

Date: 04/06/2023



Corporate Office : Aakash Tower, 8, Pusa Road, New Delhi-110005 | Ph.: 011-47623456

Time : 3 hrs.

# Questions & Answers

Max. Marks: 180

for

## JEE (Advanced)-2023 (Paper-1)

### PART-I : PHYSICS

#### SECTION 1 (Maximum Marks : 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

*Full Marks* : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

*Partial Marks* : +3 If all the four options are correct but **ONLY** three options are chosen;

*Partial Marks* : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

*Partial Marks* : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

*Negative Marks* : -2 In all other cases.

1. A slide with a frictionless curved surface, which becomes horizontal at its lower end, is fixed on the terrace of a building of height  $3h$  from the ground, as shown in the figure. A spherical ball of mass  $m$  is released on the slide from rest at a height  $h$  from the top of the terrace. The ball leaves the slide with a velocity  $\vec{u}_0 = u_0 \hat{x}$  and falls on the ground at a distance  $d$  from the building making an angle  $\theta$  with the horizontal. It bounces off with a velocity

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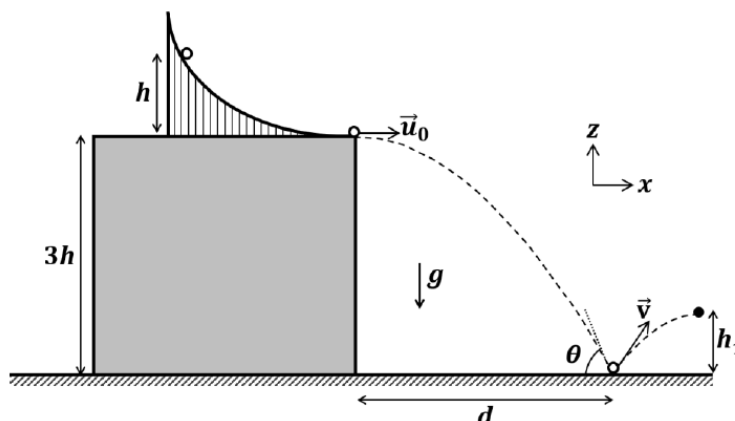


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$\vec{v}$  and reaches a maximum height  $h_1$ . The acceleration due to gravity is  $g$  and the coefficient of restitution of the ground is  $1/\sqrt{3}$ . Which of the following statement(s) is(are) correct?



(A)  $\vec{u}_0 = \sqrt{2gh}\hat{x}$

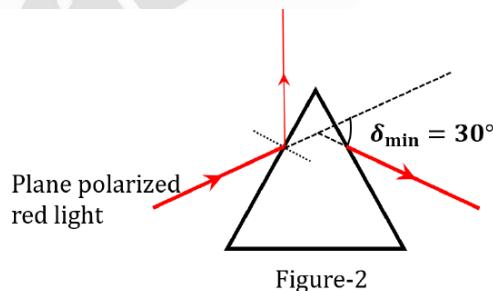
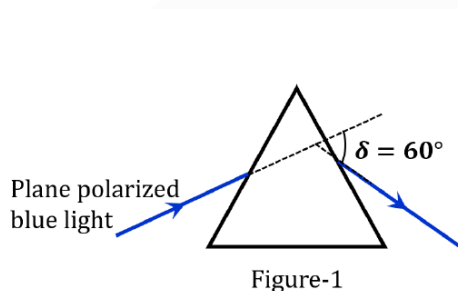
(B)  $\vec{v} = \sqrt{2gh}(\hat{x} - \hat{z})$

(C)  $\theta = 60^\circ$

(D)  $d/h_1 = 2\sqrt{3}$

**Answer (A, C, D)**

2. A plane polarized blue light ray is incident on a prism such that there is no reflection from the surface of the prism. The angle of deviation of the emergent ray is  $\delta = 60^\circ$  (see Figure-1). The angle of minimum deviation for red light from the same prism is  $\delta_{\min} = 30^\circ$  (see Figure-2). The refractive index of the prism material for blue light is  $\sqrt{3}$ . Which of the following statement(s) is(are) correct?



- (A) The blue light is polarized in the plane of incidence.  
 (B) The angle of the prism is  $45^\circ$ .  
 (C) The refractive index of the material of the prism for red light is  $\sqrt{2}$ .  
 (D) The angle of refraction for blue light in air at the exit plane of the prism is  $60^\circ$ .

**Answer (A, C, D)**

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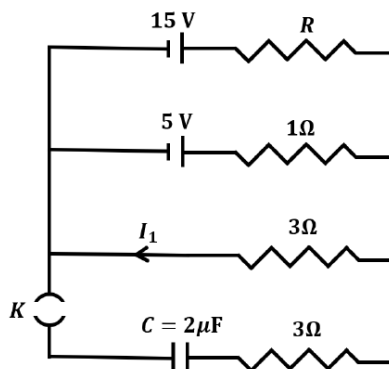
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3. In a circuit shown in the figure, the capacitor  $C$  is initially uncharged and the key  $K$  is open. In this condition, a current of  $1\text{ A}$  flows through the  $1\ \Omega$  resistor. The key is closed at time  $t = t_0$ . Which of the following statement(s) is(are) correct?

[Given :  $e^{-1} = 0.36$ ]



- (A) The value of the resistance  $R$  is  $3\ \Omega$ .  
 (B) For  $t < t_0$ , the value of current  $I_1$  is  $2\text{ A}$ .  
 (C) At  $t = t_0 + 7.2\ \mu\text{s}$ , the current in the capacitor is  $0.6\text{ A}$ .  
 (D) For  $t \rightarrow \infty$ , the charge on the capacitor is  $12\ \mu\text{C}$ .

**Answer (A, B, C, D)**

### SECTION 2 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

**Full Marks** : +3 If **ONLY** the correct option is chosen;

**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);

**Negative Marks** : -1 In all other cases.

4. A bar of mass  $M = 1.00\text{ kg}$  and length  $L = 0.20\text{ m}$  is lying on a horizontal frictionless surface. One end of the bar is pivoted at a point about which it is free to rotate. A small mass  $m = 0.10\text{ kg}$  is moving on the same horizontal surface with  $5.00\text{ ms}^{-1}$  speed on a path perpendicular to the bar. It hits the bar at a distance  $L/2$  from the pivoted

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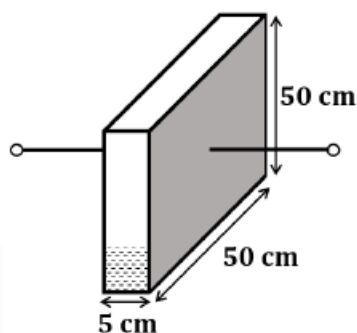
end and returns back on the same path with speed  $v$ . After this elastic collision, the bar rotates with an angular velocity  $\omega$ . Which of the following statement is correct?

