VPM CLASSES

BHU

PHYSICS

SOLVED SAMPLE PAPER

* DETAILED SOLUTIONS

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BHU-PH **PHYSICS** **FMTP**

MAX.MARKS : 360 **MARKS SCORED :** **Time : 2 Hours**

INSTRUCTIONS

Attempt all 120 questions. Each question carries 3 marks. 1 negative mark for each wrong answer.

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1. Sound waves in air cannot be polarized because

(A) Their speed is small

(B) They require medium

(C) These are longitudinal

(D) Their speed is temperature dependent.

2. In Newton's rings experiment, the diameters of the bright rings are proportional to the square roots of

(A) Natural numbers

(B) Odd numbers

(C) Even natural numbers

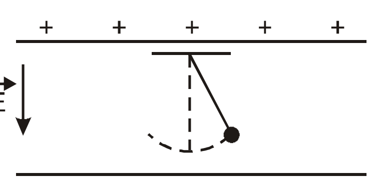
(D) Half integral multiples of natural numbers

3. Light transmitted by a single nicol is

(A) Unpolarised (B) Circularly polarised

(C) Plane polarised (D) None of the above

4. A simple pendulum having charge Q, length ℓ and mass m is hung from a fixed support between the horizontal plates of a charged capacitor. Time period of vibrations of the pendulum is given by



(A) $2\pi\sqrt{\frac{m\ell}{qE+g}}$ (B) $2\pi\sqrt{\frac{\ell^2}{\left(\frac{qE}{m}+g\right)^2}}$

(C) $2\pi\sqrt{\frac{\ell}{\frac{qE}{m}+g}}$ (D) $2\pi\sqrt{\frac{\ell}{g}}$

5. In a dielectric sphere the polarization $\vec{P}$ is given by $\vec{p} = \frac{k\vec{r}}{r^3}$. The corresponding bound volume charge density is equal to

(A) 0 (B) –6k (C) 6k (D) –3k

6. In a capillary tube experiment, a vertical 30 cm long capillary tube is dipped in water. The water rises up to a higher of 10 cm due to capillary action. If this experiment s conducted in a freely falling elevator, the length of the water column becomes

(A) 10 cm (B) 20 cm (C) 30 cm (D) Zero

7. A thin rod of length $\frac{f}{3}$ is placed along the optic axis of a concave mirror of focal length f such that at its image which is real and elongated, just touches the rod. The magnification is..

(A) 1.9 (B) 2.25 (C) 2.266 (D) 1.5

8. A thin transparent sheet is placed in front of both the slits of Young's expt. The fringe width will

(A) Increase (B) Decrease

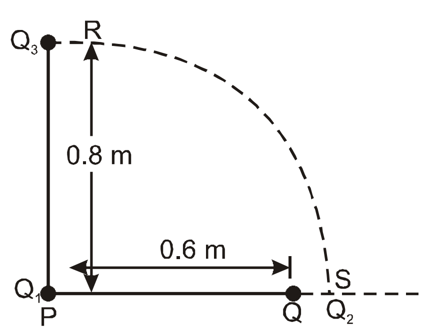
(C) Become non uniform (D) Shall remain the same

9. Which one of the following can be polarized

(A) Sound waves (B) Sodium lamp

(C) Radio-waves (D) Head light of a car

10. Two charges Q_1 and Q_2 coulombs are shown in figure. A third charge Q_3 coulomb is moved from R to S along a circular path. Change in potential energy of the charge is



(A) $kQ_1Q_2Q_3$ (B) $4kQ_1Q_2$ (C) $4kQ_2Q_3$ (D) $\frac{2}{3}kQ_2Q_3$

11. Surface charge density of a soap bubble of radius r and surface tension S is σ. If excess pressure is p, the value of surface charge density is

(A) $\left[\varepsilon_0\left(\frac{4S}{r}-p\right)\right]^{3/2}$

(B) $\left[2\varepsilon_0\left(\frac{4S}{r}-p\right)\right]^{1/2}$

(C) $\left[\frac{4S}{r}\right]$

(D) $\left[4\varepsilon_0\left(\frac{2S}{r}-p\right)\right]^{1/2}$

12. A capacitor filled with dielectric of permittivity ε = 2.1 loses half the charge acquired during a time interval t = 3.0 min. Assuming the charge to leak through only the dielectric filler, calculate its resistivity

(A) $1.4 \times 10^{13}\ \Omega$m

(B) $1.4 \times 10^{-13}\ \Omega$ m

(C) $1.3 \times 10^{14}\ \Omega$ m

(D) $1.3 \times 10^{-14}\ \Omega$ m

13. A proton of mass 1.67×10^{-27} kg and charge 1.6×10^{-19} C is projected with a speed of 2×10^6 ms^{-1} at an angle of 60° to x-axis. If a uniform magnetic field of 0.104 T is applied along the y-axis, the path of the proton is

(A) A circle of radius $\cong$ 0.1 m and time period $2\pi \times 10^{-7}$ s

(B) A circle of radius $\cong$ 0.2 m and time period $\pi \times 10^{-7}$ s

(C) A helix of radius $\cong$ 0.1 m and time period $2\pi \times 10^{-7}$ s

(D) A helix of radius $\cong$ 0.2 m and time period $4\pi \times 10^{-7}$ s

14. In a solid an atom has

(A) 3 vibrational degrees of freedom

(B) 3 rotational degrees of freedom

(C) 6 vibrational degrees of freedom

(D) 6 rotational of freedom

15. When the number of nucleons in nuclei increases, the binding energy per nucleon

(A) increases continuously with mass number

(B) decreases continuously with mass number

(C) remains constant with mass number

(D) first increases and then decreases with increase of mass number

16. The number of alpha and beta decay ${}_{88}Ra^{222}$ experiences before turning into stable Pb^{206} isotope is

(A) 4, 2 (B) 2, 4 (C) 1, 3 (D) 6, 10

17. In a simple cubic structure of lattice constant a, one plane among a set of parallel planes intercepts x, y and z-axis a, 2a and 3a respectively. The interplanar spacing is

(A) $a\sqrt{6}$ (B) 3a (C) $a/\sqrt{6}$ (D) a/4

18. The heat capacity of a monatomic lattice in one dimension in the Debye approximation is proportional to

(A) $\frac{T}{\theta}$ for low temperature (B) $\frac{T}{\theta}$ for high temperature

(C) $\frac{\theta}{T}$ for low temperature (D) $\frac{\theta}{T}$ for high temperature

where θ is the effective Debye temperature, $\theta = \frac{\hbar\omega}{K_B} = \frac{\hbar\pi c_s}{K_B a}$

$K_B \rightarrow$ Boltzmann constant, a $\rightarrow$ interatomic separation.

19. The forbidden energy band gaps in conductor, semiconductors and insulators are E_{g1}, E_{g2} and E_{g3} respectively. The relation among them is:

(A) $E_{g1} = E_{g2} = E_{g3}$ (B) $E_{g1} < E_{g2} < E_{g3}$

(C) $E_{g1} > E_{g2} > E_{g3}$ (D) $E_{g1} < E_{g2} > E_{g3}$

20. On increasing the reverse bias to a large value in a P-N junction diode current

(A) increases slowly

(B) remains fixed

(C) suddenly increases

(D) decreases slowly.

21. An artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy E_0. Its potential energy is

(A) $-E_0$ (B) 1.5 E_0

(C) 2 E_0 (D) E_0

22. Locate the centre of mass of a system of particles of masses m_1 = 1 kg, m_2 = 2 kg and m_3 = 3 kg, situated at the corners of an equilateral triangle of side 1.0 meter.

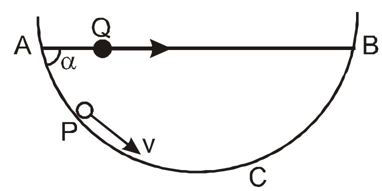
(A) $\left(\frac{1}{2}, \frac{\sqrt{3}}{2}\right)$ (B) $\left(\frac{1}{4}, \frac{\sqrt{3}}{4}\right)$ (C) $\left(\frac{3.5}{\sqrt{6}}, \frac{\sqrt{3}}{4}\right)$ (D) $\left(\frac{5.3}{\sqrt{6}}, \frac{\sqrt{3}}{2}\right)$

23. Drops of liquid of density d are floating half immeresd in a liquid of density ρ. If the surface tension of liquid is T then radius of the drop will be

(A) $\sqrt{\left\{\frac{3T}{g(2d-\rho)}\right\}}$ (B) $\sqrt{\left\{\frac{3T}{g(d-\rho)}\right\}}$

(C) $\sqrt{\left\{\frac{6T}{g(2d-\rho)}\right\}}$ (D) $\sqrt{\left\{\frac{6T}{g(d-\rho)}\right\}}$

24. A particle P is sliding down a frictionless hemispherical bowl. It passes the point A at t = 0. At this instant of time, the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at t = 0 along the horizontal string AB(see fig.) with the speed v. Friction between the bead and the string may be neglected. Let t_P and t_Q be the respective times taken by P and Q to reach the point B. Then



(A) $t_P < t_Q$

(B) $t_P = t_Q$

(C) $t_P > t_Q$

(D) $t_P / t_Q = \frac{\text{length of arc ACB}}{\text{length of chord AB}}$

25. A soundin body emitting a frequency of 150 Hz is dropped from a height. During its fall under gravity it crosses a balloon moving with constant velocity of 2 m/s one second after it started to fall. Find the number of beats heard by observer in the balloon at the moment he crosses the body. Velocity of sound in air is 300 m/sec.

(A) 12 (B) 6 (C) 8 (D) 4

26. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at x = 0 and positive plate is at x = 3d. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to 3d,

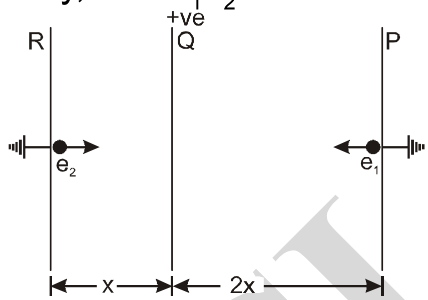
(A) The magnitude of the electric field remains the same.

(B) The direction of the electric field remains the same.

(C) The electric potential decreases continuously.

(D) The electric potential increases at first, then decreases and again increases.

27. P, Q and R are three parallel plates. Two electrons e_1 and e_2 starts from P and R respectively and reach Q, already having some positive charge, in time t_1 and t_2 respectively, then t_1/t_2 =



(A) $\frac{1}{2}$

(B) 2

(C) 4

(D) $\frac{3}{2}$

28. IF the magnetic monopoles existed then which of the following Maxwell's equations would be modified?

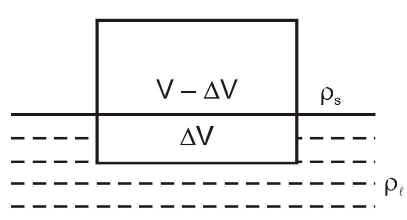
(A) $\oint \vec{E}.d\vec{s} = \frac{q}{\epsilon_0}$

(B) $\oint \vec{B}.d\vec{s} = 0$

(C) $\oint \vec{E}.d\vec{\ell} = -\frac{d}{dt}\int \vec{B}.d\vec{s}$

(D) $\oint \vec{B}.d\vec{t} = \mu_0 \epsilon_0 \frac{d}{dt}\int \vec{E}.d\vec{s} + \mu_0 I$

29. A solid cube of density ρ_s floats in a liquid of density ρ_ℓ at 0°C as shown in fig. If γ and f be the coefficient of volume expansion of the liquid and fraction of the cube immersed in the liquid respectively, then the temperature at which the solid will be completely immersed will be



(A) $\frac{1-f}{\gamma f}$

(B) $\frac{1+f}{\gamma f}$

(C) $\frac{\gamma f}{1-f}$

(D) $\frac{\gamma f}{1+f}$

30. During adiabatic compression of a gas, its temperature

(A) Rises (B) Falls

(C) Remains constant (D) Becomes zero

31. Hydrogen is used in a carnot cycle as a working substance. Find the efficiency of the cycle if as a result efficiency of the cycle if as a result of an adiabatic expansion the

(A) 0.18 (B) 0.252 (C) 0.13 (D) 0.243

32. The earth receives at its surface radiation from the sun at the rate of 1400 W/ m^2. The distance of the center of the sun from the surface of the earth is 1.5×10^{11} m and the radius of the sun is 7.0×10^8 m. Treating sun as a black body, it follows from the above data that its surface temperature is

(A) 5801 K (B) 10^6 K (C) 50.1 K (D) 5801 °C

33. Which one of following is correct

(A) Only a charged particle in motion is accompanied by matter waves

(B) Only subatomic particles in motion are accompanied by matter waves

(C) Any particle in motion, whether charged or uncharged, is accompanied by matter waves

(D) No particle, whether at rest or in motion, is ever accompanied by matter waves.

34. Obtain approximately the ratio of nuclear radii of the gold isotope $_{79}Au^{197}$ and the silver isotope $_{47}Ag^{107}$. What is the approximate ratio of their nuclear densities?

(A) 0.5 (B) 1 (C) 1.5 (D) 2

35. When a deutron of atomic mass 2.0147 amu and negligible kinetic energy is absorbed by a Li^6 nucleus of mass 6.0169 amu, the intermediate nucleus disintegrates spontaneously into two α particles, each of mass 4.0039 amu. Energy given to each α particle is (1 amu = 931. 3 MeV)

(A) 1.18 MeV (B) 8.11 MeV

(C) 1.1 MeV (D) 11.08 MeV

36. A metal of atomic weight W and density P has hcp structure. The side a of its conventional cubic cell is given by

(A) $\left(\frac{6w}{p}\right)^{1/3}$ (B) $\left(\frac{4w}{p}\right)^{1/3}$ (C) $\left(\frac{2w}{p}\right)^{1/3}$ (D) $\left(\frac{w}{p}\right)^{1/3}$

37. Doping is a process of :

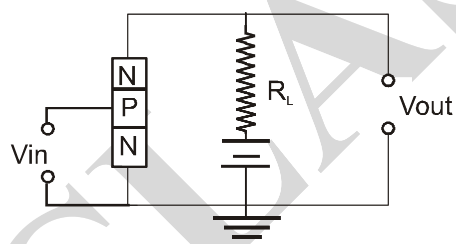
(A) purifying the material

(B) adding controlled impurities in the material

(C) make the material crystalline

(D) making the material amorphous

38. An N-P-N transistor circuit is arranged as shown in figure It is



(A) a common- base amplifier circuit

(B) a common emitter amplifier circuit

(C) a common-collector amplifier circuit

(D) neither of the above.

39. Imagine a light planet revolving around a very massive star in a circular orbit of radius r with a period of revolution T. On what power of r, will the square of time period depend if the gravitational force of attraction between the planet and the star is proportional to $r^{-5/2}$.

(A) $r^{3/2}$ (B) $r^{5/2}$ (C) $r^{7/2}$ (D) $r^{9/2}$

40. A threaded rod with 12 turns/cm and diameter 1.18 cm is mounted horizontally. A bar with a threaded hole to match the rod is screwed onto the rod. The bar spins at 216 rev/min. How long will it take for the bar to move 1.50 cm along the rod?

(A) 7s (B) 6s (C) 5s (D) 4s

41. If the earth, supposed to be a uniform sphere contracts slightly so that its radius less by $\left(\frac{1}{n}\right)$ than before, calculate the length of the day shortens by

(A) $\frac{24}{n}$hours (B) 24 n hours

(C) $\frac{48}{n}$hours (D) 48 n hours

42. A uniform rod of mass m = 5.0 kg and length ℓ = 90 cm. rests on a smooth horizontal surface. One of the ends of the rod is struck with the impulse J = 3.0 N-s in a horizontal direction perpendicular to the rod. As a result, the rod, obtains the momentum p = 3.0 N-s. Find the force with which one half of the rod will act on the other in the process of motion.

