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ENTRANCE EXAMINATIONS, JUNE 2010
QUESTION PAPER BOOKLET

M.Sc. (PHYSICS)

Marks : 75
Time : 2.00 hrs.

Hall Ticket No.:

I. Please **enter your Hall Ticket Number on Page 1 and OMR sheet** without fail.

II. Read carefully the following instructions:

This Question paper has Two Sections: **Section- A** and **Section- B**

1. **Section- A** consists of 25 objective type questions of one mark each. **There is negative marking of 0.33 mark for every wrong answer.** The marks obtained by the candidate in this Section will be used for resolving tie cases.

2. **Section- B** consists of 50 objective type questions of one mark each. **There is no negative marking in this Section.**

3. Answers are to be marked on the OMR answer sheet following the instructions provided there upon.

   100. (A) (B) (C) ●

4. Calculators are permitted. Logarithmic tables are not allowed.

5. All questions are to be answered.

6. Hand over both question booklet and the OMR sheet at the end of the examination.

This book contains 25 pages

III. Values of physical constants:

$c = 3 \times 10^8$ m/s ; $h = 6.63 \times 10^{-34}$ J.s ; $k_B = 1.38 \times 10^{-23}$ J/K

$e = 1.6 \times 10^{-19}$ C ; $\mu_0 = 4\pi \times 10^{-7}$ Henry/m ; $\varepsilon_0 = 8.85 \times 10^{-12}$ farad/m

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SECTION - A

1. If $\vec{r}$ is a position vector, then $\vec{\nabla} \times \vec{r}$ is given by

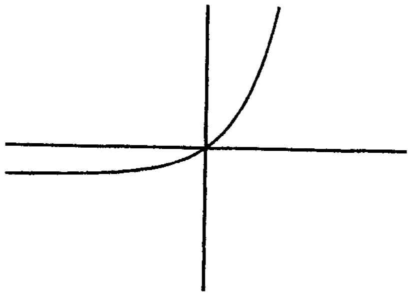
   A. $r^{3/2}$

   B. $r^{1/2}$

   C. 0

   D. 3

2. The curve in the given figure is described by the equation



   A. $y = e^{x} - 1$

   B. $y = e^{-x} - 1$

   C. $y = x$

   D. $y = \frac{1}{x}$

3. It is given that $\int_{-\infty}^{\infty} e^{-\alpha x^2} dx = \sqrt{\frac{\pi}{\alpha}}$. The value of $\int_{-\infty}^{\infty} x^2 e^{-\alpha x^2} dx$ is given by

   A. $-\frac{\partial}{\partial \alpha}\left(\sqrt{\frac{\pi}{\alpha}}\right)$

   B. $-\frac{\partial^2}{\partial x^2}\left(\sqrt{\frac{\pi}{\alpha}}\right)$

   C. $\frac{\partial}{\partial \alpha}\left(\sqrt{\frac{\pi}{\alpha}}\right)$

   D. $-\frac{\partial}{\partial \alpha}\left(\frac{\pi}{\alpha}\right)$

4. The mutual potential energy V of a system of two particles depends on their separation r as

$$V = \frac{a}{r^2} - \frac{b}{r} \quad ; \quad a > 0 \quad , \quad b > 0.$$

   If the particles are in static equilibrium, their separation is given by

   A. $\frac{2a}{b}$

B. $\dfrac{2b}{a}$

C. $\dfrac{a}{b}$

D. $\dfrac{b}{a}$

5. Six particles are held together by rigid bonds acting between every two particles. How many independent coordinates are required to describe this system?

