3×10^{-19} J *(1988)*

Answer Key

1. (a)	**2.** (a, d)	**3.** (a)	**4.** (d)	**5.** (c)	**6.** (b)	**7.** (c)	**8.** (a)	**9.** (d)	**10.** (d)
11. (b)	**12.** (b)	**13.** (c)	**14.** (a)	**15.** (b)	**16.** (d)	**17.** (a)	**18.** (c)	**19.** (d)	**20.** (a)
21. (b)	**22.** (d)	**23.** (a)	**24.** (b)	**25.** (b)	**26.** (c)	**27.** (b)	**28.** (d)	**29.** (a)	**30.** (b)
31. (b)	**32.** (d)	**33.** (b)	**34.** (a)	**35.** (a)	**36.** (c)	**37.** (c)	**38.** (a)	**39.** (a)	**40.** (d)
41. (d)	**42.** (c)	**43.** (a)	**44.** (c)	**45.** (a)	**46.** (b)	**47.** (c)	**48.** (d)	**49.** (d)	**50.** (c)
51. (d)	**52.** (d)	**53.** (b)	**54.** (b)	**55.** (a)	**56.** (a)	**57.** (b)	**58.** (a)	**59.** (a)	**60.** (a)
61. (a)	**62.** (c)	**63.** (d)	**64.** (a)	**65.** (c)	**66.** (c)	**67.** (a)	**68.** (a)	**69.** (c)	**70.** (*)
71. (d)	**72.** (a)	**73.** (b)	**74.** (a)	**75.** (a)	**76.** (a)	**77.** (d)	**78.** (b)	**79.** (c)	**80.** (a)
81. (a)	**82.** (b)	**83.** (a)	**84.** (b)	**85.** (b)	**86.** (a)				

* None is correct.

EXPLANATIONS

1. **(a) :** Kinetic energy of a neutron in thermal equilibrium with heavy water at a temperature T is given as

$$K = \frac{3}{2}kT \quad \text{...(i)}$$

Also momentum (p) is, $p = \sqrt{2mK}$

From eqn. (i)

$$p = \sqrt{2m \cdot \frac{3}{2}kT} = \sqrt{3mkT}$$

Required de-Broglie wavelength is given as

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mkT}}$$

2. **(a, d) :** The maximum kinetic energy is given as

$$K_{max} = h\upsilon - \phi_0 = h\upsilon - h\upsilon_o = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

where λ_0 = threshold wavelength

or $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

Here, $h = 4.14 \times 10^{-15}$ eV s, $c = 3 \times 10^8$ m s^{-1}

$\lambda_o = 3250 \times 10^{-10}$ m = 3250 Å

$\lambda = 2536 \times 10^{-10}$ m = 2536 Å,

$m = 9.1 \times 10^{-31}$ kg

$hc = 4.14 \times 10^{-15}$ eV s $\times 3 \times 10^8$ m s^{-1}

= 12420 eV Å

$$\therefore \frac{1}{2}mv^2 = 12420\left[\frac{1}{2536} - \frac{1}{3250}\right] \text{eV}$$

= 1.076 eV

$$v^2 = \frac{2.152 \text{ eV}}{m} = \frac{2.152 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}$$

$\therefore$ $v \approx 6 \times 10^5$ m s^{-1} = 0.6×10^6 m s^{-1}

Note: Options (a) and (d) are same. So both are correct.

3. **(a) :** Kinetic energy of electrons

$$K = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m} = \frac{h^2}{2m\lambda^2}$$

So, maximum energy of photon = K

$$\frac{hc}{\lambda_0} = \frac{h^2}{2m\lambda^2} \quad \therefore \lambda_0 = \frac{2mc\lambda^2}{h}$$

4. **(d) :** According Einstein's photoelectric equation maximum kinetic energy of photoelectrons,

$KE_{max} = E_v - \phi$

or $2 = 5 - \phi$ $\therefore \phi = 3$ eV

When $E_v = 6$ eV then

$KE_{max} = 6 - 3 = 3$ eV

or $e(V_{cathode} - V_{anode}) = 3$ eV

or $V_{cathode} - V_{anode} = 3\text{ V} = -V_{stopping}$

$\therefore$ $V_{stopping} = -3$ V

5. **(c) :** For electron of energy E,

de-Broglie wavelength, $\lambda_e = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$

For photon of energy, $E = h\upsilon = \frac{hc}{\lambda_p}$

$$\Rightarrow \lambda_p = \frac{hc}{E}$$

$$\therefore \frac{\lambda_e}{\lambda_p} = \frac{h}{\sqrt{2mE}} \times \frac{E}{hc} = \frac{1}{c}\left(\frac{E}{2m}\right)^{1/2}$$

6. **(b) :** According to Einstein's photoelectric equation,

$$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$\therefore$ As per question, $eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ...(i)

$$\frac{eV}{4} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} \quad \text{...(ii)}$$

From equations (i) and (ii), we get

$$\frac{hc}{2\lambda} - \frac{hc}{4\lambda} = \frac{hc}{\lambda_0} - \frac{hc}{4\lambda_0}$$

$$\Rightarrow \frac{hc}{4\lambda} = \frac{3hc}{4\lambda_0} \text{ or } \lambda_0 = 3\lambda$$

7. **(c) :** Let ϕ_0 be the work function of the surface of the material. Then,

According to Einstein's photoelectric equation, the maximum kinetic energy of the emitted photoelectrons in the first case is

$$K_{max_1} = \frac{hc}{\lambda} - \phi_0$$

and that in the second case is

$$K_{max_2} = \frac{hc}{\frac{\lambda}{2}} - \phi_0 = \frac{2hc}{\lambda} - \phi_0$$

But $K_{max_2} = 3K_{max_1}$ (given)

$$\therefore \frac{2hc}{\lambda} - \phi_0 = 3\left(\frac{hc}{\lambda} - \phi_0\right)$$

$$\frac{2hc}{\lambda} - \phi_0 = \frac{3hc}{\lambda} - 3\phi_0$$

$$3\phi_0 - \phi_0 = \frac{3hc}{\lambda} - \frac{2hc}{\lambda}$$

$$2\phi_0 = \frac{hc}{\lambda} \quad \text{or} \quad \phi_0 = \frac{hc}{2\lambda}$$

8. (a) : According to Einstein's photoelectric equation, the maximum kinetic energy of the emitted electron is

$$K_{max} = \frac{hc}{\lambda} - \phi_0$$

where λ is the wavelength of incident light and ϕ_0 is the work function.

Here, $\lambda = 500$ nm, $hc = 1240$ eV nm and $\phi_0 = 2.28$ eV

$$\therefore \quad K_{max} = \frac{1240 \text{ eV nm}}{500 \text{ nm}} - 2.28 \text{ eV}$$

$$= 2.48 \text{ eV} - 2.28 \text{ eV} = 0.2 \text{ eV}$$

The de Broglie wavelength of the emitted electron is

$$\lambda_{min} = \frac{h}{\sqrt{2\, mK_{max}}}$$

where h is the Planck's constant and m is the mass of the electron.

As $h = 6.6 \times 10^{-34}$ J s, $m = 9 \times 10^{-31}$ kg

and $K_{max} = 0.2$ eV $= 0.2 \times 1.6 \times 10^{-19}$ J

$$\therefore \quad \lambda_{min} = \frac{6.6 \times 10^{-34} \text{ J s}}{\sqrt{2(9\times 10^{-31}\text{kg})(0.2\times 1.6 \times 10^{-19}\text{J})}}$$

$$= \frac{6.6}{2.4} \times 10^{-9}\text{m} = 2.8 \times 10^{-9}\text{m}$$

So, $\lambda \geq 2.8 \times 10^{-9}$ m

9. (d) : de-Broglie wavelength, $\lambda = \frac{h}{p}$

or $\lambda \propto \frac{1}{p}$, $\lambda p =$ constant

This represents a rectangular hyperbola.

10. (d)

11. (b) : According to Einstein's photoelectric equation,

The kinetic energy of emitted photoelectrons is

$K = h\upsilon - \phi_0$

where $h\upsilon$ is the energy of incident radiation and ϕ_0 is work function of the metal.

As per question,

$$0.5 \text{ eV} = h\upsilon - \phi_0 \qquad \text{... (i)}$$

$$0.8 \text{ eV} = 1.2h\upsilon - \phi_0 \qquad \text{... (ii)}$$

On solving eqns. (i) and (ii), we get

$\phi_0 = 1.0$ eV

12. (b) : de Broglie wavelength,

$$\lambda = \frac{h}{\sqrt{2mK}} \qquad \text{...(i)}$$

where m is the mass and K is the kinetic energy of the particle.

When kinetic energy of the particle is increased to 16 times, then its de Broglie wavelength becomes,

$$\lambda' = \frac{h}{\sqrt{2m(16K)}} = \frac{1}{4}\frac{\lambda}{\sqrt{2mK}} = \frac{\lambda}{4} \quad \text{(Using (i))}$$

% change in the de Broglie wavelength

$$= \frac{\lambda - \lambda'}{\lambda} \times 100 = \left(1 - \frac{\lambda'}{\lambda}\right) \times 100$$

$$= \left(1 - \frac{1}{4}\right) \times 100 = 75\%$$

13. (c) : Wavelength of an electron of energy E is

$$\lambda_e = \frac{h}{\sqrt{2m_e E}} \qquad \text{...(i)}$$

Wavelength of a photon of same energy E is

$$\lambda_p = \frac{hc}{E} \quad \text{or} \quad E = \frac{hc}{\lambda_p} \qquad \text{...(ii)}$$

Squaring both sides of Eq. (i), we get

$$\lambda_e^2 = \frac{h^2}{2m_e E} \quad \text{or} \quad E = \frac{h^2}{2m_e \lambda_e^2} \qquad \text{...(iii)}$$

Equating (ii) and (iii), we get

$$\frac{hc}{\lambda_p} = \frac{h^2}{2m_e \lambda_e^2} \quad \text{or} \quad \lambda_p = \frac{2m_e c}{h}\lambda_e^2$$

$$\lambda_p \propto \lambda_e^2$$

14. (a) : Work function, $\phi = h\upsilon$

According to Einstein's photoelectric equation

$$\frac{1}{2}mv_{max}^2 = h(2\upsilon) - h\upsilon$$

$$\frac{1}{2}mv_{max}^2 = h\upsilon$$

$$v_{max}^2 = \frac{2h\upsilon}{m} \Rightarrow v_{max} = \sqrt{\frac{2h\upsilon}{m}}$$

15. (b) : By changing the position of source of light from photocell, there will be a change in the intensity of light falling on photocell.

As stopping potential is independent of the intensity of the incident light, hence stopping potential remains same *i.e.*, V_0.

