Download IIT-JEE Previous Year Paper - I "2010" (Physics)

Useful Data

Atomic Numbers: Be 4; C 6; N 7; O 8; Al 13; Si 14; Cr24; Fe 26; Zn 30; Br 35.

1 amu	=	1.66×10^{-27} kg	R	=	0.082 L-atm K^{-1} mol^{-1}
h	=	6.626×10^{-34} J s	N_A	=	6.022×10^{23}
m_e	=	9.1×10^{-31} kg	e	=	1.6×10^{-19} C
c	=	3.0×10^{8} m s^{-1}	F	=	96500 C mol^{-1}
R_H	=	2.18×10^{-18} J	$4\pi\epsilon_0$	=	1.11×10^{-10} J^{-1} C^2 m^{-1}

IIT-JEE-2010

CODE **3**

PAPER 1

Time: 3 Hours

Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

INSTRUCTIONS

A. General:

1. This Question Paper contains 32 pages having 84 questions.
2. The **question paper** CODE is printed on the right hand top corner of this sheet and also on the back page (page no. 32) of this booklet.
3. No additional sheets will be provided for rough work.
4. Blank papers, clipboards, log tables, slide rules, calculators, cellular phones, pagers and electronic gadgets in any form are not allowed.
5. The answer sheet, a machine-gradable Objective Response Sheet **(ORS)**, is provided separately.
6. Do not Tamper / mutilate the ORS or this booklet.
7. Do not break the seals of the question – paper booklet before instructed to do so by the invigilators.

B. Filling the bottom-half of the ORS:

8. The ORS has CODE printed on its lower and upper Parts.
9. Make sure the CODE on the **ORS** is the same as that on this booklet. **If the Codes do not match, ask for a change of the Booklet.**
10. Write your Registration No., Name and Name of centre and sign with pen in appropriate boxes. **Do not write these any where else.**
11. Darken the appropriate bubbles below your registration number with **HB Pencil.**

C. Question paper format and Marking scheme:

12. The question paper consists of **3 parts** (Chemistry, Mathematics and Physics). Each part consists of four Sections.
13. For each question in **Section I,** you will be **awarded 3 marks** if you darken only the bubble corresponding to the correct answer and zero mark if no bubbles are darkened. In all other cases, minus **one (–1) mark** will be awarded.
14. For each question in **Section II,** you will be awarded **3 marks** if you darken only the bubble corresponding to the correct answer and zero mark if no bubbles are darkened. **Partial marks** will be awarded for partially correct answers. No negative marks will be awarded in this Section.
15. For each question in **Section III,** you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubbles are darkened. In all other cases, **minus one (–1)** mark will be awarded.
16. For each question in **Section IV,** you will be awarded **3 marks** if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for in this Section

Write your name, registration number and sign in the space provided on the back page of this booklet.

Useful Data

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PART - III: PHYSICS

SECTION – I (Single Correct Choice Type)

This Section contains **8 multiple choice questions.** Each question has four choices A), B), C) and D) out of which **ONLY ONE** is correct.

57. Incandescent bulbs are designed by keeping in mind that the resistance of their filament increases with the increase in temperature. If at room temperature, 100 W, 60 W and 40 W bulbs have filament resistances R_{100}, R_{60} and R_{40}, respectively, the relation between these resistances is

A) $\frac{1}{R_{100}} = \frac{1}{R_{40}} + \frac{1}{R_{60}}$

B) $R_{100} = R_{40} + R_{60}$

C) $R_{100} > R_{60} > R_{40}$

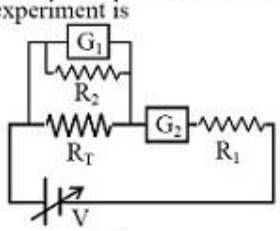
D) $\frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

Sol. ***(D)***

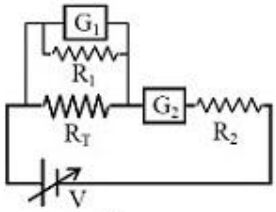
Power $\propto 1/R$

58. To Verify Ohm's law, a student is provided with a test resistor R_T, a high resistance R_1, a small resistance R_2, two identical galvanometers G_1 and G_2, and a variable voltage source V. The correct circuit to carry out the experiment is

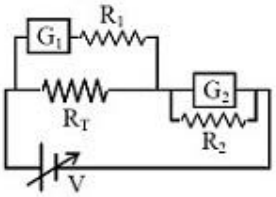
A)



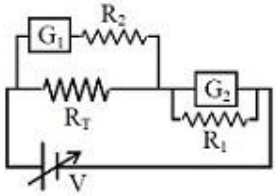
B)



C)



D)



Sol. ***(C)***

G_1 is acting as voltmeter and G_2 is acting as ammeter.