   A. 15

   B. 12

   C. 6

   D. 10

6. The torque on a particle at position $\vec{r}$ with momentum $\vec{p}$ is given by

   A. $\vec{r} \times \dfrac{d\vec{p}}{dt}$

   B. $\dfrac{d}{dt}\left(\vec{r} \times \dfrac{d\vec{p}}{dt}\right)$

   C. $\vec{p} \times \dfrac{d\vec{p}}{dt}$

   D. $\vec{r} \times \dfrac{d\vec{r}}{dt}$

7. The efficiency of a Carnot engine operating between the temperatures T_h and T_c, where $T_h > T_c$, is given by

   A. $1 + T_c/T_h$

   B. $1 - T_c/T_h$

   C. T_c/T_h

   D. $T_c - T_h$

8. Which of thc following are all extensive paraneters?

   A. Volume and temperature

   B. Pressure and temperature

   C. Entropy and volume

   D. Internal energy and temperature

9. According to the Debye theory, the specific heat of a solid at high temperature is proportional to

   A. T^0

   B. T^2

   C. T^3

   D. T^4

10. An astronaut moves in a spaceship traveling at a speed of 0.8 c (c is the velocity of light), and observes a photon approaching him from space. The speed of photon with respect to the spaceship is

    A. 1.8 c

    B. 0.2 c

    C. 0.9 c

    D. c

11. Special relativity predicts that an outside inertial observer sees a moving object as bearing one of the following relationships with respect to an observer moving with the object

    A. longer

    B. shorter

    C. brighter

    D. unchanged

12. According to the semiempirical mass formula, surface energy correction to the atomic mass of a nucleus is proportional to

    A. $A^{1/3}$

    B. $A^{3/2}$

    C. $A^{1/2}$

    D. $A^{2/3}$

    where A is the number of nucleons.

13. If 3.6 gm of uranium is to be completely converted to energy, how many Joules of energy will be obtained from it?

    A. 100×10^{13} J

    B. 3.24×10^{13} J

    C. 32.4×10^{13} J

    D. 324.0×10^{13} J

14. A particle moves with a constant speed v in a magnetic field B. The work done is

A. zero

B. proportional to the velocity

C. proportional to the magnetic field

D. proportional to the charge q of the particle

15. For a spherical shell of radius R which carries a uniform surface charge,

A. both the field and the potential inside the shell are non-zero

B. both the field and the potential inside the shell are zero

C. the field inside the shell is non-zero while potential inside the shell is zero

D. the field inside the shell is zero while potential inside the shell is non-zero

16. The energy stored in a system of four identical charges of 4 x 10^{-9}C at the corners of a square of side 1 m is

A. 97.5 J

B. 97.5 x 10^{-9}J

C. 780 J

D. 780 x 10^{-9}J

17. The fundamental frequency of a string of length L, tension T and mass per unit length μ is given by

A. $\sqrt{\frac{T}{\mu}}\frac{n\pi}{L}$

B. $\sqrt{\frac{T}{\mu}}\frac{\pi}{L}$

C. $\sqrt{\frac{L}{\mu}}\frac{\pi}{T}$

D. $\sqrt{\frac{T}{\mu}}L$

18. Intensity of sound is increased by a factor of 20. By how many decibels is the sound level increased?

A. 20 db

B. 1.3 db

C. 13 db

D. 30 db

19. A negative (diverging) lens has a focal length of 5 cm. An object is kept at 7cm from the centre of the lens along the lens axis. The image is a

A. real image, 30 cms from the lens, on the same side as the object and magnified

B. virtual image, 30 cms from the lens, on the same as the object and magnified

C. virtual image nearly at 3 cm from the lens, on the same side as the object, reduced to nearly half the size of object and inverted

D. virtual image nearly at 3 cm from the lens, on the same side as the object, reduced to nearly half its size of the object and vertical.