16. (d) : de Broglie wavelength of neutrons in thermal equilibrium at temperature T is

$$\lambda = \frac{h}{\sqrt{2mk_BT}}$$

where m is the mass of the neutron

Here, $m = 1.67 \times 10^{-27}$ kg

$k_B = 1.38 \times 10^{-23}$ J K^{-1}

$h = 6.63 \times 10^{-34}$ J s

$$\therefore \quad \lambda = \frac{6.63\times10^{-34}}{\sqrt{2\times1.67\times10^{-27}\times1.38\times10^{-23}\times T}}$$

$$= \frac{3.08\times10^{-34}\times10^{25}}{\sqrt{T}}\text{m}$$

$$= \frac{30.8\times10^{-10}}{\sqrt{T}} = \frac{30.8}{\sqrt{T}}\text{Å}$$

17. (a) : Energy of a photon,

$$= \frac{(6.6\times10^{-34}\text{ J s})(3\times10^{8}\text{ m s}^{-1})}{0.6\times10^{-6}\text{ m}} = 33 \times 10^{-20}\text{ J}$$

Number of photons emitted per second is

$$N = \frac{\frac{25}{100}P}{E} = \frac{\frac{25}{100}\times200\text{ W}}{33\times10^{-20}\text{ J}} = 1.5\times10^{20}$$

18. (c) : For hydrogen atom, $E_n = -\frac{13.6}{n^2}$ eV

For ground state, $n = 1$

$$\therefore \quad E_1 = -\frac{13.6}{1^2} = -13.6\text{ eV}$$

For first excited state, $n = 2$

$$\therefore \quad E_2 = -\frac{13.6}{2^2} = -3.4\text{ eV}$$

The energy of the emitted photon when an electron jumps from first excited state to ground state is

$h\upsilon = E_2 - E_1 = -3.4$ eV $- (-13.6$ eV$) = 10.2$ eV

Maximum kinetic energy,

$K_{max} = eV_s = e \times 3.57$ V $= 3.57$ eV

According to Einstein's photoelectric equation

$K_{max} = h\upsilon - \phi_0$

where ϕ_0 is the work function and $h\upsilon$ is the incident energy

$\phi_0 = h\upsilon - K_{max} = 10.2$ eV $- 3.57$ eV $= 6.63$ eV

$$\text{Threshold frequency, } \upsilon_0 = \frac{\phi_0}{h} = \frac{6.63\times1.6\times10^{-19}\text{ J}}{6.63\times10^{-34}\text{ J s}}$$

$= 1.6 \times 10^{15}$ Hz

19. (d) : Radius of the circular path of a charged particle in a magnetic field is given by

$$R = \frac{mv}{Bq} \quad \text{or} \quad mv = RBq$$

Here, $R = 0.83$ cm $= 0.83 \times 10^{-2}$ m

$B = 0.25$ Wb m^{-2}

$q = 2e = 2 \times 1.6 \times 10^{-19}$ C

$\therefore \quad mv = (0.83 \times 10^{-2})(0.25)(2 \times 1.6 \times 10^{-19})$

de Broglie wavelength,

$$\lambda = \frac{h}{mv} = \frac{6.6\times10^{-34}}{0.83\times10^{-2}\times0.25\times2\times1.6\times10^{-19}}$$

$= 0.01$ Å

20. (a) : de Broglie wavelength associated with an electron is

$$\lambda = \frac{h}{P} \quad \text{or} \quad P = \frac{h}{\lambda}$$

$$\therefore \quad \frac{\Delta P}{P} = -\frac{\Delta\lambda}{\lambda}$$

$$\frac{P}{P_{\text{initial}}} = \frac{0.5}{100}$$

$P_{\text{initial}} = 200P$

21. (b) : According to Einstein's photoelectric equation

$$\frac{1}{2}mv_{\max}^2 = h\upsilon - \phi_0$$

where $\frac{1}{2}mv_{\max}^2$ is the maximum kinetic energy of the emitted electrons, $h\upsilon$ is the incident energy and ϕ_0 is the work function of the metal.

$$\therefore \quad \frac{1}{2}mv_{\max_1}^2 = 1\text{ eV} - 0.5\text{ eV} = 0.5\text{ eV} \quad \text{...(i)}$$

$$\text{and} \quad \frac{1}{2}mv_{\max_2}^2 = 2.5\text{ eV} - 0.5\text{ eV} = 2\text{ eV} \quad \text{...(ii)}$$

Divide (i) and (ii), we get

$$\frac{v_{\max_1}^2}{v_{\max_2}^2} = \frac{0.5}{2}$$

$$\frac{v_{\max_1}}{v_{\max_2}} = \sqrt{\frac{0.5}{2}} = \frac{1}{2}$$

22. (d) : According to Einstein's photoelectric equation

$$K_{max} = h\upsilon - h\upsilon_0$$

Since K_{max} is +ve, the photoelectric emission occurs only if

$h\upsilon > h\upsilon_0$ or $\upsilon > \upsilon_0$

The photoelectric emission occurs only when the incident light has more than a certain minimum frequency. This minimum frequency is called threshold frequency.

23. (a)

24. (b) : Here, work function, $\phi_0 = 0.5$ eV

According to Einstein's photoelectric equation

Maximum kinetic energy of the emitted electrons = Incident photon energy – Work function

$\therefore \quad K_{max_1} = 1 \text{ eV} - 0.5 \text{ eV} = 0.5 \text{ eV} \quad \text{...(i)}$

and $K_{max_2} = 2.5 \text{ eV} - 0.5 \text{ eV} = 2 \text{ eV} \quad \text{...(ii)}$

Divide (i) by (ii), we get

$$\frac{K_{max_1}}{K_{max_2}} = \frac{0.5 \text{ eV}}{2 \text{ eV}} = \frac{1}{4}$$

$$\frac{\frac{1}{2}mv^2_{max_1}}{\frac{1}{2}mv^2_{max_2}} = \frac{1}{4} \quad \text{or} \quad \frac{v_{max_1}}{v_{max_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

25. (b) : The de Broglie wavelength λ associated with the electrons is

$$\lambda = \frac{1.227}{\sqrt{V}} \text{ nm}$$

where V is the accelerating potential in volts.

or $\quad \lambda \propto \frac{1}{\sqrt{V}}$

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{100 \times 10^3}{25 \times 10^3}} = 2 \text{ or } \lambda_2 = \frac{\lambda_1}{2}$$

26. (c) : The stopping potential V_s is related to the maximum kinetic energy of the emitted electrons K_{max} through the relation

$K_{max} = eV_s$

$0.5 \text{ eV} = eV_s \quad \text{or} \quad V_s = 0.5 \text{ V}$

27. (b) : According to Einstein's photoelectric equation

$eV_0 = h\upsilon - h\upsilon_0$

where, υ = Incident frequency

υ_0 = Threshold frequency

V_0 = Cut-off or stopping potential

or $\quad V_0 = \frac{h}{e}(\upsilon - \upsilon_0)$

Substituting the given values, we get

$$V_0 = \frac{6.63 \times 10^{-34}(8.2 \times 10^{14} - 3.3 \times 10^{14})}{1.6 \times 10^{-19}} \approx 2 \text{ V}$$

28. (d) : When a beam of cathode rays (or electrons) are subjected to crossed electric (E) and magnetic (B) fields, the beam is not deflected, if

Force on electron due to magnetic field = Force on electron due to electric field

$Bev = eE$

or $\quad v = \frac{E}{B} \quad \text{...(i)}$

If V is the potential difference between the anode and the cathode, then

$\therefore \quad \frac{1}{2}mv^2 = eV$

$\frac{e}{m} = \frac{v^2}{2V} \quad \text{...(ii)}$

Substituting the value of v from equation (i) in equation (ii), we get

$$\frac{e}{m} = \frac{E^2}{2VB^2}$$

Specific charge of the cathode rays $\frac{e}{m} = \frac{E^2}{2VB^2}$

29. (a) : For a source S_1,

Wavelength, $\lambda_1 = 5000$ Å

Number of photons emitted per second, $N_1 = 10^{15}$

Energy of each photon, $E_1 = \frac{hc}{\lambda_1}$

Power of source S_1, $P_1 = E_1N_1 = \frac{N_1hc}{\lambda_1}$

For a source S_2,

Wavelength, $\lambda_2 = 5100$ Å

Number of photons emitted per second,

$N_2 = 1.02 \times 10^{15}$

Energy of each photon, $E_2 = \frac{hc}{\lambda_2}$

Power of source S_2, $P_2 = N_2E_2 = \frac{N_2hc}{\lambda_2}$

$$\therefore \quad \frac{\text{Power of } S_2}{\text{Power of } S_1} = \frac{P_2}{P_1} = \frac{\frac{N_2hc}{\lambda_2}}{\frac{N_1hc}{\lambda_1}} = \frac{N_2\lambda_1}{N_1\lambda_2}$$

$$= \frac{(1.02 \times 10^{15} \text{ photons/s}) \times (5000 \text{ Å})}{(10^{15} \text{ photons/s}) \times (5100 \text{ Å})} = \frac{51}{51} = 1$$

30. (b) : Here,

Incident wavelength, $\lambda = 200$ nm

Work function, $\phi_0 = 5.01$ eV

According to Einstein's photoelectric equation

$eV_s = h\upsilon - \phi_0$

$eV_s = \frac{hc}{\lambda} - \phi_0$

where V_s is the stopping potential

$$eV_s = \frac{(1240\text{ eV nm})}{(200\text{ nm})} - 5.01\text{ eV}$$
$$= 6.2\text{ eV} - 5.01\text{ eV} = 1.2\text{ eV}$$

Stopping potential, $V_s = 1.2$ V

The potential difference that must be applied to stop photoelectrons $= -V_s = -1.2$ V

31. (b) : The number of photoelectrons ejected is directly proportional to the intensity of incident light. Maximum kinetic energy is independent of intensity of incident light but depends upon the frequency of light. Hence option (b) is correct.

32. (d) : Energy released when electron in the atom jumps from excited state ($n = 3$) to ground state ($n = 1$) is

$$E = h\upsilon = E_3 - E_1 = \frac{-13.6}{3^2} - \left(\frac{-13.6}{1^2}\right)$$
$$= \frac{-13.6}{9} + 13.6 = 12.1\text{ eV}$$

Therefore, stopping potential

$$eV_0 = h\upsilon - \phi_0$$
$$= 12.1 - 5.1 \quad [\because \text{work function } \phi_0 = 5.1]$$
$$V_0 = 7\text{ V}$$

33. (b) : The number of photoelectrons decide the photocurrent. Assuming that the number of electrons emitted depends on the number of photons incident, the number of photoelectrons depend on the intensity of light.

34. (a)

35. (a) : $\lambda = 6670$ Å

$$E \text{ of a photon} = \frac{12400\text{ eVÅ}}{6670\text{ Å}} = \frac{12400}{6670} \times 1.6 \times 10^{-19}\text{ J.}$$

Energy emitted per second, power $P = 9 \times 10^{-3}$ J

$$\therefore \quad \text{Number of photons incident} = \frac{\text{Power}}{\text{Energy}} = \frac{P}{E}$$
$$= \frac{9 \times 10^{-3} \times 6670}{12400 \times 1.6 \times 10^{-19}} = 3 \times 10^{16}.$$

36. (c) : $W_{ex} = 6.2$ eV.

$K_{max} = 5$ eV; $\therefore$ $h\upsilon = 11.2$ eV

$$\therefore \quad \lambda = \frac{hc}{E} = \frac{12400\text{ eV.Å}}{11.2\text{ eV}} = 1107\text{ Å}$$

This wavelength is in the ultraviolet region.

37. (c) : $\lambda = \dfrac{h}{10^{-6}\text{ kg} \times v}$

$$= \frac{h}{9.1 \times 10^{-31}\text{ kg} \times 3 \times 10^{6}\text{ m/s}}$$

$\therefore$ $v = 2.7 \times 10^{-18}$ m/s.

38. (a) : Collisions of the charged particles with the atoms in the gas.

39. (a) : Electron travelling in a magnetic field perpendicular to its velocity - circular path.

40. (d) : Power of monochromatic light beam is $P = Nh\upsilon$ where N is the number of photons emitted per second.

Power $P = 2 \times 10^{-3}$ W

Energy of one photon $E = h\upsilon$

$= 6.63 \times 10^{-34} \times 6 \times 10^{14}$ J

Number of photons emitted per second,

$N = P/E$

$$= \frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}} = 0.05 \times 10^{17} = 5 \times 10^{15}.$$

41. (d) : For a light source of power P watt, the intensity at a distance d is given by

$$I = \frac{P}{4\pi d^2}$$

where we assume light to spread out uniformly in all directions *i.e.* it is a spherical source.

$$\therefore \quad I \propto \frac{1}{d^2} \quad \text{or} \quad \frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$$

$$\text{or,} \quad \frac{I_1}{I_2} = \left(\frac{1}{0.5}\right)^2 \quad \text{or,} \quad \frac{I_1}{I_2} = 4 \quad \text{or,} \quad I_2 = \frac{I_1}{4}.$$

In a photoelectric emission, the number of photoelectrons liberated per second from a photosensitive metallic surface is proportional to the intensity of the light. When a intensity of source is reduced by a factor of four, the number of photoelectrons is also reduced by a factor of 4.