59. An AC voltage source of variable angular frequency ω and fixed amplitude V_0 is connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased

A) the bulb glows dimmer

B) the bulb glows brighter

C) total impedance of the circuit is unchanged

D) total impedance of the circuit increases

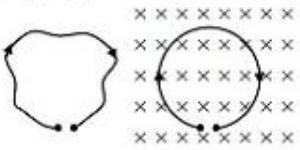
Sol. ***(B)***

Impedance $Z = \sqrt{\frac{1}{(\omega C)^2} + R^2}$

as ω increases, Z decreases.

Hence bulb will glow brighter

60. A thin flexible wire of length L is connected to two adjacent fixed points and carries a current I in the clockwise direction, as shown in the figure. When the system is put in a uniform magnetic field of strength B going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is



A) IBL

B) $\frac{IBL}{\pi}$

C) $\frac{IBL}{2\pi}$

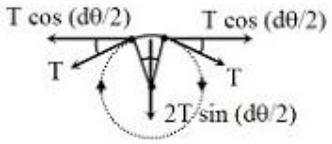
D) $\frac{IBL}{4\pi}$

Sol. ***(C)***

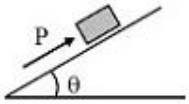
$2T\sin\frac{d\theta}{2} = BiRd\theta$

$Td\theta = BiRd\theta$ (for θ small)

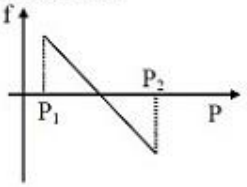
$T = BiR = \frac{BiL}{2\pi}$



61. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and tan θ > μ. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like



A)



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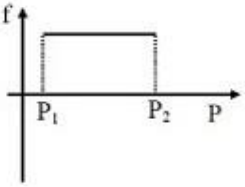
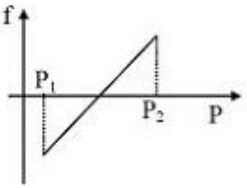
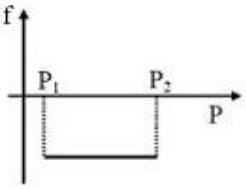


C)



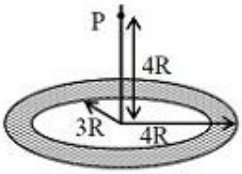
D)



Sol. ***(A)***

Initially the frictional force is upwards as P increases frictional force decreases.

62. A thin uniform annular disc (see figure) of mass M has outer radius 4R and inner radius 3R. The work required to take a unit mass from point P on its axis to infinity is



A) $\frac{2GM}{7R}(4\sqrt{2}-5)$

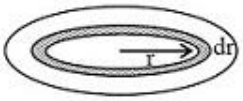
B) $-\frac{2GM}{7R}(4\sqrt{2}-5)$

C) $\frac{GM}{4R}$

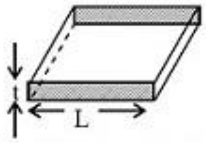
B) $\frac{2GM}{5R}(\sqrt{2}-1)$

Sol. ***(A)***

$$V = -\int_{3R}^{4R} \frac{\sigma 2\pi r dr G}{\sqrt{r^2 + 16R^2}}$$



63. Consider a thin square sheet of side L and thickness t, made of a material of resistivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is



A) directly proportional to L
B) directly proportional to t
C) independent of L
D) independent of t

Sol. ***(C)***

$$R = \frac{\rho L}{Lt}$$

64. A real gas behaves like an ideal gas if its
A) pressure and temperature are both high
B) pressure and temperature are both low
C) pressure is high and temperature is low
D) pressure is low and temperature is high

Sol. ***(D)***

SECTION – II (Multiple Correct Choice Type)

This section contains **5 multiple choice questions.** Each question has four choices A), B), C) and D) out of which **ONE OR MORE** may be correct.