20. A monochromatic wave passes through media of different refractive indices n. What is the impact of the media on the frequency ν, velocity v , wavelength λ and wavenumber k of the monochromatic wave

A. ν remains the same, $v = c/n$, $\lambda = \lambda_o/n$, $k = k_o n$

B. ν remains the same, $v = cn$, $\lambda = \lambda_o/n$, $k = k_o n$

C. ν remains the same, $v = c/n$, $\lambda = \lambda_o n$, $k = k_o n$

D. ν remains the same, $v = c/n$, $\lambda = \lambda_o/n$, $k = k_o/n$

where k_0 is the corresponding value in vacuum

21. If a sphere of radius r moves through a stationary fluid of viscosity η so that its velocity relative to the fluid is v, the resistive force the sphere experiences can be written as

A. $F = 6\eta a/v$

B. $F = 6\eta a r e^v$

C. $F = 6\pi a\eta v^3$

D. $F = 6\pi a\eta v$

22. A soap bubble has a radius r and surface tension T. The excess pressure in the bubble is

A. $\Delta p = \dfrac{T}{r}$

B. $\Delta p = \dfrac{2T}{r}$

C. $\Delta p = \dfrac{4T}{r}$

D. $\Delta p = (T-1)/2r$

23. An electron of mass m and charge e, initially at rest, gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of this electron with time, (ignoring relativistic effects) is given by

A. $-\dfrac{h}{eEt^2}$

B. $-\dfrac{eht}{E}$

C. $-\dfrac{mh}{eEt^2}$

D. $-\dfrac{h}{eE}$

24. The uncertainty relation holds for the following situation

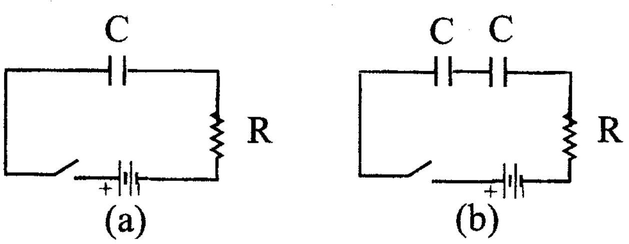
A. holds for particles only

B. does not hold for macroscopic particles

C. holds for both microscopic and macroscopic particles

D. depends on the nature of the particle

25. The current in circuit (a) will reach a saturation value in τ_a seconds. The current in circuit (b) will saturate in τ_b seconds. If value of R, C and V are identical in both circuits, then



A. $\tau_a = \tau_b$

B. $\tau_a = 2\tau_b$

C. $\tau_a = 0.5\tau_b$

D. $\tau_a = 0.25\tau_b$

SECTION - B

26. The most general solution of the equation

$$\frac{d^2x}{dt^2} + \omega^2 x = ce^{-\alpha t}$$

can be written as

A. $A\sin\omega t + B\cos\omega t$

B. $A\sin\omega t + B\cos\omega t + Ce^{-\alpha t}$

C. $A\sin\omega t + B\cos\omega t + C(\alpha^2+\omega^2)e^{-\alpha t}$

D. $A\sin\omega t + B\cos\omega t + Ce^{-\alpha t}/(\alpha^2+\omega^2)$

27. The rank of the following matrix is

$$\begin{pmatrix} 2 & -2 & 0 & 6 \\ 4 & 2 & 0 & 2 \\ 1 & -1 & 0 & 3 \\ 1 & -2 & 1 & 2 \end{pmatrix}$$

A. 2

B. 3

C. 1

D. 4

28. For a given vector $\vec{A} = x^2\hat{i} + y^2\hat{j} + z^2\hat{k}$, the value of the integral $\int\int_s \vec{A}\cdot d\vec{S}$, over the cube defined by $0 \le x,\ y, z \le 1$ is given by

A. 0

B. 2

C. 3

D. 4

29. The square roots of $(-15 - 8i)$ are

A. $1-4i,\ -1+4i$

B. $1+4i,\ 1-4i$

C. $\sqrt{15}-\sqrt{8}i$

D. $2\sqrt{2}-\sqrt{15}\,i$

30. It is given that the matrix

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \alpha & -\alpha \\ 0 & \alpha & \alpha \end{pmatrix}$$

is orthogonal. The value of α must be equal to

A. 1

B. 0

C. $\sqrt{2}$

D. $\frac{1}{\sqrt{2}}$

31. The sum of the series $\sum_{1}^{\infty} \dfrac{1}{n(n+1)}$ is equal to

A. $\dfrac{1}{2}$

B. $\dfrac{1}{4}$

C. 1

D. ∞

32. Two asteroids collide in space and one of them breaks into two equal pieces. If the initial velocity of the second asteroid was v and those of its components are also v each, then the velocity of the first asteroid after the impact can be deduced as