(A) 9 N (B) 6 N (C) 0.5 N (D) 4 N

43. Water from a tap (at the end of a horizontal pipe) emerges vertically downwards with an initial speed of 1.0 ms^{-1}. The cross-sectional area of the tap is $10^{-4}m^2$. Assume that the pressure is constant throughout the stream of water and the flow is steady. The cross-sectional area of the stream 0.15 m below the tap is (g = 10 ms^{-2})

(A) 5.0×10^{-4} m^2 (B) 1.0×10^{-5} m^2

(C) 5×10^{-5} m^2 (D) 2.0×10^{-5} m^2

44. A particle of mass m moves on the x-axis as follows. It starts from rest at t = 0 from point x = 0 and comes to rest at t = 1 at the point x = 1. No other information is available about its motion at intermediate time (0 < t < 1). If α denotes the instantaneous acceleration of the particle, then which of the following statements are true

(A) α cannot remain positive for all t in the interval $0 \le t \le 1$.

(B) $|\alpha|$ cannot exceed 2 at any point in its path.

(C) $|\alpha|$ must be ≥ 4 at some point or points in its path.

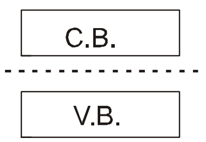
(D) α must change sign during the motion but no other assertion can be made with the information given

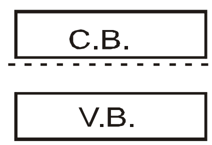
45. A radar operates at wavelength 50 cm. If the beat frequency between transmitted signal and signal reflected from an aircraft is equal to 1 kHz at the radar location, the velocity of approaching aircraft will be

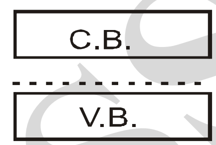
(A) 900 km/hr (B) 450 km/hr

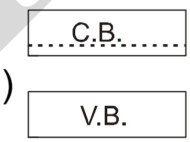
(C) 1000 km/hr (D) 500 km/hr

46. Which one of following diagrams correctly represents the energy levels in a P-type semiconductor?

(A) 

(B) 

(C) 

(D) 

47. The depiction layer in a P-N junction diode consists of:

(A) positively charge donors on the P-side and negatively charged acceptors on the N-side

(B) negatively charged donors on the P -side and positively charged acceptors on the N-side

(C) positively charged donors on the N-side and negatively charged acceptors on the P-side

(D) negatively charged donors on the N-side and positively charged acceptors the P–side

48. The acceleration experienced by a moving boat after its engine is cut off, is given by $\frac{dv}{dt} = -kv^3$, where k is a constant. If v_0 is the magnitude of the velocity at cut off, find the magnitude of the velocity at time t after the cut off.

(A) v_0 (B) $\frac{v_0}{\sqrt{1-2kv_0^2t}}$ (C) $\frac{v_0}{\sqrt{1+2kv_0t}}$ (D) $\frac{v_0}{\sqrt{1+2kv_0^2t}}$

49. A carpenter has constructed a toy as shown in fig. If the density of the material of the sphere is 12 times that of cone, compute the position of the center of mass of the toy.

(A) 12 R (B) 5 R (C) 4 R (D) 2 R

50. Two capillary tubes of the same length but different radii r_1 and r_2 are fitted in parallel to the bottom of a vessel. The pressure head is p. What should be the radius of a single tube that can replace the two tubes so that the rate of flow is same as before?

(A) $r_1 + r_2$

(B) $r_1^2 + r_2^2$

(C) $r_1^4 + r_2^4$

(D) None of the above

51. Which one of the following statement is INCORRECT for semiconductor

(A) semiconductor is damaged by a strong current

(B) conductivity increases with rise of temperature in case of semiconductor

(C) Mobility of n-type semiconductor is more then P-type semiconductor.

(D) n-type semiconductor is obtained by doping trivalent imparity

52. A current is flowing in the + x direction in a semiconducting slab, magnetic along z-direction. What will be the direction field which is set up inside the slab?

(A) + y direction

(B) – z direction

(C) –x-direction

(D) –y direction

53. Which of the following statements concerning the depletion zone of an unbiased p-n junction is (are) true?

(A) The width of the zone is independent of the densities of the dopants (impurities)

(B) The width of the zone is dependent on the densities of the dopants

(C) The electric field in the zone is provided by the electrons in the conduction band and holes in the valence band.

(D) The electric field in the zone is produced by the ionized dopant atoms.

54. The dominant mechanisms for motion of charge carriers in forward and reverse biased silicon p-n junction are

(A) drift in forward biased, diffusion in reverse bias

(B) diffusion in forward biased, drift in reverse bias

(C) diffusion in both forward and reverse bias

(D) drift in both forward and reverse bias.

55. A load of 981 N is suspended from a steel wire of radius 1 mm. What is the maximum angle through which the wire with the load can be deflected so that it does not break when the load passes through the position of equilibrium. Breaking stress is 7.85×10^8 N/m^2.

(A) 76°65’ (B) 76°56’ (C) 74°26’ (D) 75°56’

56. The current amplification of the common b N-P-N transistor is 0.96. What is the current (β) if it is used as common emitter amplifier?

(A) 16 (B) 24 (C) 20 (D) 32

57. The radius of a planet is double that of the earth but their average densities are the same. If the escape velocities at the planet and at the earth are V_P and V_E respectively. Then which of the following relation is correct

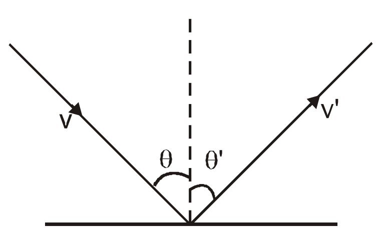
(A) $V_O = V_E$ (B) $V_O = \sqrt{2}V_E$

(C) $V_O = \frac{3}{2}V_E$ (D) $V_O = 2V_E$

58. A stone of mass m, tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then the tension in the string is given by $T = Ar^n$, where A is constant, r is the instantaneous radius of the circle, and n = ...

(A) –2 (B) –3 (C) 2 (D) 3

59. A ball of mass m hits a floor with a speed v making an angle of incidence θ with the normal. The coefficient of restitution is e. Find the angle of reflection of the ball.



(A) $\sin^{-1}(\tan\theta/e)$ (B) $\tan^{-1}(\tan\theta/e)$

(C) $\tan^{-1}(\sin\theta/e)$ (D) $\tan^{-1}(\cos\theta/e)$

60. The minimum force required to punch a hole of dia d in a steel plate of thickness t when ultimate shear strength of steel = σ is given by

(A) $\pi d\sigma t$ (B) $\pi\left(\frac{d}{2}\right)^2 \sigma t$

(C) $2\pi d\sigma t$ (D) $\pi\frac{d}{2}\sigma t$

61. Two simple pendulums of length 1 m and 16 m respectively are both given small displacement in the same direction at the same instant. They will be again in phase after the shorter pendulum has completed n oscillations. Calculate n.

(A) $\frac{1}{4}$ (B) $\frac{4}{3}$ (C) 5 (D) 4

62. Light of wavelength 5000 Å is diffracted by an aperture of width 2 mm. For what distance travelled by the diffracted beam does the spreading due to diffraction become greater than the width of the aperature?

(A) 2m (B) 4m

(C) 6m (D) 8m

63. When two mutually perpendicular plane polarized coherent light waves of unequal amplitudes and differing in phase by non-integral multiples of π are compounded together the resulting wave is

(A) Elliptically polarised

(B) Parabolically polarised

(C) Remains plane polarised with some modifications

(D) Circularly polarised

64. A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre

(A) Increases as r increases, for $r < R$

(B) Decreases as r increases, for $0 < r < \infty$

(C) Decreases as r decreases for $R < r < \infty$

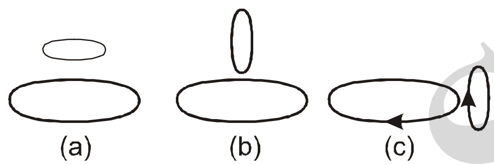
(D) Is discontinuous at $r = R$

65. A metal can be suspended by a silk thread carrying a positive charge (not uniformly distributed). At a certain point very near the surface of the can, the electric field has a value E = 600 kV/m. Evaluate the surface charge density σ near that point

(A) 5.313 c/m^2 (B) 3.513 c/m^2

(C) 5.313 μ c/m^2 (D) 3.5 μ c/m^2

66. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



(A) Maximum in situation (a) (B) Maximum in situation (b)

(C) Maximum in situation (c) (D) The same in all situations.

67. A proton, a deutron and a-particle, whose kinetic energies are same, enter perpendicularly a uniform magnetic field. Compare the radii of their circular paths.

(A) $1 : \sqrt{2} : \sqrt{2}$ (B) $1 : 1 : \sqrt{2}$

(C) $1 : \sqrt{2} : 11$ (D) $\sqrt{2} : 1 : 1$

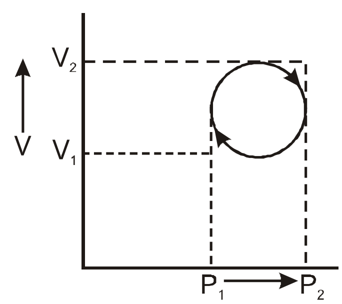
68. In the given V-P diagram, the magnitude of thermodynamic work is given by

(A) $\pi(V_2 - V_1)^2$

(B) $\pi(P_2 - P_1)(V_2 - V_1)$

(C) $\frac{\pi}{4}(V_2 - V_1)(P_2 - P_1)$

(D) $\frac{4}{\pi}(P_2 - P_1), (V_2 - V_1)$



69. The efficiency of the reversible heat engine is η_r and of irreversible heat engine is η_i. Which of the following relations is correct?

(A) $\eta_r > \eta_i$

(B) $\eta_r > \eta_i$

(C) $\eta_r = \eta_i$

(D) η_r is greater than 1 and η_i is less than 1.

70. Two bodies A and B have thermal emmissiviteis of 0.01 and 0.81 respectively. The outer surface areas of two bodies are the same. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A by 1 μm. If the temperature of A is 5802 K.

(A) The temperature of B is 17406 K.

(B) The temperature of B is 1934 K and λ_B = 1.5 μ m.

(C) The temperature of B is 11604 K.

(D) The temperature of B is 2901 K.

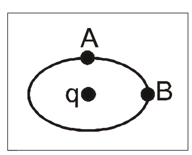
71. Calculate the thickness of a quartz half wave plate for sodium light of wavelength 5893 Å.

Given μ_E = 1.5533, μ_0 = 1.5442

(A) 0.3832×10^{-4} cm (B) 0.3238×10^{-4} cm

(C) 0.3238×10^{-4} m (D) 0.3832×10^{-4} m

72. An ellipsoidal cavity is curved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in figure. Then



(A) Electrical field near A in the cavity = electric field near B in the cavity.

(B) Charge density at A = charge density at B.

(C) Potential at A = potential at B.

(D) Total electric field flux through the surface of the cavity is $q/2\varepsilon_0$.

73. A capacitor is filled with two dielectrics of the same dimensions but of dielectric constant 2 and 3 respectively. Find the ratio of capacities in the two possible arrangements.

(A) 6 (B) $\frac{24}{25}$ (C) $\frac{15}{24}$ (D) $\frac{12}{5}$

74. Two inductors of inductance L each are connected in series with opposite magnetic fluxes. What is the resultant inductance ?

(A) zero (B) L (C) 2 L (D) 3 L

75. A current I flows along the length of an infinitely long, straight, thin walled pipe. Then

(A) The magnetic field at all point inside the pipe is the same, but not zero

(B) The magnetic field at any joint inside the pipe is zero

(C) The magnetic field is zero only on the axis of the pipe

(D) The magnetic field is different at different points inside the pipe.

76. In an adiabatic change.

(A) The change takes place slowly and the system is in good thermal contact with the surroundings

(B) The change takes place quickly and the system is in good thermal contact with the surroundings

(C) The change takes place slowly and the system is thermally insulated from the surroundings

(D) The change takes place quickly and the system is thermally insulated from the surroundings.

77. An ideal black body at room temperature is thrown into a furnace. It is observed that

(A) Initially it is the darkest body and at later times the brightest.

(B) It is the darkest body at all times.

(C) It cannot be distinguished at all times.

(D) Initially it is the darkest body and at later times it can not be distinguished.

78. Electrons are accelerated through 344 volts and are reflected from a crystal. The first reflection maximum occurs when glancing angle is 60°. Determine the spacing of the crystal. Given

$h = 6.62 \times 10^{-34}$ joule-sec., $e = 1.6 \times 10^{-19}$ column, $m = 9\times 10^{-31}$ kg.

(A) 0.5A° (B) 0.5 m (C) 1.5 A° (D) 1.5 m

79. Calculate binding energy of an alpha particle from the following data

mass of free proton = 1.007825 a.m.u.

mass of free neutron = 1.00866 a.m.u.

mass of helium nucleus = 4.002800 a.m.u.

Take 1 a.m.u. = 931.5 MeV.

(A) 28.11 MeV (B) 0.03081 MeV

(C) 28.11 a.m.u. (D) 7.052 MeV

80. Binding energy per nucleon for C^{12} is 7.68 MeV and that for C^{13} is 7.47 MeV. The energy required to remove a neutron from C^{13} is

(A) 5.49 (B) 4.95 MeV

(C) 9.45 MeV (D) 5.94 MeV

81. Calculate the ratio of the packing graction in fraction for sc, and hcp structure respectively (treating the atoms as spherical)

(A) 0.5 : 0.5 : 0.7 (B) 0.7 : 0.5 : 0.7

(C) 0.7 : 0.7 : 0.5 (D) 0.5 : 0.7 : 0.7

82. An P-type semiconductor has

(A) More electrons than holes

(B) Equal number of holes and electrons

(C) Boron as impurity

(D) phosphorous as impurity

83. In a common emitter amplifier, output resistance is 500 Ω and input resistance is 2000 Ω peak value of signal voltage is 10 mV and β = 50, then the peak value of output voltage

(A) 5×10^{-6} volt

(B) 2.5×10^{-4} volt

(C) 1.25 volt

(D) 125 volt.

84. Which one of the following statement is correct?

(A) The relative velocity of two particles in a head on collision is unchanged both in magnitude and direction

(B) The relative velocity of two particles in a head on collision is changes both in magnitude and direction.

(C) The relative velocity of two particles in head on collision is changed in magnitude but direction unchanged.

(D) The relative velocity of two particles in head on collision is unchanged in magnitude but direction changed.

85. A horizontal cylinder has a piston of cross-sectional area A and it contains a volume of water V of density ρ in it. The cylinder has an orifice of cross-sectional area a (A > > a) at its closed end. The work done to squeeze all the liquid in time t by means of a force F acting on the piston is

(A) $\rho\frac{V^3}{a^2t^2}$ (B) $2\rho\frac{V^3}{a^2t^2}$ (C) $\frac{1}{2}\rho\frac{V^3}{a^2t^2}$ (D) $\frac{2}{3}\rho\frac{V^3}{a^2t^2}$

86. An ideal gas is taken from the state A (pressure P, volume V) to the state B (pressure P/2, volume 2V) along a straight line path in the P-V diagram. Select the correct statement(s) from the following

(A) The work done by the gas in the process A to B exceeds the work that would be a done by it if the system were taken from A to B along the isotherm.

(B) In the T-V diagram, the path AB becomes a part of the parabola.

(C) In the P-T diagram, the path AB becomes a part of hyperbola.

(D) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases

87. Calculate the average energy $\bar{\varepsilon}$ of an oscillator of frequency 0.60×10^{14} sec^{-1} at T = 1800 K treating it as planck's oscillator.

(A) 1.01×10^{20} J (B) 1.10×10^{-20} J

(C) 1.01×10^{-20} J (D) 1.10×10^{-20} J

88. Which of the following statement is not correct for the Bohr model of the hydrogen atom

(A) The radius of the nth object is proportional to n^2

(B) The total energy of the electron in the n^{th} orbit is inversely proportional to n

(C) The angular momentum of the electron in an orbit is an integral multiple of $\frac{h}{2\pi}$

(D) The magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy.