65. A point mass of 1 kg collides elastically with a stationary point mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with a speed of 2 ms^{-1}. Which of the following statement(s) is (are) correct for the system of these two masses?
A) Total momentum of the system is 3 kg ms^{-1}
B) Momentum of 5 kg mass after collision is 4 kg ms^{-1}
C) Kinetic energy of the centre of mass is 0.75 J
D) Total kinetic energy of the system is 4J

Sol. ***(A, C)***

By conservation of linear momentum

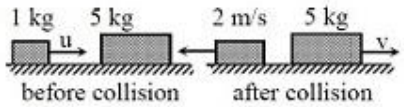
$u = 5v - 2$ …(i)

By Newton's experimental law of collision

$u = v + 2$ …(ii)

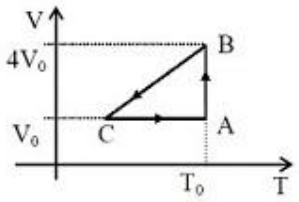
using (i) and (ii) we have

$v = 1$ m/s and $u = 3$ m/s



Kinetic energy of the centre of mass = $\frac{1}{2} m_{system} v_{cm}^2 = 0.75$ J

66. One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, as shown in the figure. Its pressure at A is P_0. Choose the correct option(s) from the following



A) Internal energies at A and B are the same

B) Work done by the gas in process AB is P_0V_0 ℓn 4

C) Pressure at C is $\frac{P_0}{4}$

D) Temperature at C is $\frac{T_0}{4}$

Sol. ***(A, B)***

Process AB is isothermal process

67. A student uses a simple pendulum of exactly 1m length to determine g, the acceleration due to gravity. He uses a stop watch with the least count of 1 sec for this and records 40 seconds for 20 oscillations. For this observation, which of the following statement(s) is (are) true?

A) Error ΔT in measuring T, the time period, is 0.05 seconds

B) Error ΔT in measuring T, the time period, is 1 second

C) Percentage error in the determination of g is 5%

D) Percentage error in the determination of g is 2.5%

Sol. ***(A, C)***

$$\frac{\Delta T}{T}=\frac{\Delta t}{t}=\frac{1}{40}$$

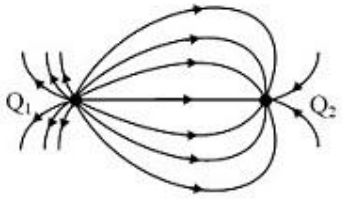
$\Delta T = 0.05$ sec

$$g=\frac{4\pi^2 Ln^2}{t^2}$$

$$\frac{\Delta g}{g}=\frac{2\Delta t}{t}$$

$$\Rightarrow \%\ \text{error} = \frac{2\Delta t}{t}\times 100 = 5\%$$

68. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis are shown in the figure. These lines suggest that



A) $|Q_1| > |Q_2|$

B) $|Q_1| < |Q_2|$

C) at a finite distance to the left of Q_1 the electric field is zero

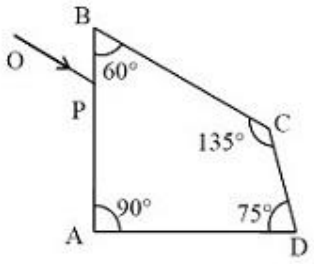
D) at a finite distance to the right of Q_2 the electric field is zero

Sol. ***(A, D)***

No. of electric field lines of forces emerging from Q_1 are larger than terminating at Q_2

69. A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60° (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct?

A) The ray gets totally internally reflected at face CD
B) The ray comes out through face AD
C) The angle between the incident ray and the emergent ray is 90°
D) The angle between the incident ray and the emergent ray is 120°

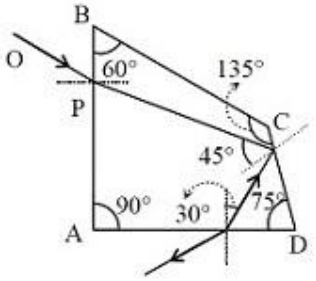


Sol. ***(A, B, C)***

Using snell's law

$$\sin^{-1}\frac{1}{\sqrt{3}} < \sin^{-1}\frac{1}{\sqrt{2}}$$

Net deviation is 90°

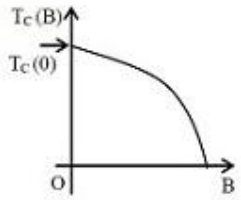


SECTION –III (Paragraph Type)