- (A)  $\omega = 6.98 \text{ rad s}^{-1}$  and  $v = 4.30 \text{ ms}^{-1}$  (B)  $\omega = 3.75 \text{ rad s}^{-1}$  and  $v = 4.30 \text{ ms}^{-1}$   
(C)  $\omega = 3.75 \text{ rad s}^{-1}$  and  $v = 10.0 \text{ ms}^{-1}$  (D)  $\omega = 6.80 \text{ rad s}^{-1}$  and  $v = 4.10 \text{ ms}^{-1}$

**Answer (A)**

5. A container has a base of  $50 \text{ cm} \times 5 \text{ cm}$  and height  $50 \text{ cm}$ , as shown in the figure. It has two parallel electrically conducting walls each of area  $50 \text{ cm} \times 50 \text{ cm}$ . The remaining walls of the container are thin and non-conducting. The container is being filled with a liquid of dielectric constant 3 at a uniform rate of  $250 \text{ cm}^3 \text{ s}^{-1}$ . What is the value of the capacitance of the container after 10 seconds?

[Given: Permittivity of free space  $\epsilon_0 = 9 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$ , the effects of the non-conducting walls on the capacitance are negligible]



- (A)  $27 \text{ pF}$  (B)  $63 \text{ pF}$   
(C)  $81 \text{ pF}$  (D)  $135 \text{ pF}$

**Answer (B)**

6. One mole of an ideal gas expands adiabatically from an initial state  $(T_A, V_0)$  to final state  $(T_f, 5V_0)$ . Another mole of the same gas expands isothermally from a different initial state  $(T_B, V_0)$  to the same final state  $(T_f, 5V_0)$ . The ratio of the specific heats at constant pressure and constant volume of this ideal gas is  $\gamma$ . What is the ratio  $T_A/T_B$ ?
- (A)  $5^{\gamma-1}$  (B)  $5^{1-\gamma}$   
(C)  $5^\gamma$  (D)  $5^{1+\gamma}$

**Answer (A)**

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7. Two satellites  $P$  and  $Q$  are moving in different circular orbits around the Earth (radius  $R$ ). The heights of  $P$  and  $Q$  from the Earth surface are  $h_P$  and  $h_Q$ , respectively, where  $h_P = \frac{R}{3}$ . The accelerations of  $P$  and  $Q$  due to Earth's gravity are  $g_P$  and  $g_Q$ , respectively. If  $\frac{g_P}{g_Q} = \frac{36}{25}$ , what is the value of  $h_Q$ ?

- (A)  $\frac{3R}{5}$   
 (B)  $\frac{R}{6}$   
 (C)  $\frac{6R}{5}$   
 (D)  $\frac{5R}{5}$

Answer (A)

### SECTION 3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

8. A Hydrogen-like atom has atomic number  $Z$ . Photons emitted in the electronic transitions from level  $n = 4$  to level  $n = 3$  in these atoms are used to perform photoelectric effect experiment on a target metal. The maximum kinetic energy of the photoelectrons generated is 1.95 eV. If the photoelectric threshold wavelength for the target metal is 310 nm, the value of  $Z$  is \_\_\_\_\_.

[Given  $hc = 1240$  eV-nm and  $Rhc = 13.6$  eV, where  $R$  is the Rydberg constant,  $h$  is the Planck's constant and  $c$  is the speed of light in vacuum]

Answer (3)

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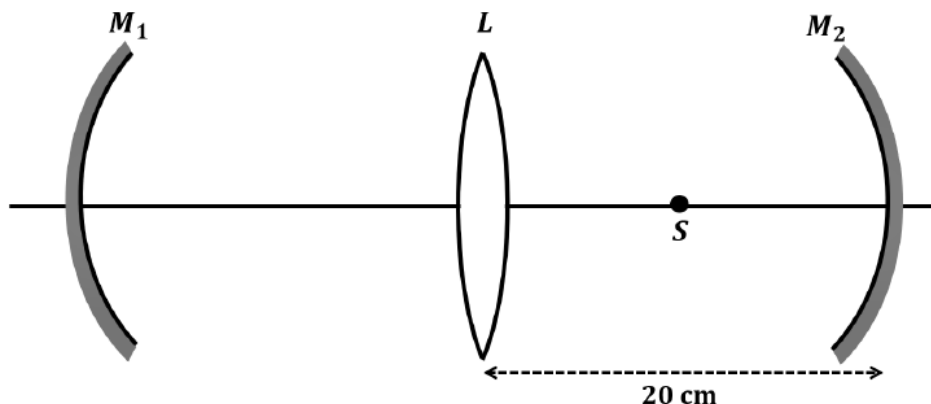
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9. An optical arrangement consists of two concave mirrors  $M_1$  and  $M_2$ , and a convex lens  $L$  with a common principal axis, as shown in the figure. The focal length of  $L$  is 10 cm. The radii of curvature of  $M_1$  and  $M_2$  are 20 cm and 24 cm, respectively. The distance between  $L$  and  $M_2$  is 20 cm. A point object  $S$  is placed at the mid-point between  $L$  and  $M_2$  on the axis. When the distance between  $L$  and  $M_1$  is  $\frac{n}{7}$  cm, one of the images coincides with  $S$ . The value of  $n$  is \_\_\_\_\_.



**Answer (80 or 150 or 220)**

10. In an experiment for determination of the focal length of a thin convex lens, the distance of the object from the lens is  $10 \pm 0.1$  cm and the distance of its real image from the lens is  $20 \pm 0.2$  cm. The error in the determination of focal length of the lens is  $n\%$ . The value of  $n$  is \_\_\_\_\_.

**Answer (1)**

11. A closed container contains a homogeneous mixture of two moles of an ideal monatomic gas ( $\gamma = 5/3$ ) and one mole of an ideal diatomic gas ( $\gamma = 7/5$ ). Here,  $\gamma$  is the ratio of the specific heats at constant pressure and constant volume of an ideal gas. The gas mixture does a work of 66 Joule when heated at constant pressure. The change in its internal energy is \_\_\_\_\_ Joule.

**Answer (121)**

12. A person of height 1.6 m is walking away from a lamp post of height 4 m along a straight path on the flat ground. The lamp post and the person are always perpendicular to the ground. If the speed of the person is  $60 \text{ cm s}^{-1}$ , the speed of the tip of the person's shadow on the ground with respect to the person is \_\_\_\_\_  $\text{cm s}^{-1}$ .

**Answer (40)**

13. Two point-like objects of masses 20 gm and 30 gm are fixed at the two ends of a rigid massless rod of length 10 cm. This system is suspended vertically from a rigid ceiling using a thin wire attached to its center of mass,

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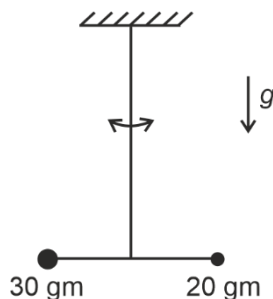


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as shown in the figure. The resulting torsional pendulum undergoes small oscillations. The torsional constant of the wire is  $1.2 \times 10^{-8} \text{ N m rad}^{-1}$ . The angular frequency of the oscillations in  $n \times 10^{-3} \text{ rad s}^{-1}$ . The value of  $n$  is \_\_\_\_\_.



