P2-09-3-4

24021

CODE 4

PAPER 2

Time : 3 Hours **Maximum Marks : 240**

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

INSTRUCTIONS

A. General :

1. This booklet is your Question Paper containing **57** questions. The booklet has 44 pages.
2. The **question paper CODE** is printed on the right hand top corner of this sheet and on the back page (page no. 44) of this booklet.
3. The question paper contains **10** blank pages for your rough work. 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 to be carried inside the examination hall.
5. Fill in the boxes provided below on this page and also write your **Name** and **Registration No.** in the space provided on the back page (page no. 44) of this booklet.
6. The answer sheet, a machine-readable Objective Response Sheet (**ORS**), is provided separately.
7. DO NOT TAMPER WITH/MUTILATE THE ORS OR THE BOOKLET.
8. Do not break the seals of the question-paper booklet before being instructed to do so by the invigilators.

B. Filling the ORS :

9. On the lower part of the ORS, write in ink, your Name in Box L1, your Registration No. in Box L2 and Name of the Centre in Box L3. **Do not write these anywhere else.**
10. Write your Registration No. in ink, in Box L4 provided in the lower part of the ORS and darken the appropriate bubble **UNDER** each digit of your Registration No. with a good quality **HB** pencil.
11. The ORS has a **CODE** printed on its lower and upper parts.
12. Make sure that the CODE on the ORS is the same as that on this booklet. Put your signature in ink in Box L5 on the ORS affirming that you have verified this.
13. IF THE CODES DO NOT MATCH, ASK FOR A CHANGE OF THE BOOKLET.

C. Question paper format
D. Marking scheme
} Read the instructions printed on the back page (page no. 44) of this booklet.

SEAL

DO NOT BREAK THE SEALS WITHOUT BEING INSTRUCTED TO DO SO BY THE INVIGILATOR

SEAL

Name of the Candidate

Registration Number

I have read all the instructions and shall abide by them.

Signature of the Candidate

I have verified all the information filled in by the Candidate.

Signature of the Invigilator

PART I : CHEMISTRY

SECTION – I

Single Correct Choice Type

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

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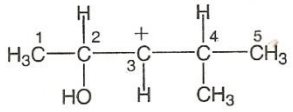
1. In the following carbocation, H/CH_3 that is most likely to migrate to the positively charged carbon is



(A) CH_3 at C-4 (B) H at C-4

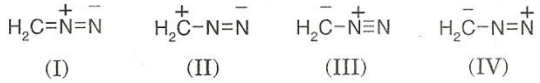
(C) CH_3 at C-2 (D) H at C-2

2. The spin only magnetic moment value (in Bohr magneton units) of $Cr(CO)_6$ is

(A) 0 (B) 2.84 (C) 4.90 (D) 5.92

Space for rough work

3. The correct stability order of the following resonance structures is



(I) (II) (III) (IV)

(A) (I) > (II) > (IV) > (III)
(B) (I) > (III) > (II) > (IV)
(C) (II) > (I) > (III) > (IV)
(D) (III) > (I) > (IV) > (II)

4. For a first order reaction A→P, the temperature (T) dependent rate constant (k) was found to follow the equation $\log k = -(2000)\frac{1}{T} + 6.0$. The pre-exponential factor A and the activation energy E_a, respectively, are

(A) 1.0×10^6 s^{-1} and 9.2 kJ mol^{-1}
(B) 6.0 s^{-1} and 16.6 kJ mol^{-1}
(C) 1.0×10^6 s^{-1} and 16.6 kJ mol^{-1}
(D) 1.0×10^6 s^{-1} and 38.3 kJ mol^{-1}