A. same as initial velocity

B. 0

C. twice the initial velocity

D. any arbitrary value

33. The centre of mass of a solid hemisphere of constant density and radius a, and symmetric about the z-axis with $x-y$ plane coinciding with the equatorial plane, can be written as

A. $(0, 0, a)$

B. $\left(\frac{a}{8}, 0, 0\right)$

C. $\left(0, 0, \dfrac{3a}{8}\right)$

D. $\left(\dfrac{3a}{8}, \dfrac{3a}{8}, \dfrac{3a}{8}\right)$

34. A particle at rest is attracted towards a centre of force according to the relation $F = -mk^2/x^3$. (Here, m is the mass, x is the position from the center of force and k is a constant of proportionality). The time required for the particle to reach the force centre from a distance d is

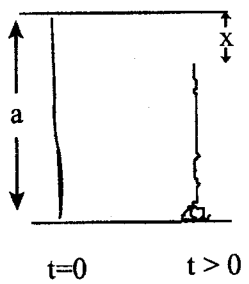
A. d/k

B. dm/k

C. d/mk

D. d^2/k

35. Consider a uniform rope of mass per unit length ρ and length a suspended just above a table as shown in figure. If the rope is released from rest at the top, what is the force on the table when a length x of the rope has dropped onto the table?



A. $\rho x g$

B. $2\rho x g$

C. $3\rho x g$

D. $4\rho x g$

36. Two gravitationally bound stars with equal masses m, separated by a distance d, revolve about their centre of mass. The period T is proportional to

A. $d^{1/2}$

B. d^2

C. $d^{3/2}$

D. $d^{1/3}$

37. Consider a particle of m whose motion starts from rest in a constant gravitational field. If a resistive force, kmv^2, where v is the velocity, is encountered, the distance h the particle falls in accelerating from v_o to v_1 is given by

A. $\dfrac{1}{2k} \ln\left(\dfrac{g + kv_o^2}{g + kv_1^2}\right)$

B. $\dfrac{1}{2k} \ln\left(\dfrac{g - kv_o^2}{g - kv_1^2}\right)$

C. $\dfrac{1}{2k}\ln\left(\dfrac{g+kv_o^2}{g-kv_1^2}\right)$

D. $\dfrac{1}{2k}\ln\left(\dfrac{g-kv_o^2}{g+kv_1^2}\right)$

38. Two thermally insulated vessels are filled with an ideal gas and connected by a short pipe equipped with a valve. The volumes of the vessels and their pressure and temperature are given by (V, p, T) and (V', p', T). If the valve is opened the pressure inside them would be

A. $p'' = (pV + p'V')/(V + V')$

B. $p'' = (pV + p'V')(V + V')$

C. $p'' = pV/(V + V')$

D. $p'' = (p + p')(V + V')/(pV + p'V')$

39. The change of entropy (dS) of an ideal gas of N molecules at temperature T and volume V in a reversible transformation is given by

A. $dS = Nk_B\dfrac{dT}{T} + Nk_B\dfrac{dV}{V}$

B. $dS = \dfrac{3}{2}Nk_B dT + Nk_B dV$

C. $dS = \dfrac{3}{2}Nk_B\dfrac{dT}{T} + \dfrac{3}{2}Nk_B\dfrac{dV}{V}$

D. $dS = \dfrac{3}{2}Nk_B\dfrac{dT}{T} + Nk_B\dfrac{dV}{V}$

40. The Maxwell-Boltzmann velocity distribution in an ideal gas is given by

$$f(\vec{v}) = \left(\frac{m}{2\pi k_B T}\right)^{3/2} \exp\left(-\frac{mv^2}{2k_B T}\right)$$

What would be the root mean square velocity of a molecule for such a gas?