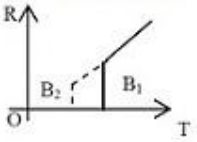
This section contains **2 paragraphs.** Based upon the first paragraph 2 multiple choice questions and based upon the second paragraph **3 multiple choice questions** have to be answered. Each of these questions has four choices A), B), C) and D) out of **WHICH ONLY ONE CORRECT.**

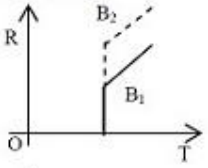
Paragraph for Questions 70 to 71

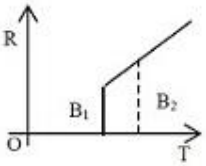
Electrical resistance of certain materials, known as superconductors, changes abruptly from a nonzero value to zero as their temperature is lowered below a critical temperature $T_c(0)$. An interesting property of superconductors is that their critical temperature becomes smaller than $T_c(0)$ if they are placed in a magnetic field, i.e., the critical temperature T_c (B) is a function of the magnetic field strength B. The dependence of $T_c(B)$ on B is shown in the figure.

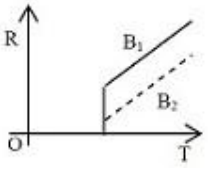


70. In the graphs below, the resistance R of a superconductor is shown as a function of its temperature T for two different magnetic fields B_1 (solid line) and B_2 (dashed line). If B_2 is larger than B_1 which of the following graphs shows the correct variation of R with T in these fields?

A)


B)


C)


D)


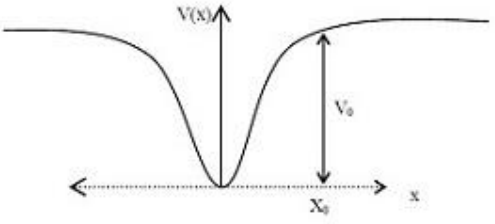
Sol. ***(A)***
Larger the magnetic field smaller the critical temperature.

71. A superconductor has T_C (0) = 100 K. When a magnetic field of 7.5 Tesla is applied, its T_c decreases to 75 K. For this material one can definitely say that when
A) B = 5 Tesla, T_c (B) = 80 K
B) B = 5 Tesla, 75 K < T_c (B) < 100 K
C) B = 10 Tesla, 75K < T_c < 100 K
D) B = 10 Tesla, T_c = 70K

Sol. ***(B)***

Paragraph for Questions 72 to 74

When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$ it performs simple harmonic motion. The corresponding time period is proportional to $\sqrt{\frac{m}{k}}$, as can be seen easily using dimensional analysis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of x = 0 in a way different from kx^2 and its total energy is such that the particle does not escape to infinity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = \alpha x^4$ ($\alpha > 0$) for |x| near the origin and becomes a constant equal to V_0 for $|x| \geq X_0$ (see figure).



72. If the total energy of the particle is E, it will perform periodic motion only if
A) E < 0
B) E > 0
C) $V_0 > E > 0$
D) $E > V_0$

Sol. ***(C)***
Energy must be less than V_0

73. For periodic motion of small amplitude A, the time period T of this particle is proportional to
A) $A\sqrt{\frac{m}{\alpha}}$
B) $\frac{1}{A}\sqrt{\frac{m}{\alpha}}$
C) $A\sqrt{\frac{\alpha}{m}}$
D) $A\sqrt{\frac{\alpha}{m}}$

Sol. ***(B)***
$[\alpha] = ML^{-2}T^{-2}$
Only (B) option has dimension of time
Alternatively

$$\frac{1}{2}m\left(\frac{dx}{dt}\right)^2 + kx^4 = kA^4$$

$$\left(\frac{dx}{dt}\right)^2 = \frac{2k}{m}\left(A^4 - x^4\right)$$

$$4\sqrt{\frac{m}{2k}}\int_0^A \frac{dx}{\sqrt{A^4 - x^4}} = \int dt = T$$

$$4\sqrt{\frac{m}{2k}}\frac{1}{A}\int_0^1 \frac{du}{\sqrt{1-u^4}} = T \qquad \text{Substitute } x = Au$$

74. The acceleration of this particle for $|x| > X_0$ is

A) proportional to V_0

B) proportional to $\frac{V_0}{mX_0}$

C) proportional to $\sqrt{\frac{V_0}{mX_0}}$

D) zero

Sol. ***(D)***

As potential energy is constant for $|x| > X_0$, the force on the particle is zero hence acceleration is zero.