89. What amount of energy should be added to an electron to reduce its de Broglie wavelength from 100 to 50 pm?

(A) 150eV (B) 50eV (C) 450eV (D) 300eV

90. As the mass number A increases, which of the following quantities related to a nucleus do not change?

(A) binding energy (B) density

(C) volume (D) mass.

91. When a deutron of atomic mass 2.0147 amu and negligible kinetic energy os absorbed by a Li^6 nucleus of mass 6.0169 amu, the intermediate nucleus disintegrates spontaneously into two α particles, each of mass 4.0039 amu. Energy given to each α particles is (1 amu = 931.3 MeV)

(A) 1.18 MeV (B) 8.11 MeV

(C) 1.1 MeV (D) 11.08 MeV

92. A set of parallel planes makes intercepts in the ratio 2b : 3c on the y and z ones and are parallel along X-axis. Find the Miller indices of the planes. Also calculate the interplant spacing of the planes taking the lattice to be cube with sides a = b = c= 3 Å.

(A) $\frac{3}{\sqrt{13}}$ A° (B) $\frac{3}{\sqrt{15}}$ A°

(C) $\frac{3}{\sqrt{14}}$ A° (D) $\frac{3}{4}$ A°

93. Pieces of copper and germanium are cooled from room temperature to 80 K. which one of the following statement is correct for their resistances?

(A) Resistance of Ge will increase and cu will decrease

(B) Resistance of Ge will decrease and cu will increase

(C) Resistance of both Ge and cu will increase

(D) Resistance of both Ge and cu will decrease.

94. In an N-P-N transistor circuit , the collector current is 10 mA. If 90% of the electrons emitted reach the collector,

(A) the emitter current will be 9 mA

(B) the emitter current will be 11 mA

(C) the base current will be 1 mA

(D) the base current will be –1 mA

95. Two particles of masses m_1 and m_2 in projectile motion have velocities v_1 and v_2 respectively at time, t = 0. They collide at time t_0. Their velocities become v_1' and and v_2' at time 2 t_0, while still moving in air. The value of

$(m_1 v_1' + m_2 v_2') – (m_1 v_1 + m_2 v_2)$ is

(A) Zero

(B) $(m_1 + m_2)\, g\, t_0$

(C) $2(m_1 + m_2)\, g\, t_0$

(D) $\frac{1}{2}(m_1 + m_2)\, g\, t_0$

96. A fixed horizontal wire carries current i_1. Below it another wire of linear density ρ carrying current i_2 is kept at a depth d and parallel to first wire. If the second wire hangs in air and the current in the wire increases to i_1', the acceleration of second wire is

(A) $g\left(\frac{i_1'}{i_1} - 1\right)$

(B) $\rho g\left(\frac{i_1'}{i_1} - 1\right)$

(C) $g\left(\frac{i_1}{i_1'} - 1\right)$

(D) $g\left(\frac{i_1'}{i_1} + 1\right)$

97. The frequencies of X-rays and ultraviolet rays are respectively a, b and c. Then

(A) a < b, a > c

(B) a > b, a > c

(C) a > b, a < c

(D) a < b, a < c

98. If η = 166 ×10^{-6} dyne per sq. cm. per unit velocity gradient $\bar{v} = 4.5 \times 10^4$ cm/s, ρ = 1.25 × 10^{-3} g/c.c. and n = 2.7 × 10^{19} molecules per c.c. for nitrogen, calculate the molecule diameter of nitrogen molecules

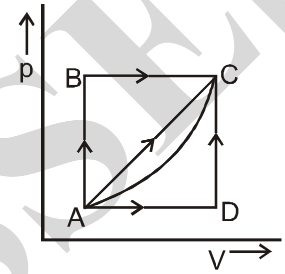
(A) 8.8 × 10^{-6} cm (B) 3.08 × 10^{-8} m

(C) 3.08 × 10^{-8} cm (D) 3.8 × 10^{-8} cm

99. A thermodynamical process is shown in the figure. The pressure and volumes corresponding to some points in the figure are

$p_A = 3 \times 10^4$ Pa $V_A = 2 \times 10^{-3}$ m^3

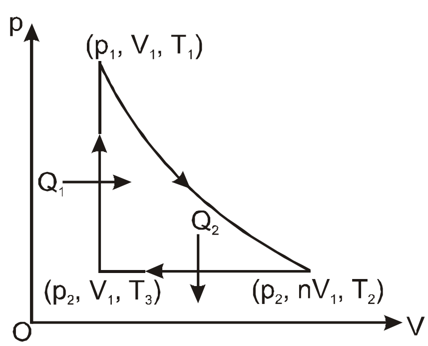
$p_B = 8 \times 10^4$ Pa $V_D = 5 \times 10^{-3}$ m^3



In the process AB, 600 J of heat is added to the system and process BC 200 J of heat is added to the system. Figure the change in internal energy of the system in process AC would be

(A) 560 J (B) 800 J (C) 600 J (D) 640 J

100. An ideal gas with the adiabatic exponent γ goes through a direct (clockwise) cycle consisting of adiabatic, isobaric and isochoric lines. Find the efficiency of the cycle if in the adiabatic process the volume of the ideal gas increases n-fold.



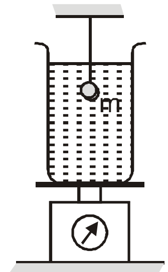
(A) $1-\gamma\frac{n-1}{1-n^{\gamma}}$ (B) $1-\gamma\frac{n-1}{n^{\gamma}-1}$ (C) $1-\gamma\frac{n^{\gamma}-1}{n-1}$ (D) $1-\gamma\frac{1-n^{\gamma}}{n-1}$

101. When a copper sphere is heated, maximum percentage change will be observed in

(A) radius (B) area

(C) volume (D) none of these

102. A spring balance has a beaker almost full of water placed on it. A suspended body of mass m is lowered into the beaker without touching the walls and bottom of the beaker. Then



(A) Reading of spring balance will increase equal to the weight of the body.

(B) Reading of spring balance will decrease.

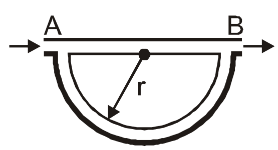
(C) Reading of spring balance will increase equal to the upthrust.

(D) Reading will increase and then decrease

103. An RCC pillar is subjected to a compressive load. If modulus of elasticity of concreate is one tenth of steel and area of cross-section of steel is one twentieth of concreate, the portion of load acting on concrete is

(A) $\frac{1}{2}$ (B) $\frac{3}{2}$ (C) $\frac{2}{3}$ (D) $\frac{1}{3}$

104. Sound signal is sent through a composite tube as shown in the figure. The radius of the semicircular portion of the tube is r. Speed of sound in air is υ.

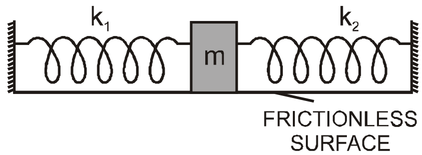


The source of sound is capable of giving varied frequencies in the range of v_1 and v_2 (where $v_2 > v_1$). If n is an integer then frequency for maximum intensity is given by

(A) $\frac{n\upsilon}{r}$ (B) $\frac{n\upsilon}{r(\pi-2)}$

(C) $\frac{n\upsilon}{\pi r}$ (D) $\frac{n\upsilon}{(r-2)\pi}$

105. The frequency of the mass when it is displaced slightly is



(A) $\frac{1}{2\pi}\sqrt{\frac{k_1k_2}{(k_1+k_2)m}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{k_1+k_2}{m}}$ (C) $\frac{1}{2\pi}\sqrt{\frac{k_1k_2}{m}}$ (D) $\sqrt{\frac{(k_1+k_2)}{k_1k_2m}}$

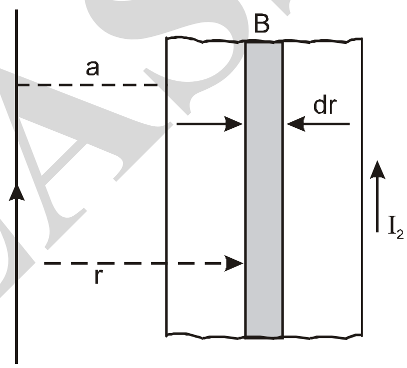
106. Two long thin parallel conductors of the shape shown in the figure carry direct currents I_1 and I_2. The separation between the conductors is a, the width of the right-hand conductor is equal to b. With both conductors lying in one plane, find the magnetic interaction force between them reduced to a unit length.

(A) $\frac{\mu_0 I_1 I_2}{4\pi b}\log_e\left[\frac{a}{(a+b)}\right]$

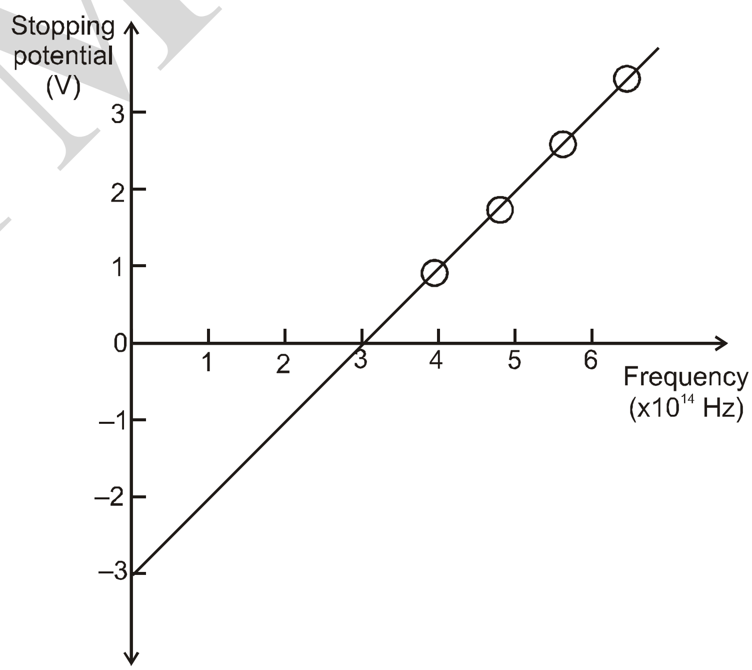
(B) $\frac{\mu_0 I_1 I_2}{2\pi b}\log\left(\frac{a+b}{a}\right)$

(C) $\frac{\mu_0 I_1 I_2}{2\pi b}\log\left(\frac{a}{a+b}\right)$

(D) $\frac{\mu_0 I_1 I_2}{4\pi b}\log\left(\frac{a+b}{a}\right)$



107. The figure shows the results obtained during a photoelectric effect experiment where the stopping potential is plotted against the frequency of the incident radiation. The work function of the metal is close to



(A) 2.5 eV (B) 2.0 eV (C) 1.5 eV (D) 0.5 eV

108. Binding energy per nucleon for C^{12} is 7.68 MeV and that for C^{13} is 7.47 MeV. The energy required to remove a neutron from C^{13} is

(A) 5.49 MeV
(B) 4.95 MeV
(C) 9.45 MeV
(D) 5.94 MeV

109. The decay constant of radioactive sample is λ. The half-life and mean-life of the sample are respectively given by

(A) $1/\lambda$ and (In 2)/λ
(B) (In2)/λ and $1/\lambda$
(C) λ(In 2) and $1/\lambda$
(D) λ (In 2) and $1/\lambda$

110. A substance with face-centred cubic lattice has lattice has density 6250 kg/m^3 and and molecular weight 60.2 Calculate the lattice constant a. Give Avogadro number 6.02×10^{26} (kg. mole)$^{-1}$.

(A) 2A°
(B) 4A°
(C) 40 A°
(D) 20 A°

111. A specimen of silicon is to be made P-type semiconductor. For this one atom of indium, on an average, is doped in 5×10^7 silicon atoms. If the number density of silicon is 5×10^{28} atoms/m^3, then find the number of acceptor atoms per cm^3.

(A) 10^{15} per cm^3
(B) 10^{30} per cm^3
(C) 10^{22} per cm^3
(D) 10^{25} per cm^3

112. When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seem at the centre of the shadow of the obstacle, this effect is seen because of

(A) Interference
(B) Diffraction
(C) Polarization
(D) Total internal reflection

113. The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will be

(A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$
(B) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$
(C) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$
(D) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{2\sqrt{2}R^2}$

114. The electron in a hydrogen atom makes a transition $n_1 \rightarrow n_2$, where n_1 and n_2 are principle quantum numbers of the two states. Assume the Bohr 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) $n_1 = 4, n_2 = 2$ (B) $n_1 = 8, n_2 = 2$

(C) $n_1 = 8, n_2 = 1$ (D) $n_1 = 6, n_2 = 4$

115. An X-ray tube operates at V volt and current through it is I when n electrons of mass m each hit the target in t second. The velocity υ of electrons when they hit target is given by

(A) $\left(\frac{2Ve}{m}\right)^{\frac{1}{2}}$ (B) $\frac{Ve}{m}$ (C) $\left(\frac{Ve}{2m}\right)^{3/2}$ (D) $\left(\frac{3Ve}{m}\right)^{\frac{1}{3}}$

116. A diffraction pattern is obtained using a beam of red light. What happens if the red light is replaced by blue light?

(A) No change

(B) Diffraction bands become narrower and crowded together

(C) Bands become broader and farther apart

(D) Bands disappear.

117. In case of diffraction at single slit if the wavelength of light becomes equal to the aperture of slit, on the screen we shall observe

(A) Image of slit

(B) Diffraction bands

(C) Uniform illumination

(D) Non-uniform illumination

118. The polaroid glass is used in sunglasses as

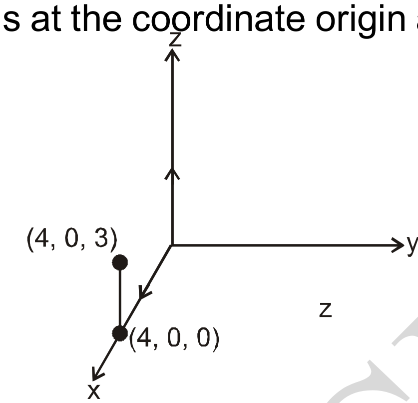
(A) It is a fashion

(B) This reduces glare

(C) This is cheaper than other types

(D) This looks more beautiful

119. The electric field in a certain region is given by $E = 5\hat{i} - 3\hat{j}\ kV/m$. Calculate the difference in potential $V_B - V_A$ if A is at the coordinate origin and point B is (4, 0, 3) m



(A) –30 kV

(B) –20V

(C) Zero

(D) 20 kV

120. The electron in a hydrogen atom makes a transition from an excited state to ground state. Which of the following statements is true?

(A) Its kinetic energy increases and its potential and total energies decrease.

(B) Its kinetic energy decreases, potential energy increases and its total energy remains same.

(C) Its kinetic and total energies decrease and its potential energy increases

(D) Its kinetic, potential and total energies decrease.

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Answer	C	B	C	C	A	C	D	D	C	B	B	A	C	C	D	A	C	A	B	C
Question	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Answer	C	C	A	A	A	B	B	B	A	A	A	A	C	B	D	A	B	B	C	C
Question	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Answer	C	A	C	A,D	A	C	C	D	C	D	D	D	A,B	B	D	B	D	B	B	A
Question	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Answer	B	D	A	A	C	A	C	C	A	B	B	C	B	C	B	D	A	A	A	B
Question	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Answer	D	C	C	D	C	A,B	C	B	C	D	D	A	A,B	B	C	A	A	C	A	B
Question	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Answer	C	C	C	B	B	B	C	B	B	B	A	B	C	A	A	B	D	B	A	A

HINTS AND SOLUTIONS

1.(C) Polarization is possible only in transerve waves and not in longitudinal waves.