Space for rough work

SECTION – II

Multiple Correct Choice Type

This section contains 5 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

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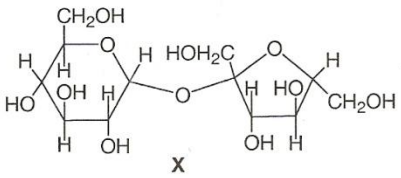
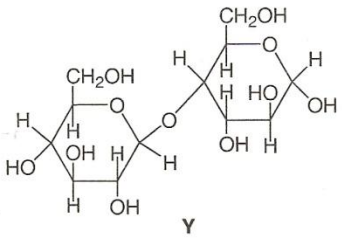
5. The nitrogen oxide(s) that contain(s) N-N bond(s) is(are)

(A) N_2O (B) N_2O_3 (C) N_2O_4 (D) N_2O_5

6. The correct statement(s) about the following sugars **X** and **Y** is(are)





(A) **X** is a reducing sugar and **Y** is a non-reducing sugar

(B) **X** is a non-reducing sugar and **Y** is a reducing sugar

(C) The glucosidic linkages in **X** and **Y** are α and β, respectively

(D) The glucosidic linkages in **X** and **Y** are β and α, respectively

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Space for rough work

7. In the reaction

$$2\mathbf{X} + B_2H_6 \rightarrow [BH_2(\mathbf{X})_2]^+ [BH_4]^-$$

the amine(s) **X** is(are)

(A) NH_3 (B) CH_3NH_2

(C) $(CH_3)_2NH$ (D) $(CH_3)_3N$

8. Among the following, the state function(s) is(are)

(A) Internal energy (B) Irreversible expansion work

(C) Reversible expansion work (D) Molar enthalpy

9. For the reduction of NO_3^- ion in an aqueous solution, E^0 is +0.96 V. Values of E^0 for some metal ions are given below

$V^{2+}(aq) + 2e^- \rightarrow V$ $E^0 = -1.19$ V

$Fe^{3+}(aq) + 3e^- \rightarrow Fe$ $E^0 = -0.04$ V

$Au^{3+}(aq) + 3e^- \rightarrow Au$ $E^0 = +1.40$ V

$Hg^{2+}(aq) + 2e^- \rightarrow Hg$ $E^0 = +0.86$ V

The pair(s) of metals that is(are) oxidized by NO_3^- in aqueous solution is(are)

(A) V and Hg (B) Hg and Fe

(C) Fe and Au (D) Fe and V

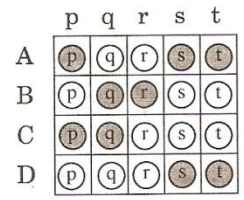
Space for rough work

SECTION – III

Matrix – Match Type

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in **Column I** are labelled A, B, C and D, while the statements in **Column II** are labelled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:

If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.



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10. Match each of the reactions given in **Column I** with the corresponding product(s) given in **Column II**.

Column I	**Column II**
(A) $Cu + dil\ HNO_3$	(p) NO
(B) $Cu + conc\ HNO_3$	(q) NO_2
(C) $Zn + dil\ HNO_3$	(r) N_2O
(D) $Zn + conc\ HNO_3$	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

Space for rough work

Solution:

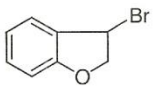
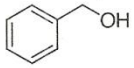
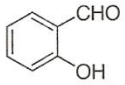
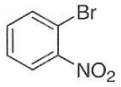
A → p, s

B → q, s

C → r, t

D → q, t

11. Match each of the compounds given in **Column I** with the reaction(s), that they can undergo, given in **Column II**.