42. (c) : The photoelectric current is directly proportional to the intensity of illumination. Therefore a change in the intensity of the incident radiation will change the photocurrent also.

43. (a) : Let K and K' be the maximum kinetic energy of photoelectrons for incident light of frequency υ and 2υ respectively.

According to Einstein's photoelectric equation,

$K = h\upsilon - E_0$ ... (i)

and $K' = h(2\upsilon) - E_0$ ... (ii)

$= 2h\upsilon - E_0 = h\upsilon + h\upsilon - E_0$

$K' = h\upsilon + K$ [using (i)]

44. (c)

45. (a) : Energy of photon E = 1 MeV

Momentum of photon $p = E/c$

$$\therefore \; p = \frac{E}{c} = \frac{1\times10^6\times1.6\times10^{-19}\text{ J}}{3\times10^8\text{ ms}^{-1}} = 0.53\times10^{-21}$$

$$\approx 5\times10^{-22}\text{ kg m/s.}$$

46. (b)

47. (c) : K.E. = $h\upsilon - W$

$$i.e. \; \frac{1}{2}mv^2{}_{\max} = h\upsilon - W$$

$$\Rightarrow \frac{1}{2}m\times(4\times10^6)^2 = 2h\upsilon_0 - h\upsilon_0$$

$$\text{or, } \frac{1}{2}m\times(4\times10^6)^2 = h\upsilon_0$$

Another case, $2h\upsilon_0 \rightarrow 5h\upsilon_0$

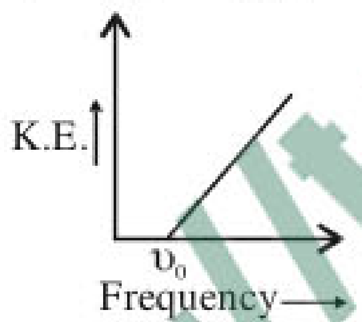
$$\frac{1}{2}mv^2_{\max} = 4h\upsilon_0$$

$$\Rightarrow \frac{1}{2}mv^2_{\max} = 4\times\frac{1}{2}\times m\times(4\times10^6)^2$$

$$\Rightarrow v^2_{\max} = 64\times10^{12} \;\Rightarrow\; v_{\max} = 8\times10^6\text{ m/s.}$$

48. (d) : The maximum kinetic energy of photoelectron ejected is given by

K.E. = $h\upsilon - W = h\upsilon - h\upsilon_0$



where work function depends on the type of material. If the frequency of incident radiation is greater than υ_0 only then the ejection of photoelectrons start. After that as frequency increases kinetic energy also increases.

49. (d) : Photoelectric current $I \propto$ intensity of light

$$\text{and intensity} \propto \frac{1}{(\text{distance})^2}$$

$$\therefore \; I \propto \frac{1}{(\text{distance})^2}.$$

50. (c)

51. (d) : The value of Planck's constant is 6.63×10^{-34} J-sec.

52. (d) : de Broglie wavelength for a particle is given by $\lambda = \frac{h}{p} = \frac{h}{mv}$, where m, v and p are the mass, velocity and momentum respectively. h is Planck's constant. Now, since all the particles are moving with same velocity, the particle with least mass will have maximum de-Broglie wavelength. Out of the given four particles (proton, α-particles, *i.e.* He nucleus and β-particles, *i.e.* electrons) β-particles has the lowest mass and therefore it has maximum wavelength.

53. (b)

54. (b) : Cathode rays are basically negatively charged particles (electrons). If the cathode rays are allowed to pass between two plates kept at a difference of potential, the rays are found to be deflected from the rectilinear path. The direction of deflection shows that the rays carry negative charges.

55. (a)

56. (a) : $eE = evB \quad \therefore \; v = \frac{|E|}{|B|}$

57. (b) : Intensity becomes 4 times. So number increases.

58. (a) **59. (a)**

60. (a) : K.E. = $1.6\times10^{-19}\times1 = 1$ eV.

61. (a) : $\phi = h\upsilon = \frac{hc}{\lambda}$

$$\Rightarrow \lambda = \frac{hc}{\phi} = \frac{1242\text{ eV. nm}}{4.125} \approx 3000\text{ Å}$$

62. (c) : If the intensity of light of a given frequency is increased, then the number of photons striking the surface per second will increase in the same ratio. This increased number of photons strikes more electrons of metals and hence number of photolectrons emitted through the surface increase and hence photoelectric current increases.

63. (d) : According to Einstein's photoelectric equation,

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - W_0 \quad \text{or,} \quad \frac{hc}{\lambda} = \frac{1}{2}mv^2 + W_0$$

$$\text{and } \frac{1}{2}mv_1{}^2 = \frac{hc}{3\lambda/4} - W_0 = \frac{4}{3}\left(\frac{1}{2}mv^2 + W_0\right) - W_0$$

So, v_1 is greater than $v(4/3)^{1/2}$.

64. (a) : Since the emission of photoelectrons is directly proportional to the intensity of the incident light, therefore photocurrent increases with the intensity of light.

65. (c) : Potential difference (V) = 100 volts.

Kinetic energy of an electron (K.E.)

$= eV = (1.6 \times 10^{-19}) \times 100 = 1.6 \times 10^{-17}$ joule.

66. (c) : Kinetic energy $(E) = 100$ eV;
Mass of electron $(m) = 9.1 \times 10^{-31}$ kg;
1 eV $= 1.6 \times 10^{-19}$ J and
Planck's constant $(h) = 6.6 \times 10^{-34}$ J-s.
Energy of an electron $(E) = 100 \times (1.6 \times 10^{-19})$ J

or $\lambda = \dfrac{h}{\sqrt{2mE}} = \dfrac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times100\times1.6\times10^{-19}}}$

$= 1.2 \times 10^{-10}$ m $= 1.2$ Å.

67. (a)

68. (a) : The kinetic energy of an electron

$\dfrac{1}{2}\times mv^2 = eV$

or final velocity of electron $(v) = \sqrt{\dfrac{2eV}{m}}$.

69. (c) : Energy of the photon $E = \dfrac{hc}{\lambda}$ or $\lambda = \dfrac{hc}{E}$, where λ is the wavelength.

70. (*) : The velocity of a photon in vacuum is a constant. $c = \upsilon\lambda$. But c = constant and one cannot say that it is proportional to υ or λ but only $c = \upsilon\lambda$. In media, for a particular medium, υ remain the same, velocity changes. Therefore λ changes. The question is wrong.

71. (d) : Momentum of electrons $(p_e) = \sqrt{2meV}$ and momentum for proton $(p_p) = \sqrt{2MeV}$

Therefore, $\dfrac{\lambda_p}{\lambda_e} = \dfrac{h/p_p}{h/p_e} = \dfrac{p_e}{p_p} = \dfrac{\sqrt{2meV}}{\sqrt{2MeV}} = \sqrt{\left(\dfrac{m}{M}\right)}$.

Therefore $\lambda_p = \lambda\sqrt{\left(\dfrac{m}{M}\right)}$

72. (a) : Wavelength $(\lambda) = \dfrac{h}{mv} = \dfrac{h}{p}$. Therefore for same wavelength of electrons and photons, the momentum should be same.

73. (b) : $W_0 = \dfrac{hc}{\lambda_0}$ or $W_0 \propto \dfrac{1}{\lambda_0}$;

$\Rightarrow \dfrac{W_1}{W_2} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{600}{300} = 2$

74. (a) : Photoelectric current is directly proportional to the intensity of incident light.

75. (a) : Momentum of the photon $= \dfrac{h\upsilon}{c}$

76. (a) : The work function has no effect on photoelectric current so long as $h\upsilon > W_0$. The photoelectric current is proportional to the intensity of incident light. Since there is no change in the intensity of light, hence $I_1 = I_2$.

77. (d) : $h\upsilon = W + \dfrac{1}{2}mv^2$ or $\dfrac{hc}{\lambda} = W + \dfrac{1}{2}mv^2$

Here $\lambda = 3000$ Å $= 3000 \times 10^{-10}$ m
and $W = 1$ eV $= 1.6 \times 10^{-19}$ joule

$\therefore \dfrac{(6.6\times10^{-34})(3\times10^8)}{3000\times10^{-10}}$

$= (1.6\times10^{-19}) + \dfrac{1}{2}\times(9.1\times10^{-31})v^2$

Solving we get $v \cong 10^6$ m/s

78. (b) : Here, $\dfrac{hc}{\lambda} = 10^3$ eV and $h\upsilon = 10^6$ eV

Hence, $\upsilon = \dfrac{10^3 c}{\lambda} = \dfrac{10^3\times3\times10^8}{1.24\times10^{-9}}$

$= 2.4 \times 10^{20}$ Hz

79. (c) : $m = \dfrac{m_0}{\sqrt{1-\dfrac{v^2}{c^2}}} = \dfrac{m_0}{\sqrt{\dfrac{c^2-(0.8c)^2}{c^2}}} = \dfrac{5m_0}{3}$

80. (a) : No. of photons emitted per sec,

$n = \dfrac{\text{Power}}{\text{Energy of photon}}$

$= \dfrac{P}{h\upsilon} = \dfrac{10000}{6.6\times10^{-34}\times880\times10^3} = 1.72 \times 10^{31}$

81. (a) : Momentum of the photon $= \dfrac{h\upsilon}{c}$

$\Rightarrow \dfrac{c}{\upsilon} = \dfrac{h}{p} = \lambda$

$\upsilon = \dfrac{c}{\lambda} = \dfrac{cp}{h} = 3\times10^8\times\dfrac{3.3\times10^{-29}}{6.6\times10^{-34}}$

$= 1.5 \times 10^{13}$ Hz

where, υ = frequency of radiation

82. (b) : Kinetic energy of fastest electron

$= E - W_0 = 6.2 - 4.2 = 2.0$ eV
$= 2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ J

83. (a) : de Broglie wavelength, $\lambda = \dfrac{h}{p} = \dfrac{h}{mv}$.

84. (b) : Energy of a photon $E = h\upsilon = \dfrac{hc}{\lambda}$.

85. (b) : When a metal is heated, electrons are ejected out of it, which are called thermions.

86. (a) : $W_0 = \dfrac{hc}{\lambda_0}$

$= \dfrac{6.63\times10^{-34}\times3\times10^8}{5000\times10^{-10}} = 4\times10^{-19}$ J

Chapter 20

Atoms and Nuclei

1. Radioactive material 'A' has decay constant '8λ' and material 'B' has decay constant 'λ'. Initially they have same number of nuclei. After what time, the ratio of number of nuclei of material 'B' to that 'A' will be $\frac{1}{e}$?