Answer (10)

#### SECTION 4 (Maximum Marks : 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:  
**Full Marks** : +3 **ONLY** if the option corresponding to the correct combination is chosen;  
**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);  
**Negative Marks** : -1 In all other cases.

14. List-I shows different radioactive decay processes and List-II provides possible emitted particles. Match each entry in List-I with an appropriate entry from List-II, and choose the correct option.

#### List-I

- (P)  ${}_{92}^{238}\text{U} \rightarrow {}_{91}^{234}\text{Pa}$   
 (Q)  ${}_{82}^{214}\text{Pb} \rightarrow {}_{82}^{210}\text{Pb}$   
 (R)  ${}_{81}^{210}\text{Tl} \rightarrow {}_{82}^{206}\text{Pb}$   
 (S)  ${}_{91}^{228}\text{Pa} \rightarrow {}_{88}^{224}\text{Ra}$

- (A)  $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 2, S \rightarrow 1$   
 (C)  $P \rightarrow 5, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 4$

#### List-II

- (1) one  $\alpha$  particle and one  $\beta^+$  particle  
 (2) three  $\beta^-$  particles and one  $\alpha$  particle  
 (3) two  $\beta^-$  particles and one  $\alpha$  particle  
 (4) one  $\alpha$  particle and one  $\beta^-$  particle  
 (5) one  $\alpha$  particle and two  $\beta^+$  particles  
 (B)  $P \rightarrow 4, Q \rightarrow 1, R \rightarrow 2, S \rightarrow 5$   
 (D)  $P \rightarrow 5, Q \rightarrow 1, R \rightarrow 3, S \rightarrow 2$

Answer (A)

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15. Match the temperature of a black body given in List-I with an appropriate statement in List-II, and choose the correct option.

[Given: Wien's constant as  $2.9 \times 10^{-3}$  m-K and  $\frac{hc}{e} = 1.24 \times 10^{-6}$  V-m]

**List-I**

(P) 2000 K

(Q) 3000 K

(R) 5000 K

(S) 10000 K

(A) P  $\rightarrow$  3, Q  $\rightarrow$  5, R  $\rightarrow$  2, S  $\rightarrow$  3

(C) P  $\rightarrow$  3, Q  $\rightarrow$  4, R  $\rightarrow$  2, S  $\rightarrow$  1

**List-II**

(1) The radiation at peak wavelength can lead to emission of photoelectrons from a metal of work function 4 eV.

(2) The radiation at peak wavelength is visible to human eye.

(3) The radiation at peak emission wavelength will result in the widest central maximum of a single slit diffraction.

(4) The power emitted per unit area is 1/16 of that emitted by a blackbody at temperature 6000 K.

(5) The radiation at peak emission wavelength can be used to image human bones.

(B) P  $\rightarrow$  3, Q  $\rightarrow$  2, R  $\rightarrow$  4, S  $\rightarrow$  1

(D) P  $\rightarrow$  1, Q  $\rightarrow$  2, R  $\rightarrow$  5, S  $\rightarrow$  3

**Answer (C)**

16. A series LCR circuit is connected to a  $45 \sin(\omega t)$  Volt source. The resonant angular frequency of the circuit is  $10^5 \text{ rad s}^{-1}$  and current amplitude at resonance is  $I_0$ . When the angular frequency of the source is  $\omega = 8 \times 10^4 \text{ rad s}^{-1}$ , the current amplitude in the circuit is  $0.05 I_0$ . If  $L = 50 \text{ mH}$ , match each entry in List-I with an appropriate value from List-II and choose the correct option.

List-I	List-II
(P) $I_0$ in mA	(1) 44.4
(Q) The quality factor of the circuit	(2) 18
(R) The bandwidth of the circuit in $\text{rad s}^{-1}$	(3) 400
(S) The peak power dissipated at resonance in Watt	(4) 2250
	(5) 500

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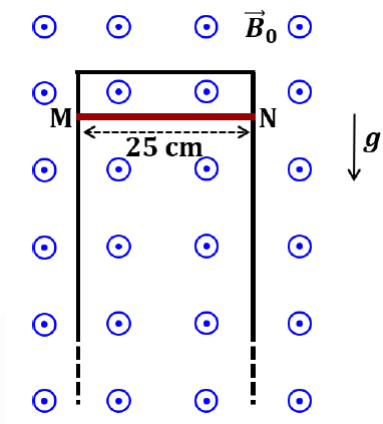


- (A)  $P \rightarrow 2, Q \rightarrow 3, R \rightarrow 5, S \rightarrow 1$   
 (B)  $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 4, S \rightarrow 2$   
 (C)  $P \rightarrow 4, Q \rightarrow 5, R \rightarrow 3, S \rightarrow 1$   
 (D)  $P \rightarrow 4, Q \rightarrow 2, R \rightarrow 1, S \rightarrow 5$

**Answer (B)**

17. A thin conducting rod MN of mass 20 gm, length 25 cm and resistance  $10 \Omega$  is held on frictionless, long, perfectly conducting vertical rails as shown in the figure. There is a uniform magnetic field  $B_0 = 4 \text{ T}$  directed perpendicular to the plane of the rod-rail arrangement. The rod is released from rest at time  $t = 0$  and it moves down along the rails. Assume air drag is negligible. Match each quantity in List-I with an appropriate value from List-II, and choose the correct option.

[Given: The acceleration due to gravity  $g = 10 \text{ m s}^{-2}$  and  $e^{-1} = 0.4$ ]



List-I	List-II
(P) At $t = 0.2 \text{ s}$ , the magnitude of the induced emf in Volt	(1) 0.07
(Q) At $t = 0.2 \text{ s}$ , the magnitude of the magnetic force in Newton	(2) 0.14
(R) At $t = 0.2 \text{ s}$ , the power dissipated as heat in Watt	(3) 1.20
(S) The magnitude of terminal velocity of the rod in $\text{m s}^{-1}$	(4) 0.12
	(5) 2.00

- (A)  $P \rightarrow 5, Q \rightarrow 2, R \rightarrow 3, S \rightarrow 1$       (B)  $P \rightarrow 3, Q \rightarrow 1, R \rightarrow 4, S \rightarrow 5$   
 (C)  $P \rightarrow 4, Q \rightarrow 3, R \rightarrow 1, S \rightarrow 2$       (D)  $P \rightarrow 3, Q \rightarrow 4, R \rightarrow 2, S \rightarrow 5$

**Answer (D)**

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## PART-II : CHEMISTRY

### SECTION 1 (Maximum Marks : 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

*Full Marks* : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

*Partial Marks* : +3 If all the four options are correct but **ONLY** three options are chosen;

*Partial Marks* : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

*Partial Marks* : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

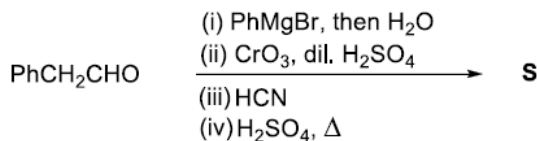
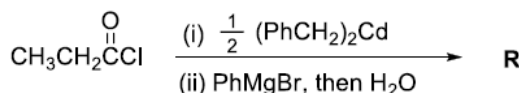
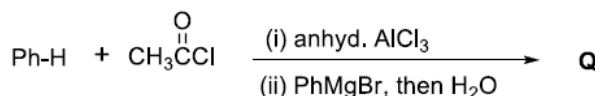
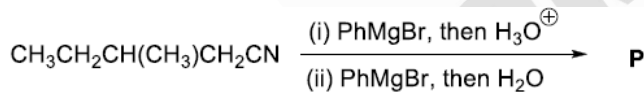
*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

*Negative Marks* : -2 In all other cases.