Column I	**Column II**
(A) 	(p) Nucleophilic substitution
(B) 	(q) Elimination
(C) 	(r) Nucleophilic addition
(D) 	(s) Esterification with acetic anhydride
	(t) Dehydrogenation

Space for rough work

Solution

A → p, q, t

B → p, q, t

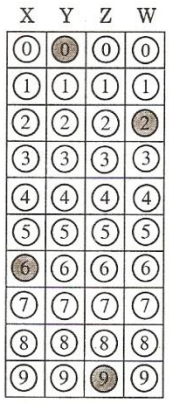
C → r, s

D → p

SECTION – IV

Integer Answer Type

This section contains 8 questions. The answer to each of the questions is a single–digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2, respectively, then the correct darkening of bubbles will look like the following:



12. The coordination number of Al in the crystalline state of $AlCl_3$ is

Ans : 6

13. The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is

Ans: 6

14. The total number of α and β particles emitted in the nuclear reaction $^{238}_{92}U \rightarrow {}^{214}_{82}Pb$ is Ans : 8

Space for rough work

15. The dissociation constant of a substituted benzoic acid at 25°C is 1.0×10^{-4}. The pH of a 0.01 M solution of its sodium salt is

Ans: 8

16. The number of water molecule(s) directly bonded to the metal centre in $CuSO_4 \cdot 5H_2O$ is

Ans: 4

17. At 400 K, the root mean square (rms) speed of a gas **X** (molecular weight = 40) is equal to the most probable speed of gas **Y** at 60 K. The molecular weight of the gas **Y** is

Ans: 4

18. The total number of cyclic structural as well as stereo isomers possible for a compound with the molecular formula C_5H_{10} is

Ans: 7

19. In a constant volume calorimeter, 3.5 g of a gas with molecular weight 28 was burnt in excess oxygen at 298.0 K. The temperature of the calorimeter was found to increase from 298.0 K to 298.45 K due to the combustion process. Given that the heat capacity of the calorimeter is 2.5 kJ K^{-1}, the numerical value for the enthalpy of combustion of the gas in kJ mol^{-1} is Ans: 9

Space for rough work

PART II : MATHEMATICS

SECTION – I

Single Correct Choice Type

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

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20. The normal at a point P on the ellipse $x^2 + 4y^2 = 16$ meets the x-axis at Q. If M is the mid point of the line segment PQ, then the locus of M intersects the latus rectums of the given ellipse at the points

(A) $\left(\pm\frac{3\sqrt{5}}{2}, \pm\frac{2}{7}\right)$ (B) $\left(\pm\frac{3\sqrt{5}}{2}, \pm\frac{\sqrt{19}}{4}\right)$

(C) $\left(\pm 2\sqrt{3}, \pm\frac{1}{7}\right)$ (D) $\left(\pm 2\sqrt{3}, \pm\frac{4\sqrt{3}}{7}\right)$

21. A line with positive direction cosines passes through the point $P(2, -1, 2)$ and makes equal angles with the coordinate axes. The line meets the plane

$$2x + y + z = 9$$

at point Q. The length of the line segment PQ equals

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

Space for rough work

22. The locus of the orthocentre of the triangle formed by the lines

$$(1+p)x - py + p(1+p) = 0,$$
$$(1+q)x - qy + q(1+q) = 0,$$

and $y = 0$, where $p \neq q$, is

(A) a hyperbola
(B) a parabola
(C) an ellipse
(D) a straight line

23. If the sum of first n terms of an A.P. is cn^2, then the sum of squares of these n terms is

(A) $\frac{n(4n^2-1)c^2}{6}$
(B) $\frac{n(4n^2+1)c^2}{3}$
(C) $\frac{n(4n^2-1)c^2}{3}$
(D) $\frac{n(4n^2+1)c^2}{6}$

Space for rough work

SECTION – II

Multiple Correct Choice Type

This section contains 5 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

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24. The tangent PT and the normal PN to the parabola $y^2 = 4ax$ at a point P on it meet its axis at points T and N, respectively. The locus of the centroid of the triangle PTN is a parabola whose

(A) vertex is $\left(\frac{2a}{3}, 0\right)$ (B) directrix is $x = 0$

(C) latus rectum is $\frac{2a}{3}$ (D) focus is $(a, 0)$

25. For $0 < \theta < \frac{\pi}{2}$, the solution(s) of

$$\sum_{m=1}^{6} \operatorname{cosec}\left(\theta + \frac{(m-1)\pi}{4}\right) \operatorname{cosec}\left(\theta + \frac{m\pi}{4}\right) = 4\sqrt{2}$$

is(are)