(a) $\frac{1}{7\lambda}$ (b) $\frac{1}{8\lambda}$ (c) $\frac{1}{9\lambda}$ (d) $\frac{1}{\lambda}$

(NEET 2017)

2. The ratio of wavelengths of the last line of Balmer series and the last line of Lyman series is

(a) 1 (b) 4
(c) 0.5 (d) 2 *(NEET 2017)*

3. If an electron in a hydrogen atom jumps from the 3rd orbit to the 2nd orbit, it emits a photon of wavelength λ. When it jumps from the 4th orbit to the 3rd orbit, the corresponding wavelength of the photon will be

(a) $\frac{16}{25}\lambda$ (b) $\frac{9}{16}\lambda$ (c) $\frac{20}{7}\lambda$ (d) $\frac{20}{13}\lambda$

(NEET-II 2016)

4. The half-life of a radioactive substance is 30 minutes. The time (in minutes) taken between 40% decay and 85% decay of the same radioactive substance is

(a) 15 (b) 30 (c) 45 (d) 60

(NEET-II 2016)

5. Given the value of Rydberg constant is 10^7 m^{-1}, the wave number of the last line of the Balmer series in hydrogen spectrum will be

(a) $0.25 \times 10^7\ \text{m}^{-1}$ (b) $2.5 \times 10^7\ \text{m}^{-1}$
(c) $0.025 \times 10^4\ \text{m}^{-1}$ (d) $0.5 \times 10^7\ \text{m}^{-1}$

(NEET-I 2016)

6. When an α-particle of mass m moving with velocity v bombards on a heavy nucleus of charge Ze, its distance of closest approach from the nucleus depends on m as

(a) $\frac{1}{m^2}$ (b) m (c) $\frac{1}{m}$ (d) $\frac{1}{\sqrt{m}}$

(NEET-I 2016)

7. A nucleus of uranium decays at rest into nuclei of thorium and helium. Then

(a) The helium nucleus has more momentum than the thorium nucleus.
(b) The helium nucleus has less kinetic energy than the thorium nucleus.
(c) The helium nucleus has more kinetic energy than the thorium nucleus.
(d) The helium nucleus has less momentum than the thorium nucleus.

(2015)

8. In the spectrum of hydrogen, the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series is

(a) $\frac{27}{5}$ (b) $\frac{5}{27}$ (c) $\frac{4}{9}$ (d) $\frac{9}{4}$

(2015)

9. If radius of the $^{27}_{13}\text{Al}$ nucleus is taken to be R_{Al}, then the radius of $^{125}_{53}\text{Te}$ nucleus is nearly

(a) $\frac{3}{5}R_{\text{Al}}$ (b) $\left(\frac{13}{53}\right)^{1/3} R_{\text{Al}}$

(c) $\left(\frac{53}{13}\right)^{1/3} R_{\text{Al}}$ (d) $\frac{5}{3}R_{\text{Al}}$

(2015 Cancelled)

10. Consider 3rd orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given $K = 9 \times 10^9$ constant, $Z = 2$ and h (Planck's Constant) $= 6.6 \times 10^{-34}$ J s]

(a) 0.73×10^6 m/s (b) 3.0×10^8 m/s
(c) 2.92×10^6 m/s (d) 1.46×10^6 m/s

(2015 Cancelled)

11. Hydrogen atom in ground state is excited by a monochromatic radiation of $\lambda = 975$ Å. Number of spectral lines in the resulting spectrum emitted will be

(a) 3 (b) 2 (c) 6 (d)0 10

(2014)

12. The binding energy per nucleon of and nuclei are 5.60 MeV and 7.06 MeV respectively. In the nuclear reaction

$$^7_3\text{Li} + ^1_1\text{H} \rightarrow ^4_2\text{He} + ^4_2\text{He} + Q$$

the value of energy Q released is
(a) 19.6 MeV (b) –2.4 MeV
(c) 8.4 MeV (d) 17.3 MeV
(2014)

13. A radioisotope X with a half life 1.4×10^9 years decays to Y which is stable. A sample of the rock from a cave was found to contain X and Y in the ratio 1 : 7. The age of the rock is
(a) 1.96×10^9 years (b) 3.92×10^9 years
(c) 4.20×10^9 years (d) 8.40×10^9 years
(2014)

14. Ratio of longest wave lengths corresponding to Lyman and Balmer series in hydrogen spectrum is
(a) $\frac{7}{29}$ (b) $\frac{9}{31}$ (c) $\frac{5}{27}$ (d) $\frac{3}{23}$
(NEET 2013)

15. A certain mass of Hydrogen is changed to Helium by the process of fusion. The mass defect in fusion reaction is 0.02866 u. The energy liberated per u is (given 1 u = 931 MeV)
(a) 6.675 MeV (b) 13.35 MeV
(c) 2.67 MeV (d) 26.7 MeV
(NEET 2013)

16. The half life of a radioactive isotope 'X' is 20 years. It decays to another element 'Y' which is stable. The two elements 'X' and 'Y' were found to be in the ratio 1 : 7 in a sample of a given rock. The age of the rock is estimated to be
(a) 80 years (b) 100 years
(c) 40 years (d) 60 years
(NEET 2013)

17. How does the Binding Energy per nucleon vary with the increase in the number of nucleons?
(a) Decrease continuously with mass number.
(b) First decreases and then increases with increase in mass number.
(c) First increases and then decreases with increase in mass number.
(d) Increases continuously with mass number. *(Karnataka NEET 2013)*

18. An electron in hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are principal quantum numbers of the two states. Assuming Bohr's model to be valid, the time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are
(a) $n_1 = 6$ and $n_2 = 2$ (b) $n_1 = 8$ and $n_2 = 1$
(c) $n_1 = 8$ and $n_2 = 2$ (d) $n_1 = 4$ and $n_2 = 2$
(Karnataka NEET 2013)

19. α-particles, β-particles and γ-rays are all having same energy. Their penetrating power in a given medium in increasing order will be
(a) γ, α, β (b) α, β, γ
(c) β, α, γ (d) β, γ, α
(Karnataka NEET 2013)

20. Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelengths $\lambda_1 : \lambda_2$ emitted in the two cases is
(a) $\frac{7}{5}$ (b) $\frac{27}{20}$ (c) $\frac{27}{5}$ (d) $\frac{20}{7}$
(2012)

21. If the nuclear radius of ^{27}Al is 3.6 fermi, the approximate nuclear radius of ^{64}Cu in fermi is
(a) 2.4 (b) 1.2 (c) 4.8 (d) 3.6
(2012)

22. A mixture consists of two radioactive materials A_1 and A_2 with half lives of 20 s and 10 s respectively. Initially the mixture has 40 g of A_1 and 160 g of A_2. The amount of the two in the mixture will become equal after
(a) 60 s (b) 80 s (c) 20 s (d) 40 s
(2012)

23. An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be
(a) $\frac{24hR}{25m}$ (b) $\frac{25hR}{24m}$
(c) $\frac{25m}{24hR}$ (d) $\frac{24m}{25hR}$ *(2012)*
(m is the mass of the electron, R, Rydberg constant and h Planck's constant)

24. The transition from the state $n = 3$ to $n = 1$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(a) $2 \rightarrow 1$ (b) $3 \rightarrow 2$
(c) $4 \rightarrow 2$ (d) $4 \rightarrow 3$
(Mains 2012)

25. The half life of a radioactive nucleus is 50 days. The time interval $(t_2 - t_1)$ between the time t_2 when $\frac{2}{3}$ of it has decayed and the time t_1 when $\frac{1}{3}$ of it had decayed is
(a) 30 days (b) 50 days
(c) 60 days (d) 15 days
(Mains 2012)

26. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is
(a) 3 (b) 4
(c) 1 (d) 2 *(2011)*

27. The half life of a radioactive isotope X is 50 years. It decays to another element Y which is stable. The two elements X and Y were found to be in the ratio of 1 : 15 in a sample of a given rock. The age of the rock was estimated to be
(a) 150 years (b) 200 years
(c) 250 years (d) 100 years *(2011)*

28. The power obtained in a reactor using U^{235} disintegration is 1000 kW. The mass decay of U^{235} per hour is
(a) 10 microgram (b) 20 microgram
(c) 40 microgram (d) 1 microgram
(2011)

29. A radioactive nucleus of mass M emits a photon of frequency υ and the nucleus recoils. The recoil energy will be
(a) $Mc^2 - h\upsilon$ (b) $h^2\upsilon^2/2Mc^2$
(c) zero (d) $h\upsilon$ *(2011)*

30. A nucleus ^m_nX emits one α particle and two β^- particles. The resulting nucleus is
(a) $^{m-6}_{n-4}Z$ (b) $^{m-6}_{n}Z$
(c) $^{m-4}_{n}X$ (d) $^{m-4}_{n-2}Y$ *(2011)*

31. Fusion reaction takes place at high temperature because
(a) nuclei break up at high temperature
(b) atoms get ionised at high temperature
(c) kinetic energy is high enough to overcome the coulomb repulsion between nuclei
(d) molecules break up at high temperature
(2011)

32. An electron in the hydrogen atom jumps from excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10 V, then the value of n is
(a) 2 (b) 3
(c) 4 (d) 5 *(Mains 2011)*

33. Two radioactive nuclei P and Q, in a given sample decay into a stable nucleus R. At time $t = 0$, number of P species are $4\,N_0$ and that of Q are N_0. Half-life of P (for conversion to R) is 1 minute where as that of Q is 2 minutes. Initially there are no nuclei of R present in the sample. When number of nuclei of P and Q are equal, the number of nuclei of R present in the sample would be
(a) $2\,N_0$ (b) $3\,N_0$ (c) $\frac{9N_0}{2}$ (d) $\frac{5N_0}{2}$
(Mains 2011)

34. Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model?
(a) 0.65 eV (b) 1.9 eV
(c) 11.1 eV (d) 13.6 eV
(Mains 2011)

35. The mass of a ^7_3Li nucleus is 0.042 u less than the sum of the masses of all its nucleons. The binding energy per nucleon of ^7_3Li nucleus is nearly
(a) 46 MeV (b) 5.6 MeV
(c) 3.9 MeV (d) 23 MeV *(2010)*

36. The activity of a radioactive sample is measured as N_0 counts per minute at $t = 0$ and N_0/e counts per minute at $t = 5$ minutes. The time (in minutes) at which the activity reduces to half its value is
(a) $\log_e \frac{2}{5}$ (b) $\frac{5}{\log_e 2}$
(c) $5\log_{10} 2$ (d) $5\log_e 2$ *(2010)*

37. The energy of a hydrogen atom in the ground state is -13.6 eV. The energy of a He^+ ion in the first excited state will be
(a) -13.6 eV (b) -27.2 eV
(c) -54.4 eV (d) -6.8 eV *(2010)*

38. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to

(a) $\frac{1}{Ze}$ (b) v^2 (c) $\frac{1}{m}$ (d) $\frac{1}{v^4}$ *(2010)*

39. The decay constant of a radio isotope is λ. If A_1 and A_2 are its activities at times t_1 and t_2 respectively, the number of nuclei which have decayed during the time $(t_1 - t_2)$

(a) $A_1t_1 - A_2t_2$ (b) $A_1 - A_2$
(c) $(A_1 - A_2)/\lambda$ (d) $\lambda(A_1 - A_2)$ *(Mains 2010)*

40. The binding energy per nucleon in deuterium and helium nuclei are 1.1 MeV and 7.0 MeV, respectively. When two deuterium nuclei fuse to form a helium nucleus the energy released in the fusion is

(a) 23.6 MeV (b) 2.2 MeV
(c) 28.0 MeV (d) 30.2 MeV *(Mains 2010)*

41. In the nuclear decay given below

$${}^{A}_{Z}X \rightarrow {}_{Z+1}^{A}Y \rightarrow {}^{A-4}_{Z-1}B^* \rightarrow {}^{A-4}_{Z-1}B,$$

the particles emitted in the sequence are

(a) γ, β, α (b) β, γ, α
(c) α, β, γ (d) β, α, γ *(2009, 1993)*

42. The number of beta particles emitted by a radioactive substance is twice the number of alpha particles emitted by it. The resulting daughter is an

(a) isomer of parent (b) isotone of parent
(c) isotope of parent (d) isobar of parent *(2009)*

43. In a Rutherford scattering experiment when a projectile of charge z_1 and mass M_1 approaches a target nucleus of charge z_2 and mass M_2, the distance of closest approach is r_0. The energy of the projectile is

