SOLUTIONS TO IIT - JEE, 2004 (SCREENING)

MEMORY BASED QUESTIONS

PHYSICS

1. White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains
(a) yellow, orange, red
(b) violet, indigo, blue
(c) all colours
(d) all colours except green

Sol. $C = \sin^{-1}\left(\frac{1}{\mu}\right)$ and in the sequence VIBGYOR, C increases.
In this case the angle of incidence is such that it is equal to critical angle for green colour.
$\therefore$ (a)

2. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represents the variation of temperature with time?

Sol. Liquid oxygen when heated from 50 K to 300 K will change its phase. During phase change the temperature will not change. After that (i.e. in gaseous phase) the temperature will increase linearly if rate of heating is constant.
$\therefore$ (c)

3. A ray of light is incident on an equilateral glass prism placed on a horizontal table. For minimum deviation which of the following is true?

(a) PQ is horizontal
(b) QR is horizontal
(c) RS is horizontal
(d) Either PQ or RS is horizontal

Sol. When the prism is in the position of minimum deviation, the ray *inside* the prism is parallel to the base of the prism.

$\therefore$ (b)

4. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then

(a) $P_3 > P_1$, $W > 0$ (b) $P_3 < P_1$, $W < 0$
(c) $P_3 > P_1$, $W < 0$ (d) $P_3 = P_1$, $W = 0$

Sol. The two processes are shown in the adjoining PV - diagram.

$\therefore$ (c)

5. A block P of mass m is placed on a frictionless horizontal surface. Another block Q of same mass is kept on P and connected to the wall with the help of a spring of spring constant k as shown in the figure. μ_s is the coefficient of friction between P and Q. The blocks move together performing SHM of amplitude A. The maximum value of the friction force between P and Q is

(a) kA (b) $\frac{kA}{2}$
(c) zero (d) $\mu_s mg$

Sol. For block P, friction will provide the necessary restoring force.

$\therefore$ $f_{max} = m\omega^2 A$ with $\omega^2 = \frac{k}{m+m}$

$\therefore$ (b)

6. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample in dps is

(a) 6000 (b) 9000
(c) 3000 (d) 24000

Sol. The half-life of the substance is 140 days. In 420 days, there will be three half-lives.

$\therefore$ (d)

7. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de-Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio λ_1/λ_2 is proportional to

(a) E^o (b) $E^{1/2}$
(c) E^{-1} (d) E^{-2}

Sol. $\lambda_1 = \dfrac{h}{\sqrt{2mE}}$ and $\lambda_2 = \dfrac{hc}{E}$

$\therefore$ (b)

8. A closed organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open organ pipe is

(a) $\dfrac{L}{3}$ (b) $\dfrac{4L}{3}$
(c) $\dfrac{4L}{3}\sqrt{\dfrac{\rho_1}{\rho_2}}$ (d) $\dfrac{4L}{3}\sqrt{\dfrac{\rho_2}{\rho_1}}$

Sol. According to question,

$$\frac{3v_c}{4L} = \frac{2v_o}{2l} \quad \text{and} \quad \frac{v_o}{v_c} = \sqrt{\frac{\rho_1}{\rho_2}}$$

$\therefore$ (c)

9. In the relation

$$P = \frac{\alpha}{\beta} e^{-\frac{\alpha Z}{k\theta}}$$

P is pressure, Z is distance, k is Boltzmann constant and θ is the temperature.
The dimensional formula of β will be

(a) $[M^oL^2T^o]$ (b) $[M^1L^2T^1]$
(c) $[M^1L^oT^{-1}]$ (d) $[M^oL^2T^{-1}]$

Sol. (a)

10. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is a positive constant). If $U(0) = 0$, the graph of $U(x)$ versus x will be (where U is the potential energy function)

Sol. $F = -\dfrac{dU}{dx} = kx$

$\therefore \quad U(x) = -\dfrac{1}{2}kx^2$

$\therefore$ (a)

11. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to

(a) q_2 (b) only the positive charges
(c) all the charges (d) $+q_1$ and $-q_1$

Sol. In Gauss' law, the electric field is due to all the charges present whether inside or outside the Gaussian surface.