(A) $\frac{\pi}{4}$ (B) $\frac{\pi}{6}$ (C) $\frac{\pi}{12}$ (D) $\frac{5\pi}{12}$

Space for rough work

26. For the function

$$f(x)=x\cos\frac{1}{x},\quad x\geq 1,$$

(A) for at least one x in the interval $[1,\infty)$, $f(x+2)-f(x)<2$

(B) $\lim\limits_{x\to\infty} f'(x)=1$

(C) for all x in the interval $[1,\infty)$, $f(x+2)-f(x)>2$

(D) $f'(x)$ is strictly decreasing in the interval $[1,\infty)$

27. An ellipse intersects the hyperbola $2x^2-2y^2=1$ orthogonally. The eccentricity of the ellipse is reciprocal of that of the hyperbola. If the axes of the ellipse are along the coordinate axes, then

(A) Equation of ellipse is $x^2+2y^2=2$

(B) The foci of ellipse are $(\pm 1, 0)$

(C) Equation of ellipse is $x^2+2y^2=4$

(D) The foci of ellipse are $(\pm\sqrt{2}, 0)$

28. If

$$I_n=\int_{-\pi}^{\pi}\frac{\sin nx}{(1+\pi^x)\sin x}\,dx,\quad n=0,1,2,\ldots,$$

then

(A) $I_n=I_{n+2}$

(B) $\sum\limits_{m=1}^{10} I_{2m+1}=10\pi$

(C) $\sum\limits_{m=1}^{10} I_{2m}=0$

(D) $I_n=I_{n+1}$

Space for rough work

SECTION – III

Matrix – Match Type

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If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.

	p	q	r	s	t
A	●	○	○	●	●
B	○	●	●	○	○
C	●	●	○	○	○
D	○	○	○	●	●

29. Match the statements/expressions given in **Column I** with the values given in **Column II**.

Column I	**Column II**
(A) Root(s) of the equation $2\sin^2\theta + \sin^2 2\theta = 2$	(p) $\frac{\pi}{6}$
(B) Points of discontinuity of the function $f(x) = \left[\frac{6x}{\pi}\right] \cos\left[\frac{3x}{\pi}\right]$, where $[y]$ denotes the largest integer less than or equal to y	(q) $\frac{\pi}{4}$
	(r) $\frac{\pi}{3}$
(C) Volume of the parallelopiped with its edges represented by the vectors $\hat{i}+\hat{j}$, $\hat{i}+2\hat{j}$ and $\hat{i}+\hat{j}+\pi\hat{k}$	(s) $\frac{\pi}{2}$
	(t) π
(D) Angle between vectors $\vec{a}$ and $\vec{b}$ where $\vec{a}, \vec{b}$ and $\vec{c}$ are unit vectors satisfying $\vec{a}+\vec{b}+\sqrt{3}\vec{c} = \vec{0}$	

Space for rough work

Solution:

A → q, s

B → p, r, s, t

C → t

D → s

30. Match the statements/expressions given in **Column I** with the values given in **Column II**.

Column I	**Column II**
(A) The number of solutions of the equation $x e^{\sin x} - \cos x = 0$ in the interval $\left(0, \frac{\pi}{2}\right)$	(p) 1
(B) Value(s) of k for which the planes $kx + 4y + z = 0$, $4x + ky + 2z = 0$ and $2x + 2y + z = 0$ intersect in a straight line	(q) 2
(C) Value(s) of k for which $\lvert x-1\rvert + \lvert x-2\rvert + \lvert x+1\rvert + \lvert x+2\rvert = 4k$ has integer solution(s)	(r) 3
(D) If $y' = y + 1$ and $y(0) = 1$, then value(s) of $y(\ln 2)$	(s) 4
	(t) 5