(a) directly proportional to z_1z_2
(b) inversely proportional to z_1
(c) directly proportional to mass M_1
(d) directly proportional to $M_1 \times M_2$ *(2009)*

44. The ionization energy of the electron in the hydrogen atom in its ground state is 13.6 eV. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

(a) $n = 3$ to $n = 1$ states
(b) $n = 2$ to $n = 1$ states
(c) $n = 4$ to $n = 3$ states
(d) $n = 3$ to $n = 2$ states *(2009)*

45. If $M(A; Z)$, M_p and M_n denote the masses of the nucleus ${}^{A}_{Z}X$, proton and neutron respectively in units of u (1 u = 931.5 MeV/c^2) and BE represents its bonding energy in MeV, then

(a) $M(A, Z) = ZM_p + (A - Z)M_n - BE$
(b) $M(A, Z) = ZM_p + (A - Z)M_n + BE/c^2$
(c) $M(A, Z) = ZM_p + (A - Z)M_n - BE/c^2$
(d) $M(A, Z) = ZM_p + (A - Z)M_n + BE$ *(2008, 2004)*

46. Two nuclei have their mass numbers in the ratio of 1 : 3. The ratio of their nuclear densities would be

(a) $(3)^{1/3} : 1$ (b) 1 : 1
(c) 1 : 3 (d) 3 : 1 *(2008)*

47. The ground state energy of hydrogen atom is –13.6 eV. When its electron is in the first excited state, its excitation energy is

(a) 10.2 eV (b) 0
(c) 3.4 eV (d) 6.8 eV *(2008)*

48. Two radioactive materials X_1 and X_2 have decay constants 5λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that X_2 will be $1/e$ after a time

(a) $1/4\lambda$ (b) e/λ
(c) λ (d) $\frac{1}{2}\lambda$ *(2008)*

49. Two radioactive substances A and B have decay constants 5λ and λ respectively. At $t = 0$ they have the same number of nuclei. The ratio of number of nuclei of A to those of B will be $(1/e)^2$ after a time interval

(a) 4λ (b) 2λ
(c) $1/2\lambda$ (d) $1/4\lambda$. *(2007)*

50. In a radioactive decay process, the negatively charged emitted β-particles are

(a) the electrons produced as a result of the decay of neutrons inside the nucleus
(b) the electrons produced as a result of collisions between atoms
(c) the electrons orbiting around the nucleus
(d) the electrons present inside the nucleus. *(2007)*

51. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to

(a) $1/R^2$ (b) R^2
(c) R (d) $1/R$. *(2007)*

52. A nucleus ^A_ZX has mass represented by $M(A, Z)$. If M_p and M_n denote the mass of proton and neutron respectively and B.E. the binding energy in MeV, then

(a) B.E. $= [ZM_p + (A - Z)M_n - M(A, Z)]c^2$
(b) B.E. $= [ZM_p + AM_n - M(A, Z)]c^2$
(c) B.E. $= M(A, Z) - ZM_p - (A - Z)M_n$
(d) B.E. $= [M(A, Z) - ZM_p - (A - Z)M_n]c^2$. *(2007)*

53. If the nucleus $^{27}_{13}\text{Al}$ has a nuclear radius of about 3.6 fm, then $^{125}_{32}\text{Te}$ would have its radius approximately as

(a) 9.6 fm (b) 12.0 fm
(c) 4.8 fm (d) 6.0 fm. *(2007)*

54. The total energy of electron in the ground state of hydrogen atom is –13.6 eV. The kinetic energy of an electron in the first excited state is

(a) 6.8 eV (b) 13.6 eV
(c) 1.7 eV (d) 3.4 eV. *(2007)*

55. Ionization potential of hydrogen atom is 13.6 eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

(a) one (b) two
(c) three (d) four. *(2006)*

56. In a radioactive material the activity at time t_1 is R_1 and at a later time t_2, it is R_2. If the decay constant of the material is λ, then

(a) $R_1 = R_2$ (b) $R_1 = R_2e^{-\lambda(t_1-t_2)}$
(c) $R_1 = R_2e^{\lambda(t_1-t_2)}$ (d) $R_1 = R_2(t_2/t_1)$. *(2006)*

57. The binding energy of deuteron is 2.2 MeV and that of ^4_2He is 28 MeV. If two deuterons are fused to form one ^4_2He then the energy released is

(a) 30.2 MeV (b) 25.8 MeV
(c) 23.6 MeV (d) 19.2 MeV. *(2006)*

58. The radius of germanium (Ge) nuclide is measured to be twice the radius of ^9_4Be. The number of nucleons in Ge are

(a) 72 (b) 73
(c) 74 (d) 75. *(2006)*

59. In the reaction $^2_1\text{H} + ^3_1\text{H} \rightarrow ^4_2\text{He} + ^1_0n$, if the binding energies of ^2_1H, ^3_1H and ^4_2He are respectively a, b and c (in MeV), then the energy (in MeV) released in this reaction is

(a) $a + b + c$ (b) $a + b - c$
(c) $c - a - b$ (d) $c + a - b$. *(2005)*

60. The total energy of an electron in the first excited state of hydrogen atom is about – 3.4 eV. Its kinetic energy in this state is

(a) 3.4 eV (b) 6.8 eV
(c) – 3.4 eV (d) – 6.8 eV. *(2005)*

61. Which one of the following pairs of nuclei are isotones?

(a) $_{34}\text{Se}^{74}$, $_{31}\text{Ga}^{71}$ (b) $_{38}\text{Sr}^{84}$, $_{38}\text{Sr}^{86}$
(c) $_{42}\text{Mo}^{92}$, $_{40}\text{Zr}^{92}$ (d) $_{20}\text{Ca}^{40}$, $_{16}\text{S}^{32}$. *(2005)*

62. In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is

(a) equal to 1
(b) greater than 1
(c) less than 1
(d) depends on the mass of the parent nucleus. *(2005)*

63. Energy levels A, B and C of a certain atom corresponding to increasing values of energy *i.e.* $E_A < E_B < E_C$. If λ_1, λ_2 and λ_3 are wavelengths of radiations corresponding to transitions C to B, B to A and C to A respectively, which of the following relations is correct?

(a) $\lambda_3 = \lambda_1 + \lambda_2$ (b) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$
(c) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (d) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$. *(2005, 1990)*

64. Fission of nuclei is possible because the binding energy per nucleon in them

(a) increases with mass number at low mass numbers

(b) decreases with mass number at low mass numbers
(c) increases with mass number at high mass numbers
(d) decreases with mass number at high mass numbers. *(2005)*

65. A nucleus represented by the symbol ${}_Z^AX$ has
(a) Z neutrons and $A - Z$ protons
(b) Z protons and $A - Z$ neutrons
(c) Z protons and A neutrons
(d) A protons and $Z - A$ neutrons *(2004)*

66. If in a nuclear fusion process the masses of the fusing nuclei be m_1 and m_2 and the mass of the resultant nucleus be m_3, then
(a) $m_3 = m_1 + m_2$ (b) $m_3 = |m_1 - m_2|$
(c) $m_3 < (m_1 + m_2)$ (d) $m_3 > (m_1 + m_2)$ *(2004)*

67. The Bohr model of atoms
(a) Assumes that the angular momentum of electrons is quantized.
(b) Uses Einstein's photoelectric equation.
(c) Predicts continuous emission spectra for atoms.
(d) Predicts the same emission spectra for all types of atoms. *(2004)*

68. The half life of radium is about 1600 years. Of 100 g of radium existing now, 25 g will remain unchanged after
(a) 4800 years (b) 6400 years
(c) 2400 years (d) 3200 years *(2004)*

69. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The Coulomb force $\vec{F}$ between the two is
(a) $K\dfrac{e^2}{r^2}\hat{r}$ (b) $-K\dfrac{e^2}{r^3}\hat{r}$
(c) $K\dfrac{e^2}{r^3}\vec{r}$ (d) $-K\dfrac{e^2}{r^3}\vec{r}$
$\left(\text{where } K = \dfrac{1}{4\pi\varepsilon_0}\right)$ *(2003)*

70. Solar energy is mainly caused due to
(a) burning of hydrogen in the oxygen
(b) fission of uranium present in the Sun
(c) fusion of protons during synthesis of heavier elements
(d) gravitational contraction *(2003)*

71. The volume occupied by an atom is greater than the volume of the nucleus by a factor of about
(a) 10^1 (b) 10^5
(c) 10^{10} (d) 10^{15} *(2003)*

72. A sample of radioactive element has a mass of 10 g at an instant $t = 0$. The approximate mass of this element in the sample after two mean lives is
(a) 1.35 g (b) 2.50 g
(c) 3.70 g (d) 6.30 g *(2003)*

73. In which of the following systems will the radius of the first orbit ($n = 1$) be minimum ?
(a) doubly ionized lithium
(b) singly ionized helium
(c) deuterium atom
(d) hydrogen atom *(2003)*

74. The mass of proton is 1.0073 u and that of neutron is 1.0087 u (u = atomic mass unit). The binding energy of ${}_2^4\text{He}$ is
(Given helium nucleus mass ≈ 4.0015 u.)
(a) 0.0305 J (b) 0.0305 erg
(c) 28.4 MeV (d) 0.061 u *(2003)*

75. The mass number of a nucleus is
(a) always less than its atomic number
(b) always more than its atomic number
(c) sometimes equal to its atomic number
(d) sometimes less than and sometimes more than its atomic number *(2003)*

76. A nuclear reaction given by
${}_ZX^A \rightarrow {}_{Z+1}Y^A + {}_{-1}e^0 + \bar{\nu}$ represents
(a) β-decay (b) γ-decay
(c) fusion (d) fission *(2003)*

77. Which of the following are suitable for the fusion process?
(a) light nuclei
(b) heavy nuclei
(c) element lying in the middle of the periodic table
(d) middle elements, which are lying on binding energy curve. *(2002)*

78. A sample of radioactive element containing 4×10^{16} active nuclei. Half life of element is 10 days, then number of decayed nuclei after 30 days
(a) 0.5×10^{16} (b) 2×10^{16}
(c) 3.5×10^{16} (d) 1×10^{16}. *(2002)*

79. A deutron is bombarded on ${}_8O^{16}$ nucleus then α-particle is emitted. The product nucleus is
(a) ${}_7N^{13}$ (b) ${}_5B^{10}$
(c) ${}_4Be^9$ (d) ${}_7N^{14}$. *(2002)*

80. Which rays contain (positive) charged particles?
(a) α-rays (b) β-rays
(c) γ-rays (d) X-rays. *(2001)*

81. $X(n, \alpha)\ {}^7_3\text{Li}$, then X will be
(a) ${}^{10}_5\text{B}$ (b) ${}^9_5\text{B}$
(c) ${}^{11}_4\text{Be}$ (d) ${}^4_2\text{He}$. *(2001)*

82. Half life of a radioactive element is 12.5 hour and its quantity is 256 g. After how much time its quantity will remain 1 g?
(a) 50 hrs (b) 100 hrs
(c) 150 hrs (d) 200 hrs. *(2001)*

83. The interplanar distance in a crystal is 2.8×10^{-8} m. The value of maximum wavelength which can be diffracted
(a) 2.8×10^{-8} m (b) 5.6×10^{-8} m
(c) 1.4×10^{-8} m (d) 7.6×10^{-8} m. *(2001)*

84. The energy of hydrogen atom in n^{th} orbit is E_n then the energy in n^{th} orbit of singly ionised helium atom will be
(a) $4E_n$ (b) $E_n/4$
(c) $2E_n$ (d) $E_n/2$. *(2001)*

85. M_n and M_p represent the mass of neutron and proton respectively. An element having mass M has N neutrons and Z protons, then the correct relation will be
(a) $M < \{N \cdot M_n + Z \cdot M_p\}$
(b) $M > \{N \cdot M_n + Z \cdot M_p\}$
(c) $M = \{N \cdot M_n + Z \cdot M_p\}$
(d) $M = N\ \{M_n + M_p\}$ *(2001)*