$\therefore$ (c)

12. The variation of induced emf (ε) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as

(a)

(b)

(c)

(d)

Sol. As the magnet moves towards the coil, the magnetic flux increases (nonlinearly). Also there is a change in polarity of induced emf when the magnet passes on to the other side of the coil.

∴ (b)

13. Six equal resistances are connected between points P, Q and R as shown in the figure. Then the net resistance will be maximum between

(a) P and Q
(b) Q and R
(c) P and R
(d) any two points

Sol. When resistances are connected in parallel, the equivalent is less than the minimum resistance.

∴ (a)

14. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at O is double the electric field when *only* one positive charge of same magnitude is placed at R. Which of the following arrangements of charges is possible for P, Q, R, S, T and U respectively?

(a) +, –, +, –, –, + (b) +, –, +, –, +, –
(c) +, +, –, +, –, – (d) –, +, +, –, +, –

Sol. If the charges are arranged according to the option (d), the electric fields due to P and S and due to Q and T add to zero, while due to U and R will be added up.
∴ (d)

15. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300m/s. The frequency of sound recorded by an observer who is standing in air is
(a) 200 Hz (b) 3000 Hz
(c) 120 Hz (d) 600 Hz

Sol. The frequency, a characteristic of source, is independent of the medium.
∴ (d)

16. A point object is placed at the center of a glass sphere of radius 6 cm and refractive index 1.5. The distance of the virtual image from the surface of the sphere is
(a) 2 cm (b) 4 cm
(c) 6 cm (d) 12 cm

Sol. The rays from the object fall normally on the surface of the sphere and emerge undeviated.
∴ (c)

17. In a YDSE bi-chromatic light of wavelengths 400 nm and 560 nm are used. The distance between the slits is 0.1 mm and the distance between the plane of the slits and the screen is 1 m. The **minimum** distance between two successive regions of complete darkness is
(a) 4 mm (b) 5.6 mm
(b) 14 mm (d) 28 mm

Sol. Let nth minima of 400 nm coincides with mth minima of 560 nm then

$$(2n-1)400 = (2m-1)560$$

$$\Rightarrow \quad \frac{2n-1}{2m-1} = \frac{7}{5} = \frac{14}{10} = \frac{21}{15}$$

i.e. 4th minima of 400 nm coincides with 3rd minima of 560 nm.

The location of this minima is = $\dfrac{7(1000)(400\times10^{-6})}{2\times0.1} = 14$ mm

Next , 11th minima of 400 nm will coincide with 8th minima of 560 nm

Location of this minima is = $\dfrac{21(1000)(400\times10^{-6})}{2\times0.1}$ = 42 mm

∴ Required distance = 28 mm

∴ (d)

18. A particle starts from rest. Its acceleration (α) versus time (*t*) is as shown in the figure. The maximum speed of the particle will be

(a) 110 m/s (b) 55 m/s

(c) 550 m/s (d) 660 m/s

Sol. The area under the acceleration time graph gives change in velocity.

∴ (b)

19. Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 g/s be the rate of melting of ice in the two cases respectively. The ratio q_1/q_2 is

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

(c) $\frac{4}{1}$ (d) $\frac{1}{4}$

Sol. The rate of the melting of the ice will be inversely proportional to the equivalent thermal resistance between the two vessels.

In the first case, equivalent thermal resistance is $\frac{R}{2}$ and in the second case it is 2*R*. (where *R* is the thermal resistance of the rod).

∴ (c)

20. Three discs *A*, *B*, and *C* having radii 2 m, 4 m and 6 m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are Q_A, Q_B and Q_C respectively.

(a) Q_A is maximum (b) Q_B is maximum

(c) Q_C is maximum (d) $Q_A = Q_B = Q_C$

Sol. $Q \propto A\,T^4$ and $\lambda_m T$ = constant $\Rightarrow$ $Q \propto \dfrac{r^2}{(\lambda_{max})^4}$

∴ (b)

21. The figure shows the variation of photocurrent with anode potential for a photo-sensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively.