Space for rough work

Solution:

A → p

B → q, s

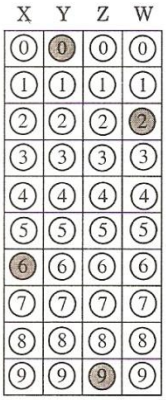
C → q, r, s, t

D → r

SECTION – IV

Integer Answer Type

This section contains 8 questions. The answer to each of the questions is a single–digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2, respectively, then the correct darkening of bubbles will look like the following:



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31. The smallest value of k, for which both the roots of the equation

$$x^2 - 8kx + 16\,(k^2 - k + 1) = 0$$

are real, distinct and have values at least 4, is

Ans: 2

32. Let $f : \mathbb{R} \to \mathbb{R}$ be a continuous function which satisfies

$$f(x) = \int_0^x f(t)\,dt.$$

Then the value of $f(\ln 5)$ is

Ans: 0

Space for rough work

33. Let $p(x)$ be a polynomial of degree 4 having extremum at $x = 1, 2$ and

$$\lim_{x \to 0} \left(1 + \frac{p(x)}{x^2}\right) = 2.$$

Then the value of $p(2)$ is

Ans: 0

34. Let ABC and ABC' be two non-congruent triangles with sides $AB = 4$, $AC = AC' = 2\sqrt{2}$ and angle $B = 30°$. The absolute value of the difference between the areas of these triangles is Ans: 4

Space for rough work

35. The centres of two circles C_1 and C_2 each of unit radius are at a distance of 6 units from each other. Let P be the mid point of the line segment joining the centres of C_1 and C_2 and C be a circle touching circles C_1 and C_2 externally. If a common tangent to C_1 and C passing through P is also a common tangent to C_2 and C, then the radius of the circle C is

Ans : 8

36. Let (x, y, z) be points with integer coordinates satisfying the system of homogeneous equations:

$$3x - y - z = 0$$
$$-3x + z = 0$$
$$-3x + 2y + z = 0.$$

Ans : 7

Then the number of such points for which $x^2 + y^2 + z^2 \leq 100$ is

Space for rough work

37. If the function $f(x) = x^3 + e^{\frac{x}{2}}$ and $g(x) = f^{-1}(x)$, then the value of $g'(1)$ is

Ans : 2

38. The maximum value of the function $f(x) = 2x^3 - 15x^2 + 36x - 48$ on the set $A = \{x \mid x^2 + 20 \leq 9x\}$ is Ans : 7

Space for rough work

PART III : PHYSICS

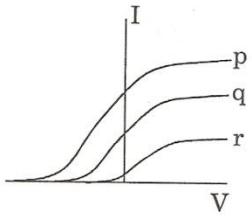
SECTION – I

Single Correct Choice Type

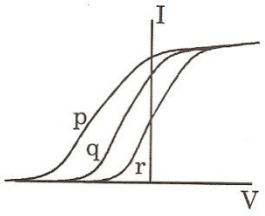
This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

39. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p = 2.0$ eV, $\phi_q = 2.5$ eV and $\phi_r = 3.0$ eV, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is [Take $hc = 1240$ eV nm]

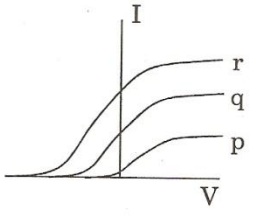
(A)



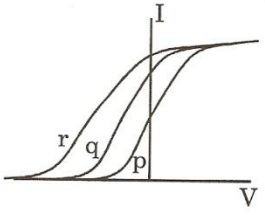
(B)



(C)



(D)

