**CODE ⟩ A**

# JEE Main - 7 | JEE-2024

**Date: 28/12/2023**                                    **Maximum Marks: 300**

**Timing: 3:30 PM to 6:30 PM**                          **Duration : 3.0 Hours**

## General Instructions

1.   The test is of **3 hours** duration and the maximum marks is **300.**

2.   The question paper consists of **3 Parts** (Part I: **Physics**, Part II: **Chemistry**, Part III: **Mathematics**). Each Part has **two** sections (Section 1 & Section 2).

3.   **Section 1** contains **20 Multiple Choice Questions**. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE CHOICE** is correct.

4.   **Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted. You will NOT be allowed to attempt the sixth question. If you wish to attempt any other question apart from the five already attempted, then you will have to delete any one response from the five previously answered and then proceed to answer the new one.**
     The answer to each question should be **rounded off to the nearest integer**.

5.   No candidate is allowed to carry any textual material, printed or written, bits of papers, pager, mobile phone, any electronic device, etc. inside the examination room/hall.

6.   On completion of the test, the candidate must hand over the Answer Sheet to the **Invigilator** on duty in the Room/Hall. **However, the candidates are allowed to take away this Test Booklet with them**.

## Marking Scheme

1.   **Section – 1:** +4 for correct answer, –1 (negative marking) for incorrect answer, 0 for all other cases.
2.   **Section – 2:** +4 for correct answer, –1 (negative marking) for incorrect answer, 0 for all other cases.

## Syllabus

**Physics:** Full Syllabus Class - XI

**Chemistry:** Full Syllabus Class - XI

**Mathematics:** Full Syllabus Class - XI

Name of the Candidate (In CAPITALS) : - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Roll Number : - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - .

OMR Bar Code Number : - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Candidate's Signature : - - - - - - - - - - - - - - - - -       Invigilator's Signature - - - - - - - - - - - - -

| **PART I : PHYSICS** | **MARKS: 100** |

## SECTION-1

This section contains 20 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE CHOICE is correct.

**1.** A particle of mass $m$ is suspended from a ceiling through a string of length $L$. The particle moves in a horizontal circle of radius $r$ such that $r = \dfrac{L}{2}$. The speed of particle will be:

(A) $\left(\dfrac{gr}{\sqrt{3}}\right)^{1/2}$ 
(B) $\left(\sqrt{3gr}\right)^{1/2}$ 
(C) $(gr)^{1/2}$ 
(D) $\left(\dfrac{gr}{2}\right)^{1/2}$

**2.** The coefficient of static friction between two blocks is 0.6 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is : (Take $g = 10 \text{ ms}^{-2}$)
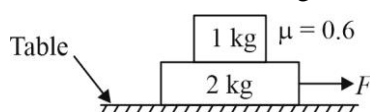


(A) 15 N 
(B) 18 N 
(C) 21 N 
(D) 20 N

**3.** Column -I shows $x$-$t$ graph for a particle moving on straight line and column -II shows $v$-$t$ graph. Match Column-I with Column-II.

| | **Column-I** | | **Column-II** |
|---|---|---|---|
| **A.** |  | **I.** |  |
| **B.** |  | **II.** |  |
| **C.** |  | **III.** |  |
| **D.** |  | **IV.** |  |

Choose the correct answer from the options given below:

(A) A-II, B-IV, C-III, D-I 
(B) A-I, B-II, C-III, D-IV 
(C) A-II, B-III, C-IV, D-I 
(D) A-I, B-III, C-IV, D-II

**SPACE FOR ROUGH WORK**

**4.** The distribution of relative intensity of blackbody radiation from a solid object versus the wavelength $\lambda$ is shown in the figure. If the Wien displacement law constant is $2.9 \times 10^{-3} mK$, what is the approximate temperature of the object?
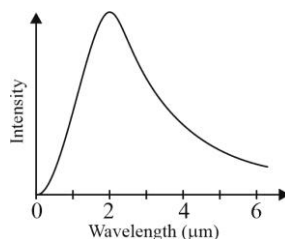


**(A)** 10 K **(B)** 50 K **(C)** 250 K **(D)** 1500 K

**5.** During an adiabatic expansion, a gas does 50 J of work against the surroundings. It is then cooled at constant volume by removing 20 J of energy from the gas. The magnitude of the total change in internal energy of the gas is:

**(A)** 70 J **(B)** 50 J **(C)** 30 J **(D)** 20 J

**6.** Given below are two statements: one is labeled as **Assertion A** and the other is labeled as **Reason R**.

**Assertion A:** A pendulum clock when taken to Mount Everest becomes fast.

**Reason R:** The value of g (acceleration due to gravity) is less at Mount Everest than its value on the surface of earth.

In the light of the above statements, choose the most appropriate answer from the options given below:

**(A)** Both A and R are correct and R is the correct explanation of A.

**(B)** A is correct but R is not correct.

**(C)** Both A and R are correct but R is not the correct explanation of A.

**(D)** A is not correct but R is correct.

**7.** A cylindrical container filled with a liquid is being rotated about its central axis at a constant angular velocity $\omega$. Four points $A$, $B$, $C$ and $D$ are chosen in the same plane such that $ABCD$ is a square of side length $a$ and $AB$ is horizontal while $BC$ is vertical. $A$ and $D$ lie on the axis of rotation. Let the pressure at $A$, $B$, $C$ and $D$ be denoted by $P_A, P_B, P_C$ and $P_D$. Now, consider the following two statements:
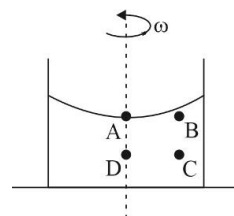


**(I)** $P_C < P_A$ for all values of $\omega$ **(II)** $P_B > P_D$ only if $\omega > \sqrt{\dfrac{2g}{a}}$

Which of these options is correct?