86. Energy released in nuclear fission is due to
(a) some mass is converted into energy
(b) total binding energy of fragments is more than the binding energy of parental element
(c) total binding energy of fragments is less than the binding energy of parental element
(d) total binding energy of fragments is equal to the binding energy of parental element. *(2001)*

87. For the given reaction, the particle X is
$${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + X$$
(a) neutron (b) anti neutrino
(c) neutrino (d) proton. *(2000)*

88. Maximum frequency of emission is obtained for the transition
(a) $n = 2$ to $n = 1$ (b) $n = 6$ to $n = 2$
(c) $n = 1$ to $n = 2$ (d) $n = 2$ to $n = 6$. *(2000)*

89. The relation between λ and $T_{1/2}$ as ($T_{1/2} \rightarrow$ half life)
(a) $T_{1/2} = \frac{\ln 2}{\lambda}$ (b) $T_{1/2}\ \ln 2 = \lambda$
(c) $T_{1/2} = \frac{1}{\lambda}$ (d) $(\lambda + T_{1/2}) = \ln 2$. *(2000)*

90. Nuclear fission is best explained by
(a) liquid droplet theory
(b) Yukawa π-meson theory
(c) independent particle model of the nucleus
(d) proton-proton cycle. *(2000)*

91. The life span of atomic hydrogen is
(a) fraction of one second
(b) one year
(c) one hour
(d) one day. *(2000)*

92. When an electron does transition from $n = 4$ to $n = 2$, then emitted line spectrum will be
(a) first line of Lyman series
(b) second line of Balmer series
(c) first line of Paschen series
(d) second line of Paschen series. *(2000)*

93. Alpha particles are
(a) neutrally charged
(b) positron
(c) protons
(d) ionized helium atoms *(1999)*

94. After 1α and 2β-emissions
(a) mass number reduces by 6
(b) mass number reduces by 4
(c) mass number reduces by 2
(d) atomic number remains unchanged *(1999)*

95. Complete the equation for the following fission process

$_{92}U^{235} + _0n^1 \rightarrow _{38}Sr^{90} + ...$

(a) $_{57}X^{142} + 3_0n^1$ (b) $_{54}X^{145} + 3_0n^1$
(c) $_{54}X^{143} + 3_0n^1$ (d) $_{54}X^{142} + _0n^1$ *(1998)*

96. A nucleus $_nX^m$ emits one α and two β particles. The resulting nucleus is

(a) $_{n-4}Z^{m-4}$ (b) $_{n-2}Y^{m-4}$
(c) $_nX^{m-4}$ (d) $_nZ^{m-4}$ *(1998)*

97. Atomic weight of Boron is 10.81 and it has two isotopes $_5B^{10}$ and $_5B^{11}$. Then the ratio of $_5B^{10}$: $_5B^{11}$ in nature would be

(a) 15 : 16 (b) 10 : 11
(c) 19 : 81 (d) 81 : 19 *(1998)*

98. In the Bohr model of a hydrogen atom, the centripetal force is furnished by the coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass and e is the charge on the electron and ε_0 is the vacuum permittivity, the speed of the electron is

(a) $\dfrac{e}{\sqrt{4\pi\varepsilon_0 a_0 m}}$ (b) $\dfrac{e}{\sqrt{\varepsilon_0 a_0 m}}$
(c) 0 (d) $\dfrac{\sqrt{4\pi\varepsilon_0 a_0 m}}{e}$ *(1998)*

99. The 21 cm radiowave emitted by hydrogen in interstellar space is due to the interaction called the hyperfine interaction in atomic hydrogen. The energy of the emitted wave is nearly

(a) 7×10^{-8} joule (b) 1 joule
(c) 10^{-17} joule (d) 10^{-24} joule *(1998)*

100. Half-lives of two radioactive substances A and B are respectively 20 minutes and 40 minutes. Initially the samples of A and B have equal number of nuclei. After 80 minutes the ratio of remaining numbers of A and B nuclei is

(a) 1 : 4 (b) 4 : 1
(c) 1 : 16 (d) 1 : 1 *(1998)*

101. Due to earth's magnetic field, the charged cosmic rays particles

(a) can never reach the pole
(b) can never reach the equator
(c) require greater kinetic energy to reach the equator than pole
(d) require less kinetic energy to reach the equator than pole. *(1997)*

102. Which of the following is used as a moderator in nuclear reaction?

(a) cadmium (b) plutonium
(c) uranium (d) heavy water. *(1997)*

103. The energy of the ground electronic state of hydrogen atom is – 13.6 eV. The energy of the first excited state will be

(a) – 27.2 eV (b) – 52.4 eV
(c) – 3.4 eV (d) – 6.8 eV. *(1997)*

104. When hydrogen atom is in its first excited level, its radius is .... of the Bohr radius.

(a) twice (b) 4 times
(c) same (d) half. *(1997)*

105. The most penetrating radiation out of the following are

(a) β-rays (b) γ-rays
(c) X-rays (d) α-rays. *(1997)*

106. The minimum wavelength of the X-rays produced by electrons accelerated through a potential difference of V volts is directly proportional to

(a) $\dfrac{1}{\sqrt{V}}$ (b) $\dfrac{1}{V}$ (c) $\sqrt{V}$ (d) V^2. *(1996)*

107. The energy of a hydrogen atom in its ground state is – 13.6 eV. The energy of the level corresponding to the quantum number $n = 2$ in the hydrogen atom is

(a) – 0.54 eV (b) – 3.4 eV
(c) – 2.72 eV (d) – 0.85 eV. *(1996)*

108. According to Bohr's principle, the relation between principal quantum number (n) and radius of orbit (r) is

(a) $r \propto \dfrac{1}{n}$ (b) $r \propto \dfrac{1}{n^2}$
(c) $r \propto n$ (d) $r \propto n^2$. *(1996)*

109. A nucleus ruptures into two nuclear parts, which have their velocity ratio equal to 2 : 1. What will be the ratio of their nuclear size (nuclear radius)?

(a) $3^{1/2} : 1$ (b) $1 : 3^{1/2}$
(c) $2^{1/3} : 1$ (d) $1 : 2^{1/3}$. *(1996)*

110. What is the respective number of α and β particles emitted in the following radioactive decay?

$$^{200}X_{90} \rightarrow {}^{168}Y_{80}$$

(a) 8 and 8 (b) 8 and 6
(c) 6 and 8 (d) 6 and 6. *(1995)*

111. The binding energies per nucleon for a deuteron and an α-particle are x_1 and x_2 respectively. The energy Q released in the reaction

$$^2H_1 + {}^2H_1 \rightarrow {}^4He_2 + Q, \text{ is}$$

(a) $4(x_1 + x_2)$ (b) $4(x_2 - x_1)$
(c) $2(x_2 - x_1)$ (d) $2(x_1 + x_2)$. *(1995)*

112. The count rate of a Geiger Muller counter for the radiation of a radioactive material of half-life of 30 minutes decreases to 5 second^{-1} after 2 hours. The initial count rate was

(a) 80 second^{-1} (b) 625 second^{-1}
(c) 20 second^{-1} (d) 25 second^{-1}. *(1995)*

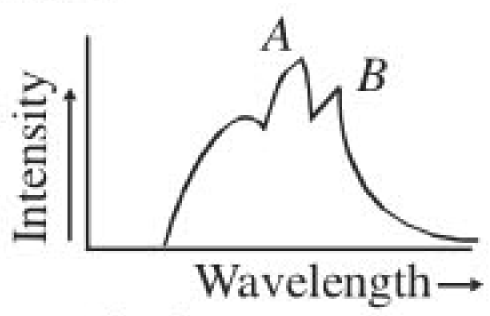
113. An electron makes a transition from orbit $n = 4$ to the orbit $n = 2$ of a hydrogen atom. What is the wavelength of the emitted radiations? (R = Rydberg's constant)

(a) $\frac{16}{4R}$ (b) $\frac{16}{5R}$ (c) $\frac{16}{2R}$ (d) $\frac{16}{3R}$. *(1995)*

114. When a hydrogen atom is raised from the ground state to an excited state,

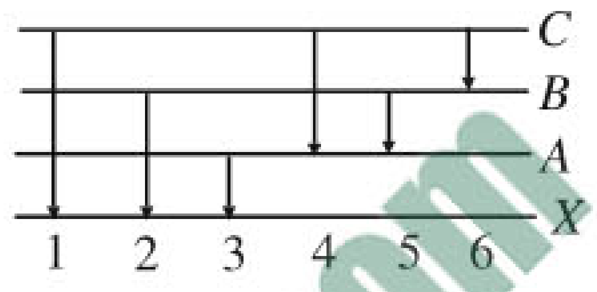
(a) both K.E. and P.E. increase
(b) both K.E. and P.E. decrease
(c) the P.E. decreases and K.E. increases
(d) the P.E. increases and K.E. decreases. *(1995)*

115. The figure represents the observed intensity of X-rays emitted by an X-ray tube, as a function of wavelength. The sharp peaks A and B denote



(a) white radiations
(b) characteristic radiations
(c) band spectrum
(d) continuous spectrum *(1995)*

116. The figure indicates the energy level diagram of an atom and the origin of six spectral lines in emission (*e.g.* line no. 5 arises from the transition from level B to A). Which of the following spectral lines will occur in the absorption spectrum?



(a) 4, 5, 6 (b) 1, 2, 3, 4, 5, 6
(c) 1, 2, 3 (d) 1, 4, 6. *(1995)*

117. The mass number of He is 4 and that of sulphur is 32. The radius of sulphur nucleus is larger than that of helium by the factor of

(a) 4 (b) 2
(c) 8 (d) $\sqrt{8}$. *(1995)*

118. The binding energy per nucleon is maximum in case of

(a) ^4_2He (b) $^{56}_{26}Fe$
(c) $^{141}_{56}Ba$ (d) $^{235}_{92}U$ *(1993)*

119. Which source is associated with a line emission spectrum?

(a) Electric fire (b) Neon street sign
(c) Red traffic light (d) Sun *(1993)*

120. Energy released in the fission of a single $^{235}_{92}U$ nucleus is 200 MeV. The fission rate of $^{235}_{92}U$ filled reactor operating at a power level of 5 W is

(a) $1.56 \times 10^{-10}\ s^{-1}$ (b) $1.56 \times 10^{11}\ s^{-1}$
(c) $1.56 \times 10^{-16}\ s^{-1}$ (d) $1.56 \times 10^{-17}\ s^{-1}$ *(1993)*

121. Hydrogen atoms are excited from ground state of the principle quantum number 4. Then the number of spectral lines observed will be

(a) 3 (b) 6
(c) 5 (d) 2 *(1993)*

122. In terms of Bohr radius a_0, the radius of the second Bohr orbit of a hydrogen atom is given by

(a) $4a_0$ (b) $8a_0$
(c) $\sqrt{2}a_0$ (d) $2a_0$ *(1992)*

123. Solar energy is due to
(a) fusion reaction (b) fission reaction
(c) combustion reaction
(d) chemical reaction *(1992)*

124. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3^{rd} and 4^{th} orbit is
(a) 3.40 eV (b) 1.51 eV
(c) 0.85 eV (d) 0.66 eV *(1992)*

125. The energy equivalent of one atomic mass unit is
(a) 1.6×10^{-19} J (b) 6.02×10^{23} J
(c) 931 MeV (d) 9.31 MeV *(1992)*

126. The mass of α-particle is
(a) less than the sum of masses of two protons and two neutrons
(b) equal to mass of four protons
(c) equal to mass of four neutrons
(d) equal to sum of masses of two protons and two neutrons *(1992)*