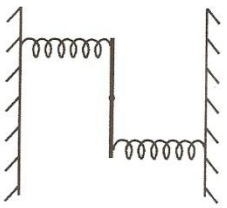


Space for rough work

40. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is

(A) $\frac{a}{gk}$ (B) $\frac{a}{2gk}$ (C) $\frac{2a}{gk}$ (D) $\frac{a}{4gk}$

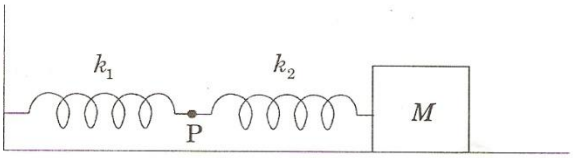
41. A uniform rod of length L and mass M is pivoted at the centre. Its two ends are attached to two springs of equal spring constants k. The springs are fixed to rigid supports as shown in the figure, and the rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle θ in one direction and released. The frequency of oscillation is



(A) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$ (C) $\frac{1}{2\pi}\sqrt{\frac{6k}{M}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{24k}{M}}$

Space for rough work

42. The mass M shown in the figure oscillates in simple harmonic motion with amplitude A. The amplitude of the point P is



(A) $\frac{k_1 A}{k_2}$ (B) $\frac{k_2 A}{k_1}$ (C) $\frac{k_1 A}{k_1 + k_2}$ (D) $\frac{k_2 A}{k_1 + k_2}$

Space for rough work

SECTION – II

Multiple Correct Choice Type

This section contains 5 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

---

43. Under the influence of the Coulomb field of charge $+Q$, a charge $-q$ is moving around it in an elliptical orbit. Find out the correct statement(s).

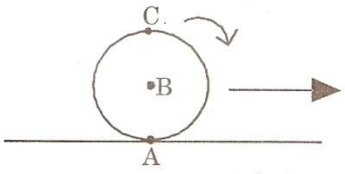
(A) The angular momentum of the charge $-q$ is constant

(B) The linear momentum of the charge $-q$ is constant

(C) The angular velocity of the charge $-q$ is constant

(D) The linear speed of the charge $-q$ is constant

44. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact, B is the centre of the sphere and C is its topmost point. Then,



(A) $\vec{V}_C - \vec{V}_A = 2\left(\vec{V}_B - \vec{V}_C\right)$

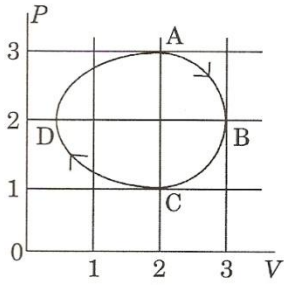
(B) $\vec{V}_C - \vec{V}_B = \vec{V}_B - \vec{V}_A$

(C) $\left|\vec{V}_C - \vec{V}_A\right| = 2\left|\vec{V}_B - \vec{V}_C\right|$

(D) $\left|\vec{V}_C - \vec{V}_A\right| = 4\left|\vec{V}_B\right|$

Space for rough work

45. The figure shows the *P-V* plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then,



(A) the process during the path A → B is isothermal

(B) heat flows out of the gas during the path B → C → D

(C) work done during the path A → B → C is zero

(D) positive work is done by the gas in the cycle ABCDA

Space for rough work

46. A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air-column is the second resonance. Then,

(A) the intensity of the sound heard at the first resonance was more than that at the second resonance

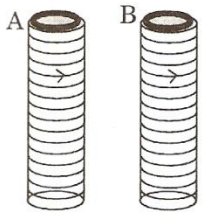
(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube

(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm

(D) the length of the air-column at the first resonance was somewhat shorter than 1/4th of the wavelength of the sound in air

Space for rough work

47. Two metallic rings A and B, identical in shape and size but having different resistivities ρ_A and ρ_B, are kept on top of two identical solenoids as shown in the figure. When current I is switched on in both the solenoids in identical manner, the rings A and B jump to heights h_A and h_B, respectively, with $h_A > h_B$. The possible relation(s) between their resistivities and their masses m_A and m_B is(are)



