PART – III : PHYSICS

SECTION – I (Single Correct Choice Type)

39. A Vernier calipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier calipers, the least count is

A) 0.02 mm B) 0.05 mm C) 0.1 mm D) 0.2 mm

ANSWER: D

40. A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is 320 ms^{-1}, the mass of the string is

A) 5 grams B) 10 grams C) 20 grams D) 40 grams

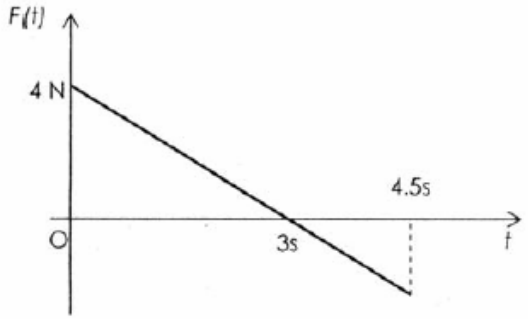
ANSWER: B

41. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

A) virtual and at a distance of 16 cm from the mirror
B) real and at a distance of 16 cm from the mirror
C) virtual and at a distance of 20 cm from the mirror
D) real and at a distance of 20 cm from the mirror

ANSWER: B

42. A block of mass 2 kg is free to move along the x-axis. It is at rest and from $t = 0$ onwards it is subjected to a time-dependent force $F(t)$ in the x direction. The force $F(t)$ varies with t as shown in the figure. The kinetic energy of the block after 4.5 seconds is



A) 4.50 J B) 7.50 J C) 5.06 J D) 14.06 J

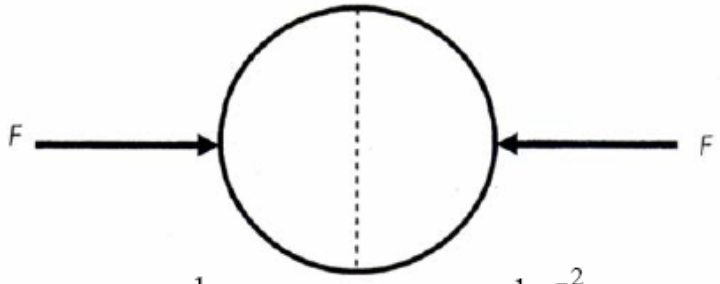
ANSWER: C

43. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7}\times 10^5$ Vm^{-1}. When the field is switched off, the drop is observed to fall with terminal velocity 2×10^{-3} m s^{-1}. Given g = 9.8 m s^{-2}, viscosity of the air = 1.8×10^{-5} Ns m^{-2} and the density of oil = 900 kg m^{-3}, the magnitude of q is

A) 1.6×10^{-19} C B) 3.2×10^{-19} C C) 4.8×10^{-19} C D) 8.0×10^{-19} C

ANSWER: D

44. A uniformly charged thin spherical shell of radius R carries uniform surface charge density of σ per unit area. It is made of two hemispherical shells, held together by pressing them with force F (see figure). F is proportional to



A) $\frac{1}{\varepsilon_0}\sigma^2 R^2$ B) $\frac{1}{\varepsilon_0}\sigma^2 R$ C) $\frac{1}{\varepsilon_0}\frac{\sigma^2}{R}$ D) $\frac{1}{\varepsilon_0}\frac{\sigma^2}{R^2}$

ANSWER: A

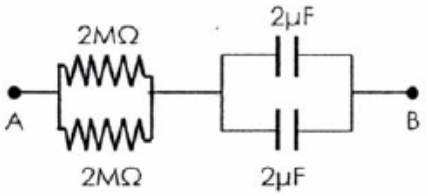
SECTION – II (Integer Type)

45. A diatomic ideal gas is compressed adiabatically to $\frac{1}{32}$ of its initial volume. In the initial temperature of the gas is T_i (in Kelvin) and the final temperature is aT_i, the value of a is

ANSWER: 4

46. At time $t = 0$, a battery of 10 V is connected across points A and B in the given circuit. If the capacitors have no charge initially, at what time (in seconds) does the voltage across them become 4 V ?

[Take : $\ell n\ 5 = 1.6$, $\ell n\ 3 = 1.1$]



ANSWER: 2

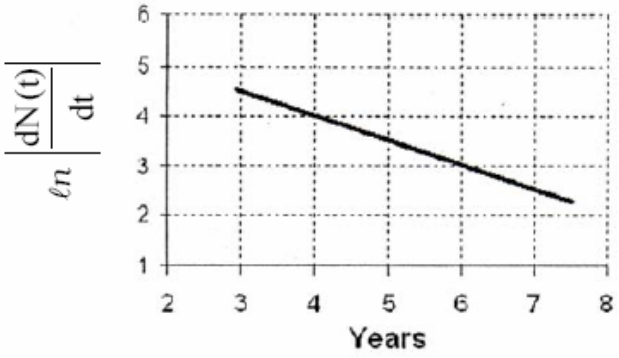
47. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed of the object in km per hour ?