A. $\sqrt{\dfrac{k_B T}{m}}$

B. $\sqrt{\dfrac{2k_B T}{m}}$

C. $\sqrt{\dfrac{3k_B T}{m}}$

D. $\sqrt{\dfrac{k_B T}{2m}}$

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41. Consider a thermally isolated system consisting of two volumes V and $2V$ of an ideal gas separated by a thermally conducting and movable partition, with temperature and pressure as shown.

3p T 2V	p T V

The partition is allowed to move without allowing the gasses to mix. If n_1 and n_2 are the molar numbers of the gas on the two sides, the change in the total entropy of the system is

A. $n_1, R\ln\frac{9}{7} + n_2R\ln\frac{3}{7}$

B. $n_1R\ln 2 + n_2R\ln 3$

C. $(n_1+n_2)RT$

D. $\dfrac{n_1}{n_2}R\ln V$

42. Consider an ideal gas whose entropy is given by

$$S = \frac{n}{2}\left[\sigma + 5R\ln\frac{U}{n} + 2R\ln\frac{V}{n}\right]$$

where n = number of moles, R = universal gas constant, U = internal energy, V = volume and σ = constant. The specific heat at constant volume is given by

A. $\frac{5}{2}nR$

B. $\frac{1}{2}nR$

C. $\frac{3}{2}nR$

D. $\frac{9}{2}nR$

43. For an ideal gas initially at temperature T_i, the final temperature T_f when the gas is expanded from V_i to V_f reversibly and adiabatically, is given by

A. $T_f = T_i\left(\dfrac{V_i}{V_f}\right)^{\gamma-1}$

B. $T_f = T_i\left(\dfrac{V_f}{V_i}\right)^{\gamma}$

C. $T_f = T_i\ln\left(\dfrac{V_i}{V_f}\right)$

D. $T_f = T_i\left(\dfrac{V_i}{V_f}\right)^{1-\gamma}$

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44. The proper length of a space vehicle is l_o. According to an observer on earth, the length of the spaceship is 25% of its proper length. The speed of the spaceship according to the observer on earth is given by

A. $\frac{\sqrt{3}}{2}c$

B. $\sqrt{\frac{3}{2}}c$

C. c

D. 0.968 c

45. Two electrons move towards each other, the speed of each being 0.9 c. What is their relative velocity according to special theory of relativity?

A. 0.995 c

B. 1.09 c

C. 0.89 c

D. 0.91 c

46. Two events occur at an interval Δt at the same point in a rest frame. In a frame which is moving with a uniform velocity v, the time interval between the events will be given by

A. $\frac{\Delta t}{\sqrt{1-v^2}}$

B. $(\Delta t)\sqrt{1-v^2/c^2}$

C. $\frac{\Delta t}{\sqrt{1-v^2/c^2}}$

D. $\frac{\Delta t}{\sqrt{1+v^2/c^2}}$

47. A measuring rule of rest length l moves relative to an observer with the velocity v. The observer measures the length of the rule as $\frac{2}{3}l$. What is the velocity v?

A. c

B. 0.1 c

C. 0.745 c

D. 0.345 c

48. An electron and a positron at rest annihilate each other and two γ-ray photons are emitted. The wavelength of the γ-rays is given by

A. 2.4 Å

B. 0.048 Å

C. 24.0 Å

D. 0.024 Å

49. A sample of uranium emitting α particles of 4.18 MeV is placed near an ionization chamber. Assume that only 10 particles enter the chamber per second and the energy required to create an ion-pair by an α-particle is 35 eV. What will be the current produced?

A. 19×10^{-13}A

B. 19×10^{-20}A

C. 1.9×10^{-13}A

D. 1.9×10^{19}A

50. Five grams of radium is reduced by 10.5 mg in 5 years by α-decay. The half-life of radium is

A. 10.5 years

B. 150.4 years

C. 1000.5 years

D. 501.5 years

51. What is the amount of energy released when 10 micrograms of uranium (^{235}U) undergoes fission, if energy released per fission is 200 MeV?