2.(B) In Newton's rings experiment, the radius of the bright rings are proportional to $r_B \ \alpha \ \sqrt{2n-1}$ the square roots of odd numbers. So the diameters of the bright rings are also proportional to the square roots of odd numbers.

3.(C) By using the phenomenon of double refraction and isolating one ray from the other we can obtain plane polarised light which actually happens in a nicol prism. So, light transmitted by a single nicol is plane polarised.

4.(C) Net force F = qE + mg (downward)

Net acceleration g' = $\frac{F}{m} = \frac{qE}{m} + g$

$\therefore$ Time period,

$$T = 2\pi\sqrt{\frac{\ell}{g'}} = 2\pi\sqrt{\frac{\ell}{\frac{qE}{m}+g}}$$

5.(A) The bound volume charge density or density of polarisation charge ρ_P is

$$\rho_P = -\nabla.P \quad ...(1)$$

Since ρ is given by $\rho = k\frac{\vec{r}}{r^3}$

$\therefore \quad \nabla.P = \left(\hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}\right)\cdot k\frac{\vec{r}}{r^3}$

$= K\nabla\cdot\left(\frac{\vec{r}}{r^3}\right)$ ....(2)

$\nabla\cdot\left(\frac{\vec{r}}{r^3}\right) = \nabla\cdot(r^{-3}\vec{r}) = r^{-3}(\nabla\cdot\vec{r}) + (\nabla e^{-3})\cdot\vec{r} = r^{-3}(3) + \left(\frac{\partial r^{-3}}{\partial r}\hat{r}\right)\cdot\vec{r} = 3r^{-3} + (-3r^{-4})\frac{\vec{r}}{r}\cdot\vec{r} =$

$3r^{-3} - 3r^{-5}(\vec{r}\cdot\vec{r})$

$= 3r^{-3} - 3r^{-3}$ [since $\vec{r}\cdot\vec{r} = r^2$]

above equation use in equation (2)

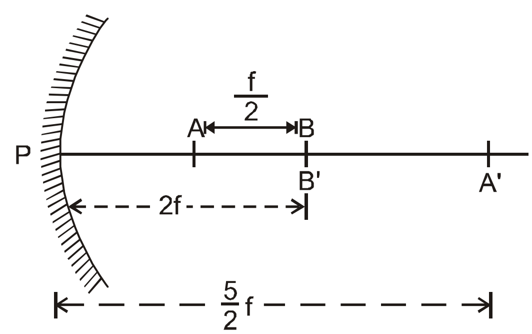
$\nabla\cdot P = k \times 0 = 0$

6.(C) $h = \frac{2\cos\theta}{r\rho g}$, In freely falling elevator, g = 0.

$\therefore$ $h = \infty$, But there will be no over flowing of water in tube and water stands up to maximum height in tube available i.e. 30 cm.

7.(D) For the given condition, the end B of the rod AB must be at the center of curvature C of the mirror. Now the image B' of B (see fig.) will coincide with B itself. The distance of A from the pole P of the mirror

$= 2f - \left(\frac{f}{3}\right) = \left(\frac{5}{3}\right)f$



Applying the mirror formula

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f'}$ we have

$\frac{1}{v_A} + \frac{3}{5f} = \frac{1}{f}$ or $\frac{1}{v_A} = \frac{3}{f} - \frac{3}{5f} = \frac{2}{5f}$

$\therefore \quad v_A = \frac{5}{2}f$

So the image of A will be formed at a distance $\left(\frac{5f}{2}\right)$ from P i.e., at A'.

The size of the image of the rod

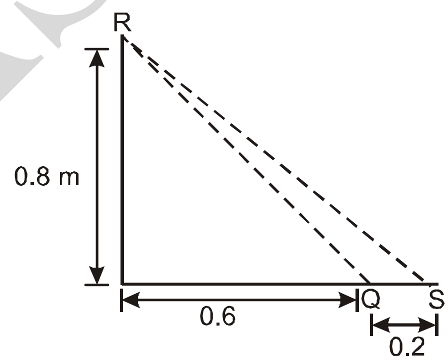
$$A'B' = \frac{5}{2}f - 2f = \frac{f}{2}$$

$$\text{Magnification} = \frac{A'B'}{AB} = \frac{\left(\frac{f}{2}\right)}{\left(\frac{f}{3}\right)} = \frac{3}{2} = 1.5$$

8.(D) Fringe width $\beta = \frac{\lambda D}{d}$ shall remain the same as the waves travel in air only, after passing through the thin transparent sheet.

9.(C) Only radio-waves can be polarized because this is transverse in nature.

10.(B) Potential energy of Q_3 at point R,



$$U_R = k\left[\frac{Q_1Q_3}{0.8} + \frac{Q_3Q_2}{1}\right]$$

Potential energy of Q_3 at point S,

$$U_S = k\left[\frac{Q_1Q_3}{0.8} + \frac{Q_3Q_2}{0.2}\right]$$

Then $U_R - U_S = kQ_2Q_3\left[\frac{1}{0.2} - 1\right] = 4kQ_2Q_3$

11.(B) For equilibrium, $p + \frac{\sigma^2}{2\varepsilon_0} = \frac{4S}{r}$

or $\frac{\sigma^2}{2\varepsilon_0} = \frac{4S}{r} - p$

or $\sigma^2 = 2\varepsilon_0\left(\frac{4S}{r} - p\right)$

or $\sigma = \left[2\varepsilon_0\left(\frac{4S}{r} - p\right)\right]^{1/2}$

12.(A) The discharge equation of a capacitor is

$$V = V_0 e^{-t/RC} \Rightarrow \frac{q}{C} = \frac{q_0}{C} e^{-t/RC}, \qquad t = 3 \text{ min.}$$

Now, $q = \frac{q_0}{2}$

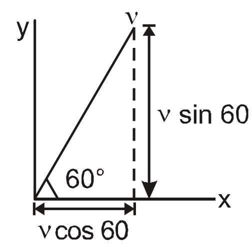
$$\therefore \qquad e^{-t/RC} = \frac{1}{2} \qquad \Rightarrow \qquad \frac{1}{RC} = \log_e 2$$

where R is the leakage resistance.

$$\therefore \qquad R = \frac{t}{\log_e 2} \cdot \frac{1}{C} = \frac{t}{\log_e 2} \cdot \frac{d}{\varepsilon \varepsilon_0 A}, \ \varepsilon = 2.1$$

$$\Rightarrow \qquad \frac{RA}{d} = \rho = \text{resistivity} = \frac{t}{\varepsilon \varepsilon_0 \log_e 2} = 1.4 \times 10^{+13} \ \Omega \text{ m}$$

13.(C) Here $\nu_{oy} = \nu_0 \sin 60 = 2 \times 10^6 \times \frac{\sqrt{3}}{2} = 3 \times 10^6 \text{ ms}^{-1}$



and $\nu_{0x} = \nu_0 \cos 60$

$= 2 \times 10^6 \times 1/2 = 10^6 \text{ ms}^{-1}$

The proton moves in a helix about y axis,

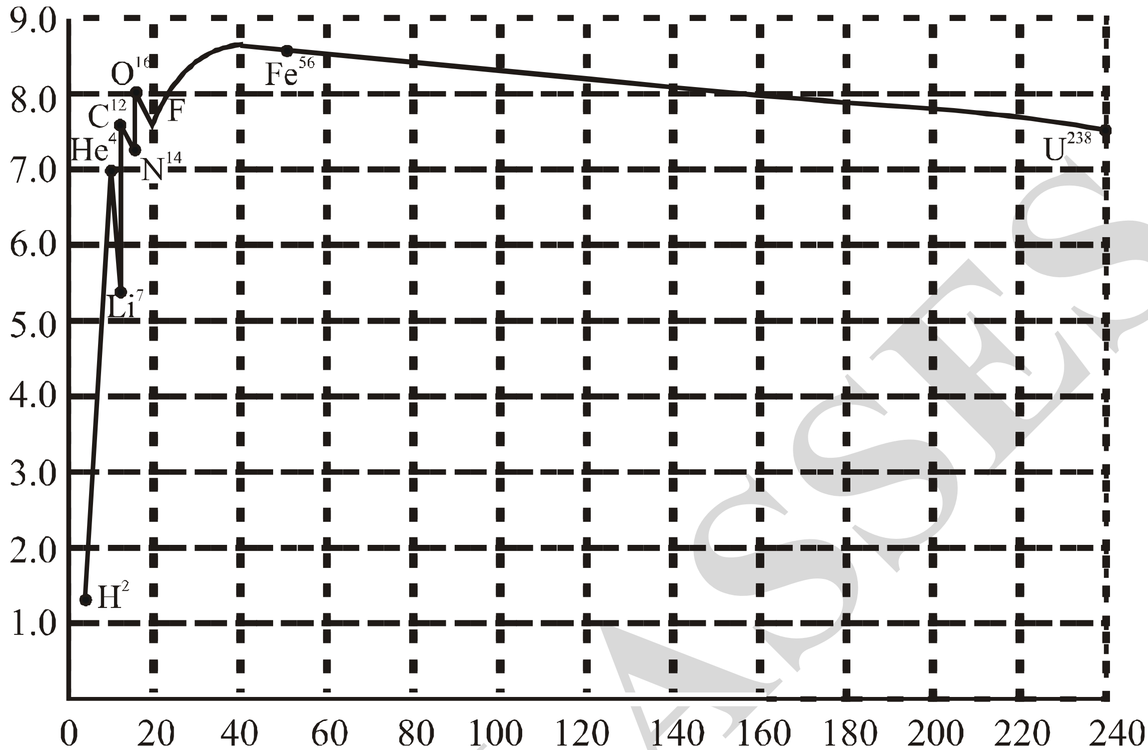
$$\therefore \qquad r = \frac{m v_{ox}}{qB} = \frac{(1.67 \times 10^{-27})(10^6)}{(1.6 \times 10^{-19})(0.104)} = 0.1\text{m}$$

Also $\omega = \frac{eB}{m} = \frac{(1.16 \times 10^{-19})(0.104)}{(1.67 \times 10^{-27})} = 10^7 \text{ rad s}^{-1}$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{10^7} = 2\pi \times 10^{-7} \text{ s}$$

14.(C) A atom n a solid though has no degree of freedom for translational and rotational motion, due to vibration along 3 axes has 3 × 2 = 6 degrees of freedom.

15.(D) When the number of nucleons (mass number) in nuclei increased, the binding energy per nucleon first increased and then decreases. This is clear from the fig.



16.(A) Here $_{88}Ra^{222} \xrightarrow{\alpha} {_{86}Rn^{218}} \xrightarrow{\beta^-} {_{87}Fr^{218}} \xrightarrow{\alpha} {_{85}At^{214}} \xrightarrow{\beta^-} {_{86}Rn^{214}} \xrightarrow{\alpha} {_{84}Po^{210}} \xrightarrow{\alpha} {_{82}Pb^{206}}$

$\Rightarrow$ 4α decays and 2β decays.

17.(C) Given intercepts

$$(pa, qa, ra) = (a, 2a, 2a)$$

So $$(p, q, r) = (1, 2, 2)$$

$$\left(\frac{1}{p}, \frac{1}{q}, \frac{1}{r}\right) = \left(1, \frac{1}{2}, \frac{1}{2}\right)$$

$$(h, k, \ell) = \left(\frac{1}{p}, \frac{1}{q}, \frac{1}{r}\right) = (2, 1, 1)$$

So miller indices $(h, k\ \ell) = (2, 1, 1)$

we know interplanar spacing for cubic structure is

$$d = \frac{a}{\sqrt{h^2 + k^2 + \ell^2}} = \frac{a}{\sqrt{4+1+1}}$$

$$d = \frac{a}{\sqrt{6}}$$

18.(A) According to Debye approximation, the internal energy is given by

$$E = \int_0^{\omega_m} \text{Number of energy states per unit frequency range} \times \frac{\hbar\omega}{\left[\exp\left(\frac{\hbar\omega}{K_B T}\right) - 1\right]} \quad ...(1)$$

Number of energy states per unit frequency range in one dimension

$$= \frac{2L}{C_S} \cdot \frac{d\omega}{2\pi} = \frac{L\, d\omega}{\pi C_S}$$

$$\therefore \qquad E = \frac{L}{\pi C_S} \int_0^{\omega_m} \frac{\hbar\omega\, d\omega}{\left[\exp\left(\frac{\hbar\omega}{K_B T}\right) - 1\right]} \quad ...(2)$$

Again let $\frac{\hbar\omega}{K_B T} = x$,

i.e. $$d\omega = \frac{K_B T\, dx}{\hbar} \quad ...(3)$$

Subsituting equation (3) in equation (2), we have

$$E = \frac{L}{\pi C_S} \frac{(K_B T)^2}{\hbar} \int_0^{x_m} \frac{x\, dx}{(e^x - 1)}$$

$$= \frac{Na\,(K_B T)^2}{\pi C_S \hbar} \int_0^{x_m} \frac{x\, dx}{(e^x - 1)} \qquad \text{where } L = Na$$

$$= NK_B T\left(\frac{T}{\Theta}\right) \int_0^{x_m} \frac{x\, dx}{(e^x - 1)} \qquad \text{where } \Theta = \frac{\hbar\pi C_S}{K_B a}$$

In the long temperature range T << Θ hence $x \to \infty$ and then

$$E = N\, K_B T\left(\frac{T}{\Theta}\right) \int_0^{\infty} x e^{-x} dx.$$

Now $$\int_0^{\infty} x e^{-x} dx = \left[-x e^{-x}\right]_0^{\infty} + \int_0^{\infty} e^{-x}\, dx$$

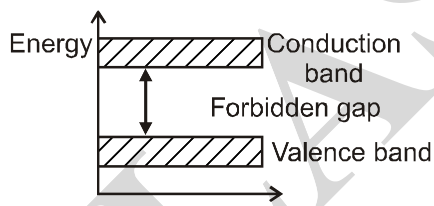
$$= \left[-e^{-x}\right]_0^{\infty} = 1$$

$\therefore \qquad E = N K_B T\left(\frac{T}{\Theta}\right)$

$$C_v = \frac{\partial E}{\partial T} = 2NK_B\left(\frac{T}{\Theta}\right)$$

or $\qquad C_v \propto \frac{T}{\Theta}$

19.(B) The lower completely filled band is called the valence band while the upper unfilled band is known as the conduction band. These two bands are separated by a gap called an energy gap or forbidden energy band whose width is denoted by Eg. This is as shown



In case of conductor, either the conduction and valence bands overlap or the conduction band is partially filled.

Semiconductor. Semiconductor are material that have a small energy gap of the order of 1 eV. At OK, the valence band is completely filled and there are no electrons in the conduction band. Thus at low temperature semiconductor are almost like insulators. At ordinary temperature. However, they are very different from insulators.

Insulator. In insulator the valence band is almost completely filled while the conduction band is empty. The energy gap is very large and can be up to 10 eV.

If the forbidden energy band gaps in conductor, semiconductors and insulators are Eg_1, Eg_2 and Eg_3, then relation among them is as follows

$$Eg_1 < Eg_2 < Eg_3$$

20.(C) On increasing the reverse bias to a large value in a P-N junction diode, the junction brakes down. Now a large reverse current is set up due to minority charge carries.

21.(C) Here centripetal force = gravitational force

i.e., $\frac{mv^2}{r} = \frac{Gmm_e}{r^2}$

or $\frac{1}{2}mv^2 = \frac{1}{2}\frac{Gm\,m_e}{r}$

Total Energy = K.E. + P.E.