ANSWER: 3

48. A large glass slab $(\mu = 5/3)$ of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R ?

ANSWER: 6

49. To determine the half life of a radioactive element, a student plots a graph of $\ell n \left|\frac{dN(t)}{dt}\right|$ versus t. Here $\frac{dN(t)}{dt}$ is the rate of radioactive decay at time t. If the number of radioactive nuclei of this element decreases by a factor of p after 4.16 years, the value of p is



ANSWER: 8

SECTION – III (Paragraph Type)

Paragraph for questions 50 to 52.

When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

50. If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (assuming $r << R$) is

A) $2\pi rT$ B) $2\pi RT$ C) $\frac{2\pi r^2 T}{R}$ D) $\frac{2\pi R^2 T}{r}$

ANSWER: C

51. If $r = 5\times10^{-4}\,m, \rho = 10^{3}\,kgm^{-3}, g = 10\ ms^{-2}, T = 0.11\,Nm^{-1}$, the radius of the drop when it detaches from the dropper is approximately

A) $1.4\times10^{-3}\,m$ B) $3.3\times10^{-3}\,m$ C) $2.0\times10^{-3}\,m$ D) $4.1\times10^{-3}\,m$

ANSWER: A

52. After the drop detaches, its surface energy is

A) $1.4\times10^{-6}J$ B) $2.7\times10^{-6}J$ C) $5.4\times10^{-6}J$ D) $8.1\times10^{-6}J$

ANSWER: B

Paragraph for Questions 53 to 55.

The key feature of Bohr's theory of spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid. The rule to be applied is Bohr's quantization condition.

53. A diatomic molecule has moment of inertia *I*. By Bohr's quantization condition its rotational energy in the n^{th} level (n = 0 is not allowed) is

A) $\frac{1}{n^2}\left(\frac{h^2}{8\pi^2 I}\right)$ B) $\frac{1}{n}\left(\frac{h^2}{8\pi^2 I}\right)$ C) $n\left(\frac{h^2}{8\pi^2 I}\right)$ D) $n^2\left(\frac{h^2}{8\pi^2 I}\right)$

ANSWER: D

54. It is found that the excitation frequency from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi}\times 10^{11}$ Hz. Then the moment of inertia of CO molecule about its center of mass is close to (Take $h = 2\pi\times 10^{-34}$ J s)

A) 2.76×10^{-46} kg m^2
B) 1.87×10^{-46} kg m^2
C) 4.67×10^{-47} kg m^2
D) 1.17×10^{-47} kg m^2

ANSWER: B

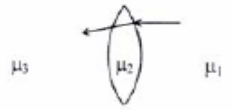
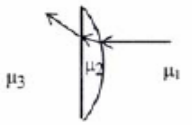
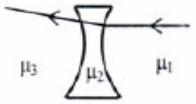
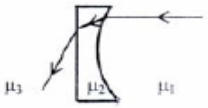
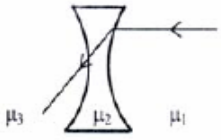
55. In a CO molecule, the distance between C (mass = 12 a.m.u.) and O (mass = 16 a.m.u.), where 1 a.m.u. $=\frac{5}{3}\times 10^{-27}$ kg, is close to

A) 2.4×10^{-10} m
B) 1.9×10^{-10} m
C) 1.3×10^{-10} m
D) 4.4×10^{-11} m

ANSWER: C

SECTION – IV (Matrix Type)

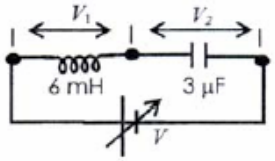
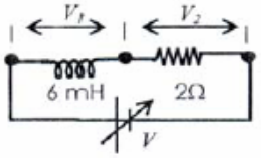
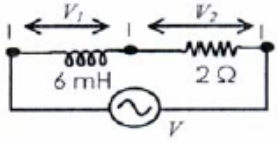
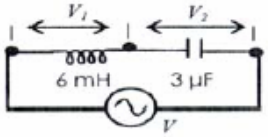
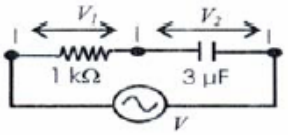
56. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transpar material of refractive index μ_2 between them as shown in figures in **Column II**. A traversing these media is also shown in the figures. In **Column I** different relationsh between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in **Column**

Column I	**Column II**
A) $\mu_1 < \mu_2$	p) 
B) $\mu_1 > \mu_2$	q) 
C) $\mu_2 = \mu_3$	r) 
D) $\mu_2 > \mu_3$	s) 
	t) 

ANSWER:

A: p and r
B: q and s and t
C: p and r and t
D: q and s

57. You are given many resistances, capacitors and inductors. These are connected to variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequenc (the next three circuits) in different ways as shown in **Column II.** When a current (steady state for DC or *rms* for AC) flows through the circuit, the corresponding voltage V and V_2. (indicated in circuits) are related as shown in **column I.** Match the two

Column I	**Column II**
A) $I \neq 0, V_1$ is proportional to I	p) 
B) $I \neq 0, V_2 > V_1$	q) 
C) $V_1 = 0, V_2 = V$	r) 
D) $I \neq 0, V_2$ is proportional to I	s) 
	t) 

ANSWER:

A: r and s and t
B: q and r and s and t
C: p and q
D: q and r and s and t

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