- The correct statement(s) related to processes involved in the extraction of metals is(are)
  - Roasting of Malachite produces Cuprite
  - Calcination of Calamine produces Zincite
  - Copper pyrites is heated with silica in a reverberatory furnace to remove iron
  - Impure silver is treated with aqueous KCN in the presence of oxygen followed by reduction with zinc metal

**Answer (B, C, D)**

- In the following reactions, **P, Q, R** and **S** are the major products.



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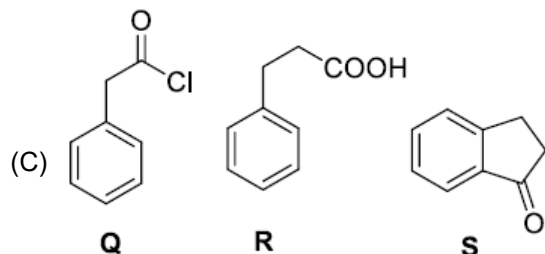
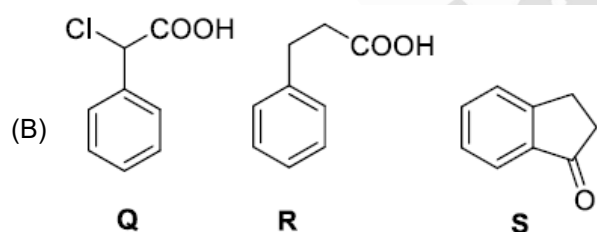
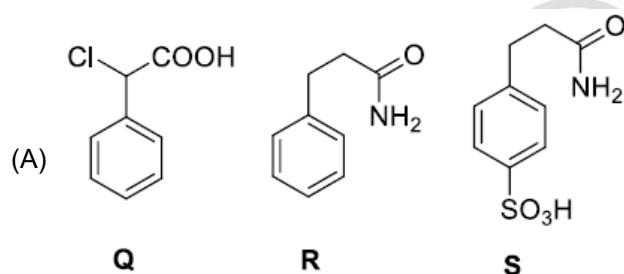
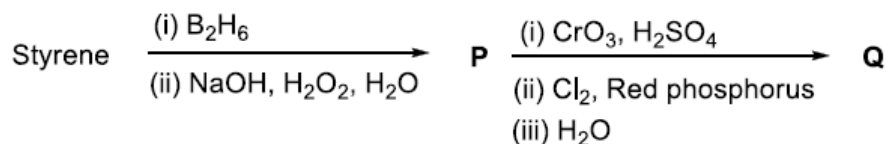
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The correct statement(s) about **P**, **Q**, **R** and **S** is(are)

- (A) Both **P** and **Q** have asymmetric carbon(s)  
 (B) Both **Q** and **R** have asymmetric carbon(s)  
 (C) Both **P** and **R** have asymmetric carbon(s)  
 (D) **P** has asymmetric carbon(s), **S** does **not** have any asymmetric carbon

**Answer (C, D)**

3. Consider the following reaction scheme and choose the correct option(s) for the major products **Q**, **R** and **S**.



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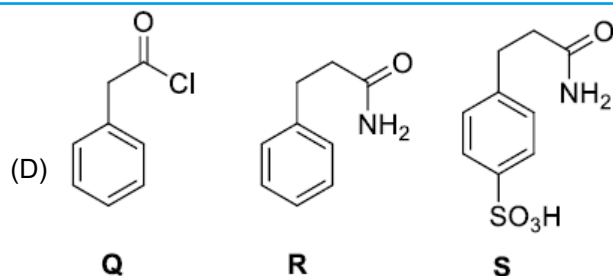


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**Answer (B)**

**SECTION 2 (Maximum Marks : 12)**

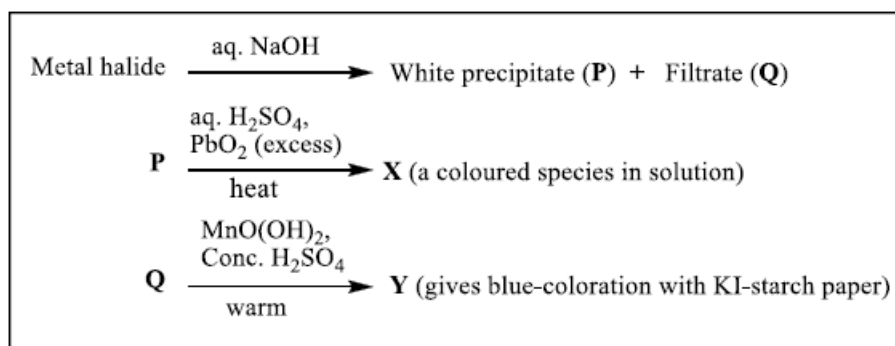
- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

*Full Marks* : +3 If **ONLY** the correct option is chosen;

*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

*Negative Marks* : -1 In all other cases.

4. In the scheme given below, **X** and **Y**, respectively, are



(A)  $\text{CrO}_4^{2-}$  and  $\text{Br}_2$

(B)  $\text{MnO}_4^{2-}$  and  $\text{Cl}_2$

(C)  $\text{MnO}_4^-$  and  $\text{Cl}_2$

(D)  $\text{MnSO}_4$  and  $\text{HOCl}$

**Answer (C)**

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5. Plotting  $1/\Lambda_m$  against  $c\Lambda_m$  for aqueous solutions of a monobasic weak acid (HX) resulted in a straight line with y-axis intercept of P and slope of S. The ratio P/S is

$[\Lambda_m = \text{molar conductivity}]$

$\Lambda_m^\circ = \text{limiting molar conductivity}$

$c = \text{molar concentration}$

$K_a = \text{dissociation constant of HX}$

- (A)  $K_a \Lambda_m^\circ$  (B)  $K_a \Lambda_m^\circ / 2$   
 (C)  $2 K_a \Lambda_m^\circ$  (D)  $1/(K_a \Lambda_m^\circ)$

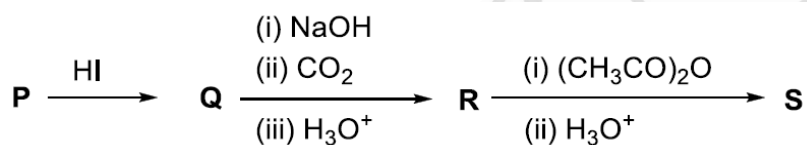
**Answer (A)**

6. On decreasing the pH from 7 to 2, the solubility of a sparingly soluble salt (MX) of a weak acid (HX) increased from  $10^{-4} \text{ mol L}^{-1}$  to  $10^{-3} \text{ mol L}^{-1}$ . The  $pK_a$  of HX is

- (A) 3 (B) 4  
 (C) 5 (D) 2

**Answer (B)**

7. In the given reaction scheme, **P** is a phenyl alkyl ether, **Q** is an aromatic compound; **R** and **S** are the major products.