**(A)** Both (I) and (II) are correct **(B)** (I) is correct and (II) is incorrect

**(C)** (II) is correct and (I) is incorrect **(D)** Both (I) and (II) are incorrect

**SPACE FOR ROUGH WORK**

**8.** Let $R$ denote the radius of the earth. An object is projected vertically from the surface of the earth with velocity $v$. Its velocity when it reaches a height $R$ above the surface is $\dfrac{v}{4}$. The maximum height above the surface that the object reaches is:

(A) $\dfrac{19R}{15}$     (B) $\dfrac{22R}{15}$     (C) $\dfrac{8R}{7}$     (D) $\dfrac{10R}{7}$

**9.** When two forces $F_1$ and $F_2$ are applied in the same direction, their resultant is 30 N. If the forces are applied at an angle $90^\circ$ with each other, their resultant is $5\sqrt{26}$ N . If the forces are applied at an angle $60^\circ$ with each other, their resultant (in Newton) is:

(A) $10\sqrt{7}$     (B) $5\sqrt{31}$     (C) $5\sqrt{33}$     (D) $10\sqrt{5}$

**10.** The potential energy v/s displacement curve for a one-dimensional conservative field is as shown in diagram. Force at $P, Q$ and $R$ is respectively.
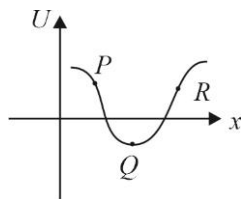


(A) Positive, zero, negative          (B) Positive, zero, positive

(C) Negative, zero, positive          (D) Positive, negative, positive

**11.** A particle of mass $m_1$ moving with uniform velocity of $25\ m/s$ collides with another mass $m_2$ at rest. After the collision both begin to move with a uniform velocity of $10\ m/s$. Then the ratio $\dfrac{m_2}{m_1}$ is:

(A) 1.5     (B) 0.66     (C) 2     (D) 0.5

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**12.** A uniform sphere is moving on a rough horizontal surface, is rolling with slipping. During this kind of motion of sphere:
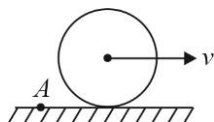


**(A)** linear momentum along the direction of motion remain conserved

**(B)** kinetic energy of sphere is conserved

**(C)** angular momentum of sphere about any point $'A'$ on the horizontal surface is conserved

**(D)** only the rotational kinetic energy of sphere is conserved

**13.** A uniform rod of mass $M$ and length $L$ is supported by two strings of equal length as shown in fig. If the right string is cut. Then the tension in the left string just after cutting of right string is:
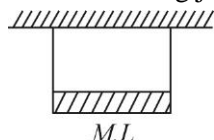


**(A)** $Mg$      **(B)** $3Mg/4$      **(C)** $Mg/4$      **(D)** $Mg/2$

**14.** If $I_c$ is the moment of inertia of a given body about an axis passing through its center of mass, and $I_1 \& I_2$ are moment of inertia of that body about two other axes at a distance of $d_1 \& d_2$ from the axis through center of mass and parallel to it. If $d_1 > d_2$. then:

**(A)** $I_c > I_1 > I_2$          **(B)** $I_c > I_2 > I_1$

**(C)** $I_c < I_1 < I_2$          **(D)** $I_c < I_2 < I_1$

**15.** On a stationary boat mass of $100\ kg$ and length $10m$ in still water, two persons $A \& B$ of mass $60\ kg$ and $80\ kg$ respectively, are sitting on it. Person $A$ is in middle of boat while person $B$ near one end as shown in fig. Now person $A$ does not move on boat while person $B$ moves and go the other end of boat and sits there. In doing so, the boat moves in still water by a distance of :
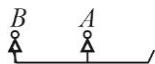


**(A)** $5m$      **(B)** $2m$      **(C)** $\dfrac{10}{3}m$      **(D)** $\dfrac{5}{3}m$

**16.** One mole of a monoatomic gas at 27ºC is allowed to expand isothermally such that its final volume is 8 times its initial volume. The work done by the gas during the expansion is: ($\log_e 2 = 0.693$)

**(A)** $576\ J$      **(B)** $1728\ J$      **(C)** $5183\ J$      **(D)** $466\ J$

**SPACE FOR ROUGH WORK**

**17.** A gas undergoes the thermodynamic process shown in the P–V diagram. The work done by the gas in this process is:



(A) $3P_0V_0$      (B) $4P_0V_0$

(C) $\dfrac{9}{2}P_0V_0$      (D) $6P_0V_0$
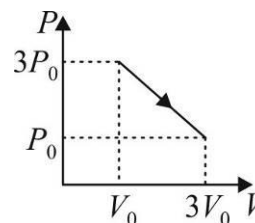
**18.** A small block of mass $m$ is placed on a frictionless horizontal surface and connected to two massless springs of spring constant $k$ and $2k$ as shown. The other ends of the springs are fixed to rigid walls. Initially, both springs are in their natural length. Now, the block is displaced by a small distance to the right and released. The time period of the resulting SHM is:



(A) $2\pi\sqrt{\dfrac{m}{3k}}$    (B) $2\pi\sqrt{\dfrac{m}{2k}}$    (C) $2\pi\sqrt{\dfrac{2m}{3k}}$    (D) $2\pi\sqrt{\dfrac{3m}{2k}}$
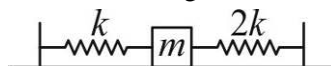
**19.** Two blocks A and B of mass 4 kg and 2 kg respectively are suspended using two metallic wires as shown. The diameter of the wires are in the ratio $\dfrac{d_1}{d_2}=1:2$, and their Young's moduli are in the ratio $\dfrac{Y_1}{Y_2}=3:1$. The strain produced in them is in the ratio:
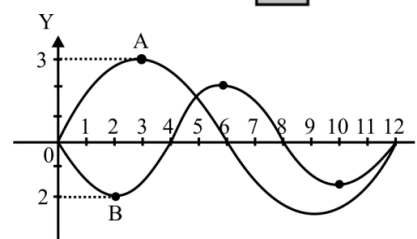


(A) 2 : 1      (B) 4 : 9

(C) 2 : 3      (D) 4 : 1
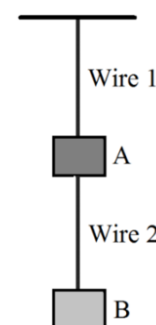
**20.** The displacement $Vs$ time graph for two waves $A$ and $B$ which travel along the same string are shown in the figure. What is the intensity ratio $\dfrac{I_A}{I_B}$?



(A) 1      (B) 1.5

(C) 2      (D) 3

**SPACE FOR ROUGH WORK**

# SECTION-2

**Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted.**
The answer to each question should be **rounded off to the nearest integer**.

1.   A boat travels upstream and after one hour has gone 10 km. The boat next travels downstream and after one hour has gone 14 km. If the boat's speed relative to the water is constant, what is the speed (in km/h) of the current in the river?

2.   Consider a circle of radius 42 cm. An insect crawls with uniform speed of 1.3 cm/s along the chord $AB$ then along the circular arc $BCD$ to reach point $D$ and then following cord $DA$ to reach finally $A$. Time (in sec) <mark>spent</mark> by the insect to crawl from $A$ to $A$ is _____ .
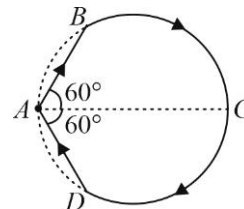
3.   A particle is projected from the ground with a speed of 20 m/s at an angle of 60° with the ground. The time after which the speed of the particle is minimum during the flight is $\sqrt{n}$ sec. Find $n$.

4.   A body of mass 4 kg collides head-on elastically with another body of mass 2 kg kept at rest in free space. Time of collision is 0.02 sec and average impulsive force acted on each body is 100N. Find the velocity (in m/s) of the 2 kg body after the impact.

5.   An object of mass $8\,kg$ is hanging from one end of a uniform rod CD of mass $2\,kg$ and length $1\,m$ pivoted at its end C on a vertical wall as shown in figure. It is supported by a cable AB such that the system is in equilibrium. The tension in the cable is _____ Newton. (Take $g = 10\,m/s^2$)

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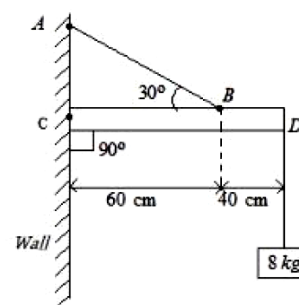
**SPACE FOR ROUGH WORK**

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**6.** A solid sphere of mass $M$ and radius $R$ is pure rolling with angular velocity $\omega$ on a horizontal plane. The angular momentum of sphere about a point $A$ is $\dfrac{kmR^2\omega}{5}$. Then $k$ is _____.
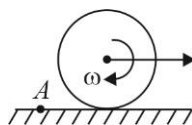


**7.** A hollow sphere is pure rolling on a highly rough surface as shown in fig., with a translational velocity $v$. If it is to climb on the surface, the velocity $v \geq \sqrt{\dfrac{kgh}{5}}$ then $k$ is _____.



**8.** When 10 g of a liquid $X$ at temperature $80\ ^{\circ}\mathrm{C}$ is mixed with 20 g of a liquid $Y$ at $20\ ^{\circ}\mathrm{C}$ in a perfectly insulated vessel, the final temperature is $32\ ^{\circ}\mathrm{C}$. Now, if 5 g more of liquid $Y$ at $20\ ^{\circ}\mathrm{C}$ is added to the mixture, the final temperature (in $^{\circ}\mathrm{C}$) is _____.

**9.** An otherwise thermally insulated room can only exchange heat with the surroundings through a window with a glass pane of area $1.2\ \mathrm{m}^2$ and thickness 0.5 cm. A heater placed inside the room supplies heat to the room at a constant rate 1800 W. On a day when the temperature outside the room is 14 °C, the temperature inside the room (in °C) a long time after the heater is switched on becomes T. write the value of 2T as your answer. (Thermal conductivity of glass $= 1\ \mathrm{W/m\ ^{\circ}C}$)

**10.** The average power transmitted across a cross section by two sound waves moving in the same direction is equal. The wave lengths of two sounds waves are in the ration of 1 : 2. Find the ratio of their pressure amplitudes.

**SPACE FOR ROUGH WORK**

| **PART II : CHEMISTRY** | **MARKS: 100** |

# SECTION-1

**This section contains 20 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE CHOICE is correct.**

1. Hydrogen and oxygen gas are combined in a reaction vessel and reacted completely to form water. What volumes of gases (at STP) will give the greatest mass of water?