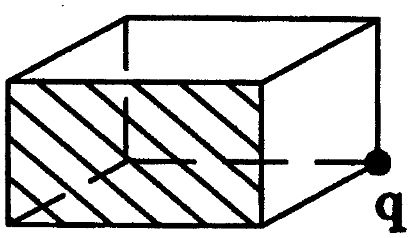
A. 5.126×10^{18} MeV

B. 5.126 MeV

C. 5.126 meV

D. 5.126×10^{6} MeV

52. A charge q sits at the back corner of a cube as shown in the figure. The electric flux through the shaded surface is



A. $q/6\epsilon_o$

B. $q/12\epsilon_o$

C. q/ϵ_o

D. $q/24\epsilon_o$

53. A soap bubble 10 cm in radius with a wall thickness of 3.3×10^{-6} cm is charged to a potential of 100 V. The bubble bursts and falls as a spherical drop. The potential of the drop is

A. 10 kV

B. 1 kV

C. 100 kV

D. 10^{-2}kV

54. A battery of emf E and internal resistance r is hooked up to a variable "load" resistance R. If you want to deliver the maximum possible power to the load, what resistance R should you choose?

A. $R = r$

B. $R = 2r$

C. $R = \frac{r}{2}$

D. $R = \infty$

(E and r remain constant)

55. A radio frequency carrier of frequency 8 MHz is amplitude modulated by an audio signal of frequency of 20 kHz. The modulated signal consists of the frequencies

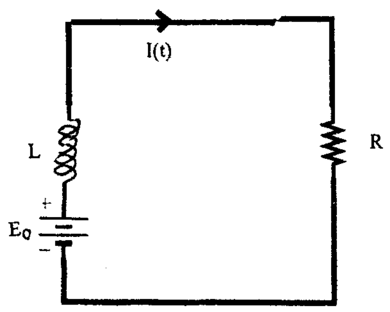
A. 20 kHz and 8 MHz

B. 20 kHz

C. 8 MHz

D. 8 MHz, 8.02 MHz and 7.98 MHz

56. A current I is flowing in the given circuit. Someone suddenly switches off the power. The current is then given by



A. $I(t) = \frac{E_o}{R}\left[1 - e^{(-R/L))t}\right]$

B. $I(t) = \frac{E_o}{R}e^{-(R/L)t}$

C. zero

D. $I = E_o/R$

57. The magnetic field at a point on the axis of an infinitely long solenoid consisting of n turns per unit length wrapped around a cylindrical tube of radius a and carrying current I is given by

A. $\mu_o nI$

B. $\mu_o nI/2$

C. $\mu_o anI$

D. $\mu_o I/(2a)$

58. The phase velocity of pressure waves v_p is related to the wave vector k by $v_p = Ck^{-1/2}$. (C is a constant). The group velocity is given by

A. $\frac{v_p}{2}$

B. $2v_p$

C. kv_p

D. zero

59. An astronaut is approaching the moon. He sends out a radio signal of frequency 5×10^9 Hz towards the moon and finds that the frequency shift in the echo received is 10^3 Hz. The speed of the astronaut is

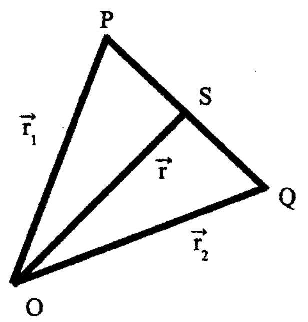
A. 3 m/s

B. 30 m/s

C. 300 m/s

D. 3 km/s

60. Consider a point source S of spherical waves at $\vec{r}$ and two points P and Q at $\vec{r}_1$ and $\vec{r}_2$ (all the three points P, S, Q being on a straight line). The amplitudes of the wave at P and Q are a_1 and a_2. The radius vector $\vec{r}$ is given by