The correct statement about **S** is

- (A) It primarily inhibits noradrenaline degrading enzymes  
 (B) It inhibits the synthesis of prostaglandin  
 (C) It is a narcotic drug  
 (D) It is *ortho*-acetylbenzoic acid

**Answer (B)**

### SECTION 3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

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8. The stoichiometric reaction of 516 g of dimethyldichlorosilane with water results in a tetrameric cyclic product **X** in 75% yield. The weight (in g) of **X** obtained is \_\_\_\_.

[Use, molar mass ( $\text{g mol}^{-1}$ ): H = 1, C = 12, O = 16, Si = 28, Cl = 35.5]

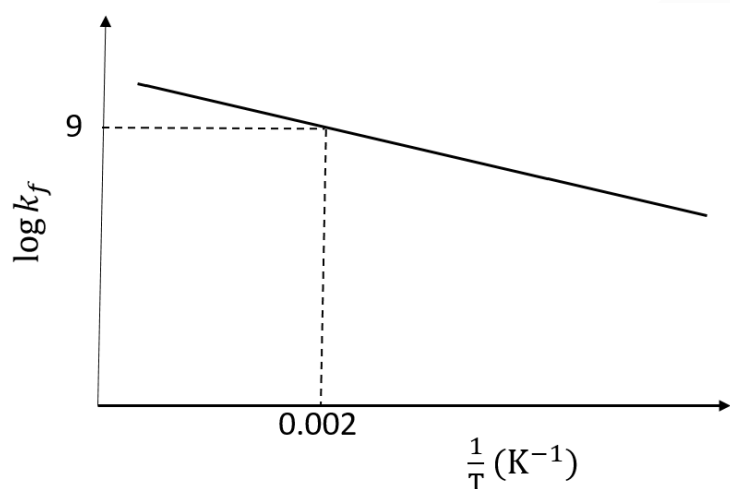
**Answer (222)**

9. A gas has a compressibility factor of 0.5 and a molar volume of  $0.4 \text{ dm}^3 \text{ mol}^{-1}$  at a temperature of 800 K and pressure **x** atm. If it shows ideal gas behaviour at the same temperature and pressure, the molar volume will be **y**  $\text{dm}^3 \text{ mol}^{-1}$ . The value of **x/y** is \_\_\_\_.

[Use: Gas constant,  $R = 8 \times 10^{-2} \text{ L atm K}^{-1} \text{ mol}^{-1}$ ]

**Answer (100)**

10. The plot of  $\log k_f$  versus  $\frac{1}{T}$  for a reversible reaction  $A(g) \rightleftharpoons P(g)$  is shown.



Pre-exponential factors for the forward and backward reactions are  $10^{15} \text{ s}^{-1}$  and  $10^{11} \text{ s}^{-1}$ , respectively. If the value of  $\log K$  for the reaction at 500 K is 6, the value of  $|\log k_b|$  at 250 K is \_\_\_\_.

[ $K$  = equilibrium constant of the reaction,  $k_f$  = rate constant of forward reaction,  $k_b$  = rate constant of backward reaction]

**Answer (5)**

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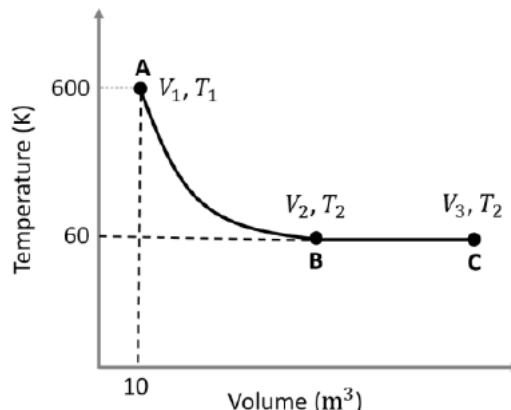
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11. One mole of an ideal monoatomic gas undergoes two reversible processes ( $A \rightarrow B$  and  $B \rightarrow C$ ) as shown in the given figure:

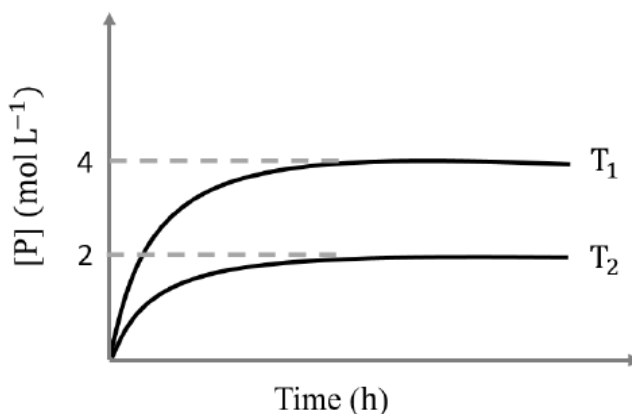


$A \rightarrow B$  is an adiabatic process. If the total heat absorbed in the entire process ( $A \rightarrow B$  and  $B \rightarrow C$ ) is  $RT_2 \ln 10$ , the value of  $2 \log V_3$  is \_\_\_\_\_.

[Use, molar heat capacity of the gas at constant pressure,  $C_{p,m} = \frac{5}{2} R$ ]

**Answer (7)**

12. In a one-litre flask, 6 moles of A undergoes the reaction  $A(g) \rightleftharpoons P(g)$ . The progress of product formation at two temperatures (in Kelvin),  $T_1$  and  $T_2$ , is shown in the figure:



If  $T_1 = 2T_2$  and  $(\Delta G_2^\ominus - \Delta G_1^\ominus) = RT_2 \ln x$ , then the value of  $x$  is \_\_\_\_\_.

[ $\Delta G_1^\ominus$  and  $\Delta G_2^\ominus$  are standard Gibb's free energy change for the reaction at temperatures  $T_1$  and  $T_2$ , respectively.]

**Answer (8)**

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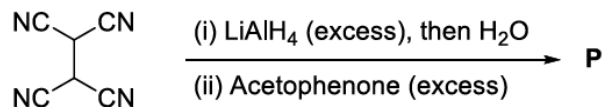
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13. The total number of  $sp^2$  hybridised carbon atoms in the major product **P** (a non-heterocyclic compound) of the following reaction is \_\_\_\_\_.



**Answer (28)**

**SECTION 4 (Maximum Marks : 12)**

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:  
**Full Marks** : +3 **ONLY** if the option corresponding to the correct combination is chosen;  
**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);  
**Negative Marks** : -1 In all other cases.

14. Match the reactions (in the given stoichiometry of the reactants) in List-I with one of their products given in List-II and choose the correct option.