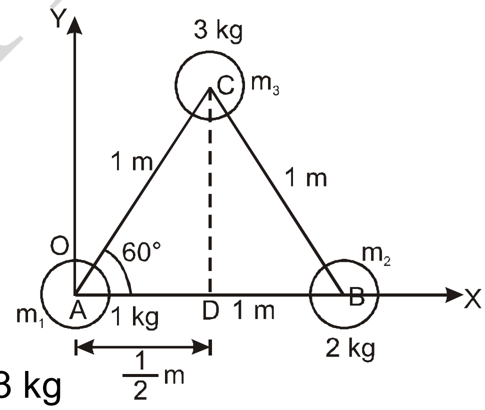
$= \frac{1}{2}\frac{Gm\,m_e}{r} - \frac{Gm\,m_e}{r}$

$= -\frac{1}{2}\frac{Gm\,m_e}{r}$

$\therefore$ P.E. = 2(total energy) = 2 E_0

22.(C) Consider an equilateral triangle of side 1 m as shown in fig. Take X and Y axes as shown in figure.

By the definition of centre of mass, we have



$\bar{x} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$

and $\bar{y} = \frac{m_1y_1 + m_2y_2 + m_3y_3}{m_1 + m_2 + m_3}$

Here m_1 = 1kg, m_2 = 2 kg and m_3 = 3 kg

[x_1 = 0, y_1 = 0], [x_2 = 1, y_2 = 0] and [x_3 = 0.5, $y_3 = \frac{\sqrt{3}}{2}$]

Here y_3 = CD = AC sin 60 = $\frac{\sqrt{3}}{2}$

$\therefore$ $\bar{x} = \frac{1\times 0 + 2\times 1 + 3\times 0.5}{1+2+3} = \frac{3.5}{6}$m

and $\bar{y} = \frac{1\times 0 + 2\times 0 + 3\times(\sqrt{3}/2)}{1+2+3} = \frac{\sqrt{3}}{4}$m

The coordinates of centre of mass are

$\left(\frac{3.5}{6}, \frac{\sqrt{3}}{4}\right)$

23.(A) The weight of the drop is equal to the sum of force due to surface tension on drop and force of buoyancy. Thus

$$\frac{4}{3}\pi r^3 dg = 2\pi rT + \frac{1}{2}\times\frac{4}{3}\pi r^3 \rho\, g$$

or $\quad 2\, r^2\, d\, g = 3\, T + r^2\, \rho\, g$

$$r = \sqrt{\left\{\frac{3T}{g(2d-\rho)}\right\}}$$

24.(A) Here the centre of mass of the particle moves along AB in the same time as along the arc ACB. The particle move with the same velocity without any change. The bead performs S.H.M. in which it velocity increases to maximum value and thereafter decreases. So the time taken by the bead is more than the time taken by the particle i.e., $t_Q > t_P$.

25.(A) Before crossing

$$n' = n\left(\frac{v+v_0}{v-v_s}\right) = 150\left(\frac{300+2}{300-9.8}\right) = 156$$

($\because$ velocity at the end of first second of falling body = 9.8 m/s)

After crossing

$$n'' = n\left(\frac{v-v_0}{v+v_s}\right) = 150\left(\frac{300-2}{300+9.8}\right) = 144$$

No of beats = 156 – 144 = 12

26.(B) Here direction of electric field does not change on introduction of dielectric slab. Thus (B) is correct.

Moreover lines move from (+) to (–)

$\therefore \quad$ Potential increases continuously.

27.(B) Here P and R being grounded are at same potential. Also potential difference between PQ is same as that between OR say V.

Then for PQ,

$$E_1 = \frac{V}{2x}$$

Now acceleration,

$$\frac{a}{2} = \frac{\text{distance}}{\text{time}^2} = \frac{2x}{t_1^2} \quad ....(1)$$

$$\left(\because\ S = \frac{1}{2}at^2\right)$$

or $$a = \frac{4x}{t_1^2}$$

but $$a = \frac{F}{m} = \frac{qE_1}{m} = \frac{qV}{2xm} \quad ...(2)$$

$\therefore$ $$\frac{4x}{t_1^2} = \frac{qV}{2xm} \quad \text{or} \quad t_1^2 = \frac{8mx^2}{qV}$$

Similarly for QR

$$t_2^2 = \frac{2mx^2}{qV}$$

$\therefore$ $$\frac{t_1^2}{t_2^2} = 4 \text{ or } \frac{t_1}{t_2} = 2$$

28.(B) If magnetic monopole exists, then the magnetic flux over a closed path will not be equal to zero.

So $\oint \vec{B}.d\vec{s} = 0$ would be modified.

29.(A) Let V be the total volume of the solid and ΔV be the volume of the solid immersed in the liquid. Then

$$\rho_s Vg = \rho_t\ \Delta Vg$$

or $$f = \frac{\Delta V}{V} = \frac{\rho_s}{\rho_\ell}$$

The density of the liquid decreases as the temperature is increased to T.

$$\rho_\ell' = \frac{\rho_\ell}{(1+\rho T)}$$

$\therefore \qquad f' = \frac{\rho_s}{\rho_1'} = \frac{\rho_s}{\rho_\ell} \times (1 + \gamma T) = f(1 + \gamma T)$

The solid gets completely immersed in the liquid when f' = 1. So

$$1 = f(1 + \gamma T) = f + f\gamma T$$

or $\qquad T = \frac{(1 - f)}{\gamma f}$

30.(A) In adiabatic compression more work will be required so temperature and internal energy of the gas will increases. So During adiabatic compression of a gas, its temperature rises.

31.(A) The equations of a carnot cycle is

$P_1V_1 = P_2V_2, P_3V_3 = P_4V_4$ (isothermal process)

$P_2V_2^\gamma = P_3V_3^\gamma, P_4V_4^\gamma = P_1V_1^\gamma$ (adiobatic process)

In this case

$$P_3 = \frac{P_2}{n}, n = 2 \qquad ....(1)$$

Then $\quad P_2V_2^\gamma = P_3V_3^\gamma \quad \Rightarrow \quad V_3^\gamma = \frac{P_2}{P_3}V_2^\gamma$

$$\Rightarrow \qquad V_3 = n^{\frac{1}{\gamma}}V_2 \qquad ....(2)$$

using equation (1)

Also $P_4V_4 = P_3V_3 = \frac{P_2}{n}n^{\frac{1}{\gamma}}V_2$ [using (1) and (2)]

$$= P_2V_2n^{1/\gamma - 1} = P_1V_1n^{\frac{1}{\gamma}-1}$$

$$\therefore \qquad \frac{V_4}{V_1} = \frac{P_1}{P_4}n^{\frac{1}{\gamma}-1} = \left(\frac{V_4}{V_1}\right)^\gamma n^{\frac{1}{\gamma}-1}$$

So $\qquad \left(\frac{V_4}{V_L}\right)^{1-\gamma} = n^{\frac{1}{\gamma}-1} = n^{\frac{1-\gamma}{\gamma}}$

$$\left(\frac{V_4}{V_1}\right)^{1-\gamma} = \left(n^{\frac{1}{\gamma}}\right)^{1-\gamma}$$

So $V_4 = n^{\frac{1}{\gamma}} V_1$ ....(4)

$$\left.\begin{aligned} &\text{Heat taken, } Q_1 = P_2V_2 \log_3 \frac{V_2}{V_1} \\ &\text{Heat rejected, } Q_2 = P_2V_3 \log_3 \frac{V_3}{V_4} \end{aligned}\right\} \quad ....(5)$$

Efficiency

$$h = 1 - \frac{Q_2}{Q_1} = 1 - \frac{P_3V_3}{P_2V_2} \frac{\log V_2 \log V_2}{\log_e V_5 - \log_e V_4} \quad \text{[using equation (5)]}$$

$$= 1 - \frac{P_2 n^{\frac{1}{\gamma}} V_2}{nP_2V_2} \frac{\log V_2 - \log V_1}{\log_e n^{\frac{1}{\gamma}} V_2 - \log n^{\frac{1}{\gamma}} V_1} = 1 - n^{\frac{1}{\gamma} - 1}$$

$$= 1 - n^{\frac{5}{7} - 1} \quad \text{[for hydrogen r = } \tfrac{7}{5}\text{]}$$

$$= 1 - (2)^{-2/7}$$

$$\approx 0.18$$

32.(A) According to Stefan's law

$$E = \sigma T^4$$

Tota surface area of the sun = $4 \pi R_s^2$

$\therefore$ Total energy radiated per second by the sun per unit solid angle

$$= [\sigma T^4 \times (4\pi R_s^2)]/4\pi = \sigma T^4 \times R_s^2$$

Let R_{es} be the distance of earth from the sun Intensity of radiation at earth.

$$I = \sigma T^4 \left(\frac{R_s 2}{R_{es}^2}\right)$$

or $1400 = (5.6 \times 10^{-8})\, T^4 \left[\frac{7.0 \times 10^8}{1.5 \times 10^{11}}\right]^2$

Solving we get T = 5801 K

33.(C) Any particle in motion is accompanied by matter waves.

34.(B) We know $R = R_0 A^{1/3}$

$$\therefore \quad \frac{R(Au^{197})}{R(Ag^{107})} = \left(\frac{197}{107}\right)^{1/3} = 1.23$$

As nuclear mass density is constant for nuclei, therefore $\frac{\rho(Au^{197})}{\rho(Ag^{107})} \approx 1.$

35.(D) Sum of masses of deutron and lithium nucleus before disintegration

= 2.0147 + 6.0169

= 8.0316

Mass of a particles

= 2 × 4.0039

= 8.0078

Difference of mass

= 8.0316 – 8.0078

= 0.9238 amu

Mass converted into energy

= 0.0238 × 931.3 MeV

Energy given to each a particle

$$= \frac{0.0238 \times 931.3}{2}$$

= 11.08 MeV

36.(A) We know density of any crystal

$$\rho = \left(\frac{nM}{Na^2}\right) \qquad ...(1)$$

$$\therefore \quad \frac{M}{N} = w$$

above eqn. use in eqnm(1)

So $\rho = \left(\frac{nW}{a^3}\right)$ ...(2)

for HCP structure

$n = 6$ ...(3)

from eq (2) and (3)

So $\rho = \frac{6w}{a^3}$

$a^3 = \frac{6w}{\rho}$

$a = \left[\frac{6w}{\rho}\right]^{1/3}$

37.(B) Doping is a process of adding controlled impurities in the material. This is of great importance in making semiconductor devices.

38.(B) The emitter is common between input and output circuits. This is also forward bias and hence, this is a circuit of common emitter amplifier.

39.(C) As gravitation provides centripetal force

$\frac{mv^2}{r} = \frac{K}{r^{5/2}}$, i.e., $v^2 = \frac{K}{mr^{3/2}}$

so that $T = \frac{2\pi r}{v} = 2\pi r\sqrt{\frac{mr^{3/2}}{K}}$

i.e., $T^2 = \frac{4\pi^2 m}{K} r^{7/2}$, so $T^2 \propto r^{7/2}$

40.(C) Here, distance between two consecutive threads = pitch = $\frac{1}{12}$ cm.

Total distance to be moved = 1.5 cm

$\therefore$ No. of rotations = $\frac{1.5}{1/12} = 18$

Total angle of turning, $\theta = 18 \times 2\pi = 36\pi$ radian

angular speed $\omega = 2\pi n$

$= 2\pi \times \frac{216}{60} = 7.2\pi$ rad/s

time taken $t = \frac{\theta}{\omega} = \frac{36\pi}{7.2\pi} = 5s$

41.(C) The present length of day, T = 24 hours, $\omega = 2\pi/T$,

Let M be the mass of the earth R and R' be the radius of earth before and after contraction.

Then $R' = R - \frac{R}{n} = R\left(1 - \frac{1}{n}\right)$

According to law of conservation of angular momentum

$$I\omega = I'\omega'$$

or $\frac{2}{5}MR^2\omega = \frac{2}{5}MR'^2\omega'^2$

or $\omega' = \frac{R^2\omega}{R'^2} = \frac{R^2\omega}{R^2[1 - \left(\frac{1}{n}\right)]^2}$

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

$\therefore$ $T' = \frac{2\pi}{\omega'} = \frac{2\pi}{[1 + (2/n)]\omega}$

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

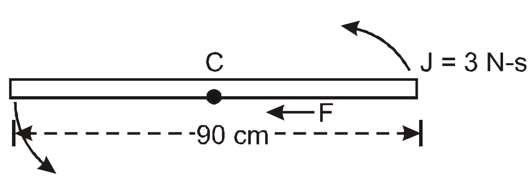
or $T' - T = \frac{2T}{n} = \frac{2 \times 24}{n} = \frac{48}{n}$ hours.

42.(A) The angular impulse about the centre of mass C = J × $\frac{\ell}{2}$

By definition this must be equal to the change in angular momentum about the centre of mass

$= I_{C.M.}(\omega - 0)$, where $I_{C.M.} = \frac{m\ell^2}{12}$

where ω is the angular velocity attained by the rod.



$\therefore \qquad \frac{m\ell^2}{12}\omega = J \times \frac{\ell}{2} \qquad \Rightarrow \qquad \omega = \frac{J\ell}{2} \cdot \frac{12}{m\ell^2} = \frac{6\,J}{m\,\ell}$

In the reference frame of centre of mass, the centre of mass of the other half rotates about an angular velocity ω. The necessary centripetal force is provided by the other half:

$$F = \frac{m}{2} \cdot \frac{\ell}{4}\omega^2 = \frac{m\ell}{8}\left(\frac{6J}{m\ell}\right)^2 = \frac{9}{2}\frac{J^2}{m\ell} = \frac{9}{2} \cdot \frac{3^2}{5 \times 0.9} = 9N$$

43.(C) Velocity of the water while falling at a depth 0.15 m will be

$$v = (u^2 + 2gs)^{1/2} = (1^2 + 2 \times 10 \times 0.15)^{1/2}$$

$$= 2 \text{ m/s}$$

From equation of continuity.

$1.0 \times 10^{-4} = 2 \times a \qquad$ or $\qquad a = 5 \times 10^{-5}\ m^2$.

44.(A),(D) As the particle starts from rest and stops, so α cannot remain positive all the time in the interval $0 \le t \le 1$. So statement (a) is correct.

Further as no other information is available about its motion, i.e., law of force is not know, so no other assertion can be made, i.e. statement (d) is also correct.

45.(A) The frequency of signal received at the plane is given by

$$n' = \frac{n(c+v)}{c}$$

where v = velocity of plane

Frequency of signal emitted by the aeroplane

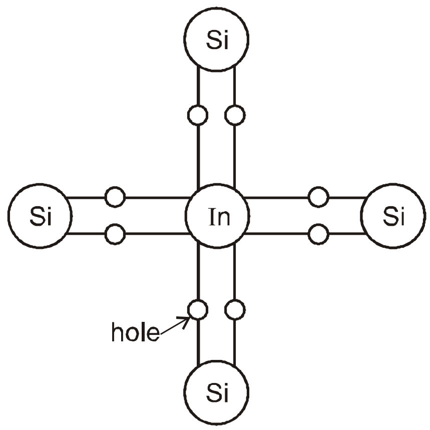
$$n'' = \frac{n'(c+v)}{c} = n\left(\frac{c+v}{c}\right)^2 = n\left(1 + \frac{v}{c}\right)^2 = n\left(1 + \frac{2v}{c}\right)$$

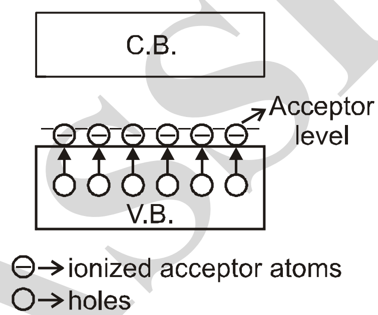
$\therefore \qquad n'' - n = \frac{2vn}{c} = \Delta n$

or $\qquad v = \frac{c\,\Delta n}{2n} = \frac{\lambda}{2}\Delta n = \frac{0.50 \times 1000}{2} = 250\ m/sec$

$\therefore \qquad v = \frac{250 \times 3600}{1000}$ km/hr = 900 km/hr]

46.(C) If the intrinsic semiconductor is doped with atoms of a trivalent element (indium or aluminium), the three electrons enter into covalent bonds with neighboring atoms, leaving a vacant place, or hole in the fourth bond. The energy levels of such vacant places also lie in the forbidden gap, just above the valence band.

