

CODE

5

PAPER-2

P2-14-5

2218845

Time : 3 Hours

Maximum Marks : 180

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

INSTRUCTIONS

A. General

1. This booklet is your Question Paper. Do not break the seal of this booklet before being instructed to do so by the invigilators.
2. The question paper CODE is printed on the left hand top corner of this sheet and on the back cover page of this booklet.
3. Blank spaces and blank pages are provided in the question paper for your rough work. No additional sheets will be provided for rough work.
4. Blank papers, clipboards, log tables, slide rules, calculators, cameras, cellular phones, pagers and electronic gadget of any kind are NOT allowed inside the examination hall.
5. Write your Name and Roll number in the space provided on the back cover of this booklet.
6. Answers to the questions and personal details are to be filled on an Optical Response Sheet, which is provided separately. The ORS is a doublet of two sheets - upper and lower, having identical layout. The upper sheet is a machine-gradable Objective Response Sheet (ORS) which will be collected by the invigilator at the end of the examination. The upper sheet is designed in such a way that darkening the bubble with a ball point pen will leave an identical impression at the corresponding place on the lower sheet. You will be allowed to take away the bottom sheet at the end of the examination, (see Figure -1 on the back cover page for the correct way of darkening the bubbles for valid answers).
7. Use a black ball point pen only to darken the bubbles on the upper original sheet. Apply sufficient pressure so that the impression is created on the lower sheet. See Figure -1 on the back cover page for appropriate way of darkening the bubbles for valid answers.
8. DO NOT TAMPER WITH/MUTILATE THE ORS OR THIS BOOKLET.
9. On breaking the seal of the booklet check that it contains 28 pages and all the 60 questions and corresponding answer choices are legible. Read carefully the instruction printed at the beginning of each section.

B. Filling the right part of the ORS

10. The ORS also has a CODE printed on its left and right parts.
11. Verify that the CODE printed on the ORS (on both the left and right parts) is the same as that on this booklet and put your signature in the Box designated as R4.
12. IF THE CODES DO NOT MATCH, ASK FOR A CHANGE OF THE BOOKLET / ORS AS APPLICABLE.
13. Write your Name, Roll No. and the name of centre and sign with pen in the boxes provided on the upper sheet of ORS. Do not write any of this anywhere else. Darken the appropriate bubble UNDER each digit of your Roll No. in such way that the impression is created on the bottom sheet. (see example in Figure 2 on the back cover)

C. Question Paper Format

The question paper consists of three parts (Physics, Chemistry and Mathematics). Each part consists of three sections.

14. Section 1 contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
15. Section 2 contains 3 paragraphs each describing theory, experiment and data etc. Six questions relate to three paragraphs with two questions on each paragraph. Each question pertaining to a particular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
16. Section 3 contains 4 multiple choice questions. Each question has two lists (List-1: P, Q, R and S; List-2 :1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

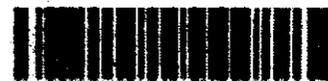
DO NOT BREAK THE SEAL WITHOUT BEING INSTRUCTED TO DO SO BY THE INVIGILATOR



Please read the last page of this booklet for rest of the instructions.

	Subject	Section		Page No.
Part I	Physics	1	Only one option correct type	3 - 5
		2	Comprehension Type - Only one option correct	6 - 8
		3	Matching List - Only one option correct	9 - 11
Part II	Chemistry	1	Only one option correct type	12 - 13
		2	Comprehension Type - Only one option correct	14 - 16
		3	Matching List - Only one option correct	17 - 19
Part III	Mathematics	1	Only one option correct type	20 - 21
		2	Comprehension Type - Only one option correct	22 - 23
		3	Matching List - Only one option correct	24 - 26

Space for Rough Work



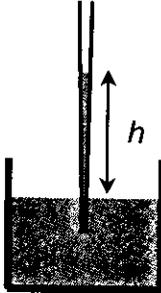
PART I : PHYSICS

SECTION – 1 : (Only One Option Correct Type)

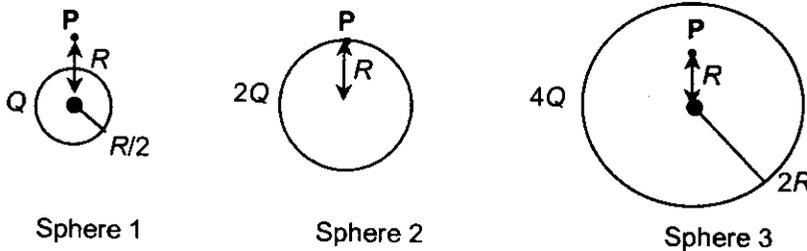
This section contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONLY ONE option is correct.

1. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h , where the radius of its cross section is b . If the surface tension of water is S , its density is ρ , and its contact angle with glass is θ , the value of h will be (g is the acceleration due to gravity)

- (A) $\frac{2S}{b\rho g} \cos(\theta - \alpha)$
 (B) $\frac{2S}{b\rho g} \cos(\theta + \alpha)$
 (C) $\frac{2S}{b\rho g} \cos(\theta - \alpha/2)$
 (D) $\frac{2S}{b\rho g} \cos(\theta + \alpha/2)$



2. A planet of radius $R = \frac{1}{10} \times$ (radius of Earth) has the same mass density as Earth. Scientists dig a well of depth $\frac{R}{5}$ on it and lower a wire of the same length and of linear mass density 10^{-3} kgm^{-1} into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it in place is (take the radius of Earth = $6 \times 10^6 \text{ m}$ and the acceleration due to gravity on Earth is 10 ms^{-2})
 (A) 96 N (B) 108 N (C) 120 N (D) 150 N
3. Charges Q , $2Q$ and $4Q$ are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii $R/2$, R and $2R$ respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1 , E_2 and E_3 respectively, then



- (A) $E_1 > E_2 > E_3$ (B) $E_3 > E_1 > E_2$ (C) $E_2 > E_1 > E_3$ (D) $E_3 > E_2 > E_1$

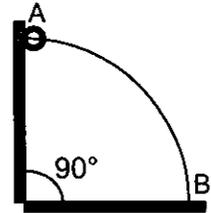
Space for Rough Work

Handwritten rough work for question 3:

- Left side: $\frac{2kQ^2}{R}$ and $**5$
- Center: A diagram of a sphere with a Gaussian surface of radius R inside. The charge enclosed is $2Q$. The electric field E is shown as a vector pointing outwards. The calculation $E \cdot 4\pi R^2 = \frac{2Q}{\epsilon_0}$ is written.
- Right side: A diagram of a sphere with a Gaussian surface of radius R inside. The charge enclosed is $4Q$. The electric field E is shown as a vector pointing outwards. The calculation $E \cdot 4\pi R^2 = \frac{4Q}{\epsilon_0}$ is written.