	List-I		List-II
(P)	$\text{P}_2\text{O}_3 + 3\text{H}_2\text{O} \rightarrow$	(1)	$\text{P}(\text{O})(\text{OCH}_3)\text{Cl}_2$
(Q)	$\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} \rightarrow$	(2)	$\text{H}_3\text{PO}_3$
(R)	$\text{PCl}_5 + \text{CH}_3\text{COOH} \rightarrow$	(3)	$\text{PH}_3$
(S)	$\text{H}_3\text{PO}_2 + 2\text{H}_2\text{O} + 4\text{AgNO}_3 \rightarrow$	(4)	$\text{POCl}_3$
		(5)	$\text{H}_3\text{PO}_4$

- (A)  $\text{P} \rightarrow 2; \text{Q} \rightarrow 3; \text{R} \rightarrow 1; \text{S} \rightarrow 5$   
 (B)  $\text{P} \rightarrow 3; \text{Q} \rightarrow 5; \text{R} \rightarrow 4; \text{S} \rightarrow 2$   
 (C)  $\text{P} \rightarrow 5; \text{Q} \rightarrow 2; \text{R} \rightarrow 1; \text{S} \rightarrow 3$   
 (D)  $\text{P} \rightarrow 2; \text{Q} \rightarrow 3; \text{R} \rightarrow 4; \text{S} \rightarrow 5$

**Answer (D)**

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15. Match the electronic configurations in List-I with appropriate metal complex ions in List-II and choose the correct option.

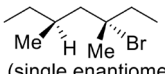
[Atomic Number: Fe = 26, Mn = 25, Co = 27]

	List-I		List-II
(P)	$t_{2g}^6 e_g^0$	(1)	$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
(Q)	$t_{2g}^3 e_g^2$	(2)	$[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
(R)	$e^2 t_2^3$	(3)	$[\text{Co}(\text{NH}_3)_6]^{3+}$
(S)	$t_{2g}^4 e_g^2$	(4)	$[\text{FeCl}_4]^-$
		(5)	$[\text{CoCl}_4]^{2-}$

- (A) P  $\rightarrow$  1; Q  $\rightarrow$  4; R  $\rightarrow$  2; S  $\rightarrow$  3  
 (B) P  $\rightarrow$  1; Q  $\rightarrow$  2; R  $\rightarrow$  4; S  $\rightarrow$  5  
 (C) P  $\rightarrow$  3; Q  $\rightarrow$  2; R  $\rightarrow$  5; S  $\rightarrow$  1  
 (D) P  $\rightarrow$  3; Q  $\rightarrow$  2; R  $\rightarrow$  4; S  $\rightarrow$  1

Answer (D)

16. Match the reactions in List-I with the features of their products in List-II and choose the correct option.

List-I	List-II
(P) (-)-1-Bromo-2-ethylpentane $\xrightarrow[\text{S}_\text{N}2 \text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(1) Inversion of configuration
(Q) (-)-2-Bromopentane $\xrightarrow[\text{S}_\text{N}2 \text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(2) Retention of configuration
(R) (-)-3-Bromo-3-methylhexane $\xrightarrow[\text{S}_\text{N}1 \text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(3) Mixture of enantiomers
(S)  $\xrightarrow[\text{S}_\text{N}1 \text{ reaction}]{\text{aq. NaOH}}$ (single enantiomer)	(4) Mixture of structural isomers
	(5) Mixture of diastereomers

- (A) P  $\rightarrow$  1; Q  $\rightarrow$  2; R  $\rightarrow$  5; S  $\rightarrow$  3  
 (B) P  $\rightarrow$  2; Q  $\rightarrow$  1; R  $\rightarrow$  3; S  $\rightarrow$  5  
 (C) P  $\rightarrow$  1; Q  $\rightarrow$  2; R  $\rightarrow$  5; S  $\rightarrow$  4  
 (D) P  $\rightarrow$  2; Q  $\rightarrow$  4; R  $\rightarrow$  3; S  $\rightarrow$  5

Answer (B)

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17. The major products obtained from the reactions in List-II are the reactants for the named reactions mentioned in List-I. Match List-I with List-II and choose the correct option.

List-I	List-II
(P) Etard reaction	(1) Acetophenone $\xrightarrow{\text{Zn-Hg, HCl}}$
(Q) Gattermann reaction	(2) Toluene $\xrightarrow[\text{(ii) SOCl}_2]{\text{(i) KMnO}_4, \text{KOH}, \Delta}$
(R) Gattermann-Koch reaction	(3) Benzene $\xrightarrow[\text{anhyd. AlCl}_3]{\text{CH}_3\text{Cl}}$
(S) Rosenmund reduction	(4) Aniline $\xrightarrow[273-278 \text{ K}]{\text{NaNO}_2/\text{HCl}}$
	(5) Phenol $\xrightarrow{\text{Zn}, \Delta}$

(A) P  $\rightarrow$  2; Q  $\rightarrow$  4; R  $\rightarrow$  1; S  $\rightarrow$  3

(B) P  $\rightarrow$  1; Q  $\rightarrow$  3; R  $\rightarrow$  5; S  $\rightarrow$  2

(C) P  $\rightarrow$  3; Q  $\rightarrow$  2; R  $\rightarrow$  1; S  $\rightarrow$  4

(D) P  $\rightarrow$  3; Q  $\rightarrow$  4; R  $\rightarrow$  5; S  $\rightarrow$  2

**Answer (D)**



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## PART-III : MATHEMATICS

### SECTION 1 (Maximum Marks : 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

*Full Marks* : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

*Partial Marks* : +3 If all the four options are correct but **ONLY** three options are chosen;

*Partial Marks* : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

*Partial Marks* : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

*Zero Marks* : 0 If none of the options is chosen (i.e. the question is unanswered);

*Negative Marks* : -2 In all other cases.

1. Let  $S = (0, 1) \cup (1, 2) \cup (3, 4)$  and  $T = \{0, 1, 2, 3\}$ . Then which of the following statements is(are) true?

- (A) There are infinitely many functions from  $S$  to  $T$
- (B) There are infinitely many strictly increasing functions from  $S$  to  $T$
- (C) The number of continuous functions from  $S$  to  $T$  is at most 120
- (D) Every continuous function from  $S$  to  $T$  is differentiable

**Answer (A, C, D)**

2. Let  $T_1$  and  $T_2$  be two distinct common tangents to the ellipse  $E: \frac{x^2}{6} + \frac{y^2}{3} = 1$  and the parabola  $P: y^2 = 12x$ .

Suppose that the tangent  $T_1$  touches  $P$  and  $E$  at the points  $A_1$  and  $A_2$ , respectively and the tangent  $T_2$  touches  $P$  and  $E$  at the points  $A_4$  and  $A_3$ , respectively. Then which of the following statements is(are) true?