   (A)   $1.0$ L $H_2$ and $4.0$ L $O_2$        (B)   $2.0$ L $H_2$ and $3.0$ L $O_2$

   (C)   $3.0$ L $H_2$ and $2.0$ L $O_2$        (D)   $4.0$ L $H_2$ and $1.0$ L $O_2$

2. Weighed samples of iron are added in increments of a given amount of liquid bromine and allowed to react completely. The reaction produces a single product that is isolated and weighed. Which statement best describes the experiments summarized by the graph? [Atomic mass Fe = 56, Br = 80]
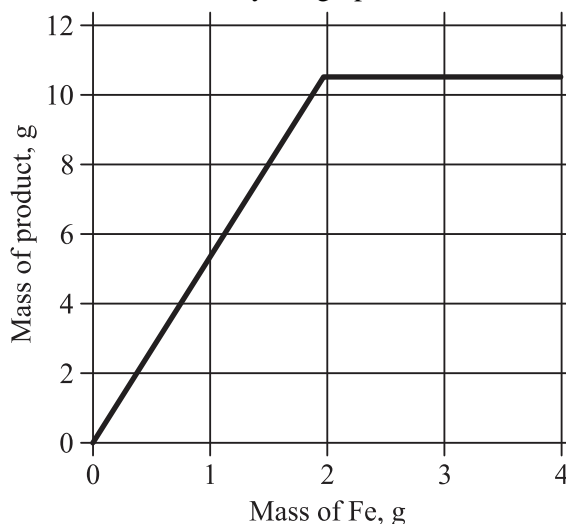
   (A)   When 1.00 g of Fe is added, Fe is the limiting reactant

   (B)   When 2.00 g of Fe is added, 10.6 g of $FeBr_2$ is formed

   (C)   When 2.50 g of Fe is added, both reactants are used completely

   (D)   When 3.50 g of Fe is added, there is an excess of $Br_2$

**SPACE FOR ROUGH WORK**

**3.** A gas-phase hydrogen atom absorbs a photon of visible light and then emits a photon of ultraviolet light. What may be concluded about its initial and its final values of the principal quantum number n?

    **(A)** Initially n = 1 and finally n = 2

    **(B)** Initially n = 2 and finally n = 1

    **(C)** Initially n = 2 and finally n = 4

    **(D)** This scenario is impossible because ultraviolet light is more energetic than visible light

**4.** Two atomic orbitals have the same shape and orientation but have a different number of nodes. Which statement about the quantum numbers of these orbitals is correct?

    **(A)** They have the same value of $\ell$ but different values of n

    **(B)** They have the same value of $\ell$ but different values of $m_\ell$

    **(C)** They have the same value of $m_\ell$ but different values of $\ell$

    **(D)** They have the same value of $m_s$ but different values of $m_\ell$

**5.** Which reaction would yield a mixture of alkene product?

    **(a)** $CH_3CH_2CH_2\overset{\overset{\textstyle OH}{|}}{C}HCH_2CH_3 \xrightarrow{\text{50\% } H_2SO_4} C_6H_{12}$

    **(b)** $CH_3CH_2\overset{\overset{\textstyle OH}{|}}{\underset{\underset{\textstyle CH_2CH_3}{|}}{C}}CH_2CH_3 \xrightarrow{\text{50\% } H_2SO_4} C_7H_{14}$

    **(c)** $CH_3CH_2CH_2\overset{\overset{\textstyle Br}{|}}{C}HCH_2CH_3 \xrightarrow[\Delta]{\text{alc. KOH}} C_6H_{12}$

    **(d)** $CH_2CH_2CH_2\overset{\overset{\textstyle Br}{|}}{\underset{\underset{\textstyle CH_3}{|}}{C}}CH_2CH_3 \xrightarrow[C_2H_5OH]{KOH} C_7H_{14}$
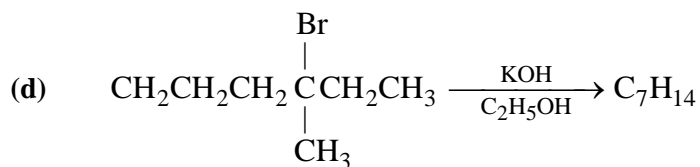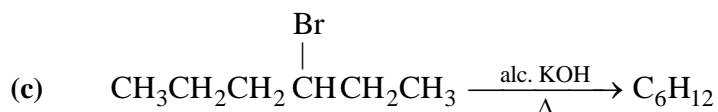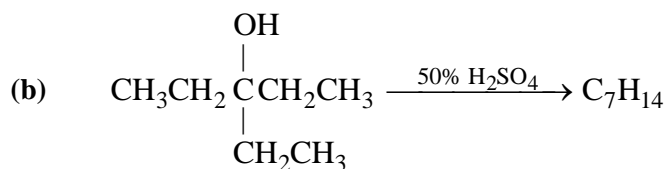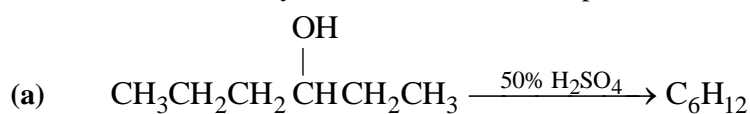
    **(A)** Only (b)     **(B)** (a), (c) & (d)     **(C)** (a), (b) & (c)     **(D)** (a), (b), (c) and (d)

**SPACE FOR ROUGH WORK**
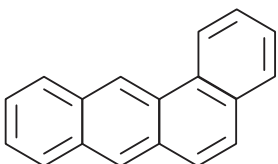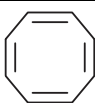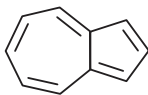
**6.** One hydrogen in 1-butene is replaced by bromine to give a chiral molecule. Which hydrogen is replaced?
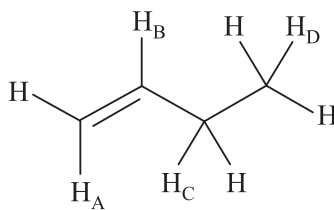


(A) $H_A$  (B) $H_B$  (C) $H_C$  (D) $H_D$

**7.** Carbon monoxide reacts with hydrogen in the presence of a catalyst to give methanol:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

A metal container at 400 K is charged with 2.00 bar of an equimolar mixture of CO and $H_2$. A catalyst for the reaction is introduced and the pressure falls to 1.29 bar once equilibrium is achieved. What is $K_p$ for this reaction at 400 K?