4. If λ_{Cu} is the wavelength of K_{α} X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the K_{α} X-ray line of molybdenum (atomic number 42), then the ratio $\lambda_{Cu}/\lambda_{Mo}$ is close to
 (A) 1.99 (B) 2.14 (C) 0.50 (D) 0.48

5. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is

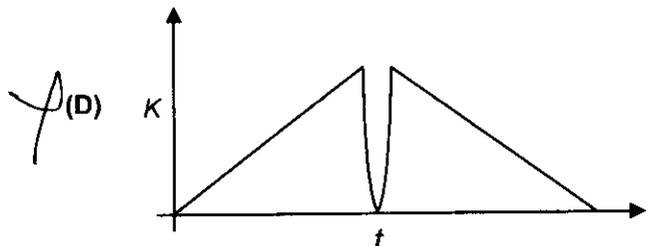
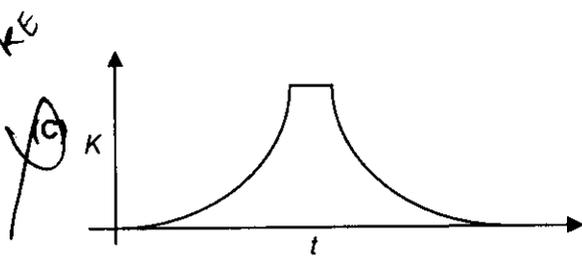
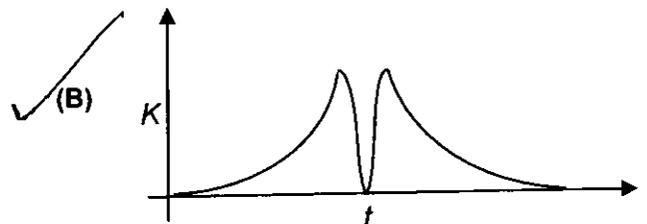
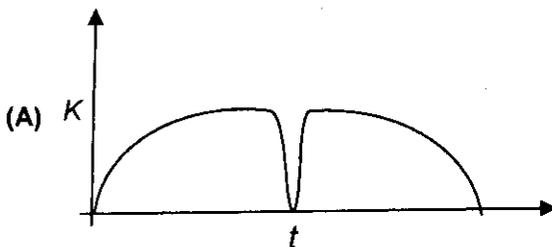


- (A) always radially outwards.
 (B) always radially inwards.
 (C) radially outwards initially and radially inwards later.
 (D) radially inwards initially and radially outwards later.

6. A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speeds of the photoelectrons corresponding to these wavelengths are u_1 and u_2 , respectively. If the ratio $u_1:u_2 = 2:1$ and $hc = 1240 \text{ eV nm}$, the work function of the metal is nearly

- (A) 3.7 eV (B) 3.2 eV (C) 2.8 eV (D) 2.5 eV

7. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately? The figures are only illustrative and not to the scale.



$KE = h\nu - \phi$
 1.45
 $\phi = \frac{h\nu}{2} - KE$

Space for Rough Work

$\frac{329}{116}$

$3 \times 6 = 18$
 $42 \times 2 = 84$
 $18 + 84 = 102$
 $102 \div 28 = 3.6428$

$29 \sqrt{42}$
 $\frac{29}{29} = 1$
 $\frac{130}{29} = 4.48$
 $\frac{116}{29} = 4$
 $\frac{140}{29} = 4.827$
 $\frac{116}{29} = 4$
 24

$42 \times 6 = 252$
 $252 \div 98 = 2.5714$

$1.5 \times 1.5 = 2.25$

$29 \sqrt{542}$
 $\frac{29}{29} = 1$
 $\frac{130}{29} = 4.48$
 $\frac{116}{29} = 4$
 $\frac{140}{29} = 4.827$
 $\frac{116}{29} = 4$
 24

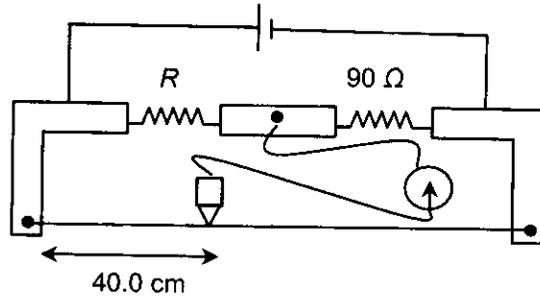
$1.4 \times 1.4 = 1.96$
 $\frac{7}{5} \times \frac{7}{5} = \frac{49}{25} = 1.96$



$1.4 \times 1.4 = 1.96$

$3 \times 49 = 147$
 $147 \div 19 = 7.7368$

8. During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at 40.0 cm using a standard resistance of $90\ \Omega$, as shown in the figure. The least count of the scale used in the metre bridge is 1 mm. The unknown resistance is

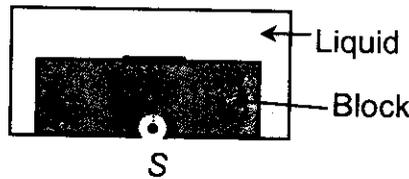


- (A) $60 \pm 0.15\ \Omega$ (B) $135 \pm 0.56\ \Omega$ (C) $60 \pm 0.25\ \Omega$ (D) $135 \pm 0.23\ \Omega$

9. Parallel rays of light of intensity $I = 912\ \text{Wm}^{-2}$ are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}\ \text{Wm}^{-2}\text{K}^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to

- (A) 330 K (B) 660 K (C) 990 K (D) 1550 K

10. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is



- (A) 1.21 (B) 1.30 (C) 1.36 (D) 1.42

$(3.3)^4 - (3)^4 = R \times 10^8$
 20.83

Space for Rough Work

Handwritten calculations for question 8:

$$\frac{R}{40} = \frac{90}{100 - 40}$$

$$R = \frac{90 \times 60}{60} = 90$$

Handwritten calculations for question 9:

$$I_{\text{inc}} = I_{\text{em}} + I_{\text{surroundings}}$$

$$912 = \sigma T^4 + \sigma T_{\text{surroundings}}^4$$

$$912 = 5.7 \times 10^{-8} T^4 + 5.7 \times 10^{-8} (300)^4$$

$$912 - 5.7 \times 10^{-8} (300)^4 = 5.7 \times 10^{-8} T^4$$

$$T \approx 660\ \text{K}$$

Handwritten calculations for question 10:

$$n_{\text{block}} \sin \theta_c = n_{\text{liquid}}$$

$$2.72 \sin \theta_c = n_{\text{liquid}}$$

$$\sin \theta_c = \frac{r}{10} = \frac{5.77}{10}$$

$$n_{\text{liquid}} = 2.72 \times \frac{5.77}{10} = 1.57$$

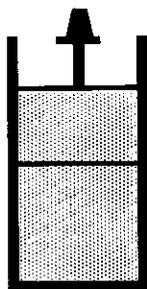
Other handwritten notes include: $(241) \times 10^8$, $1240 - \phi$, 310 , 114 , 11 , 3 , $16 - 5 = 3\phi$, 3.66 , 19 , 114 , 108 .

SECTION – 2 : Comprehension Type (Only One Option Correct)

This section contains 3 paragraphs, each describing theory, experiments, data etc. Six questions relate to the three paragraphs with two questions on each paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D).

Paragraph For Questions 11 & 12

In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The heat capacities per mole of an ideal monatomic gas are $C_V = \frac{3}{2}R$, $C_P = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_V = \frac{5}{2}R$, $C_P = \frac{7}{2}R$.



11. Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be
 (A) 550 K (B) 525 K ✓ (C) 513 K ✓ (D) 490 K
12. Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. Then total work done by the gases till the time they achieve equilibrium will be
 (A) 250 R ✓ (B) 200 R (C) 100 R (D) -100 R

Space for Rough Work

~~$\frac{3}{2} \Delta T_1 = \frac{5}{2} \Delta T_2$~~

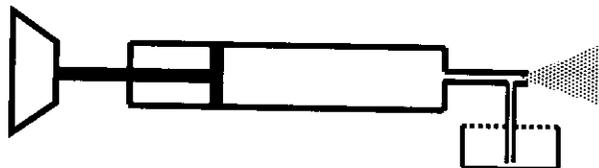
~~$3(700 - T) = 5(T - 400)$~~

**** 5** $\frac{28}{2} = \frac{100}{8} \Rightarrow T = 100$



Paragraph For Questions 13 & 14

A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20 mm and 1 mm respectively. The upper end of the container is open to the atmosphere.



13. If the piston is pushed at a speed of 5 mms^{-1} , the air comes out of the nozzle with a speed of
 (A) 0.1 ms^{-1} (B) 1 ms^{-1} (C) 2 ms^{-1} (D) 8 ms^{-1}
14. If the density of air is ρ_a and that of the liquid ρ_l , then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to
 (A) $\sqrt{\frac{\rho_a}{\rho_l}}$ (B) $\sqrt{\rho_a \rho_l}$ (C) $\sqrt{\frac{\rho_l}{\rho_a}}$ (D) ρ_l

Space for Rough Work

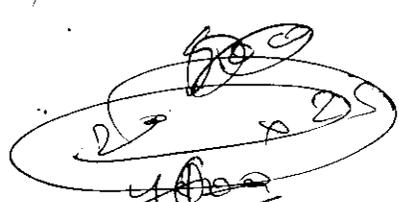
$$5(700 - T) = 7(T - 400)$$

$$3500 + 2800 = 13T = 5200$$

~~$$3(T - 700) = 5(T - 400)$$~~

~~$$2100 - 3T = 5T - 2000$$~~

~~$$4100 = 8T$$~~



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$$BRDT + nRDT$$

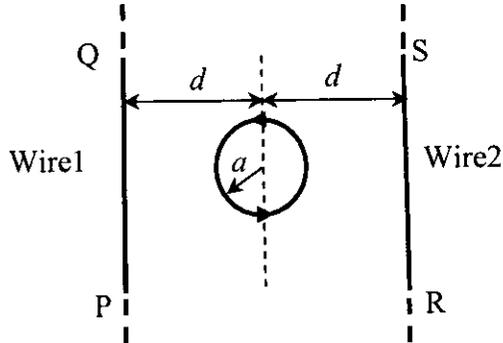
~~$$DRISD$$~~

$$\frac{1}{2} \rho_a v^2 = \frac{1}{2} \rho_l v^2$$



Paragraph For Questions 15 & 16

The figure shows a circular loop of radius a with two long parallel wires (numbered 1 and 2) all in the plane of the paper. The distance of each wire from the centre of the loop is d . The loop and the wires are carrying the same current I . The current in the loop is in the counterclockwise direction if seen from above.



15. When $d \approx a$ but wires are not touching the loop, it is found that the net magnetic field on the axis of the loop is zero at a height h above the loop. In that case
- (A) current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx a$
 - (B) current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx a$
 - (C) current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx 1.2a$
 - (D) current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx 1.2a$

16. Consider $d \gg a$, and the loop is rotated about its diameter parallel to the wires by 30° from the position shown in the figure. If the currents in the wires are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop)

- (A) $\frac{\mu_0 I^2 a^2}{d}$ (B) $\frac{\mu_0 I^2 a^2}{2d}$ (C) $\frac{\sqrt{3} \mu_0 I^2 a^2}{d}$ (D) $\frac{\sqrt{3} \mu_0 I^2 a^2}{2d}$

Space for Rough Work

$(B a^3)^{1/2}$
 $\frac{\mu_0 I^2 a^2}{2\sqrt{3} d}$

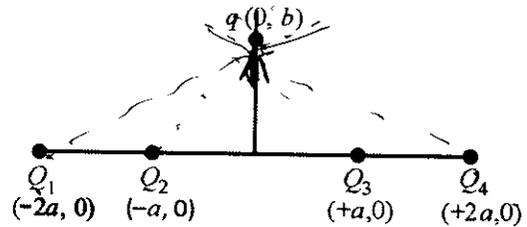


SECTION – 3 : Matching List Type (Only One Option Correct)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D), out of which one is correct.

17. Four charges Q_1, Q_2, Q_3 and Q_4 of same magnitude are fixed along the x axis at $x = -2a, -a, +a$ and $+2a$, respectively. A positive charge q is placed on the positive y axis at a distance $b > 0$. Four options of the signs of these charges are given in List I. The direction of the forces on the charge q is given in List II. Match List I with List II and select the correct answer using the code given below the lists.

- | List I | List II |
|--|---------|
| P. Q_1, Q_2, Q_3, Q_4 all positive | 1. $+x$ |
| Q. Q_1, Q_2 positive; Q_3, Q_4 negative | 2. $-x$ |
| R. Q_1, Q_4 positive; Q_2, Q_3 negative | 3. $+y$ |
| S. Q_1, Q_3 positive; Q_2, Q_4 negative | 4. $-y$ |



Code :

- | | |
|--|--|
| <input checked="" type="checkbox"/> (A) P-3, Q-1, R-4, S-2 | <input checked="" type="checkbox"/> (B) P-4, Q-2, R-3, S-1 |
| <input type="checkbox"/> (C) P-3, Q-1, R-2, S-4 | <input checked="" type="checkbox"/> (D) P-4, Q-2, R-1, S-3 |

18. Four combinations of two thin lenses are given in List I. The radius of curvature of all curved surfaces is r and the refractive index of all the lenses is 1.5. Match lens combinations in List I with their focal length in List II and select the correct answer using the code given below the lists.

- | List I | List II |
|--------|----------|
| P. | 1. $2r$ |
| Q. | 2. $r/2$ |
| R. | 3. $-r$ |
| S. | 4. r |

Code :

- | | |
|--|---|
| <input checked="" type="checkbox"/> (A) P-1, Q-2, R-3, S-4 | <input type="checkbox"/> (B) P-2, Q-4, R-3, S-1 |
| <input type="checkbox"/> (C) P-4, Q-1, R-2, S-3 | <input type="checkbox"/> (D) P-2, Q-1, R-3, S-4 |

Space for Rough Work

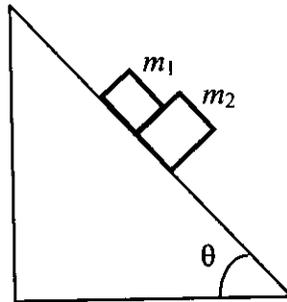
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$$\left(\frac{1}{\mu^2} - \frac{1}{9r^2} \right) \uparrow$$



19. A block of mass $m_1 = 1 \text{ kg}$ another mass $m_2 = 2 \text{ kg}$, are placed together (see figure) on an inclined plane with angle of inclination θ . Various values of θ are given in List I. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In List II expressions for the friction on block m_2 are given. Match the correct expression of the friction in List II with the angles given in List I, and choose the correct option. The acceleration due to gravity is denoted by g .