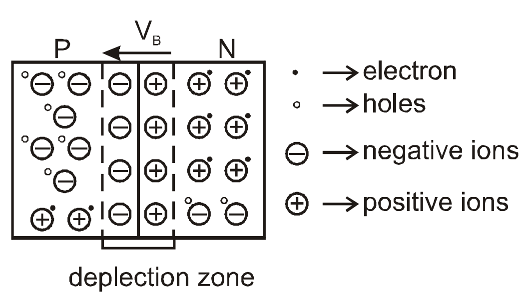




47.(C) The small region in the vicinity of the junction is deplected of charge carriers (electrons and holes) and only has the immobile ions. This region is called the deplection zone. It is only a few micron in width. Thus a P–N junction has the following configuration

On the P–side, there are (i) fixed negative ions, (ii) the majority charge carriers (the positive holes) and (iii) the minority carriers (the negative electrons). In the deplection zone on the P-side, there are only the negative ions. on the N-side, there are (i) fixed positive ions, (ii) the majority carriers (the negative electrons) and (iii) the minority carriers (the positive holes) in the deplection zone on the N-side, there are only the positive ions.

So positively charged ions (donors) on the N-side and negatively charged ions (acceptors) on the



48.(D) Given, $\frac{dv}{dt} = -kv^3$

or $\frac{dv}{v^3} = -k\,dt$. Integrating it within the condition of motion we have

$$\int_{v_0}^{v} \frac{dv}{v^3} = -\int_0^t k\,dt$$

or $$\left(-\frac{1}{2v^2}\right)_{v_0}^{v} = -k(t)_0^t$$

or $$\frac{1}{v^2} - \frac{1}{v_0^2} = 2kt$$

or $$v = \frac{v_0}{\sqrt{1 + 2k v_0^2 t}}$$

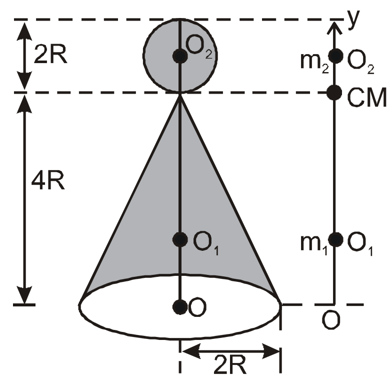
49.(C) If the density of cone be ρ, then its mass will be $m_1 = \frac{1}{3}\pi(2R)^2(4R)\rho = \frac{16}{3}\pi R^3\rho$ and its centre of mass O_1 will be at a height $\left(\frac{h}{4}\right) = \left(\frac{4R}{4}\right) = R$ from O on the line of symmetry, i.e., $y_1 = R$

Similarly the mass of the sphere $m_2 = \frac{4}{3}\pi R^3(12\rho)$ = 16 $\pi R^3\rho = 3m_1$ and its centre of mass will be at its centre O_2, i.e., $y_2 = 5R$

Now treating sphere and cone as point masses with their masses concentrated at their centre of masses respectively and taking the line of symmetry as y-axis with origin at O, for the centre of mass of the toy

$$Y_{CM} = \frac{m_1 y_1 + m_2 y_2}{m_1 + m_2} = \frac{m_1 \times R + 3m_1 \times 5R}{m_1 + 3m_1} = 4R$$

i.e., centre of mass of the toy is at a distance 4R from O on the line of symmetry, i.e., at the apex of the cone.



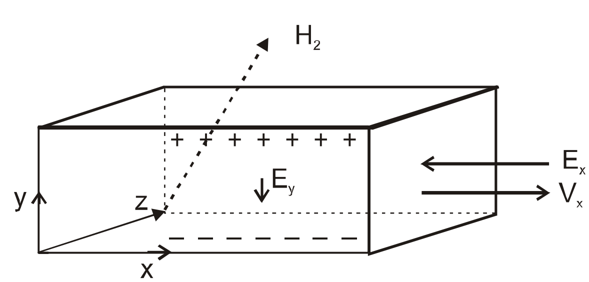
50.(D) $\frac{\pi P r^4}{8\eta\ell} = \frac{\pi P r_1^4}{8\eta\ell} + \frac{\pi P r_2^4}{8\eta\ell}$

or $\quad r^4 = r_1^4 + r_2^4$

or $\quad r = \left[r_1^4 + r_2^4\right]^{1/4}$

51.(D) For semiconductor three statements are correct but the last statement is incorrect, because n-type semiconductor is obtained by doping penta valent impurity not trivalent impurity.

52.(D) A current is flowing is the +x direction in a semiconducting slab, so an electric field E_n along the + X direction and a magnetic field H_2 along the z-direction as shown in fig. Due to the electric field a current density J_x will flow in the direction of E_x. Here the current is carried by electrons of charge –e.



Under the influence of the magnetic field the electron will be subjected to a lorentz force such that the upper surface collects a positive charge while the lower surface a negative charge The accumulation of charge on the surface of the specimen continuous until the force on moving charges due to the electric field associated wtih it is large enough to cancel the force exerted by the magnetic field ultimately a stationary state is reached when the current along y-axis vanishes, a field Ey is set up (–y direction)

Alternate

From Lorent z force

$$F = q(v)$$

$$= e[V\hat{i} \times H\hat{k}]$$

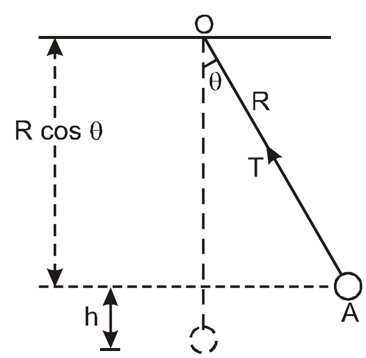
$$= -e[vHJ(\hat{J})] = eVH(-\hat{J})$$

So field is set up in –y direction.

53.(A,B) The width of the depletion zone of p-n junction is independent of the densities of dopant. The electric field across the depletion zone is due to ionized atoms present on the two sides of p-n junction.

54.(B) In p-n junction, the diffusion of majority carriers takes place when junction is forward biased and drifting of minority carrier takes place across the junction, when reverse biased.

55.(D) The situation is shown in fig.



Maximum tension T_{max} is given by

$$T_{max} = \text{Breaking stress} \times \text{area}$$

$$= (7.85 \times 10^8) \times \pi (1 \times 10^{-3})^2$$

$$= 2466.15 \text{ Newton}$$

At equilibrium position

$$T_{max} - mg = \frac{mv^2}{R} \quad ....(1)$$

and $$m g h = m g(R - R\cos\theta) = \frac{1}{2}mv^2$$

$\therefore$ $$\frac{v^2}{R} = 2g(1 - \cos\theta) \quad ....(2)$$

From eqs.(1) and (2)

$$T_{max} - m g = 2 mg (1 - \cos\theta)$$

or $T_{max} = 3\ m\ g - 2\ m\ g \cos\theta$

or $\frac{T_{max}}{mg} = 3 - 2\cos\theta$

or $\frac{2466.15}{981} = 3 - 2\cos\theta$

or $\cos\theta = 0.243$ $\therefore$ $\theta = 75°56'$

56.(B) $\beta = [\alpha/(1-\alpha)] = [0.96/(1-0.96)]$

$$= \frac{0.96}{0.04} = 24$$

57.(D) The escape velocity on earth is given by

$$v_e = \sqrt{\left(\frac{2GM_e}{R_e}\right)}$$

Let the average density of earth (and also of the planet) be ρ, then

$$M_e = \frac{4}{3}\pi R_e^3 \rho$$

$$\therefore \quad v_e = \left[\frac{2G}{R_e}\left(\frac{4}{3}\pi R_e^3 \rho\right)\right]^{1/2} = R_e\left[\frac{8}{3}G\pi\rho\right]^{1/2}$$

Similarly, escape velocity on planet

$$v_p = R_p\left[\frac{8}{3}G\pi\rho\right]^{1/2}$$

$$\therefore \quad \frac{v_p}{v_e} = \frac{R_p}{R_e} = 2 \qquad (\because\ R_p = 2R_e)$$

So, $v_p = 2v_e$

58.(B) Given that angular momentum is constant

i.e., $mr^2\omega$ = constant

or $r^2\omega$ = constant = K

$$\therefore \quad \omega = \left(\frac{K}{r^2}\right) \qquad ...(1)$$

Tension in the string = $\frac{mv^2}{r} = mr\omega^2$

$\therefore \quad T = m\,r\,\omega^2$ ....(2)

Substituting the value of ω from eq.(2) in eq.(1), we get

$$T = mr\left(\frac{K}{r^2}\right)^2 = \frac{mK^2}{r^3}$$

$$= \frac{A}{r^3} = A\,r^{-3} \quad ....(3)$$

where $A = mK^2$

Given that $T = A\,r^n$ ...(4)

Comparing eq.(3) and (4), we get

$n = -3$

59.(B) Suppose v' is speed after collision and θ' is angle of reflection.

During collision, the floor exerts a force on the ball along the normal. There is no force parallel to the surface. Therefore, velocity component of ball parallel to the floor remains constant i.e.

$v' \sin\theta' = v \sin\theta$ ...(1)

For components normal to the floor,

velocity of separation = $v' \cos\theta'$

velocity of approach = $v \cos\theta$

$\therefore \quad \frac{v'\cos\theta'}{v\cos\theta} = e$

$v' \cos\theta' = e\,v\cos\theta$ ....(2)

From (1) and (2)

$$v' = v\sqrt{\sin^2\theta + e^2\cos^2\theta}$$

and $\tan\theta' = \frac{\tan\theta}{e}$

60.(A) Using $\frac{F}{A}$ = stress, we have

Ultimate shear stress < $\frac{F}{A}$

i.e., F > Shear stress × Area

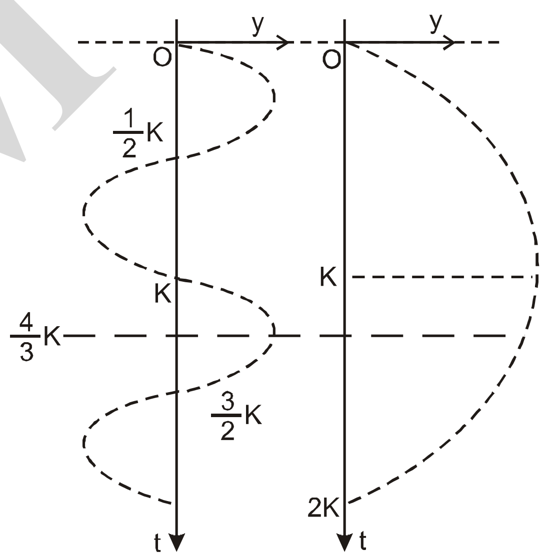
The minimum $F = \sigma\left(\frac{2\pi d}{2}\right)t$ $\left(\because \text{here area} = 2\pi\frac{d}{2}t\right)$

or $F = \pi d\sigma t$

61.(B) In case of simple pendulum as $T = 2\pi\sqrt{(L/g)},$ i.e., T = $K\sqrt{L},$ so the time period of shorter pendulum will be small, i.e., it will complete more oscillations in the same time than the longer pendulum. So if for the first time the two pendulums are in same phase when the shorter one has completed n oscillations,

$nT_S = (n-1)T_L,$ i.e., $nK\sqrt{L_S} = (n-1)K\sqrt{L_L}$

or $n\sqrt{1} = (n-1)\sqrt{16},$ i.e., $3n = 4$ or $n = \left(\frac{4}{3}\right)$, i.e. the two pendulums will be in the same phase for the first time when the shorter pendulum has completed (4/3) oscillations.



62.(D) Here, λ = 5000 Å = 5×10^{-7} m

a = 2 mm = 2×10^{-3} m

$Z_F = ?$

As Fresnel distance, $Z_F = \frac{a^2}{\lambda}$

$\therefore \qquad Z_F = \frac{(2\times10^{-3})^2}{5\times10^{-7}} = \frac{40}{5} = 8\,\text{m}$

63.(A) When two mutually perpendicular plane polarized coherent light waves of unequal amplitude and differing in phase by non integral multiples of π are compound together the resulting wave is elliptically polarised.

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos\delta = \sin^2\delta \qquad ...(1)$$

Equation of ellipse in generalization form.

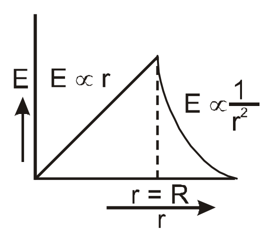
If $\delta = \frac{\pi}{2}, \frac{5\pi}{2}, \frac{9\pi}{2}, ... = \left(2n + \frac{1}{2}\right)\pi$

where n = 0, 1, 2, 3,......, $\sin\delta = 1$, $\cos\delta = 0$ so from equation (1)

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

This is the equation of ellipse ($a \neq b$). So resulting wave is elliptically polarised.

64.(A) (i) $E_{centre} = 0$



(ii) $E_{surface} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R^2}$

(iii) $E_{outside} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

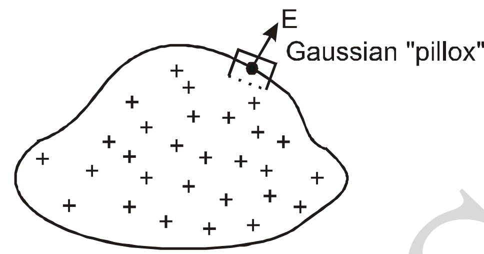
(iv) i.e. $E_{outside} \propto \frac{1}{r^2}$

(v) $E_{inside} = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{r^3} \Rightarrow E_{inside} \propto r$

65.(C) Apply Gauss's law, choosing as gaussian surface a very small, thin "pillox" sunk halfway into the conducting surface (figure). Since E must be perpendicular to the surface of a metal in electric equilibrium, the flux through one face of the pillbox is $E\Delta A$, and the flux through the other two faces is zero.

Hence,

$$E\Delta A = \frac{\sigma \Delta A}{\varepsilon_0}$$



or $\sigma = \varepsilon_0 E = (8.854 \times 10^{-12})(600 \times 10^3)$

$= 5.313\ \mu C/m^2$

66.(A) Flux linkage is maximum in the positions shown in figure (a) so mutual inductance is maximum in (a).

67.(C) Let m_1, m_2, m_3 be the masses of proton, deutron and α-particle and v_1, v_2 and v_3 be their respective velocity.

If $m_1 = m$,

then $m_2 = 2m$ and $m_3 = 4m$

Let q_1, q_2, q_3 be the charges on the proton, deutron and a-particle respectively. If $q_1 = q$, then

$q_2 = q$ and $q_3 = 2q$

As per question

$$\frac{1}{2}m_1v_1^2 = \frac{1}{2}m_2v_2^2 = \frac{1}{3}m_3v_3^2$$

or $m_1v_1^2 = m_2v_2^2 = m_3v_3^2$

or $m_1v_1^2 = 2mv_2^2 = 4mv_3^2$

or $v_1 = \sqrt{2}v_2 = 2v_3$

or $v_2 = v_1/\sqrt{2}$

and $v_3 = v_1/2$ ...(1)

Radius of the circular path of a charged particle in the magnetic field will be given by

$B\,qv = mv^2/r$ or $r = \frac{mv}{Bq}$

Let r_1, r_2, r_3 be the radii of the circular path of proton, deutron and a-particle while moving perpendicularly a magnetic field.

then $r_1 = \frac{m_1v_1}{Bq_1}, r_2 = \frac{m_2v_2}{Bq_2}, r_3 = \frac{m_3v_3}{Bq_3}$

$$\frac{r_2}{r_1} = \frac{m_2v_2q_1}{m_1v_1q_2} = \frac{2m(v_1/\sqrt{2})}{mv_1q} = \sqrt{2}$$

or $r_2 = \sqrt{2}\,r_1$

and $\frac{r_3}{r_1} = \frac{m_3v_3q_1}{m_1v_1q_3} = \frac{4m\,(v_1/2)}{mv_1\,2q} = 1$

or $r_3 = r_1$

Thus $r_1 : r_2 : r_3 = 1 : \sqrt{2} : 1$

68.(C) Work done = Area under the V-P curve

= Area of circle (assuming it to be an ellipse)

$$= \pi\frac{(P_2 - P_1)}{2}\frac{(V_2 - V_1)}{2} = \frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$$

69.(A) The efficiency of a reversible engine is always greater than the efficiency of irreversible engine. In case of irreversible engine, a part of the energy may be dissibated against friction, etc.