- (A) The area of the quadrilateral  $A_1A_2A_3A_4$  is 35 square units
- (B) The area of the quadrilateral  $A_1A_2A_3A_4$  is 36 square units
- (C) The tangents  $T_1$  and  $T_2$  meet the  $x$ -axis at the point  $(-3, 0)$
- (D) The tangents  $T_1$  and  $T_2$  meet the  $x$ -axis at the point  $(-6, 0)$

**Answer (A, C)**

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3. Let  $f: [0, 1] \rightarrow [0, 1]$  be the function defined by  $f(x) = \frac{x^3}{3} - x^2 + \frac{5}{9}x + \frac{17}{36}$ . Consider the square region  $S = [0, 1] \times [0, 1]$ . Let  $G = \{(x, y) \in S : y > f(x)\}$  be called the green region and  $R = \{(x, y) \in S : y < f(x)\}$  be called the red region. Let  $L_h = \{(x, h) \in S : x \in [0, 1]\}$  be the horizontal line drawn at a height  $h \in [0, 1]$ . Then which of the following statements is(are) true?
- (A) There exists an  $h \in \left[\frac{1}{4}, \frac{2}{3}\right]$  such that the area of the green region above the line  $L_h$  equals the area of the green region below the line  $L_h$
- (B) There exists an  $h \in \left[\frac{1}{4}, \frac{2}{3}\right]$  such that the area of the red region above the line  $L_h$  equals the area of the red region below the line  $L_h$
- (C) There exists an  $h \in \left[\frac{1}{4}, \frac{2}{3}\right]$  such that the area of the green region above the line  $L_h$  equals the area of the red region below the line  $L_h$
- (D) There exists an  $h \in \left[\frac{1}{4}, \frac{2}{3}\right]$  such that the area of the red region above the line  $L_h$  equals the area of the green region below the line  $L_h$

**Answer (B, C, D)**

**SECTION 2 (Maximum Marks : 12)**

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

**Full Marks** : +3 If **ONLY** the correct option is chosen;

**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);

**Negative Marks** : -1 In all other cases.

4. Let  $f: (0, 1) \rightarrow \mathbb{R}$  be the function defined as  $f(x) = \sqrt{n}$  if  $x \in \left[\frac{1}{n+1}, \frac{1}{n}\right]$  where  $n \in \mathbb{N}$ . Let  $g: (0, 1) \rightarrow \mathbb{R}$  be a function such that  $\int_{x^2}^x \sqrt{\frac{1-t}{t}} dt < g(x) < 2\sqrt{x}$  for all  $x \in (0, 1)$ . Then  $\lim_{x \rightarrow 0} f(x)g(x)$
- (A) Does NOT exist (B) Is equal to 1
- (C) Is equal to 2 (D) Is equal to 3

**Answer (C)**

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5. Let  $Q$  be the cube with the set of vertices  $\{(x_1, x_2, x_3) \in \mathbb{R}^3 : x_1, x_2, x_3 \in \{0, 1\}\}$ . Let  $F$  be the set of all twelve lines containing the diagonals of the six faces of the cube  $Q$ . Let  $S$  be the set of all four lines containing the main diagonals of the cube  $Q$ ; for instance, the line passing through the vertices  $(0, 0, 0)$  and  $(1, 1, 1)$  is in  $S$ . For lines  $\ell_1$  and  $\ell_2$ , let  $d(\ell_1, \ell_2)$  denote the shortest distance between them. Then the maximum value of  $d(\ell_1, \ell_2)$ , as  $\ell_1$  varies over  $F$  and  $\ell_2$  varies over  $S$ , is

- (A)  $\frac{1}{\sqrt{6}}$  (B)  $\frac{1}{\sqrt{8}}$   
 (C)  $\frac{1}{\sqrt{3}}$  (D)  $\frac{1}{\sqrt{12}}$

**Answer (A)**

6. Let  $X = \left\{ (x, y) \in \mathbb{Z} \times \mathbb{Z} : \frac{x^2}{8} + \frac{y^2}{20} < 1 \text{ and } y^2 < 5x \right\}$ . Three distinct point  $P$ ,  $Q$  and  $R$  are randomly chosen from  $X$ .

Then the probability that  $P$ ,  $Q$  and  $R$  form a triangle whose area is a positive integer, is

- (A)  $\frac{71}{220}$  (B)  $\frac{73}{220}$   
 (C)  $\frac{79}{220}$  (D)  $\frac{83}{220}$

**Answer (B)**

7. Let  $P$  be a point on the parabola  $y^2 = 4ax$ , where  $a > 0$ . The normal to the parabola at  $P$  meets the  $x$ -axis at a point  $Q$ . The area of the triangle  $PFQ$ , where  $F$  is the focus of the parabola, is 120. If the slope  $m$  of the normal and  $a$  are both positive integers, then the pair  $(a, m)$  is

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

**Answer (A)**

### SECTION 3 (Maximum Marks : 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

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8. Let  $\tan^{-1}(x) \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$ , for  $x \in \mathbb{R}$ . Then the number of real solutions of the equation

$$\sqrt{1+\cos(2x)} = \sqrt{2} \tan^{-1}(\tan x) \text{ in the set } \left(-\frac{3\pi}{2}, -\frac{\pi}{2}\right) \cup \left(-\frac{\pi}{2}, \frac{\pi}{2}\right) \cup \left(\frac{\pi}{2}, \frac{3\pi}{2}\right) \text{ is equal to}$$

**Answer (3)**

9. Let  $n \geq 2$  be a natural number and  $f : [0, 1] \rightarrow \mathbb{R}$  be the function defined by

$$f(x) = \begin{cases} n(1-2nx) & \text{if } 0 \leq x \leq \frac{1}{2n} \\ 2n(2nx-1) & \text{if } \frac{1}{2n} \leq x \leq \frac{3}{4n} \\ 4n(1-nx) & \text{if } \frac{3}{4n} \leq x \leq \frac{1}{n} \\ \frac{n}{n-1}(nx-1) & \text{if } \frac{1}{n} \leq x \leq 1 \end{cases}$$

If  $n$  is such that the area of the region bounded by the curves  $x = 0$ ,  $x = 1$ ,  $y = 0$  and  $y = f(x)$  is 4, then the maximum value of the function  $f$  is

**Answer (8)**

10. Let  $\overbrace{75\dots 57}^r$  denote the  $(r+2)$  digit number where the first and the last digits are 7 and the remaining  $r$  digits

are 5. Consider the sum  $S = 77 + 757 + 7557 + \dots + \overbrace{75\dots 57}^{98}$ . If  $S = \frac{\overbrace{75\dots 57}^{99} + m}{n}$ , where  $m$  and  $n$  are natural numbers less than 3000, then the value of  $m+n$  is

**Answer (1219)**

11. Let  $A = \left\{ \frac{1967 + 1686i \sin \theta}{7 - 3i \cos \theta} : \theta \in \mathbb{R} \right\}$ . If  $A$  contains exactly one positive integer  $n$ , then the value of  $n$  is

**Answer (281)**

12. Let  $P$  be the plane  $\sqrt{3}x + 2y + 3z = 16$  and let

$$S = \left\{ \alpha \hat{i} + \beta \hat{j} + \gamma \hat{k} : \alpha^2 + \beta^2 + \gamma^2 = 1 \text{ and the distance of } (\alpha, \beta, \gamma) \text{ from the plane } P \text{ is } \frac{7}{2} \right\}.$$

Let  $\vec{u}$ ,  $\vec{v}$  and  $\vec{w}$  be three distinct vectors in  $S$  such that  $|\vec{u} - \vec{v}| = |\vec{v} - \vec{w}| = |\vec{w} - \vec{u}|$ . Let  $V$  be the volume of the parallelepiped determined by vectors  $\vec{u}$ ,  $\vec{v}$  and  $\vec{w}$ . Then the value of  $\frac{80}{\sqrt{3}}V$  is

**Answer (45)**

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13. Let  $a$  and  $b$  be two nonzero real numbers. If the coefficient of  $x^5$  in the expansion of  $\left(ax^2 + \frac{70}{27bx}\right)^4$  is equal to the coefficient of  $x^{-5}$  in the expansion of  $\left(ax - \frac{1}{bx^2}\right)^7$ , then the value of  $2b$  is

**Answer (3)**

**SECTION 4 (Maximum Marks : 12)**

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:  
**Full Marks** : +3 **ONLY** if the option corresponding to the correct combination is chosen;  
**Zero Marks** : 0 If none of the options is chosen (i.e. the question is unanswered);  
**Negative Marks** : -1 In all other cases.