[Useful information : $\tan(5.5^\circ) \approx 0.1$; $\tan(11.5^\circ) \approx 0.2$; $\tan(16.5^\circ) \approx 0.3$]



- List I**
 P. $\theta = 5^\circ$
 Q. $\theta = 10^\circ$
 R. $\theta = 15^\circ$
 S. $\theta = 20^\circ$

- List II**
 1. $m_2 g \sin \theta$
 2. $(m_1 + m_2) g \sin \theta$
 3. $\mu m_2 g \cos \theta$
 4. $\mu(m_1 + m_2) g \cos \theta$

Code :

- (A) P-1, Q-1, R-1, S-3
~~(B) P-2, Q-2, R-2, S-3~~
~~(C) P-2, Q-2, R-2, S-4~~
 (D) P-2, Q-2, R-3, S-3

Space for Rough Work

~~3g sin 5~~
~~3g sin 10~~
~~3g sin 15~~
~~3g sin 20~~

$\tan \theta > \mu = 0.3$



20. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d of 1.2 m from the person. In the following, state of the lift's motion is given in List I and the distance where the water jet hits the floor of the lift is given in List II. Match the statements from List I with those in List II and select the correct answer using the code given below the lists.

List I

- P. Lift is accelerating vertically up.
Q. Lift is accelerating vertically down with an acceleration less than the gravitational acceleration.
R. Lift is moving vertically up with constant speed.
S. Lift is falling freely.

List II

1. $d = 1.2\text{ m}$
2. $d > 1.2\text{ m}$
3. $d < 1.2\text{ m}$
4. No water leaks out of the jar

Code :

- (A) P-2, Q-3, R-2, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-1, Q-1, R-1, S-4
(D) P-2, Q-3, R-1, S-1

Space for Rough Work



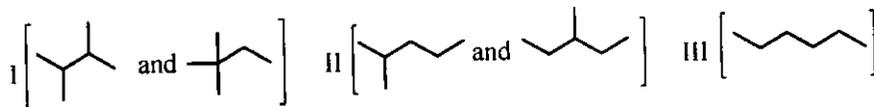
PART II : CHEMISTRY

SECTION – 1 : (Only One Option Correct Type)

This section contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which **ONLY ONE** option is correct.

21. Isomers of hexane, based on their branching, can be divided into three distinct classes as shown in the figure.

[Figure]

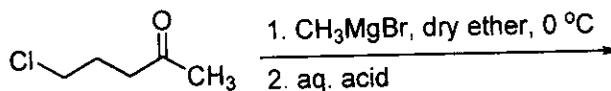


The correct order of their boiling point is

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

22. The major product in the following reaction is

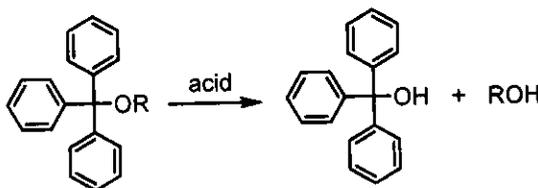
[Figure]



- (A) (B)
- (C) (D)

23. The acidic hydrolysis of ether (X) shown below is fastest when

[Figure]



[X]

- (A) one phenyl group is replaced by a methyl group.
 (B) one phenyl group is replaced by a *para*-methoxyphenyl group.
 (C) two phenyl groups are replaced by two *para*-methoxyphenyl groups.
 (D) no structural change is made to X.

Space for Rough Work

** 5

Handwritten notes and calculations:

$$T^4 - T_i^4 = (T_f^2 - T_i^2)(T_f^2 + T_i^2)$$

$$= (T_f - T_i)(T_f + T_i)(T_f^2 + T_i^2)$$

Other scribbles include: $5/7 \times 10^3$, $160 \times$, and a barcode.

24. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a
 (A) reducing agent, oxidising agent
 (B) reducing agent, reducing agent
 (C) oxidising agent, oxidising agent
 (D) oxidising agent, reducing agent

25. The product formed in the reaction of $SOCl_2$ with white phosphorous is
 (A) PCl_3 (B) SO_2Cl_2 (C) SCl_2 (D) $POCl_3$

26. For the identification of β -naphthol using dye test, it is necessary to use
 (A) dichloromethane solution of β -naphthol. (B) acidic solution of β -naphthol.
 (C) neutral solution of β -naphthol. (D) alkaline solution of β -naphthol.

27. For the process



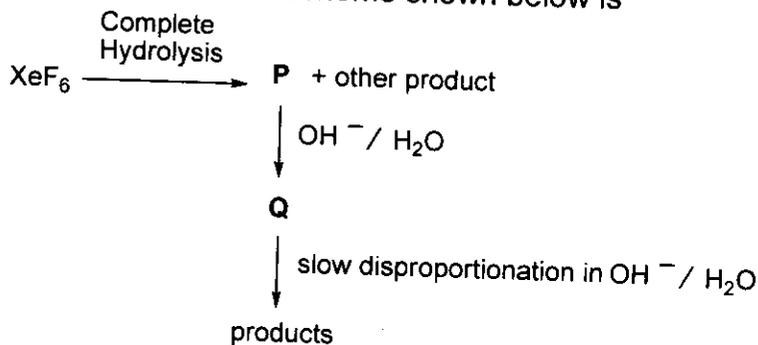
at $T = 100^\circ C$ and 1 atmosphere pressure, the correct choice is

- (A) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} > 0$
 (B) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} < 0$
 (C) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} > 0$
 (D) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} < 0$

28. For the elementary reaction $M \rightarrow N$, the rate of disappearance of M increases by a factor of 8 upon doubling the concentration of M . The order of the reaction with respect to M is

- (A) 4 (B) 3 (C) 2 (D) 1

29. Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is



- (A) 0 (B) 1 (C) 2 (D) 3

30. Assuming $2s-2p$ mixing is NOT operative, the paramagnetic species among the following is

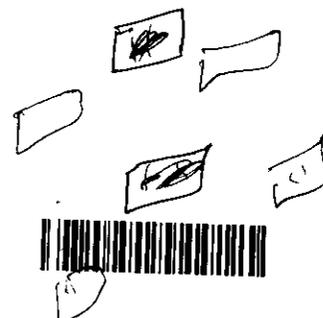
- (A) Be_2 (B) B_2 (C) C_2 (D) N_2

Space for Rough Work

Handwritten notes: H, He, Li, Be, B , 3.3×6.3 , 7 , 74



Handwritten notes: 18 , KA , dx , $2x$, $2x$

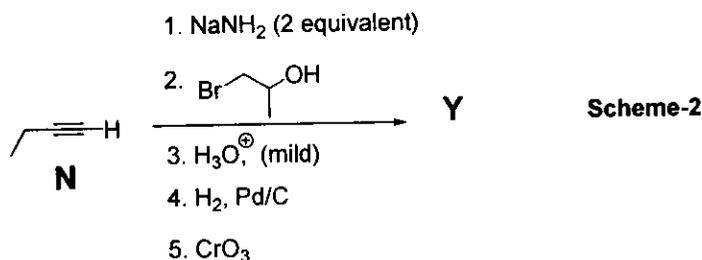
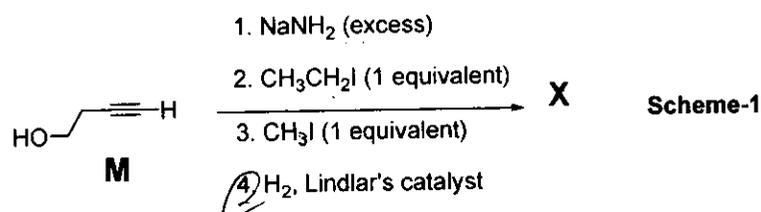