(A) 1.32  (B) 6.54  (C) 8.44  (D) 29.1

**8.** The hydrogenation of carbon monoxide represented below is exothermic.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(\ell); \qquad \Delta_r H° < 0$$

Which changes will increase the equilibrium yield of $CH_3OH$?

**I.** Increasing the temperature of the system

**II.** Removing some of the $CH_3OH(\ell)$

(A) I only  (B) II only  (C) Both I and II  (D) Neither I nor II

**9.** Which experiment would be most appropriate for determining the number of components in a commercial nail polish remover?

(A) Gas chromatography  (B) Paper chromatography

(C) Boiling point determination  (D) Combustion analysis

**SPACE FOR ROUGH WORK**

**10.** Match List-I and List-II.

| | List-I | | List-II |
|---|---|---|---|
| **(P)** |  | **(I)** | Benzenoid aromatic |
| **(Q)** |  | **(II)** | Formed on incomplete combustion of organic material |
| **(R)** |  | **(III)** | Not aromatic |
| **(S)** |  | **(IV)** | Non-benzenoid aromatic |

**(A)** P-I; Q-II; R-III; S-IV      **(B)** P-I; Q-III; R-II; S-IV

**(C)** P-I; Q-IV; R-III; S-II      **(D)** P-IV; Q-II; R-III; S-I

**11.** To a solution that is 0.010 M each in fluoride, sulphite, and phosphate ions is added dropwise a 1.00 M solution of $CaCl_2$. In what order will the solids precipitate?

| Solid | $K_{sp}$ |
|---|---|
| $CaSO_3$ | $6.8 \times 10^{-8}$ |
| $CaF_2$ | $5.3 \times 10^{-9}$ |
| $Ca_3(PO_4)_2$ | $1.0 \times 10^{-25}$ |

**(A)** First $Ca_3(PO_4)_2$, then $CaF_2$, last $CaSO_3$

**(B)** First $Ca_3(PO_4)_2$, then $CaSO_3$, last $CaF_2$

**(C)** First $CaSO_3$, then $CaF_2$, last $Ca_3(PO_4)_2$

**(D)** First $CaF_2$, then $CaSO_3$, last $Ca_3(PO_4)_2$

**12.** When a helium-filled balloon is immersed in liquid nitrogen, which statements accurately describe the changes as the balloon deflates?

**I.** The nitrogen does work on the balloon.

**II.** The entropy of the nitrogen increases.

**(A)** I only      **(B)** II only      **(C)** Both I and II      **(D)** Neither I nor II

**SPACE FOR ROUGH WORK**

**13.** A reaction has $K_{eq} = 0.020$ at 300 K, and its $K_{eq}$ value increases with increasing temperature. What can be inferred about the value of $\Delta H^\circ_{rxn}$ and $\Delta S^\circ_{rxn}$, assuming that they are independent of temperature?

**I.** $\Delta H^\circ_{rxn} < 0$  **II.** $\Delta S^\circ_{rxn} < 0$

**(A)** I only  **(B)** II only  **(C)** Both I and II  **(D)** Neither I nor II

**14.** Consider the expansion of one mole of an ideal gas from an initial state to a final state, with $\Delta S$ representing the entropy change in the process. The correct statement is:

**(A)** If the process is carried out reversibly, the value of $\Delta S$ will be higher in comparison to its irreversible counterpart

**(B)** If the process is adiabatic, the value of $\Delta S$ is always zero, irrespective of whether the process is carried out reversibly or irreversibly

**(C)** If the process is isothermal, there will not be any heat exchange with the surrounding since the temperatures of the system and the surrounding are equal

**(D)** If the process is isothermal and the final volume is double of the initial volume, the value of $\Delta S$ will be independent of the temperature

**15.** The ionization energy of which element is closest to that of fluorine (F)?

**(A)** O  **(B)** Ne  **(C)** Cl  **(D)** Ar

**16.** Rank the enthalpies of fusion, sublimation and vaporization for water.

**(A)** sublimation = vaporization = fusion

**(B)** vaporization < sublimation < fusion

**(C)** fusion < sublimation < vaporization

**(D)** fusion < vaporization < sublimation

**SPACE FOR ROUGH WORK**

**17.** Which reaction is not exothermic?
   **(A)** Dilution of concentration hydrochloric acid in water
   **(B)** Dilution of concentration sulfuric acid in water
   **(C)** Dissolution of solid sodium hydroxide in water
   **(D)** Dissolution of sodium bicarbonate in water

**18.** What are the oxidation state of the sulfur atoms in the thiosulphate ion, $S_2O_3^{2-}$ ?

   **(A)** Both sulfur atoms have an oxidation state of +2
   **(B)** Both sulfur atoms have an oxidation state of +3
   **(C)** One sulfur atom has an oxidation state of +4 and one has an oxidation state of –1
   **(D)** One sulfur atom has an oxidation state of +6 and one has an oxidation state of –2