127. Of the following pairs of species which one will have the same electronic configuration for both members?
(a) Li^+ and Na^+ (b) He and Ne^+
(c) H and Li (d) C and N^+ *(1992)*

128. The mass density of a nucleus varies with mass number A as
(a) A^2 (b) A
(c) constant (d) $1/A$ *(1992)*

129. The constituents of atomic nuclei are believed to be
(a) neutrons and protons
(b) protons only
(c) electron and protons
(d) electrons, protons and neutrons *(1991)*

130. The half life of radium is 1600 years. The fraction of a sample of radium that would remain after 6400 years
(a) 1/4 (b) 1/2
(c) 1/8 (d) 1/16 *(1991)*

131. In the nucleus of $_{11}Na^{23}$, the number of protons, neutrons and electrons are
(a) 11, 12, 0 (b) 23, 12, 11
(c) 12, 11, 0 (d) 23, 11, 12 *(1991)*

132. The ground state energy of H-atom 13.6 eV. The energy needed to ionize H-atom from its second excited state
(a) 1.51 eV (b) 3.4 eV
(c) 13.6 eV (d) none of these *(1991)*

133. If the nuclear force between two protons, two neutrons and between proton and neutron is denoted by F_{pp}, F_{nn} and F_{pn} respectively, then
(a) $F_{pp} \approx F_{nn} \approx F_{pn}$
(b) $F_{pp} \neq F_{nn}$ and $F_{pp} = F_{nn}$
(c) $F_{pp} = F_{nn} = F_{pn}$
(d) $F_{pp} \neq F_{nn} \neq F_{pn}$ *(1991)*

134. The valence electron in alkali metal is a
(a) f-electron (b) p-electron
(c) s-electron (d) d-electron *(1990)*

135. Consider an electron in the n^{th} orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of de Broglie wavelength λ of that electron as
(a) $(0.529)n\lambda$ (b) $\sqrt{n}\lambda$
(c) $(13.6)\lambda$ (d) $n\lambda$ *(1990)*

136. The nuclei $_6C^{13}$ and $_7N^{14}$ can be described as
(a) isotones
(b) isobars
(c) isotopes of carbon
(d) isotopes of nitrogen *(1990)*

137. Which of the folowing statements is true for nuclear forces?
(a) They obey the inverse square law of distance.
(b) They obey the inverse third power law of distance.
(c) They are short range forces.
(d) they are equal in strength to electromagnetic forces. *(1990)*

138. The ratio of the radii of the nuclei $_{13}Al^{27}$ and $_{52}Te^{125}$ approximately
(a) 6 : 10 (b) 13 : 52
(c) 40 : 177 (d) 14 : 73 *(1990)*

139. The nucleus $_6C^{12}$ absorbs an energetic neutron and emits a beta particle (β). The resulting nucleus is
(a) $_7N^{14}$ (b) $_7N^{13}$
(c) $_5B^{13}$ (d) $_6C^{13}$ *(1990)*

140. A radioactive element has half life period 800 years. After 6400 years what amount will remain?

(a) 1/2 (b) 1/16
(c) 1/8 (d) 1/256 *(1989)*

141. An element A decays into element C by a two step process

$A \rightarrow B + {}_2He^4;\ B \rightarrow C + 2e^-$

Then

(a) A and C are isotopes
(b) A and C are isobars
(c) A and B are isotopes
(d) A and B are isobars *(1989)*

142. Curie is a unit of

(a) energy of gamma rays
(b) half-life
(c) radioactivity
(d) intensity of gamma rays *(1989)*

143. The average binding energy of a nucleon inside an atomic nucleus is about

(a) 8 MeV (b) 8 eV
(c) 8 J (d) 8 erg *(1989)*

144. To explain his theory, Bohr used

(a) conservation of linear momentum
(b) quantisation of angular momentum
(c) conservation of quantum frequency
(d) none of these *(1989)*

145. The atomic number of silicon is 14. Its ground state electron configuration is

(a) $1s^2\ 2s^2\ 2p^2\ 2s^4$ (b) $1s^2\ 2s^2\ 2p^6\ 3s^1\ 3p^3$
(c) $1s^2\ 2s^2\ 2p^8\ 3s^2$ (d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
(1989)

146. A radioactive sample with a half life of 1 month has the label : 'Activity = 2 micro curies on 1 - 8 - 1991'. What would be its activity two months earlier?

(a) 1.0 micro curie (b) 0.5 micro curie
(c) 4 micro curie (d) 8 micro curie
(1988)

147. The nucleus ${}^{115}_{48}Cd$, after two successive β-decay will give

(a) ${}^{115}_{46}Pa$ (b) ${}^{114}_{49}In$
(c) ${}^{113}_{50}Sn$ (d) ${}^{115}_{50}Sn$ *(1988)*

148. The ionisation energy of hydrogen atom is 13.6 eV, the ionisation energy of a singly ionised helium atom would be

(a) 13.6 eV (b) 27.2 eV
(c) 6.8 eV (d) 54.4 eV *(1988)*

Answer Key

1. (*)	**2.** (b)	**3.** (c)	**4.** (d)	**5.** (a)	**6.** (c)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (d)
11. (c)	**12.** (d)	**13.** (c)	**14.** (c)	**15.** (a)	**16.** (d)	**17.** (c)	**18.** (d)	**19.** (b)	**20.** (d)
21. (c)	**22.** (d)	**23.** (a)	**24.** (d)	**25.** (b)	**26.** (d)	**27.** (b)	**28.** (c)	**29.** (b)	**30.** (c)
31. (c)	**32.** (c)	**33.** (c)	**34.** (c)	**35.** (b)	**36.** (d)	**37.** (a)	**38.** (c)	**39.** (c)	**40.** (a)
41. (d)	**42.** (c)	**43.** (a)	**44.** (c)	**45.** (c)	**46.** (b)	**47.** (a)	**48.** (a)	**49.** (c)	**50.** (a)
51. (a)	**52.** (a)	**53.** (d)	**54.** (d)	**55.** (c)	**56.** (b)	**57.** (c)	**58.** (a)	**59.** (c)	**60.** (a)
61. (a)	**62.** (c)	**63.** (b)	**64.** (d)	**65.** (b)	**66.** (c)	**67.** (a)	**68.** (d)	**69.** (d)	**70.** (c)
71. (d)	**72.** (a)	**73.** (a)	**74.** (c)	**75.** (c)	**76.** (a)	**77.** (a)	**78.** (c)	**79.** (d)	**80.** (a)
81. (a)	**82.** (b)	**83.** (b)	**84.** (a)	**85.** (a)	**86.** (a)	**87.** (c)	**88.** (a)	**89.** (a)	**90.** (a)
91. (a)	**92.** (b)	**93.** (d)	**94.** (b,d)	**95.** (c)	**96.** (c)	**97.** (c)	**98.** (a)	**99.** (d)	**100.** (a)
101. (c)	**102.** (d)	**103.** (c)	**104.** (b)	**105.** (b)	**106.** (b)	**107.** (b)	**108.** (d)	**109.** (d)	**110.** (b)
111. (b)	**112.** (a)	**113.** (d)	**114.** (b)	**115.** (b)	**116.** (c)	**117.** (b)	**118.** (b)	**119.** (b)	**120.** (b)
121. (b)	**122.** (a)	**123.** (a)	**124.** (d)	**125.** (c)	**126.** (a)	**127.** (d)	**128.** (c)	**129.** (a)	**130.** (d)
131. (a)	**132.** (a)	**133.** (c)	**134.** (c)	**135.** (d)	**136.** (a)	**137.** (c)	**138.** (a)	**139.** (b)	**140.** (d)
141. (a)	**142.** (c)	**143.** (a)	**144.** (b)	**145.** (d)	**146.** (d)	**147.** (d)	**148.** (d)		

* None is correct.

EXPLANATIONS

1. (*) : The number of radioactive nuclei 'N' at any time t is given as

$N(t) = N_0 e^{-\lambda t}$

where N_0 is number of radioactive nuclei in the sample at some aribitrary time $t = 0$ and λ is the radioactive decay constant.

Given: $\lambda_A = 8\lambda$, $\lambda_B = \lambda$, $N_{0A} = N_{0B} = N_0$

$$\therefore \quad \frac{N_B}{N_A} = \frac{e^{-\lambda t}}{e^{-8\lambda t}}$$

$$\frac{1}{e} = e^{-\lambda t}e^{8\lambda t} = e^{7\lambda t}$$

$$\Rightarrow \; -1 = 7\lambda t \text{ or } t = \frac{-1}{7\lambda}$$

*Negative value of time is not possible.

So given ratio in question should be $\frac{N_B}{N_A} = e$.

2. (b) : The wavelength of last line of Balmer series

$$\frac{1}{\lambda_B} = Rc\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{Rc}{4}$$

The wavelength of last line of Lyman series

$$\frac{1}{\lambda_L} = Rc\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = Rc$$

$$\therefore \quad \frac{l_B}{\lambda_L} = \frac{4}{1} = 4$$

3. (c) : When electron jumps from higher orbit to lower orbit then, wavelength of emitted photon is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\text{so, } \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\text{and } \frac{1}{\lambda'} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{7R}{144}$$

$$\therefore \lambda' = \frac{144}{7} \times \frac{5\lambda}{36} = \frac{20\lambda}{7}$$

4. (d) : N_0 = Nuclei at time $t = 0$

N_1 = Remaining nuclei after 40% decay

$= (1 - 0.4) N_0 = 0.6 N_0$

N_2 = Remaining nuclei after 85% decay

$= (1 - 0.85) N_0 = 0.15 N_0$

$$\therefore \quad \frac{N_2}{N_1} = \frac{0.15N_0}{0.6N_0} = \frac{1}{4} = \left(\frac{1}{2}\right)^2$$

Hence, two half life is required between 40% decay and 85% decay of a radioactive substance.

$\therefore$ Time taken $= 2\tau_{1/2} = 2 \times 30$ min $= 60$ min

5. (a) : Here, $R = 10^7$ m^{-1}

The wave number of the last line of the Balmer series in hydrogen spectrum is given by

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{R}{4} = \frac{10^7}{4} = 0.25 \times 10^7 \text{ m}^{-1}$$

6. (c) : Distance of closest approach when an α-particle of mass m moving with velocity v is bombarded on a heavy nucleus of charge Ze, is given by

$$r_0 = \frac{Ze^2}{\pi\varepsilon_0 mv^2} \quad \therefore \quad r_0 \propto \frac{1}{m}$$

7. (c) : If $\vec{p}_{Th}$ and $\vec{p}_{He}$ are the momenta of thorium and helium nuclei respectively, then according to law of conservation of linear momentum

$$0 = \vec{p}_{Th} + \vec{p}_{He} \quad \text{or} \quad \vec{p}_{Th} = -\vec{p}_{He}$$

–ve sign shows that both are moving in opposite directions.

But in magnitude

$p_{Th} = p_{He}$

If m_{Th} and m_{He} are the masses of thorium and helium nuclei respectively, then

Kinetic energy of thorium nucleus is $K_{Th} = \frac{p_{Th}^2}{2m_{Th}}$

and that of helium nucleus is

$$K_{He} = \frac{p_{He}^2}{2m_{He}}$$

$$\therefore \quad \frac{K_{Th}}{K_{He}} = \left(\frac{p_{Th}}{p_{He}}\right)^2 \left(\frac{m_{He}}{m_{Th}}\right)$$

But $p_{Th} = p_{He}$ and $m_{He} < m_{Th}$

$\therefore$ $K_{Th} < K_{He}$ or $K_{He} > K_{Th}$

Thus the helium nucleus has more kinetic energy than the thorium nucleus.