70.(B) Since power radiated is same for body A and body B

$\therefore \quad \frac{T_A^4}{T_B^4} = \frac{0.81}{0.01} \qquad \left(\because \frac{1}{\text{emissivity}} \propto T^4\right)$

or $\frac{T_A}{T_B} = \left(\frac{0.81}{0.01}\right)^{\frac{1}{4}} = 3$

or $T_B = \frac{T_A}{3} = \frac{5802}{3} = 1934\text{ K}$

Using Wien's displacement law

i.e. $\lambda_m T = \text{constant}$

We get $\lambda_m T_A = \lambda_B T_B$

or $\lambda_A = \lambda_B\left(\frac{T_B}{T_A}\right) = \frac{\lambda_B}{3}$

But $\lambda_B - \lambda_A = 1\ \mu\text{ m}$ (given)

$\Rightarrow$ $\lambda_B - \frac{\lambda_B}{3} = 1\ \mu\text{ m}$

or $\frac{2}{3}\lambda_B = 1\ \mu\text{m}$

or $\lambda_B = \frac{2}{3}\lambda_B = 1.5$

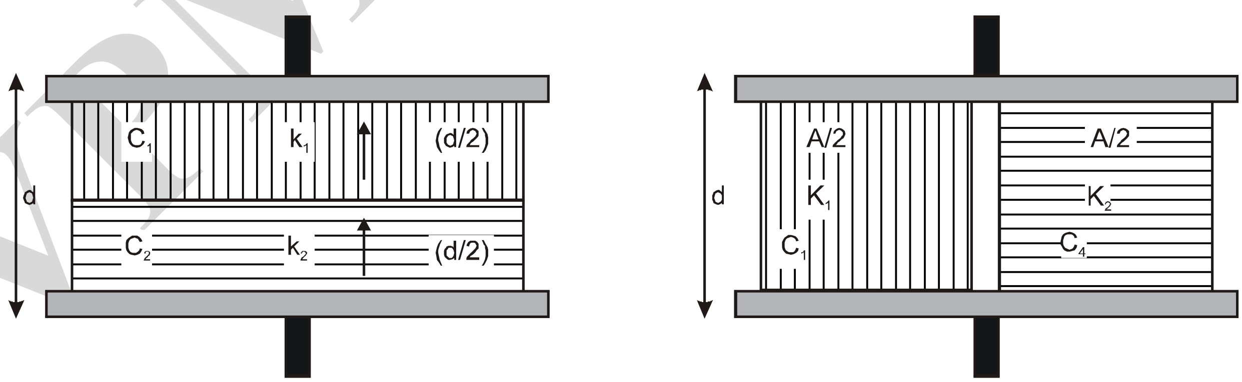
71.(B) We know

$$t = \frac{\lambda}{2(\mu_E - \mu_0)} = \frac{5893 \times 10^{-10}}{2(1.5533 - 1.5442)} = 0.3238 \times 10^{-4}\text{cm}$$

72.(C) Here potential at A = potential at B because they lie on the conductor where all points have same potential.

Using Gauss theorem, $\phi = \frac{q}{\varepsilon_0}$

73.(B) If a capacitor is filled with two dielectrics with same dimensions, only following two arrangements are possible



Arrangement (A) is equivalent to a combination of two capacitors each of area A and separation (d/2) in series, i.e.,

$$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{(d/2)}{\varepsilon_0 K_1 A} + \frac{(d/2)}{\varepsilon_0 K_2 A} \qquad \left[\text{as } C = \frac{\varepsilon_0 KA}{d}\right]$$

or, $$C_S = \frac{\varepsilon_0 A}{d}\left[\frac{2K_1K_2}{K_1 + K_2}\right] \quad ...(1)$$

And the arrangement (B) is equivalent to a combination of two capacitors each of area (A/2) and separation d in parallel, i.e.,

$$C_P = C_3 + C_4 = \frac{\varepsilon_0 K_1 (A/2)}{d} + \frac{\varepsilon K_2 (A/2)}{d} \qquad \left[\text{as } C = \frac{\varepsilon_0 KA}{d}\right]$$

or, $$C_P = \frac{\varepsilon_0 A}{d}\left[\frac{K_1 + K_2}{2}\right] \quad ...(2)$$

So that, $$\frac{C_S}{C_P} = \left[\frac{2K_1K_2}{K_1 + K_2}\right] \times \left[\frac{2}{K_1 + K_2}\right] = \frac{4K_1K_2}{(K_1 + K_2)^2}$$

Here, $K_1 = 2$ and $K_2 = 3$

So, $$\frac{C_S}{C_P} = \frac{4 \times 2 \times 3}{(2 + 3)^2} = \frac{24}{25}$$

74.(C) When magnetic fluxes are in opposite direction,

$$L' = L_1 + L_2 - 2M$$

Ignoring M, $L' = L + L - 0 = 2L$.

75.(B) According to Ampere's circutal law,

$$\oint \vec{B}.d\vec{l} = \mu_0 I_{enc}$$

Inside the tube $I_{enc} = 0$, therefore

$$\oint \vec{B}.d\vec{l} = 0 \text{ or } B\, dl = 0 \text{ or } B = 0.$$

76.(D) **Adiabatic change**

(1) System is thermally insulated from the surroundings

(2) The process takes place quickly so fourth statement is correct for adiabatic change.

77.(A) Black bodies are good absorbs as well as emitters.

78.(A) The wavelength of an electron of mass m associated with an electron of kinetic energy E is given by

$$\lambda = \frac{h}{\sqrt{(2mE)}}$$

If V is the accelerating potential, then

E = eV joule

so that $\lambda = \frac{h}{\sqrt{(2meV)}} = \frac{6.02 \times 10^{-34}}{\sqrt{(2 \times 9 \times 10^{-31} \times 1.6 \times 10^{-19} \times 344)}}$

According to Bragg's law

2d sin θ = nl.

Therefore from (2)

$$2\ d \sin 60° = \frac{1 \times 6.62 \times 10^{-34}}{\sqrt{(2 \times 9 \times 10^{-31} \times 1.6 \times 10^{-19} \times 344)}}$$

or $$2d.\frac{\sqrt{3}}{2} = \frac{6.62 \times 10^{-34}}{\sqrt{(2 \times 9 \times 10^{-31} \times 1.6 \times 10^{-19} \times 344)}}$$

or $$d = \frac{1}{\sqrt{3}} \times \frac{6.62 \times 10^{-34}}{\sqrt{(2 \times 9 \times 10^{-31} \times 1.6 \times 10^{-19} \times 344)}}$$

$= 0.5 \times 10^{-19}$ m. = **0.5 Å**

79.(A) An alpha particle is helium nucleus containing 2 protons and 2 neutrons.

Mass defect, $\Delta m = 2 \times 1.007825$

$+ 2 \times 1.008665 - 4.002800$

$= 0.03018$ a.m.u.

Binding Energy = $\Delta m \times 931.5$ MeV

$= 0.03018 \times 931.5 = 28.11267$ MeV.

80.(B) Total energy of C^{12} atom

= Number of Nucleons × 7.68

= 12 × 7.68 = 92.16 MeV

Similarly energy for C^{13} atom

= 13 × 7.47 = 97.11 MeV

Energy required to remove 1 neutron from C^{13} = (97.11 – 92.16)

= 4.95 MeV

81.(D) We know that packing fraction in crystals is defined as packing fraction = $\frac{\text{volume of al the atoms in a unit cell}}{\text{Volume of the unit cell}}$

If atomic diameter is d, the volume occupied by the atoms in sc = $\frac{1}{6}\pi d^3$

$\therefore \quad V = \frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi\left(\frac{d}{2}\right)^3 = \frac{1}{6}\pi d^3$

unit cell parameter for

sc $\Rightarrow$ a = d {a = 2r = d

Therefore the unit cell volumes of sc = $(2r)^3 = d^3$

so the packing fraction (sc) = $\frac{\frac{1}{6}\pi d^3}{d^3} = \frac{\pi}{6} = 0.5$

similarly for fcc crystal

volume occupied by the atoms = $\frac{4}{6}\pi d^3$

unit cell parameter a = $d\sqrt{2}$

the unit cell volume = $2\sqrt{2}\,d^3$

so the packing fraction = $\frac{\frac{4}{6}\pi d^3}{2\sqrt{2}d^3}$

$= \frac{\pi}{3\sqrt{2}} = 0.7$ ...(2)

Similarly for hcp structure

The volumes occupied by the atoms = $\frac{2}{6}\pi d^3$

unit cell parameters a = b = d and c = $\frac{2d\sqrt{2}}{3}$

unit cell volume = $\sqrt{2}d^3$

so the packing fraction = $\frac{\frac{2}{6}\sigma\pi d^3}{\sqrt{2}d^3} = \frac{\pi}{3\sqrt{2}}$ = 0.7 ....(3)

form eqn(1) (2) and (3), we get $(p.f.)_{sc} : (p.f.)_{fcc} : (p.f.)_{hcp}$ = 0.5 : 0.7 : 0: 7

82.(C) For P-type semiconductor, doped boron as a impurity because it is a trivalent impurity and create more holes in lattice. So, it is called acceptor impurity.

83.(C) $A_\upsilon = \beta(R_L/R_i) = 50 \times \left(\frac{5000}{2000}\right) = 125$

$\Delta V_e = A_\upsilon \times \Delta V_b$ = 125 × 10 mV = 1.25 V.

84.(D) Relative velocity $V_2 - V_1 = -(u_2 - u_1)$

V – velocity after collision

u – velocity before collision.

Thus relative velocity is unchanged in magnitude but gets reversed in direction.

85.(C) Using $P = \frac{F}{A}$ we get F = PA

i.e. $F = \frac{1}{2}\rho v^2 A = \frac{1}{2}\rho v^2$

Volume of water passing through orifice

$V = avt$

or $v = \frac{V}{at}$ $\therefore$ $F = \frac{1}{2}\sigma\frac{V^2}{a^2t^2}A$

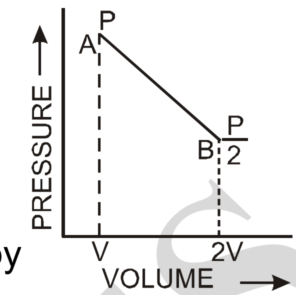
Work done W = F × S

(where S is distance moved by piston)

$$= \frac{1}{2}\sigma\frac{V^2}{a^2t^2}AS = \frac{1}{2}\rho\frac{V^2 \cdot V}{a^2t^2} \qquad (\because V\ AS)$$

$$= \frac{1}{2}\rho\frac{V^3}{a^2t^2}$$

86. (A,B) The situation is shown in figure.



Workdone from A to B = area of P-V diagram

$$= \left(P + \frac{P}{2}\right)V = \frac{3PV}{2} = \frac{3RT}{2}$$

In case of isothermal process, the workdone is given by

$$= R\,T \log_e \frac{V_2}{V_1}$$

$$= R\,T \times 2.303 \log_{10} 2$$

$$= R\,T \times 2.303 \times 0.3010 = 0.6903\,R\,T$$

The equation of straight line is given by

$$\frac{P}{P_0} + \frac{V}{V_0} = 1$$

Here P_0, V_0 are the intercepts on P and V-axes respectively.

In T-V graph.

$P = R\,T/V$ (assuming one mole of gas)

$$\therefore \quad \frac{RT}{P_0 V} + \frac{V}{V_0} = 1$$

$$\text{or} \quad \frac{RT}{P_0 V} = \left(1 - \frac{V}{V_0}\right)$$

$$T = \frac{P_0 V}{R}\left(1 - \frac{V}{V_0}\right) = \frac{P_0 V}{R} - \frac{P_0 V^2}{R V_0}$$

This represents a parabola.

87.(C) The average energy of planck's oscillator

$$\bar{\varepsilon} = \frac{h\nu}{e^{h\nu/kT} - 1} = \frac{h\nu/kT}{e^{h\nu/kT} - 1}kT$$

$$\text{now} \quad \frac{h\nu}{kT} = \frac{(6.6 \times 10^{-34})\,(0.60 \times 10^{14})}{1.38 \times 10^{-23} \times 1800} = 1.59$$

$\therefore \qquad \bar{\varepsilon} = \frac{h\nu/kT}{e^{h\nu/kT} - 1}kT = \frac{1.59}{e^{1.59} - 1} \times 2.484 \times 10^{-20}$

$= \frac{1.59}{(2.72)^{1.59} - 1} \times 2.484 \times 10^{-20}$ [e = 2.72]

$= 1.01 \times 10^{-20}$ Joule

88.(B) Here $r_n = \frac{n^2h^2\varepsilon_0}{\pi nZe^2}$ $\therefore$ $r_n \propto n^2$

Angular momentum, $L = n\left(\frac{h}{2\pi}\right)$ and

K.E. $= \frac{Ze^2}{8\pi\varepsilon_0 r}$ whereas

P.E. $= \frac{Ze^2}{4\pi\varepsilon_0 r}$

$\therefore$ |P.E.| > |K.E.|

89.(C) We know that, de Broglie wavelength

$\lambda = \frac{h}{m\upsilon}$ and $E = \frac{1}{2}m\upsilon^2$

$\therefore \qquad \lambda = \frac{h}{\sqrt{2mE}}$

In first case, $100 \times 10^{-12} = \frac{h}{\sqrt{2mE_1}}$ .....(1)

In second case, $50 \times 10^{-12} = \frac{h}{\sqrt{2mE_2}}$ .....(2)

Dividing eq.(1) by e. (2), we get

$2 = \sqrt{\left(\frac{E_2}{E_1}\right)}$ or $E_2 = 4E_1$

So, energy to be added $= 4E_1 - E_1 = 3E_1$

Now $\frac{h}{\sqrt{2mE_1}} = 100 \times 10^{-12}$

or $\sqrt{2mE_1} = \frac{6.625 \times 10^{-34}}{10^{-10}}$

or $\sqrt{2mE_1} = 6.625 \times 10^{-24}$

or $E_1 = \frac{(6.625 \times 10^{-24})^2}{2 \times (9.1 \times 10^{-31})}$

$\therefore$ Energy added

$= 3E_1 = \frac{3(6.625 \times 10^{-24})^2}{2 \times (9.1 \times 10^{-31}) \times (1.6 \times 10^{-19})} eV$

= **450 eV**

90.(D) Density of nuclear matter is independent of mass number.

91.(D) Sum of masses of deutron and lithium nucleus before disintegration

= 2.0147 + 6.0169

= 8.0078 amu

Mass of α particles

= 2 × 4.0039

= 8.0078

Difference of mass

= 8.0316 – 8.0078

= 0.00238 amu

Mass converted into energy

= 0.0238 × 931.3 MeV

Energy given to each α particle

$= \frac{0.0238 \times 931.3}{2}$ = 11.08 MeV

92.(A) In this problem we have

pa: qb : rc = ∞ :2b : 3c

So p: q: r = ∞ : 2: 3

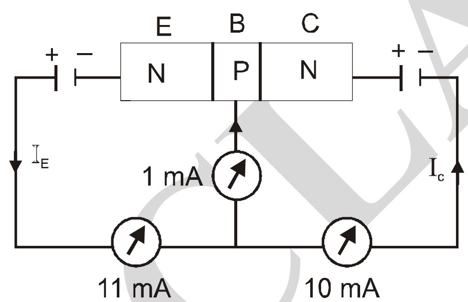
$$\frac{1}{p}:\frac{1}{q}:\frac{1}{r}=\frac{1}{\infty}:\frac{1}{2}:\frac{1}{3}=0:3:2$$

Thus, the Mioller indices of the given set of parallel planes are (0 3 2) for the second part of the problem.