**19.** Given below are the two statements : One is labelled **Assertion A** and, the other is labelled as **Reason R**.

   **Assertion (A) :** Nitrous oxide, $N_2O$ is neutral.

   **Reason (R) :** Resonance structure of nitrous oxide contain nitrogen-nitrogen triple bond.
   In the light of the above statements, choose correct most appropriate answer from the options given below:
   **(A)** Both **A** and **R** are correct and **R** is the correct explanation of **A**
   **(B)** Both **A** and **R** are correct but **R** is NOT the correct explanation of **A**
   **(C)** **A** is correct but **R** is not correct
   **(D)** **A** is not correct but **R** is correct

**20.** Given below are the two statements.

   **Statement-I :** All F – Cl – F angles are equal in $ClF_3$.

   **Statement-II :** All Cl – F bond lengths are equal in $ClF_3$.

   In the light of the above statements, choose correct answer from the options given below:
   **(A)** Both Statement-I and Statement-II are true
   **(B)** Both Statement-I and Statement-II are false
   **(C)** Statement-I is true but Statement-II is false
   **(D)** Statement-I is false but Statement-II is true

**SPACE FOR ROUGH WORK**

# SECTION-2

**Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted.**
The answer to each question should be **rounded off to the nearest integer**.

1. 20.0 mL of 0.15 M aqueous $Pb(NO_3)_2$ and 10.0 mL of 0.35 M aqueous NaBr are mixed, giving a white precipitate. What is molar mass of the least abundant ion in the supernatant?
   [Atomic mass : N = 14, O = 16, Na = 23, Br = 80, Pb = 207]

2. An orbital in a ground-state gas-phase As atom has n = 3, $\ell = 1$. How many electrons are in this orbital?

3. Consider the reaction I and II and find sum of M and N. Where N and M are number of substitution products formed (including stereoisomers) in reaction I and reaction II.

   I.
   
   CH$_2$CH$_3$
   CH$_3$
   $\xrightarrow{Br_2, \, FeBr_3}$ N
   
   II.
   
   CH$_2$CH$_3$
   CH$_3$
   $\xrightarrow{Br_2, \, UV \, light}$ M

4. Consider molecular formula $C_3H_6Cl_2$.
   
   **I.** M isomers are named as alkylidene halides.
   
   **II.** N isomers are asymmetric molecules.
   
   **III.** P isomers are named as alkylene dihalides.
   
   Find the value of sum of M, N and P.

5. Solid KOH $\Delta H^{\circ}_{soln} = -41.84 \text{ kJ mol}^{-1}$ is slowly added to distilled water contained in a well-insulated vessels, initially at 25°C. What is the pH when the temperature of the solution reaches 26.0°C?
   
   You may assume that the density of the solution remains at $1.00 \text{ g mL}^{-1}$ and its heat capacity remains at $4.184 \text{ J g}^{-1} \text{ K}^{-1}$ throughout the experiment.

**SPACE FOR ROUGH WORK**

**6.** Silver ion forms the complex $Ag(CN)_2^-$ with $K_f = 9.8 \times 10^{21}$. The minimum $x \times 10^{-2}$ mole of HCN that would need to be added to 1.00 L of a suspension of 0.010 mol of AgCl in order to dissolve all the solid. The $K_{sp}$ of AgCl is $1.8 \times 10^{-10}$ and the $K_a$ of HCN is $6.2 \times 10^{-10}$. Find the value of x.

**7.** If the average carbon-hydrogen bond dissociation enthalpy in ethane is $416 \text{ kJ mol}^{-1}$, what is the bond dissociation enthalpy (nearest integer) of the carbon-carbon bond in ethane in kJ/mol?

| Species | $\Delta H_f^\circ$, kJ mol$^{-1}$ |
|---------|------------------|
| $C_2H_6(g)$ | –84.7 |
| $H(g)$ | 217.9 |
| $C(g)$ | 718.4 |

**8.** The hypochlorite concentration in bleach can be determined by treating it with excess iodide ion in acidic solution, which causes the formation of triiodide ion according to the following balanced reaction:

$$OCl^-(aq) + 3I^-(aq) + 2H_3O^+(aq) \rightarrow Cl^-(aq) + I_3^-(aq) + 3H_2O(\ell)$$
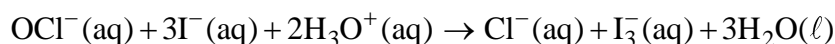
The triiodide can then be titrated with sodium thiosulphate:

$$I_3^-(aq) + 2S_2O_3^{2-}(aq) \rightarrow 3I^-(aq) + S_4O_6^{2-}(aq)$$
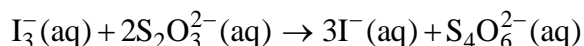
A 75.0 mL sample of liquid bleach is treated with excess KI and acid, and then titrated with 0.0235 M sodium thiosulphate solution. The endpoint is observed on the addition of 21.23 mL of this solution. The hypochlorite concentration in the bleach is $3.33 \times 10^{-x}$ M. Find the value of x.

**9.** What is the average oxidation state of tungsten in sodium phosphotungstate, $Na_3PW_{12}O_{40}$?

**10.** How many unpaired electrons are there in a ground-state NF molecules in the gas phase?

**SPACE FOR ROUGH WORK**

| **PART III : MATHEMATICS** | **MARKS: 100** |
|---|---|

## SECTION-1

**This section contains 20 Multiple Choice Questions. Each question has 4 choices (A), (B), (C) and (D), out of which ONLY ONE CHOICE is correct.**

**1.** If $\sec^2 \dfrac{\pi}{7}$ and $\tan^2 \dfrac{\pi}{7}$ are the roots of the equation $ax^2 + bx + c = 0$, then $\dfrac{5a^2 - (b^2 - c^2)}{(2a - c)^2}$ (wherever defined) is equal to:

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

**2.** If $z = 4 \cos \theta (\cos \theta + i \sin \theta)$, then locus of $z$ is:

(A) Circle with centre $(-4, 0)$      (B) Circle with centre $(2, 0)$

(C) Ellipse      (D) Hyperbola

**3.** If $m = \sum\limits_{r=0}^{\infty} a^r$, $n = \sum\limits_{r=0}^{\infty} b^r$, where $0 < a, b < 1$, then which of the following equations has roots $a$ and $b$?