SECTION – 2 : Comprehension Type (Only One Option Correct)

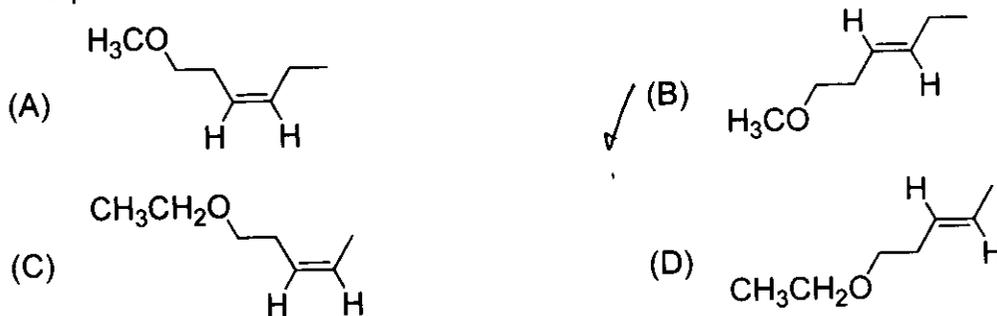
This section contains 3 paragraphs, each describing theory, experiments, data etc. Six questions relate to the three paragraphs with two questions on each paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D).

Paragraph For Questions 31 and 32

Schemes 1 and 2 describe sequential transformation of alkynes **M** and **N**. Consider only the **major products** formed in each step for both the schemes.



31. The product **X** is



32. The correct statement with respect to product **Y** is

- (A) It gives a positive Tollens test and is a functional isomer of **X**.
 (B) It gives a positive Tollens test and is a geometrical isomer of **X**.
 (C) It gives a positive iodoform test and is a functional isomer of **X**.
 (D) It gives a positive iodoform test and is a geometrical isomer of **X**.

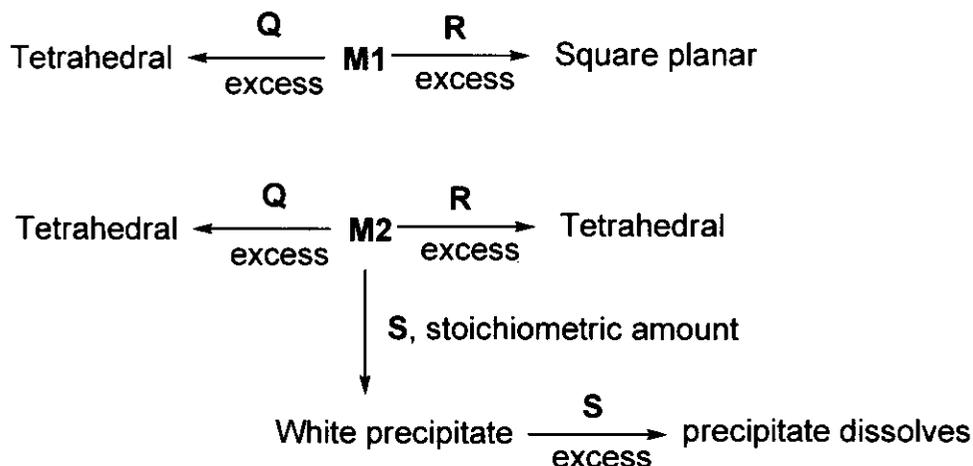
Space for Rough Work



Paragraph For Questions 33 and 34

An aqueous solution of metal ion **M1** reacts separately with reagents **Q** and **R** in excess to give tetrahedral and square planar complexes, respectively. An aqueous solution of another metal ion **M2** always forms tetrahedral complexes with these reagents. Aqueous solution of **M2** on reaction with reagent **S** gives white precipitate which dissolves in excess of **S**. The reactions are summarized in the scheme given below:

SCHEME:



33. **M1**, **Q** and **R**, respectively are

(A) Zn^{2+} , KCN and HCl

(C) Cd^{2+} , KCN and HCl

(B) Ni^{2+} , HCl and KCN

(D) Co^{2+} , HCl and KCN

34. Reagent **S** is

(A) $\text{K}_4[\text{Fe}(\text{CN})_6]$

(B) Na_2HPO_4

(C) K_2CrO_4

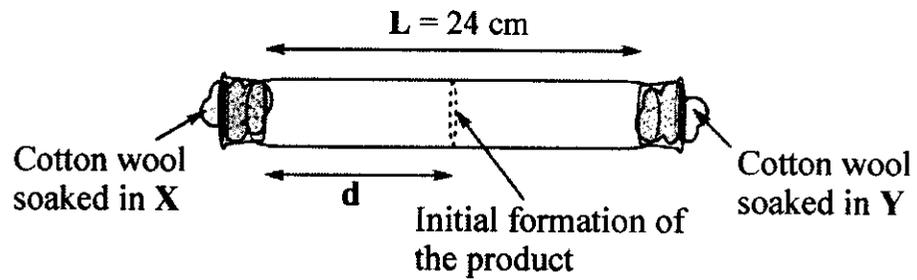
(D) KOH

Space for Rough Work



Paragraph For Questions 35 and 36

X and Y are two volatile liquids with molar weights of 10 g mol^{-1} and 40 g mol^{-1} respectively. Two cotton plugs, one soaked in X and the other soaked in Y, are simultaneously placed at the ends of a tube of length $L = 24 \text{ cm}$, as shown in the figure. The tube is filled with an inert gas at 1 atmosphere pressure and a temperature of 300 K. Vapours of X and Y react to form a product which is first observed at a distance d cm from the plug soaked in X. Take X and Y to have equal molecular diameters and assume ideal behaviour for the inert gas and the two vapours.



35. The value of d in cm (shown in the figure), as estimated from Graham's law, is
 (A) 8 (B) 12 (C) 16 (D) 20
36. The experimental value of d is found to be smaller than the estimate obtained using Graham's law. This is due to
 (A) larger mean free path for X as compared to that of Y.
 (B) larger mean free path for Y as compared to that of X.
 (C) increased collision frequency of Y with the inert gas as compared to that of X with the inert gas.
 (D) increased collision frequency of X with the inert gas as compared to that of Y with the inert gas.