SECTION –IV (Integer Type)

This section contains **TEN** questions. The answer to each question is a single digit integer ranging from 0 to 9. The correct digit below the question number in the **ORS** is to be bubbled.

75. Gravitational acceleration on the surface of a planet is $\frac{\sqrt{6}}{11}$ g, where g is the gravitational acceleration on the surface of the earth. The average mass density of the planet is $\frac{2}{3}$ times that of the earth. If the escape speed on the surface of the earth is taken to be 11 kms^{-1}, the escape speed on the surface of the planet in kms^{-1} will be

Sol. ***3***

$$\frac{g'}{g} = \frac{\sqrt{6}}{11} \; ; \; \frac{\rho'}{\rho} = \frac{2}{3}$$

Hence, $\frac{R'}{R} = \frac{3\sqrt{6}}{22}$

$$\frac{v'_{esc}}{v_{esc}} \propto \sqrt{\frac{R'^2\rho'}{R^2\rho}} = \frac{3}{11}$$

$v'_{esc} = 3$ km/s.

76. A piece of ice (heat capacity = 2100 J kg^{-1} $°C^{-1}$ and latent heat = 3.36×10^5 J kg^{-1}) of mass m grams is at -5°C at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m is

Sol. ***8***

$420 = (m \times 2100 \times 5 + 1 \times 3.36 \times 10^5) \times 10^{-3}$

where m is in gm.

77. A stationary source is emitting sound at a fixed frequency f_0, which is reflected by two cars approaching the source. The difference between the frequencies of sound reflected from the cars is 1.2% of f_0. What is the difference in the speeds of the cars (in km per hour) to the nearest integer ? The cars are moving at constant speeds much smaller than the speed of sound which is 330 ms^{-1}.

Sol. ***7***

$$f_{app} = f_0 \frac{c+v}{c-v}$$

$$df = \frac{2f_o c}{(c-v)^2} dv$$

where c is speed of sound

$$df = \frac{1.2}{100} f_o$$

hence $dv \approx 7$ km/hr.

78. The focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25 cm in front of it to 50 cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is

Sol. *6*

$$m = \frac{f}{f+u}$$

79. An α- particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de Broglie wavelengths are λ_α and λ_p respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is

Sol. *3*

$$\frac{1}{2}mv^2 = qV$$

$$\lambda = \frac{h}{mv}$$

$\lambda = \sqrt{8} \simeq 3$.

80. When two identical batteries of internal resistance 1Ω each are connected in series across a resistor R, the rate of heat produced in R is J_1. When the same batteries are connected in parallel across R, the rate is J_2. If $J_1 = 2.25\ J_2$ then the value of R in Ω is

Sol. *4*

$$J_1 = \left(\frac{2E}{R+2}\right)^2 R$$

$$J_2 = \left(\frac{E}{R+1/2}\right)^2 R \quad \text{since } J_1/J_2 = 2.25$$

$R = 4\ \Omega$.

81. Two spherical bodies A (radius 6 cm) and B(radius 18 cm) are at temperature T_1 and T_2, respectively. The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B?

Sol. *9*

$\lambda_m T$ = constant

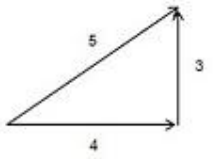
$\lambda_A T_A = \lambda_B T_B$

Rate of total energy radiated $\propto AT^4$

82. When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin\left(2x - 6t - \frac{\pi}{2}\right)$ are superimposed, the amplitude of the resultant wave is

Sol. *5*

Two waves have phase difference $\pi/2$.



83. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1m and its cross-sectional area is 4.9×10^{-7} m^2. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rad s^{-1}. If the Young's modulus of the material of the wire is $n \times 10^9$ Nm^{-2}, the value of n is

Sol. *4*

$$\omega = \sqrt{\frac{YA}{mL}}$$

84. A binary star consists of two stars A (mass $2.2M_s$) and B (mass $11M_s$), where M_s is the mass of the sun. They are separated by distance d and are rotating about their centre of mass, which is stationary. The ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass is

Sol. *6*

$$\frac{L_{total}}{L_B} = \frac{m_1 r_1^2}{m_2 r_2^2} + 1$$

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