(A) $\rho_A > \rho_B$ and $m_A = m_B$

(B) $\rho_A < \rho_B$ and $m_A = m_B$

(C) $\rho_A > \rho_B$ and $m_A > m_B$

(D) $\rho_A < \rho_B$ and $m_A < m_B$

Space for rough work

SECTION – III

Matrix – Match Type

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in **Column I** are labelled A, B, C and D, while the statements in **Column II** are labelled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statement(s) in **Column II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:

If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.

	p	q	r	s	t
A	●	○	○	●	●
B	○	●	●	○	○
C	●	●	○	○	○
D	○	○	○	●	●

48. **Column II** gives certain systems undergoing a process. **Column I** suggests changes in some of the parameters related to the system. Match the statements in **Column I** to the appropriate process(es) from **Column II**.

Column I

(A) The energy of the system is increased

(B) Mechanical energy is provided to the system, which is converted into energy of random motion of its parts

(C) Internal energy of the system is converted into its mechanical energy

(D) Mass of the system is decreased

Column II

(p) System: A capacitor, initially uncharged
Process: It is connected to a battery

(q) System: A gas in an adiabatic container fitted with an adiabatic piston
Process: The gas is compressed by pushing the piston

(r) System: A gas in a rigid container
Process: The gas gets cooled due to colder atmosphere surrounding it

(s) System: A heavy nucleus, initially at rest
Process: The nucleus fissions into two fragments of nearly equal masses and some neutrons are emitted

(t) System: A resistive wire loop
Process: The loop is placed in a time varying magnetic field perpendicular to its plane

Space for rough work

Solution

A → p, q, t

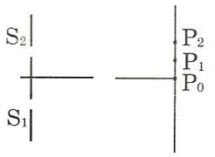
B → q

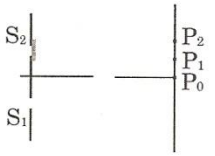
C → s

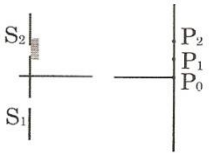
D → s

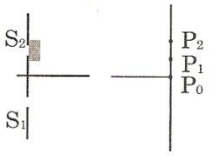
49. **Column I** shows four situations of standard Young's double slit arrangement with the screen placed far away from the slits S_1 and S_2. In each of these cases $S_1P_0 = S_2P_0$, $S_1P_1 - S_2P_1 = \lambda/4$ and $S_1P_2 - S_2P_2 = \lambda/3$, where λ is the wavelength of the light used. In the cases B, C and D, a transparent sheet of refractive index μ and thickness t is pasted on slit S_2. The thicknesses of the sheets are different in different cases. The phase difference between the light waves reaching a point P on the screen from the two slits is denoted by $\delta(P)$ and the intensity by $I(P)$. Match each situation given in **Column I** with the statement(s) in **Column II** valid for that situation.

Column I

(A) 

(B) $(\mu-1)t = \lambda/4$ 

(C) $(\mu-1)t = \lambda/2$ 

(D) $(\mu-1)t = 3\lambda/4$ 

Column II

(p) $\delta(P_0) = 0$

(q) $\delta(P_1) = 0$

(r) $I(P_1) = 0$

(s) $I(P_0) > I(P_1)$

(t) $I(P_2) > I(P_1)$

Space for rough work

Solution

A → P, A

B → q

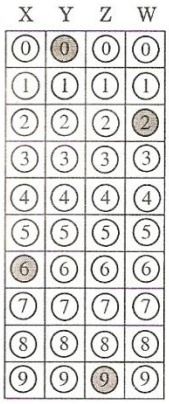
C → t

D → r, s, t

SECTION – IV

Integer Answer Type

This section contains 8 questions. The answer to each of the questions is a single–digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2, respectively, then the correct darkening of bubbles will look like the following:



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50. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = \kappa r^a$, where κ and a are constants and r is the distance from its centre. If the electric field at $r = \frac{R}{2}$ is $\frac{1}{8}$ times that at $r = R$, find the value of a.