14. Let  $\alpha$ ,  $\beta$  and  $\gamma$  be real numbers. Consider the following system of linear equations

$$x + 2y + z = 7$$

$$x + \alpha z = 11$$

$$2x - 3y + \beta z = \gamma$$

Match each entry in List-I to the correct entries in List-II.

List-I	List-II
(P) If $\beta = \frac{1}{2}(7\alpha - 3)$ and $\gamma = 28$ , then the system has	(1) a unique solution
(Q) If $\beta = \frac{1}{2}(7\alpha - 3)$ and $\gamma \neq 28$ , then the system has	(2) no solution
(R) If $\beta \neq \frac{1}{2}(7\alpha - 3)$ where $\alpha = 1$ and $\gamma \neq 28$ , then the system has	(3) infinitely many solutions
(S) If $\beta \neq \frac{1}{2}(7\alpha - 3)$ where $\alpha = 1$ and $\gamma = 28$ , then the system has	(4) $x = 11$ , $y = -2$ and $z = 0$ as a solution
	(5) $x = -15$ , $y = 4$ and $z = 0$ as a solution

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The correct option is:

- (A)  $(P) \rightarrow (3), (Q) \rightarrow (2), (R) \rightarrow (1), (S) \rightarrow (4)$   
 (B)  $(P) \rightarrow (3), (Q) \rightarrow (2), (R) \rightarrow (5), (S) \rightarrow (4)$   
 (C)  $(P) \rightarrow (2), (Q) \rightarrow (1), (R) \rightarrow (4), (S) \rightarrow (5)$   
 (D)  $(P) \rightarrow (2), (Q) \rightarrow (1), (R) \rightarrow (1), (S) \rightarrow (3)$

**Answer (A)**

15. Consider the given data with frequency distribution

$x_i$	3	8	11	10	5	4
$f_i$	5	2	3	2	4	4

Match each entry in **List-I** to the correct entries in **List-II**.

List-I	List-II
(P) The mean of the above data is	(1) 2.5
(Q) The median of the above data is	(2) 5
(R) The mean deviation about the mean of the above data is	(3) 6
(S) The mean deviation about the median of the above data is	(4) 2.7
	(5) 2.4

The correct option is

- (A)  $(P) \rightarrow (3) (Q) \rightarrow (2) (R) \rightarrow (4) (S) \rightarrow (5)$   
 (B)  $(P) \rightarrow (3) (Q) \rightarrow (2) (R) \rightarrow (1) (S) \rightarrow (5)$   
 (C)  $(P) \rightarrow (2) (Q) \rightarrow (3) (R) \rightarrow (4) (S) \rightarrow (1)$   
 (D)  $(P) \rightarrow (3) (Q) \rightarrow (3) (R) \rightarrow (5) (S) \rightarrow (5)$

**Answer (A)**

16. Let  $\ell_1$  and  $\ell_2$  be the lines  $\vec{r}_1 = \lambda(\hat{i} + \hat{j} + \hat{k})$  and  $\vec{r}_2 = (\hat{j} - \hat{k}) + \mu(\hat{i} + \hat{k})$ , respectively, Let  $X$  be the set of all the planes  $H$  that contain the line  $\ell_1$ . For a plane  $H$ , let  $d(H)$  denote the smallest possible distance between the points of  $\ell_2$  and  $H$ . Let  $H_0$  be a plane in  $X$  for which  $d(H_0)$  is the maximum value of  $d(H)$  as  $H$  varies over all planes in  $X$ .

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Match each entry in **List-I** to the correct entries in **List-II**.

List-I	List-II
(P) The value of $d(H_0)$ is	(1) $\sqrt{3}$
(Q) The distance of the point $(0, 1, 2)$ from $H_0$ is	(2) $\frac{1}{\sqrt{3}}$
(R) The distance of origin from $H_0$ is	(3) 0
(S) The distance of origin from the point of intersection of planes $y = z$ , $x = 1$ and $H_0$ is	(4) $\sqrt{2}$
	(5) $\frac{1}{\sqrt{2}}$

The correct option is

(A) (P)  $\rightarrow$  (2) (Q)  $\rightarrow$  (4) (R)  $\rightarrow$  (5) (S)  $\rightarrow$  (1)

(B) (P)  $\rightarrow$  (5) (Q)  $\rightarrow$  (4) (R)  $\rightarrow$  (3) (S)  $\rightarrow$  (1)

(C) (P)  $\rightarrow$  (2) (Q)  $\rightarrow$  (1) (R)  $\rightarrow$  (3) (S)  $\rightarrow$  (2)

(D) (P)  $\rightarrow$  (5) (Q)  $\rightarrow$  (1) (R)  $\rightarrow$  (4) (S)  $\rightarrow$  (2)

**Answer (B)**

17. Let  $z$  be a complex number satisfying  $|z|^3 + 2z^2 + 4\bar{z} - 8 = 0$ , where  $\bar{z}$  denotes the complex conjugate of  $z$ . Let the imaginary part of  $z$  be nonzero.

Match each entry in **List-I** to the correct entries in **List-II**.

List-I	List-II
(P) $ z ^2$ is equal to	(1) 12
(Q) $ z - \bar{z} ^2$ is equal to	(2) 4
(R) $ z ^2 +  z + \bar{z} ^2$ is equal to	(3) 8
(S) $ z + 1 ^2$ is equal to	(4) 10
	(5) 7

The correct option is

(A) (P)  $\rightarrow$  (1) (Q)  $\rightarrow$  (3) (R)  $\rightarrow$  (5) (S)  $\rightarrow$  (4)

(B) (P)  $\rightarrow$  (2) (Q)  $\rightarrow$  (1) (R)  $\rightarrow$  (3) (S)  $\rightarrow$  (5)

(C) (P)  $\rightarrow$  (2) (Q)  $\rightarrow$  (4) (R)  $\rightarrow$  (5) (S)  $\rightarrow$  (1)

(D) (P)  $\rightarrow$  (2) (Q)  $\rightarrow$  (3) (R)  $\rightarrow$  (5) (S)  $\rightarrow$  (4)

**Answer (B)**

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