We have $d=\frac{q}{\sqrt{h^2+x^2+\ell^2}}$ = $\sqrt{(0)^2+0+4}=\frac{3}{\sqrt{13}}$ Å.

93.(A) ∴ Capper is a metal and germanium is semiconductor so pieces of copper (cu) and germanium (Ge) are cooled from room temperature to 80 K then the resistance of cu will decrease and Ge increase.

94.(B) The current distribution is shown in figure



We have $I_E = I_C + I_B$

As 90% of the electrons emitted constitute 10 mA collector current, the base current is 10%

i.e., 1 mA.

∴ I_E = 10 mA + 1 mA + 11 mA.

95.(C) Before collision, the velocities of m_1 and m_2 at t_0 are given as

$v_1'' = v_1 + g\,t_0$ and $v_2'' = v_2 + g\,t_0$

At t = 2 t_0, the velocities of m_1 and m_2 are expressed as

$v_1' = v_1'' + 2g\,t_0$ and $v_2' = v_2'' + 2\,g\,t_0$

so, $(m_1 v_1' + m_2 v_2') - (m_1 v_1 + m_2 v_2) = 2(m_1 + m_2)\,g\,t_0$

96.(A) Force per meter on II wire = $\frac{\mu_0 i_1 i_2}{2\pi r}$, where i_2 is current in the second wire ....(1)

Weight per meter of second wire = ρg ....(2)

Here eqn.(1) = eqn.(2)

$\therefore \qquad i_2 = \frac{2\pi r\rho g}{\mu_0 i_1}$

Now when current in first wire becomes i_1', the upward force on second wire per meter.

$$= \frac{\mu_0}{2\pi}\frac{i_1' i_2}{r} = \frac{\mu_0 i_1' \times 2\pi r\rho g}{2\pi r\,\mu_0 i_1} = \frac{i_1'\,\rho g}{i_1}$$

Weight per meter of second wire = ρg

$\therefore \qquad$ Net upward force = $\rho g\left(\frac{i_1'}{i_1} - 1\right)$

Instantaneous acceleration = $\frac{\rho g\left(\frac{i_1'}{i_1} - 1\right)}{\rho}$ $\quad$ ($\because$ here ρ is mass per unit length)

$$= g\left(\frac{i_1'}{i_1} - 1\right)$$

97.(A) The frequency of γ-rays is more than that of X-rays and frequency of X-rays is more than that of ultraviolet rays i.e. b > a, a > c

98.(C) The coefficient of viscosity is given by

$$\eta = \frac{1}{3}mn\bar{v}\lambda$$

The mean free path

$$\lambda = \frac{3\eta}{mn\bar{v}} = \frac{3\eta}{\rho\bar{v}} \qquad .....(1)$$

Given $\eta = 166 \times 10^{-6}$ dyne per sq. cm. per unit velocity gradient

$mn = \rho = 1.25 \times 10^{-3}$ g/c.c.

$\bar{v} = 4.5 \times 10^4$ cm/s

put these values in equation (1)

$$\lambda = \frac{3 \times 166 \times 10^{-6}}{1.25 \times 10^{-3} \times 4.5 \times 10^{4}} = 8.8 \times 10^{-6} \text{ cm}$$

We know that

$$\lambda = \frac{1}{\sqrt{2}(\pi n \sigma^2)} = \sigma^2 = \frac{1}{\sqrt{2}(\pi n \lambda)} = \frac{1}{\sqrt{2}(3.14 \times 2.7 \times 10^{19} \times 8.8 \times 10^{-6})}$$

$\therefore$ The molecular diameter

$$\sigma = \frac{1}{\sqrt{(1.414 \times 3.14 \times 2.7 \times 10^{19} \times 8.8 \times 10^{-6})}} = 3.08 \times 10^{-8} \text{ cm}$$

99.(A) For process AB

$\Delta Q = \Delta U + \Delta W = U_B - U_A + dW$

$\therefore$ $600 = U_B - U_A + 0$ or $U_B - U_A = 600$

For process BC

$\Delta Q = \Delta U + dW$

$200 = U_C - U_B + P_B(V_C - V_B)$

$= U_C - U_B + (8 \times 10^4)\,[5 \times 10^{-3} - 2 \times 10^{-3}]$

$= U_C - U_B + 240$

$\therefore$ $U_C - U_B = 200 - 240 = -40$ J

For process AC,

Change in internal energy $= U_C = U_A = U_C - U_B + U_B - U_A = -40 + 600 = 560$ J

100.(B) In the isobaric process

$p_2V_1 = RT_3$, $p_2 \,.\, nV_1 = RT_2$

or $T_3 = \frac{T_2}{n}$ ....(1)

For adiabatic expansion

$T_1V_1^{\gamma-1} = T_2(n\,V_1)^{\gamma-1}$ or $T_1 = T_2n^{\gamma-1}$ .....(2)

Heat taken in isochoric process

$$Q_1 = C_v(T_1 - T_3) = C_v\left(T_1 - \frac{T_2}{n}\right) = C_v T_2\left(n^{\gamma-1} - \frac{1}{n}\right),$$

making use of equations (1) and (2),

Similarly heat rejected Q_2 in isobaric process

$$Q_2 = C_p(T_2 - T_3) = C_p\left(T_2 - \frac{T_2}{n}\right) = C_p T_2\left(1 - \frac{1}{n}\right),$$

Hence,

$$\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{C_p}{C_v}\frac{n-1}{n^\gamma - 1} = 1 - \gamma\frac{n-1}{n^\gamma - 1}$$

101.(C) As $V = \frac{4}{3}\pi r^3$

$$\therefore \quad \frac{\Delta V}{V} = \frac{3\,\Delta r}{r}$$

Hence maximum percentage change will be observed in volume.

102.(C) Here weight of the mass will meet a buoyant force exerted by the liquid and the mass exerts same force on water downward. For equilibrium, upward force of the spring is equated by the combined downward forces of (water + beaker) and buoyant force of suspended mass. The actual weight of body is not taken as it is because it is now being sharded by water.

103.(C) here steel and concrete face same strain

Using $Y = \frac{\text{stress}}{\text{strain}}$, we get

$$\text{strain} = \frac{\text{stress}}{Y}$$

$$\therefore \quad \frac{S_{concrete}}{Y_{concrete}} = \frac{S_{steel}}{Y_{steel}} \text{ i.e. } \frac{S_c}{Y_c} = \frac{S_s}{Y_s}$$

If F is total force and f be fraction of it on concrete, we get

$$= \frac{f\,F}{A_c Y_c} = \frac{F - f\,F}{Y_s A_s}$$

i.e. $f = \frac{A_cY_c}{A_sY_s + A_cY_c}$

or $f = \frac{A_cY_c}{\frac{1}{20}A_c(10Y_c) + A_cY_c} = \frac{1}{\frac{1}{2}+1} = \frac{2}{3}$

104.(B) Distance travelled by sound wave in semicircular portion $= \frac{2\pi r}{2} = \pi r$

Distance travelled in straight portion = 2rr At B, the path difference between sound waves = $(\pi r - 2r)$

i.e., $\Delta l = r(\pi - 2)$

Using $\upsilon = \lambda v$ we get ; $\lambda = \frac{\upsilon}{v}$

Also for constructive interference,

$\Delta l = n\lambda$

then $n\lambda = r(\pi - 2)$

or $\frac{n\upsilon}{v} = r(\pi - 2)$

or $v = \frac{n\upsilon}{r(\pi - 2)}$

105.(B) Here the effective spring constant $K = k_1 + k_2$ i.e. spring factor $= (k_1 + k_2)$; Inertia factor = m.

As frequency $v = \frac{1}{2\pi}\sqrt{\frac{\text{spring factor}}{\text{inertia factor}}} = \frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}}$

106.(B) Consider a strip dr of conductor B at a distance r. Magnetic field produced by conductor. A carrying current I_1 at a distance r from it

$B = \frac{\mu_0 I_1}{2\pi r}$ (perpendicular to thin element and directed downward)

The force dF, on thin element of width dr per unit length of conductor B, is given by dF = $B.I_2' = \frac{\mu_0 I_1}{2\pi r} \cdot I_2'$

where I_2' = current in thin element

= current per unit width in conductor B × width of element.

= $\frac{I_2}{b} \times dr$

$\therefore$ $dF = \frac{\mu_0 I_1}{2\pi r} \times \left(\frac{I_2 dr}{b}\right)$

Total force on element OB is given by

$$F = \int_a^{a+b} \frac{\mu_0 I_1 I_2}{2\pi b} \times \frac{dr}{r} = \frac{\mu_0 I_1 I_2}{2\pi b}[\log_e r]_a^{a+b}$$

$$= \frac{\mu_0 I_1 I_2}{2\pi b}[\log_e (a+b) - \log_e a] = \frac{\mu_0 I_1 I_2}{2\pi b}\log_e\left(\frac{a+b}{a}\right)$$

107.(C) Given $\nu_0 = 3.5 \times 10^{14}$ Hz

We know work function

$W = h\nu_0$

$h = 6.6 \times 10^{-34}$ JS, $\nu_0 = 3.5 \times 10^{14}$ Hz

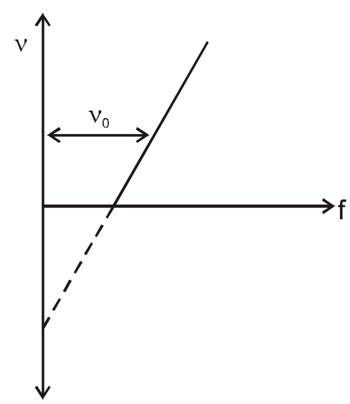
So, $W = 6.6 \times 10^{-34} \times 3.5 \times 10^{14}$

$= 23.1 \times 10^{-20}$ J

$W = \frac{23.1 \times 10^{-20}}{1.6 \times 10^{-19}} = 14.4 \times 10^{-1}$

W = 1.44 eV

W ≈ 1.5 eV



108.(B) Total energy C^{12} atom

= Number of Nucleons × 7.68

= 12 × 7.68 = 92.16 MeV

similarly energy for C^{13} atom

= 13 × 7.86 = 92.11 MeV

Energy required to remove 1 neutron from C^{13} = (97.11 – 92.16)

= 4.95 MeV

109.(B) $t_{1/2} = \frac{\log_e 2}{\lambda}$

$t_{mean} = 1/\lambda$

110.(B) The lattice constant a is given by

$$a = \left(\frac{nM}{N\rho}\right)^{1/3}$$

Here n = number of molecules per unit cell in f c c lattice \ 4,

M = 60.2, N = 6.02 × 10^{26} and ρ = 6250 kg/m^3

$$a = \left(\frac{4 \times 60.2}{6250 \times 6.02 \times 10^{26}}\right)^{1/3} = 4 \times 10^{-10}\ m = \mathbf{4\ Å}$$

111.(A) No density of silicon = 5 × 10^{28} atoms/m^3 = 5 × 10^{22} atoms/cm^3

No. of acceptor atom/cm^3

= 5 × 10^{22}/(5 × 10^7) = 10^{15}/cm^3

112.(B) This is because waves diffracted from the edges of circular obstacle interfere constructively at the centre of the shadow resulting in the formation of a bright spot.

113.(C) In case of charged ring of radius R and charge q field is given by

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2 + x^2)^{3/2}} \qquad ....(1)$$

E will be maximum,

when $\left(\frac{dE}{dx}\right) = 0$

so from equation (1)

$$\frac{1}{4\pi\varepsilon_0}\left[\frac{(R^2 + x^2)^{3/2}Q - \frac{3}{2}(R^2 + x^2)^{1/2}(2Qx^2)}{(R^2 + x^2)^3}\right] = 0$$

$$\frac{1}{4\pi\varepsilon_0}\left[\frac{Q}{(R^2+x^2)^{3/2}}\left(1-\frac{3x^2}{R^2+x^2}\right)\right]=0$$

$$\frac{1}{4\pi\varepsilon_0}\frac{Q}{(R^2+x^2)^{3/2}}\neq 0$$

so $$1-\frac{3x^2}{R^2+x^2}=0$$

$$\frac{3x^2}{R^2+x^2}=1$$

$$2x^2 = R^2 \quad \Rightarrow \quad x = \pm\frac{R}{\sqrt{2}} \qquad ...(2)$$

from equation (1) and (2), we get

$$E = \frac{1}{4\pi\varepsilon_0}\frac{QR/\sqrt{2}}{\left(R^2+\frac{R^2}{2}\right)^{3/2}} = \frac{1}{4\pi\varepsilon_0}\frac{QR}{\sqrt{2}\times\left(\frac{3R^2}{2}\right)^{3/2}}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{QR}{\sqrt{2}\times\frac{3\sqrt{3}}{2\sqrt{2}}R^3} = \frac{1}{4\pi\varepsilon_0}\frac{2Q}{3\sqrt{3}R^2}$$

114.(A) In nth state, time period $T_n = \frac{2\pi r_n}{\nu_n}$

or $T_n \propto \frac{r_n}{\nu_n} \propto n^3$ $\left(\because r_n \propto n^2 \text{ and } \nu_n \propto \frac{1}{n}\right)$

As $T_{n1} = 8T_{n2}$ (given)

$\therefore$ $n_1 = 2n_2$

$\therefore$ $n_2 = 2$

and $n_1 = 4$

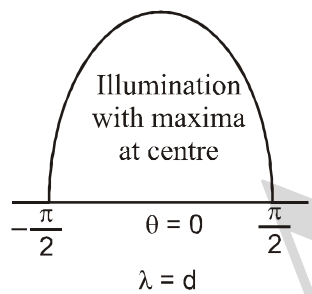
115.(A) Here loss in electrical energy = gain in kinetic energy

i.e., $Ve = \frac{1}{2}m\upsilon^2$

or $\upsilon = \sqrt{\frac{2Ve}{m}}$

116.(B) In this case wavelength decrease and hence angular position of minima will decrease narrowing the diffraction pattern. So, diffraction band become narrower and crowded together.

117.(D) If λ = d, In this situation $\theta \to \pi/2$, i.e. central maximum will extend from $-\pi/2$ to $+ \pi/2$. So in this situations, neither the image of slit nor the diffraction pattern will be observed but the whole screen will be illuminated. However, the intensity on the screen will be maximum at the centre and will decrease on either side of it as shown in fig.



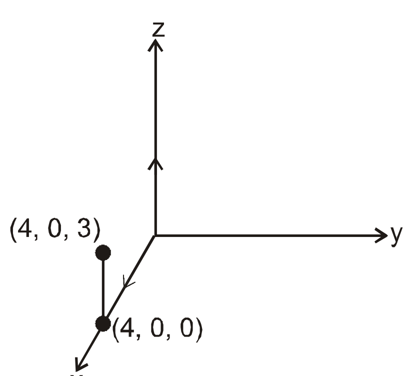
118.(B) Polaroid glass reduce glare by absorbing incident light. This is turn affects the visibility (i.e. intensity) of the object adversely. so polaroid glass is used in sunglasses as this reduce glare.

119.(A) Because the field is conservative, we can use straight line paths parallel to coordinate axes (see fig.) following the path from (0, 0, 0) to (4, 0, 0) to (4, 0, 3), the work done against the field in carrying a unit positive charge (the potential difference) is

$-E_x(4 - 0) - E_z(3 - 0)$

$= -5 \times 4k - 0$ [since there is no field component in the z direction]

$= -20$ K



120.(A) Energies are indirectly proportional to n^2 with decreased value of n (when electron jumbs from an excited state to ground state) kinetic energy increases whereas potential energy and total energy being negative increase with negative sign.

Therefore potential energy and total energy actually decrease whereas kinetic energy increases.