A. $a_1\vec{r}_1 + a_2\vec{r}_2$

B. $\dfrac{a_1\vec{r}_1 + a_2\vec{r}_2}{a_1 + a_2}$

C. $\dfrac{a_2\vec{r}_1 + a_1\vec{r}_2}{a_1 + a_2}$

D. $\dfrac{a_1\vec{r}_1 - a_2\vec{r}_2}{a_1 - a_2}$

61. A sounding body emitting a frequency of 150 Hz is dropped from a height. During its fall under gravity it crosses a balloon moving with a constant velocity of 2 m/s, one second after the body started falling. What is the number of beats heard by an observer in the balloon at the moment the body crosses the balloon?

A. 12

B. 6

C. 8

D. 4

62. To verify that the light beam is either unpolarized or circularly polarized one requires to use

A. a half wave plate and a polarizer

B. a quarter wave plate

C. a quarter wave plate and half wave plate

D. a quarter wave plate and a polarizer

63. A telescope is used to observe at two objects which are a distance of 10 km from the observer and are 0.12 m apart. They are illuminated by light of wavelength 600 nm. What should be the diameter of the objective lens on the telescope if it can just resolve the two objects?

A. 6 cm

B. 12 cm

C. 72 cm

D. 60 cm

64. What is the minimum number of grating lines needed to separate the D_1 and D_2 lines of a sodium vapour lamp?

A. 1000

B. 10000

C. 500

D. 1500

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65. Two lasers are made with semiconducting materials of band gap 4.5 eV and 1.5 eV. The lasing wavelengths are expected to be in

A. ultraviolet and blue regions, respectively.

B. blue and ultraviolet regions, respectively.

C. blue and red regions, respectively.

D: infrared and blue regions, respectively.

66. A capillary tube of radius R is dipped in alcohol of density ρ. The rise h of the liquid in the capillary tube is given by, given T is the surface tension.

A. $h = \dfrac{4T}{R\rho g}$

B. $h = \dfrac{T}{R\rho g}$

C. $h = \dfrac{2T}{R\rho}$

D. $h = \dfrac{2T}{R\rho g}$

67. A mercury drop of radius 1.0 cm is sprayed into 10^6 droplets of equal size. If the surface tension of mercury is 32×10^{-3}N/m, what is the energy spent?

A. 398×10^{-3}J

B. 39.8×10^{-3}J

C. 3.98×10^{-3}J

D. 0.398×10^{-3}J

68. An air bubble of diameter 2 mm rises steadily through a solution of density 1750 kg/m^3 at the rate of 0.35 cm/sec. What is the viscosity of the solution?

A. 1 Poise

B. 11 Poise

C. 110 Poise

D. 50 Poise

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69. The rate of evaporation from a spherical drop of liquid of constant density is proportional to its surface area. Assuming this to be the sole mechanism of mass loss, the radius R of the drop as a function of time t is given by (Assuming A and B are some constants)

A. $R = A + Bt$

B. $R = A - Bt$

C. $R = A - Bt^2$

D. $R = A + Be^{-t}$

70. According to wave mechanics, a free particle in space can possess energies of the following type:

A. Discrete energies

B. Continuous energies

C. Both types of energies

D. Only one single value of energy

71. The de-Broglie wavelength of an electron with a kinetic energy of 120 eV is nearly

A. 1000 pm

B. 100 pm

C. 10 pm

D. 1 pm

72. The energy required to remove both electrons from the helium atom in its ground state is 79 eV. How much energy is required to ionize helium (that is to remove one electron)?

A. 24.6 eV

B. 39.5 eV

C. 54.4 eV

D. 79 eV

73. The ground state electron configuration for phosphorous which has 15 electrons, is

A. $1s^2 2s^2 2p^6 3s^1 3p^4$

B. $1s^2 2s^2 2p^6 3s^2 3p^3$

C. $1s^2 2s^2 2p^6 3s^2 3d^3$

D. $1s^2 2s^2 2p^6 3p^2 3d^3$