Space for Rough Work

Handwritten calculations for question 35:

$\frac{1}{10} \times 24 = \frac{1}{40} \times (24 - d)$

$240 = 24 - d$

$d = 24 - 240 = -216$

$\frac{1}{40} (24 - d) = \frac{1}{10} (24 - d)$

$24 - d = 4(24 - d)$

$24 - d = 96 - 4d$

$3d = 72$

$d = 24$

Another calculation: $\frac{d}{24-d} = \sqrt{\frac{40}{10}} = 2$

$d = 2(24-d)$

$d = 48 - 2d$

$3d = 48$

$d = 16$

Final answer circled: 8

**5

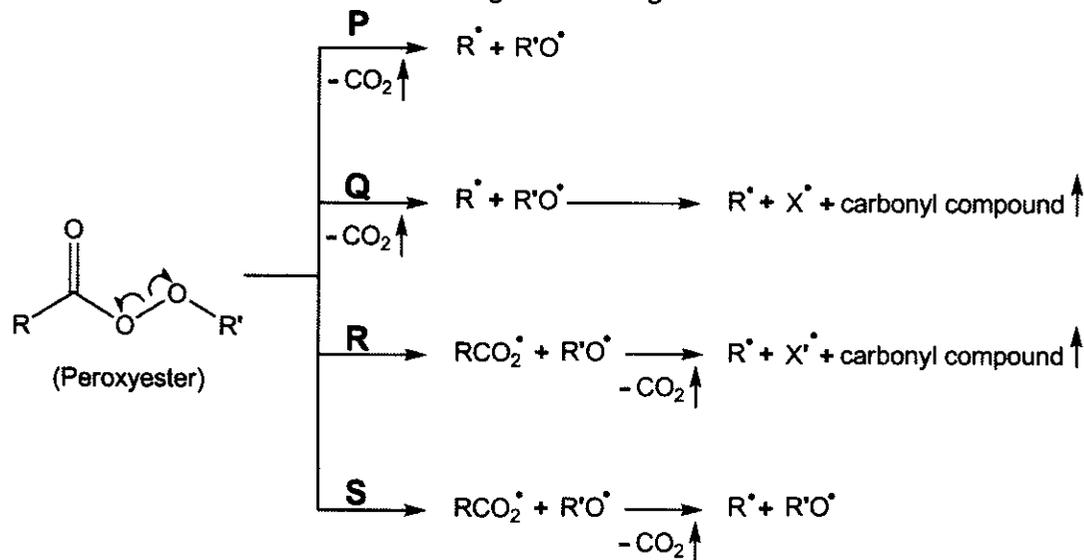
16

Barcode and numbers: 8 24 x 40 / 8

SECTION – 3 : Matching List Type (Only One Option Correct)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D), out of which one is correct.

37. Different possible thermal decomposition pathways for peroxyesters are shown below. Match each pathway from List I with an appropriate structure from List II and select the correct answer using the code given below the lists.



List-I

- P. Pathway P
- Q. Pathway Q
- R. Pathway R
- S. Pathway S

List-II

- 1.
- 2.
- 3.
- 4.

Codes :

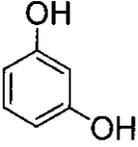
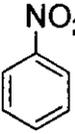
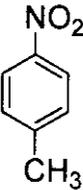
	P	Q	R	S
(A)	1	3	4	2
(B)	2	4	3	1
(C)	4	1	2	3
(D)	3	2	1	4

Space for Rough Work



CHEMISTRY

38. Match the four starting materials (P, Q, R, S) given in List I with the corresponding reaction schemes (I, II, III, IV) provided in List II and select the correct answer using the code given below the lists.

List-I	List-II
<p>P. $\text{H}-\text{C}\equiv\text{C}-\text{H}$</p> <p>Q. </p> <p>R. </p> <p>S. </p>	<p>1. Scheme I (i) $\text{KMnO}_4, \text{HO}^\ominus$, heat (ii) $\text{H}^\oplus, \text{H}_2\text{O}$? $\xrightarrow{\text{(iii) SOCl}_2 \text{ (iv) NH}_3}$ $\text{C}_7\text{H}_6\text{N}_2\text{O}_3$</p> <p>2. Scheme II (i) Sn/HCl (ii) CH_3COCl (iii) conc. H_2SO_4 ? $\xrightarrow{\text{(iv) HNO}_3 \text{ (v) dil. H}_2\text{SO}_4, \text{ heat (vi) HO}^\ominus}$ $\text{C}_6\text{H}_6\text{N}_2\text{O}_2$</p> <p>3. Scheme III (i) red hot iron, 873 K (ii) fuming $\text{HNO}_3, \text{H}_2\text{SO}_4$, heat ? $\xrightarrow{\text{(iii) H}_2\text{S}\cdot\text{NH}_3 \text{ (iv) NaNO}_2, \text{H}_2\text{SO}_4 \text{ (v) hydrolysis}}$ $\text{C}_6\text{H}_5\text{NO}_3$</p> <p>4. Scheme IV (i) conc. $\text{H}_2\text{SO}_4, 60^\circ\text{C}$ (ii) conc. $\text{HNO}_3, \text{conc. H}_2\text{SO}_4$ (iii) dil. H_2SO_4, heat ? $\xrightarrow{\hspace{10em}}$ $\text{C}_6\text{H}_5\text{NO}_4$</p>

Code :

	P	Q	R	S
(A) 	1	4	2	3
(B) 	3	1	4	2
(C) 	3	4	2	1
(D) 	4	1	3	2

Space for Rough Work



39. Match each coordination compound in **List-I** with an appropriate pair of characteristics from **List-II** and select the correct answer using the code given below the lists.

{en = H₂NCH₂CH₂NH₂; atomic numbers: Ti = 22; Cr = 24; Co = 27; Pt = 78}

List-I	List-II
P. [Cr(NH ₃) ₄ Cl ₂]Cl	1. Paramagnetic and exhibits ionisation isomerism
Q. [Ti(H ₂ O) ₅ Cl](NO ₃) ₂	2. Diamagnetic and exhibits <i>cis-trans</i> isomerism
R. [Pt(en)(NH ₃)Cl]NO ₃	3. Paramagnetic and exhibits <i>cis-trans</i> isomerism
S. [Co(NH ₃) ₄ (NO ₃) ₂]NO ₃	4. Diamagnetic and exhibits ionisation isomerism

Code :

	P	Q	R	S
(A)	4	2	3	1
(B)	3	1	4	2
(C)	2	1	3	4
(D)	1	3	4	2

40. Match the orbital overlap figures shown in **List-I** with the description given in **List-II** and select the correct answer using the code given below the lists.

List-I	List-II
P. 	1. p - d π antibonding
Q. 	2. d - d σ bonding
R. 	3. p - d π bonding
S. 	4. d - d σ antibonding

Code :

	P	Q	R	S
(A)	2	1	3	4
(B)	4	3	1	2
(C)	2	3	1	4
(D)	4	1	3	2

Cr⁺¹ 4

Space for Rough Work

$$\begin{array}{r} 144 \\ 144 \\ \hline 576 \\ 576 \\ \hline 1152 \\ 144 \\ \hline 20736 \end{array}$$

3d⁵



PART III : MATHEMATICS

SECTION – 1 : (Only One Option Correct Type)

This section contains 10 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONLY ONE option is correct.