8. (b) : The wavelength of a spectral line in the Lyman series is

$$\frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right), \; n = 2,3,4, \; ....$$

and that in the Balmer series is

$$\frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right), \; n = 3,4,5, \; ....$$

For the longest wavelength in the Lyman series, $n = 2$

$$\therefore \quad \frac{1}{\lambda_L} = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R\left(\frac{1}{1} - \frac{1}{4}\right) = R\left(\frac{4-1}{4}\right) = \frac{3R}{4}$$

$$\text{or} \quad \lambda_L = \frac{4}{3R}$$

For the longest wavelength in the Balmer series, $n = 3$

$$\therefore \quad \frac{1}{\lambda_B} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = R\left(\frac{9-4}{36}\right) = \frac{5R}{36}$$

$$\text{or} \quad \lambda_B = \frac{36}{5R}$$

$$\text{Thus,} \quad \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{3R} \times \frac{5R}{36} = \frac{5}{27}$$

9. (d) : Radius of the nucleus $R = R_0 A^{1/3}$

$$\therefore \quad \frac{R_{Al}}{R_{Te}} = \left(\frac{A_{Al}}{A_{Te}}\right)^{1/3}$$

Here, $A_{Al} = 27, A_{Te} = 125, R_{Te} = ?$

$$\frac{R_{Al}}{R_{Te}} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5} \Rightarrow \quad R_{Te} = \frac{5}{3} R_{Al}$$

10. (d) : Energy of electron in He^+ 3rd orbit

$$E_3 = -13.6 \times \frac{Z^2}{n^2}\text{ eV} = -13.6 \times \frac{4}{9}\text{ eV}$$

$$= -13.6 \times \frac{4}{9} \times 1.6 \times 10^{-19}\text{ J} \simeq 9.7 \times 10^{-19}\text{ J}$$

As per Bohr's model,

Kinetic energy of electron in the 3rd orbit = $-E_3$

$$\therefore \quad 9.7 \times 10^{-19} = \frac{1}{2} m_e v^2$$

$$v = \sqrt{\frac{2 \times 9.7 \times 10^{-19}}{9.1 \times 10^{-31}}} = 1.46 \times 10^6\text{ m s}^{-1}$$

11. (c) : Energy of the photon, $E = \frac{hc}{\lambda}$

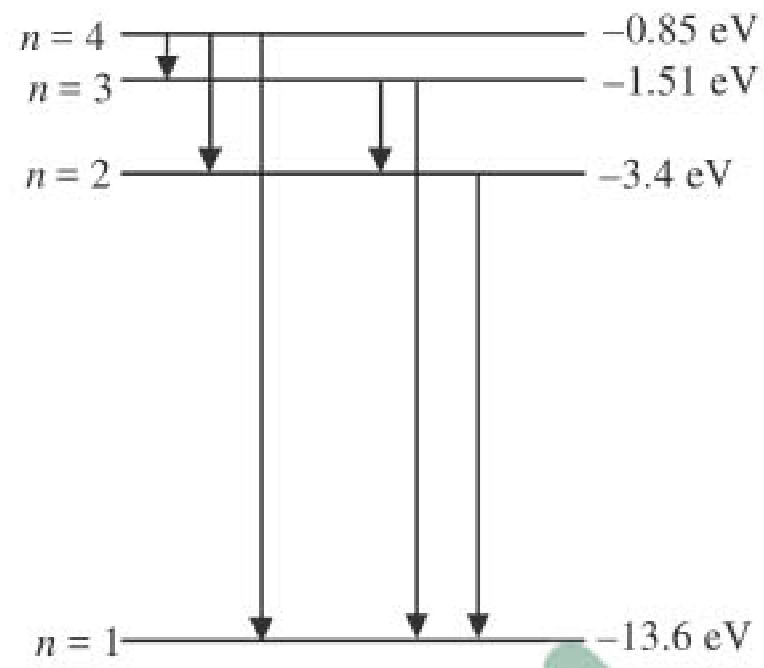
$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{975 \times 10^{-10}}\text{ J}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{975 \times 10^{-10} \times 1.6 \times 10^{-19}}\text{ eV} = 12.75\text{ eV}$$

After absorbing a photon of energy 12.75 eV, the electron will reach to third excited state of energy –0.85 eV, since energy difference corresponding to $n = 1$ and $n = 4$ is 12.75 eV.

$\therefore$ Number of spectral lines emitted

$$= \frac{(n)(n-1)}{2} = \frac{(4)(4-1)}{2} = 6$$



12. (d) : Binding energy of ${}^7_3Li$ nucleus

$= 7 \times 5.60$ MeV $= 39.2$ MeV

Binding energy of ${}_2{}^4He$ nucleus

$= 4 \times 7.06$ MeV $= 28.24$ MeV

The reaction is

${}^7_3Li + {}^1_1H \to 2({}^4_2He) + Q$

$\therefore$ $Q = 2$(BE of ${}^4_2He$) –(BE of ${}^7_3Li$)

$= 2 \times 28.24$ MeV – 39.2 MeV

$= 56.48$ MeV – 39.2 MeV = 17.28 MeV

13. (c) :

	X	$\rightarrow$	Y
Number of nuclei at $t = 0$	N_0		0
Number of nuclei after time t	$N_0 - x$		x

(As per question)

$$\frac{N_0 - x}{x} = \frac{1}{7}$$

$$7N_0 - 7x = x \quad \text{or} \quad x = \frac{7}{8} N_0$$

$\therefore$ Remaining nuclei of isotope X

$$= N_0 - x = N_0 - \frac{7}{8} N_0 = \frac{1}{8} N_0 = \left(\frac{1}{2}\right)^3 N_0$$

So three half lives would have been passed.

$\therefore$ $t = nT_{1/2} = 3 \times 1.4 \times 10^9$ years $= 4.2 \times 10^9$ years

Hence, the age of the rock is 4.2×10^9 years.

14. (c) : The wavelength of different spectral lines of Lyman series is given by

$$\frac{1}{\lambda_L} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right] \text{ where } n = 2, 3, 4, \ldots$$

where subscript L refers to Lyman.

For longest wavelength, $n = 2$

$$\therefore \quad \frac{1}{\lambda_{L_{longest}}} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}R \qquad \text{...(i)}$$

The wavelength of different spectral series of Balmer series is given by

$$\frac{1}{\lambda_B} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right] \text{ where } n = 3, 4, 5, \ldots$$

where subscript B refers to Balmer.

For longest wavelength, $n = 3$

$$\therefore \quad \frac{1}{\lambda_{B_{longest}}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36} \quad ...(ii)$$

Divide (ii) by (i), we get

$$\frac{\lambda_{L_{longest}}}{\lambda_{B_{longest}}} = \frac{5R}{36} \times \frac{4}{3R} = \frac{5}{27}$$

15. (a) : As ${}_1^2\text{H} + {}_1^2\text{H} \to {}_2^4\text{He}$

Here, $\Delta M = 0.02866$ u

$\therefore$ The energy liberated per u is $= \dfrac{\Delta M \times 931}{4}$ MeV

$$= \frac{0.02866 \times 931}{4}\text{ MeV} = \frac{26.7}{4}\text{ MeV} = 6.675\text{ MeV}$$

16. (d) :

	X	$\to$	Y
Initial number of atoms,	N_0		0
Number of atoms after time t	N		$N_0 - N$

As per question

$$\frac{N}{N_0 - N} = \frac{1}{7} \Rightarrow 7N = N_0 - N \quad \text{or} \quad 8N = N_0$$

$$\frac{N}{N_0} = \frac{1}{8}$$

As $\dfrac{N}{N_0} = \left(\dfrac{1}{2}\right)^n$ where n is the no. of half lives

$$\therefore \quad \frac{1}{8} = \left(\frac{1}{2}\right)^n \quad \text{or} \quad \left(\frac{1}{2}\right)^3 = \left(\frac{1}{2}\right)^n$$

$\therefore \quad n = 3$

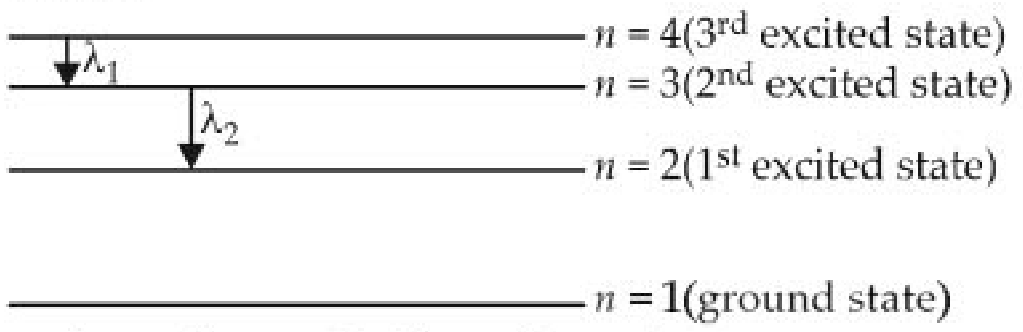
$$n = \frac{t}{T_{1/2}} \text{ or } t = nT_{1/2} = 3 \times 20 \text{ years} = 60 \text{ years}$$

Hence, the age of rock is 60 years.

17. (c) **18. (d)**

19. (b) : For a given energy, γ-rays has highest penetrating power and α-particles has least penetrating power.

20. (d) :



According to Rydberg formula

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

In first case, $n_f = 3$, $n_i = 4$

$$\therefore \quad \frac{1}{\lambda_1} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{9} - \frac{1}{16}\right] = \frac{7}{144}R \quad ...(i)$$

In second case, $n_f = 2$, $n_i = 3$

$$\therefore \quad \frac{1}{\lambda_2} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5}{36}R \quad ...(ii)$$

Divide (ii) by (i), we get

$$\frac{\lambda_1}{\lambda_2} = \frac{5}{36} \times \frac{144}{7} = \frac{20}{7}$$

21. (c) : Nuclear radius, $R = R_0 A^{1/3}$

where R_0 is a constant and A is the mass number

$$\therefore \quad \frac{R_{Al}}{R_{Cu}} = \frac{(27)^{1/3}}{(64)^{1/3}} = \frac{3}{4}$$

$$\text{or} \quad R_{Cu} = \frac{4}{3} \times R_{Al} = \frac{4}{3} \times 3.6 \text{ fermi} = 4.8 \text{ fermi}$$

22. (d) : Let after t s amount of the A_1 and A_2 will become equal in the mixture.

As $N = N_0\left(\dfrac{1}{2}\right)^n$

where n is the number of half-lives

For A_1, $N_1 = N_{01}\left(\dfrac{1}{2}\right)^{t/20}$

For A_2, $N_2 = N_{02}\left(\dfrac{1}{2}\right)^{t/10}$

According to question, $N_1 = N_2$

$$\frac{40}{2^{t/20}} = \frac{160}{2^{t/10}}$$

$$2^{t/10} = 4(2^{t/20}) \text{ or } 2^{t/10} = 2^2 2^{t/20} \Rightarrow 2^{t/10} = 2^{\left(\frac{t}{20}+2\right)}$$

$$\frac{t}{10} = \frac{t}{20} + 2 \quad \text{or} \quad \frac{t}{10} - \frac{t}{20} = 2$$

$$\text{or} \quad \frac{t}{20} = 2 \quad \text{or} \quad t = 40 \text{ s}$$

23. (a) : According to Rydberg formula

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

Here, $n_f = 1$, $n_i = 5$

$$\therefore \quad \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{5^2}\right] = R\left[\frac{1}{1} - \frac{1}{25}\right] = \frac{24}{25}R$$

According to conservation of linear momentum, we get

Momentum of photon = Momentum of atom

$$\frac{h}{\lambda} = mv \quad \text{or} \quad v = \frac{h}{m\lambda} = \frac{h}{m}\left(\frac{24R}{25}\right) = \frac{24hR}{25m}$$

24. (d)