(A) $mnx^2 + (m + n - 2mn)x - mn - m - n + 1 = 0$

(B) $mnx^2 - (2mn + m + n)x + mn + m + n + 1 = 0$

(C) $mnx^2 + (2mn + m + n)x + mn + m + n + 1 = 0$

(D) $mnx^2 - (2mn - m - n)x + mn - m - n + 1 = 0$

**4.** The total number of function '$f$' from the set $\{1, 2, 3\}$ into the set $\{1, 2, 3, 4, 5\}$ such that $f(i) \le f(j), \forall\, i < j$ is equal to:

(A) 35      (B) 30      (C) 50      (D) 60

**5.** The sum of the root (real or complex) of the equation $x^{2001} + \left(\dfrac{1}{2} - x\right)^{2001} = 0$ is:

(A) 2001      (B) 500      (C) 250      (D) $-500$

**SPACE FOR ROUGH WORK**

**6.** The coefficient of $x^{70}$ in the product $(x-1)(x^2-2)(x^3-3)(x^4-4)....(x^{12}-12)$ is:

(A) 4       (B) 6       (C) 8       (D) 12

**7.** When $32^{33}$ is divided by 34, it leaves the remainder?

(A) 2       (B) 16       (C) 18       (D) 32

**8.** The expression $\dfrac{1+\sin 2\alpha}{\cos(2\alpha - 2\pi)\cdot \tan\left(\alpha - \dfrac{3\pi}{4}\right)} - \dfrac{1}{4}\sin 2\alpha\left(\cot\dfrac{\alpha}{2} + \cot\left(\dfrac{3\pi}{2} + \dfrac{\alpha}{2}\right)\right) =$

(A) 1       (B) 0       (C) $\sin^2(\alpha/2)$       (D) $\sin^2\alpha$

**9.** The value of $\theta$ for which the three elements set $S = \{\sin\theta, \sin 2\theta, \sin 3\theta\}$ is equal to the three elements set $T = \{\cos\theta, \cos 2\theta, \cos 3\theta\}$ are:

(A) $\dfrac{n\pi}{2} + \dfrac{\pi}{8}, n \in Z$       (B) $2n\pi + \dfrac{2\pi}{3}, n \in Z$

(C) $2n\pi - \dfrac{2\pi}{3}, n \in Z$       (D) $\dfrac{n\pi}{2} + \dfrac{\pi}{12}, n \in Z$

**10.** In a $\Delta ABC$, the sides $BC = 5$, $CA = 4$ and $AB = 3$. If $A(0, 0)$ and the internal bisector of angle $A$ meets $BC$ in $D\left(\dfrac{12}{7}, \dfrac{12}{7}\right)$ then incentre of $\Delta ABC$ is:

(A) (2, 2)       (B) (3, 2)       (C) (2, 3)       (D) (1, 1)

**SPACE FOR ROUGH WORK**

**11.** $P$ and $Q$ are two points on a line passing through (2, 4) and having slope $m$. If a line segment $AB$ subtends a right angles at $P$ and $Q$, where $A$ ; (0, 0) and $B$ ; (6, 0), then range of values of $m$ is:

(A) $\left(\dfrac{2-3\sqrt{2}}{4}, \dfrac{2+3\sqrt{2}}{4}\right)$

(B) $\left(-\infty, \dfrac{2-3\sqrt{2}}{4}\right) \cup \left(\dfrac{2+3\sqrt{2}}{4}, \infty\right)$

(C) $(-4, 4)$

(D) $(-\infty, -4) \cup (4, \infty)$

**12.** The vertex of the parabola $2((x-1)^2 + (y-2)^2) = (x+y+3)^2$ is:

(A) $\left(-\dfrac{1}{2}, -\dfrac{1}{2}\right)$   (B) $\left(-\dfrac{1}{2}, \dfrac{1}{2}\right)$   (C) $\left(\dfrac{1}{2}, \dfrac{1}{2}\right)$   (D) $\left(\dfrac{1}{2}, -\dfrac{1}{2}\right)$

**13.** A point moves so that its distance from the point (2, 0) is always $\dfrac{1}{3}$ of its distance from the line $x - 18 = 0$. If the locus of the point is a conic, its length of latus rectum is:

(A) $\dfrac{16}{3}$   (B) $\dfrac{32}{3}$   (C) $\dfrac{8}{3}$   (D) $\dfrac{15}{4}$

**14.** Let $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1$ and $\dfrac{x^2}{A^2} - \dfrac{y^2}{B^2} = 1$ are confocal having $(a > A \text{ and } a > b)$ having the foci at $S_1$ and $S_2$. Let $P$ be their point of intersection, then $S_1P$ and $S_2P$ are the roots of quadratic equation.