41. Coefficient of x^{11} in the expansion of $(1+x^2)^4(1+x^3)^7(1+x^4)^{12}$ is
 (A) 1051 (B) 1106 (C) 1113 (D) 1120

42. Let $f: [0, 2] \rightarrow \mathbb{R}$ be a function which is continuous on $[0, 2]$ and is differentiable on $(0, 2)$ with $f(0) = 1$. Let

$$F(x) = \int_0^{x^2} f(\sqrt{t}) dt$$

- for $x \in [0, 2]$. If $F'(x) = f'(x)$ for all $x \in (0, 2)$, then $F(2)$ equals
 (A) $e^2 - 1$ (B) $e^4 - 1$ (C) $e - 1$ (D) e^4

43. The function $y = f(x)$ is the solution of the differential equation

$$\frac{dy}{dx} + \frac{xy}{x^2 - 1} = \frac{x^4 + 2x}{\sqrt{1 - x^2}}$$

in $(-1, 1)$ satisfying $f(0) = 0$. Then

$$\int_{-\frac{\sqrt{3}}{2}}^{\frac{\sqrt{3}}{2}} f(x) dx$$

- is
 (A) $\frac{\pi}{3} - \frac{\sqrt{3}}{2}$ (B) $\frac{\pi}{3} - \frac{\sqrt{3}}{4}$ (C) $\frac{\pi}{6} - \frac{\sqrt{3}}{4}$ (D) $\frac{\pi}{6} - \frac{\sqrt{3}}{2}$

44. The following integral

$$\int_{\frac{\pi}{4}}^{\frac{\pi}{2}} (2 \operatorname{cosec} x)^{17} dx$$

is equal to

- (A) $\int_0^{\log(1+\sqrt{2})} 2(e^u + e^{-u})^{16} du$ (B) $\int_0^{\log(1+\sqrt{2})} (e^u + e^{-u})^{17} du$
 (C) $\int_0^{\log(1+\sqrt{2})} (e^u - e^{-u})^{17} du$ (D) $\int_0^{\log(1+\sqrt{2})} 2(e^u - e^{-u})^{16} du$

Space for Rough Work



SECTION – 2 : Comprehension Type (Only One Option Correct)

This section contains 3 paragraphs, each describing theory, experiments, data etc. Six questions relate to the three paragraphs with two questions on each paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D).

Paragraph For Questions 51 and 52

Let a, r, s, t be nonzero real numbers. Let $P(at^2, 2at)$, Q , $R(ar^2, 2ar)$ and $S(as^2, 2as)$ be distinct points on the parabola $y^2 = 4ax$. Suppose that PQ is the focal chord and lines QR and PK are parallel, where K is the point $(2a, 0)$.

51. The value of r is
 (A) $-\frac{1}{t}$ (B) $\frac{t^2+1}{t}$ (C) $\frac{1}{t}$ (D) $\frac{t^2-1}{t}$
52. If $st = 1$, then the tangent at P and the normal at S to the parabola meet at a point whose ordinate is
 (A) $\frac{(t^2+1)^2}{2t^3}$ (B) $\frac{a(t^2+1)^2}{2t^3}$ (C) $\frac{a(t^2+1)^2}{t^3}$ (D) $\frac{a(t^2+2)^2}{t^3}$

Paragraph For Questions 53 and 54

Given that for each $a \in (0, 1)$,

$$\lim_{h \rightarrow 0^+} \int_h^{1-h} t^{-a}(1-t)^{a-1} dt$$

exists. Let this limit be $g(a)$. In addition, it is given that the function $g(a)$ is differentiable on $(0, 1)$.

53. The value of $g\left(\frac{1}{2}\right)$ is
 (A) π (B) 2π (C) $\frac{\pi}{2}$ (D) $\frac{\pi}{4}$
54. The value of $g'\left(\frac{1}{2}\right)$ is
 (A) $\frac{\pi}{2}$ (B) π (C) $-\frac{\pi}{2}$ (D) 0

Space for Rough Work

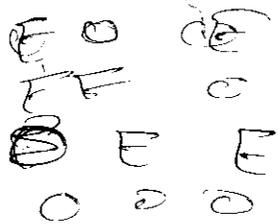


Paragraph For Questions 55 and 56

Box 1 contains three cards bearing numbers 1, 2, 3; box 2 contains five cards bearing numbers 1, 2, 3, 4, 5; and box 3 contains seven cards bearing numbers 1, 2, 3, 4, 5, 6, 7. A card is drawn from each of the boxes. Let x_i be the number on the card drawn from the i^{th} box, $i = 1, 2, 3$.

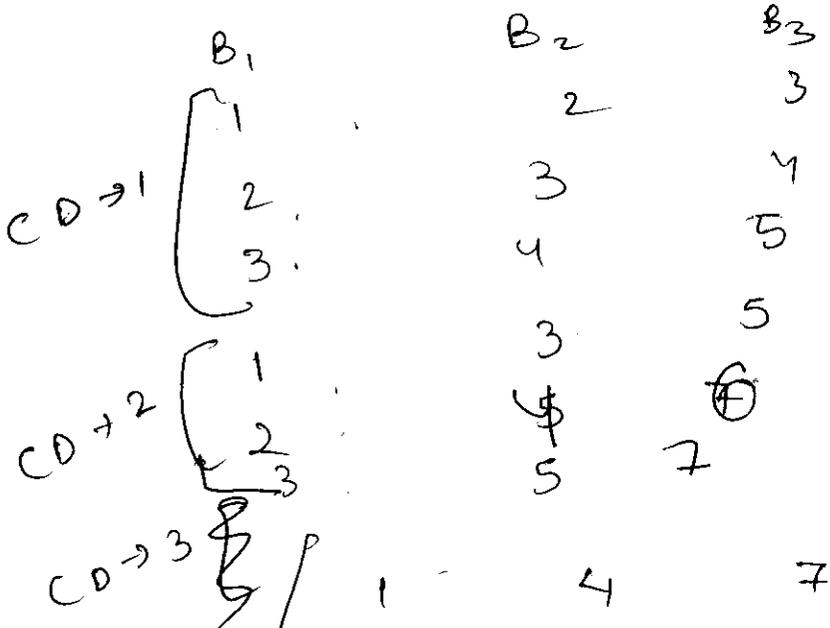
55. The probability that $x_1 + x_2 + x_3$ is odd, is
 (A) $\frac{29}{105}$ (B) $\frac{53}{105}$ (C) $\frac{57}{105}$ (D) $\frac{1}{2}$
56. The probability that x_1, x_2, x_3 are in an arithmetic progression, is
 (A) $\frac{9}{105}$ (B) $\frac{10}{105}$ (C) $\frac{11}{105}$ (D) $\frac{7}{105}$

Space for Rough Work



19
 $2 \times 2 \times 3$
 $2 \times 3 \times 4$

~~$\frac{1+2+3}{3 \times 5 \times 7}$~~ $\frac{4}{105} + \frac{8}{105} + \frac{16}{105}$ ~~$\frac{1+2+3}{105}$~~ ~~$\frac{1+2+3}{105}$~~



** 5



SECTION – 3 : Matching List Type (Only One Option Correct)

This section contains four questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D), out of which one is correct.

57. Let $z_k = \cos\left(\frac{2k\pi}{10}\right) + i \sin\left(\frac{2k\pi}{10}\right); k = 1, 2, \dots, 9$.

- | | List I | List II |
|----|--|----------|
| P. | For each z_k there exists a z_j such that $z_k \cdot z_j = 1$ | 1. True |
| Q. | There exists a $k \in \{1, 2, \dots, 9\}$ such that $z_1 \cdot z = z_k$ has no solution z in the set of complex numbers. | 2. False |
| R. | $\frac{ 1-z_1 1-z_2 \dots 1-z_9 }{10}$ equals | 3. 1 |
| S. | $1 - \sum_{k=1}^9 \cos\left(\frac{2k\pi}{10}\right)$ equals | 4. 2 |

	P	Q	R	S
✓ (A)	1	2	4	3
✗ (B)	2	1	3	4
(C)	1	2	3	4
✗ (D)	2	1	4	3

Space for Rough Work

~~$2x^2 = 3x^2$~~

~~$x^2 = 3x^2$~~

$ax^2 + bx$

$\frac{ax^3}{3} + \frac{bx^2}{2} + c \int dx$

~~$2a + 3b = 6$~~



58.