(a) $f_a = f_b$ and $I_a \neq I_b$
(b) $f_a = f_c$ and $I_a = I_c$
(c) $f_a = f_b$ and $I_a = I_b$
(d) $f_b = f_c$ and $I_b = I_c$

Sol. The stopping potential for curves a and b is same.

$\therefore \quad f_a = f_b$

Also saturation current is proportional to intensity.

$\therefore \quad I_a < I_b$

$\therefore$ (a)

22. A disc is rolling (without slipping) on a horizontal surface. C is its center and Q and P are two points equidistant from C. Let V_P, V_Q and V_C be the magnitude of velocities of points P, Q and C respectively, then

(a) $V_Q > V_C > V_P$
(b) $V_Q < V_C < V_P$
(c) $V_Q = V_P$, $V_C = \frac{1}{2} V_P$
(d) $V_Q < V_C > V_P$

Sol. For rolling without slipping

and distance $OP < OC < OQ$

$\therefore$ (a)

23. An electron moving with a speed u along the positive x-axis at $y = 0$ enters a region of uniform magnetic field $\vec{B} = -B_o\hat{k}$ which exists to the right of y-axis. The electron exits from the region after some time with the speed v at ordinate y, then

(a) $v > u, y < 0$
(b) $v = u, y > 0$
(c) $v > u, y > 0$
(d) $v = u, y < 0$

Sol. The magnetic field will not do any work. Also, the force on the electron acts in such a way that it describes a circular path in clockwise direction.

$\therefore$ (d)

24. A wire has a mass 0.3 ± 0.003 g, radius 0.5 ± 0.005 mm and length 6 ± 0.06 cm. The maximum percentage error in the measurement of its density is

(a) 1 (b) 2
(c) 3 (d) 4

Sol. Since $\rho = \dfrac{m}{\pi r^2 L}$

$$\left(\frac{\Delta\rho}{\rho}\right)\times 100 = \left(\frac{\Delta m}{m} + 2.\frac{\Delta r}{r} + \frac{\Delta L}{L}\right)\times 100 = 4$$

$\therefore$ (d)

25. A small block slides without friction down an inclined plane starting from rest. Let S_n be the distance travelled from time $t = n - 1$ to $t = n$. Then $\dfrac{S_n}{S_{n+1}}$ is

(a) $\dfrac{2n-1}{2n}$ (b) $\dfrac{2n+1}{2n-1}$
(c) $\dfrac{2n-1}{2n+1}$ (d) $\dfrac{2n}{2n+1}$

Sol. $S_t = u + \dfrac{1}{2}a(2t-1)$

$\therefore$ (c)

26. A child is standing with folded hands at the center of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is

(a) $2K$ (b) $\dfrac{K}{2}$
(c) $\dfrac{K}{4}$ (d) $4K$

Sol. From COAM, the angular velocity of the system will become half.

As rotational kinetic energy = $\frac{1}{2}I\omega^2$, the kinetic energy will become half.

$\therefore$ (b)

27. In an *RC* circuit while charging, the graph of $\ln I$ versus time is as shown by the dotted line in the adjoining diagram where *I* is the current. When the value of the resistance is doubled, which of the solid curves best represents the variation of ln *I* versus time?

(a) *P* (b) *Q*
(c) *R* (d) *S*

Sol. $I = \frac{E}{R}e^{-t/RC}$ for a charging RC circuit.

$\therefore$ $\ln I = -\frac{t}{RC} + \ln\frac{E}{R}$

When *R* is doubled, slope of the curve increases. Also, at $t = 0$ the current will be less for a increased value of resistance.

$\therefore$ (b)

28. For the post office box arrangement to determine the value of unknown resistance, the unknown resistance should be connected between

(a) *B* and *C* (b) *C* and *D*
(c) *A* and *D* (d) B_1 and C_1

Sol. *BC*, *CD* and *BA* are the known resistances. The unknown resistance is to be connected between *A* and *D*.

$\therefore$ (c)

Note: All these questions of IIT-JEE Screening 2004 are based on the memory of the select PIE students who appeared in the examination. PIE Education does not take any responsibility for any sort of discrepancy whatsoever.