Ans: 2

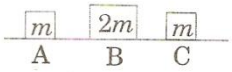
51. A steady current I goes through a wire loop PQR having shape of a right angle triangle with PQ = $3x$, PR = $4x$ and QR = $5x$. If the magnitude of the magnetic field at P due to this loop is $k\left(\frac{\mu_0 I}{48\pi x}\right)$, find the value of k.

Ans: 7

Space for rough work

52. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. These have masses m, $2m$ and m, respectively. The object A moves towards B with a speed 9 m/s and makes an elastic collision with it. Thereafter, B makes completely inelastic collision with C. All motions occur on the same straight line. Find the final speed (**in m/s**) of the object C.

Ans : 4

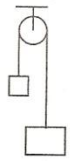


53. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m^2. The radii of bubbles A and B are 2 cm and 4 cm, respectively. Surface tension of the soap-water used to make bubbles is 0.04 N/m. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity.]

Ans → 6

54. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking $g = 10$ m/s^2, find the work done (**in joules**) by the string on the block of mass 0.36 kg during the first second after the system is released from rest.

Ans : 8



Space for rough work

55. A cylindrical vessel of height 500 mm has an orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it up to height H. Now the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with height of water column being 200 mm. Find the fall in height (**in mm**) of water level due to opening of the orifice.
[Take atmospheric pressure $= 1.0 \times 10^5$ N/m^2, density of water = 1000 kg/m^3 and $g = 10$ m/s^2. Neglect any effect of surface tension.]

Ans: 6

56. A 20 cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibrations using an external vibrator of frequency 100 Hz. Find the separation (**in cm**) between the successive nodes on the string.

Ans: 5

57. A metal rod AB of length $10x$ has its one end A in ice at 0°C and the other end B in water at 100°C. If a point P on the rod is maintained at 400°C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at a distance of λx from the ice end A, find the value of λ.
[Neglect any heat loss to the surrounding.] Ans: 9

Space for rough work

CODE 4

Name : _____ Registration No. : _____

SEAL

C. Question paper format :

14. The question paper consists of 3 parts (Chemistry, Mathematics and Physics). Each part has 4 sections.

15. **Section I** contains **4** multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **only one is correct**.

16. **Section II** contains **5** multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **one or more is/are correct.**

17. **Section III** contains **2** questions. Each question has four statements (A, B, C and D) given in Column I and five statements (p, q, r, s and t) in Column II. Any given statement in Column I can have correct matching with **one or more** statement(s) given in Column II. For example, if for a given question, statement B matches with the statements given in q and r, then for that particular question, against statement B, darken the bubbles corresponding to q and r in the ORS.

18. **Section IV** contains **8** questions. The answer to each of the questions is a **single-digit integer**, ranging from 0 to 9. The answer will have to be appropriately bubbled in the ORS as per the instructions given at the beginning of the section.

D. Marking Scheme :

19. For each question in **Section I**, you will be **awarded 3 marks** if you darken the bubble corresponding to the correct answer and **zero mark** if no bubble is darkened. In case of bubbling of incorrect answer, **minus one (–1) mark** will be awarded.

20. For each question in **Section II**, you will be **awarded 4 marks** if you darken the bubble(s) corresponding to the correct choice(s) for the answer, and **zero mark** if no bubble is darkened. In all other cases, **minus one (–1) mark** will be awarded.

SEAL

21. For each question in **Section III**, you will be **awarded 2 marks** for **each row** in which you have darkened the bubble(s) corresponding to the correct answer. Thus, each question in this section carries a maximum of **8** marks. There is **no negative marking** for incorrect answer(s) for this section.

22. For each question in **Section IV**, you will be **awarded 4 marks** if you darken the bubble corresponding to the correct answer, and **zero mark** if no bubble is darkened. In all other cases, **minus one (–1) mark** will be awarded.