List I

- P.** The number of polynomials $f(x)$ with non-negative integer coefficients of degree ≤ 2 , satisfying $f(0) = 0$ and $\int_0^1 f(x)dx = 1$, is
- Q.** The number of points in the interval $[-\sqrt{13}, \sqrt{13}]$ at which $f(x) = \sin(x^2) + \cos(x^2)$ attains its maximum value, is
- R.** $\int_{-2}^2 \frac{3x^2}{(1+e^x)} dx$ equals
- S.** $\frac{\left(\int_{-\frac{1}{2}}^{\frac{1}{2}} \cos 2x \log\left(\frac{1+x}{1-x}\right) dx\right)}{\left(\int_0^2 \cos 2x \log\left(\frac{1+x}{1-x}\right) dx\right)}$ equals

	P	Q	R	S
--	---	---	---	---

(A)	3	2	4	1
-----	---	---	---	---

(B)	2	3	4	1
----------------	--------------	--------------	--------------	--------------

(C)	3	2	1	4
-----	---	---	---	---

(D)	2	3	1	4
----------------	--------------	--------------	--------------	--------------

List II

1. 8

2. 2

3. 4

4. 0

59.

List I

- P.** Let $y(x) = \cos(3 \cos^{-1} x)$, $x \in [-1, 1]$, $x \neq \pm \frac{\sqrt{3}}{2}$. Then $\frac{1}{y(x)} \left\{ (x^2 - 1) \frac{d^2 y(x)}{dx^2} + x \frac{dy(x)}{dx} \right\}$ equals
- Q.** Let A_1, A_2, \dots, A_n ($n > 2$) be the vertices of a regular polygon of n sides with its centre at the origin. Let \vec{a}_k be the position vector of the point A_k , $k = 1, 2, \dots, n$. If $|\sum_{k=1}^{n-1} (\vec{a}_k \times \vec{a}_{k+1})| = |\sum_{k=1}^{n-1} (\vec{a}_k \cdot \vec{a}_{k+1})|$, then the minimum value of n is
- R.** If the normal from the point $P(h, 1)$ on the ellipse $\frac{x^2}{6} + \frac{y^2}{3} = 1$ is perpendicular to the line $x + y = 8$, then the value of h is
- S.** Number of positive solutions satisfying the equation $\tan^{-1}\left(\frac{1}{2x+1}\right) + \tan^{-1}\left(\frac{1}{4x+1}\right) = \tan^{-1}\left(\frac{2}{x^2}\right)$ is

	P	Q	R	S
--	---	---	---	---

(A)	4	3	2	1
-----	---	---	---	---

(B)	2	4	3	1
-----	---	---	---	---

(C)	4	3	1	2
-----	---	---	---	---

(D)	2	4	1	3
-----	---	---	---	---

List II

1. 1

2. 2

3. 8

4. 9

Space for Rough Work



60. Let $f_1: \mathbb{R} \rightarrow \mathbb{R}$, $f_2: [0, \infty) \rightarrow \mathbb{R}$, $f_3: \mathbb{R} \rightarrow \mathbb{R}$ and $f_4: \mathbb{R} \rightarrow [0, \infty)$ be defined by

$$f_1(x) = \begin{cases} |x| & \text{if } x < 0, \\ e^x & \text{if } x \geq 0; \end{cases}$$

$$f_2(x) = x^2;$$

$$f_3(x) = \begin{cases} \sin x & \text{if } x < 0, \\ x & \text{if } x \geq 0 \end{cases}$$

and

$$f_4(x) = \begin{cases} f_2(f_1(x)) & \text{if } x < 0, \\ f_2(f_1(x)) - 1 & \text{if } x \geq 0. \end{cases}$$

List I

- P. f_4 is
- Q. f_3 is
- R. $f_2 \circ f_1$ is
- S. f_2 is

List II

- 1. onto but not one-one
- 2. neither continuous nor one-one
- 3. differentiable but not one-one
- 4. continuous and one-one

P Q R S

ψ (A) 3 1 4 2

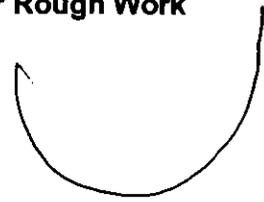
ψ (B) ~~1 3 4 2~~

ψ (C) 3 1 2 4

ψ (D) 1 3 2 4

Space for Rough Work

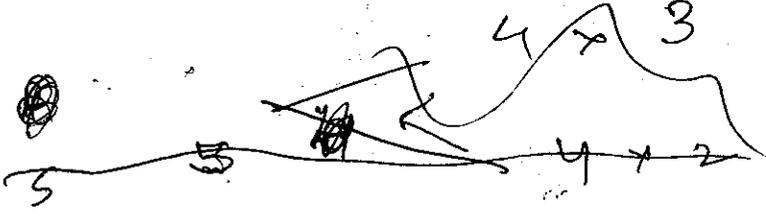
~~(1-t)^{-a}~~
~~(t)^{a-1}~~



Space for Rough Work

① ② ③ 2 ④

⑤ ⑥ ⑦ ⑧



D. Marking Scheme

17. For each question in **Section 1, 2 and 3** 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 all other cases, **minus one (-1) mark** will be awarded.

Appropriate way of darkening the bubble for your answer to be evaluated :

		The one and the only acceptable	Answer will not be evaluated - no marks, no negative marks
		Part darkening	
		Darkening the rim	
		Cancelling after darkening	
		Erasing after darkening	

Figure-1 : Correct way of bubbling for valid answer and a few examples of invalid answers. Any other form of partial marking such as ticking or crossing the bubble will be invalid.

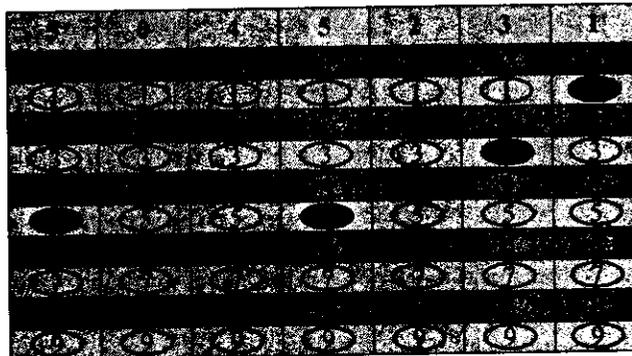


Figure-2 : Correct Way of Bubbling your Roll Number on the ORS. (Example Roll Number : 5045231)

Name of the Candidate	Roll Number							
<p><i>Mudit Gang</i></p>	<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="padding: 5px;">2</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">8</td> <td style="padding: 5px;">0</td> <td style="padding: 5px;">4</td> <td style="padding: 5px;">5</td> </tr> </table>	2	0	4	8	0	4	5
2	0	4	8	0	4	5		
<p>I have read all instructions and shall abide by them.</p> <p style="text-align: center; margin-top: 20px;"><i>Mudit</i></p> <hr style="border-top: 1px dotted black;"/> <p style="text-align: center;">Signature of the Candidate</p>	<p>I have verified all the information filled by the candidate.</p> <p style="text-align: center; margin-top: 20px;"><i>[Signature]</i></p> <hr style="border-top: 1px dotted black;"/> <p style="text-align: center;">Signature of the Invigilator</p>							