(A) $x^2 + 2ax + (a^2 - A^2) = 0$

(B) $x^2 - 2Ax + (a^2 + A^2) = 0$

(C) $x^2 - 2Ax + (a^2 - A^2) = 0$

(D) $x^2 - 2ax + (a^2 - A^2) = 0$

**15.** $\displaystyle\sum_{r=1}^{10} \dfrac{r^2 + 3r + 3}{r(r+1)(r+2)(r+3)} =$

(A) $\dfrac{205}{492}$   (B) $\dfrac{250}{429}$   (C) $\dfrac{205}{429}$   (D) $\dfrac{250}{492}$

**SPACE FOR ROUGH WORK**

**16.** For $a, b, c \in R - \{0\}$, let $\dfrac{a+b}{1-ab}, b, \dfrac{b+c}{1-bc}$ are in A.P. If $\alpha, \beta$ are the roots of the quadratic equation

$2ac \, x^2 + 2abc \, x + (a+c) = 0$, then the value of $(1+\alpha)(1+\beta)$ is:

**(A)** 0 **(B)** 1 **(C)** –1 **(D)** 2

**17.** The given figure is graph of $y = p(x)$ a fourth degree polynomial in $x$:
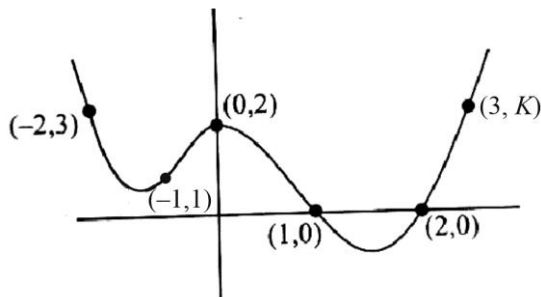


The product of all the imaginary roots of $p(x) = 0$ is $\lambda$, then $\lambda + K$ is:

**(A)** 20 **(B)** $\dfrac{221}{11}$ **(C)** $\dfrac{222}{11}$ **(D)** 21

**18.** The least distance of the line $8x - 4y + 73 = 0$ from the circle $16x^2 + 16y^2 + 48x - 8y - 43 = 0$ is:

**(A)** $\dfrac{\sqrt{5}}{2}$ **(B)** $2\sqrt{5}$ **(C)** $3\sqrt{5}$ **(D)** $4\sqrt{5}$

**19.** If a variable $X$ takes values 0, 1, 2, …. $n$ with frequencies proportional to the binomial coefficients

$^nC_0, {}^nC_1, {}^nC_2, ..., {}^nC_n$, then var($X$) is:

**(A)** $\dfrac{n^2 - 1}{12}$ **(B)** $\dfrac{n^2}{2}$ **(C)** $\dfrac{n}{4}$ **(D)** $\dfrac{n^2 + n + 1}{4}$

**20.** If $X = \{8^n - 7^n - 1 : n \in N\}$ and $Y = \{7n : n \in N\}$, then set $X - Y$ contains

**(A)** No element **(B)** One element

**(C)** Two elements **(D)** Infinitely many elements

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**SPACE FOR ROUGH WORK**

# SECTION-2

**Section 2 contains 10 Numerical Value Type Questions Out of which ONLY 5 (any) questions have to be attempted.**
The answer to each question should be **rounded off to the nearest integer**.

1. Seven people leave their bags outside temple and returning after worshiping picked one bag each at random. In how many ways at least one and at most three of them get their correct bags?

2. Coefficient of $x$ in the expansion of $\left(1 - 2x^3 + 3x^5\right) \times \left(1 + \dfrac{1}{x}\right)^8$ is:

3. If '$m$' and '$M$' represents the least and greatest values of the function $f(\theta) = \dfrac{1}{2\cos 2\theta - 4\cos\theta + 6}$, then $\dfrac{M}{m}$ is:

4. If $\dfrac{\sin\alpha}{\sin\beta} = \dfrac{\cos\gamma}{\cos\delta}$, then $\dfrac{\sin\left(\dfrac{\alpha-\beta}{2}\right)\cdot\cos\left(\dfrac{\alpha+\beta}{2}\right)\cdot\cos\delta}{\sin\left(\dfrac{\delta-\gamma}{2}\right)\cdot\sin\left(\dfrac{\delta+\gamma}{2}\right)\cdot\sin\beta}$ is equal to:

5. Three families of lines are:

   $2x + 3y + 1 + k_1\left(2x + 4y + 4\right) = 0,$

   $\left(3 + 6\tan\theta\right)x + \left(4 + 4\tan\theta\right)y + 4 + \tan\theta = 0$

   $\left(x + y + \lambda\right) + k_3\left(2x + y + 1\right) = 0$

   The value of $\lambda$ so that three families have a common member is $\dfrac{K}{19}$. Find $K$

6. The greatest integral value of a such that $\sqrt{9 - a^2 + 2ax - x^2} \geq \sqrt{16 - x^2}$ for at least one positive value of $x$ is:

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**SPACE FOR ROUGH WORK**

**7.** Square of the area of the triangle formed by end points of a focal chord $PQ$ of length 32 units of the parabola $y^2 = 8x$ and its vertex is:

**8.** A triangle is formed by the points $A(0, 0)$, $B(3, 0)$ and $C(3, 4)$. $A$ and $C$ are foci of ellipse and $B$ lies on the ellipse. If area of ellipse is $\dfrac{7\pi}{2}\sqrt{P}\left(P \in N\right)$, then the value of $P$ is:

**9.** If a function $f(x) = ax^3 + bx^2 + cx + d$, where $a$, $b$, $c$ and $d$ are integers and $a > 0$, is such that $f\left(\sin \dfrac{\pi}{18}\right) = 0$, then the smallest possible value of $f(1)$ is:

**10.** It is given that complex numbers $z_1$ and $z_2$ satisfy $|z_1| = 2$ and $|z_2| = 3$. If the included angle of their corresponding vectors is $60°$ then $\left|\dfrac{z_1 + z_2}{z_1 - z_2}\right|$ can be expressed on $\dfrac{\sqrt{N}}{7}$ where N is natural number then $N$ equals _____.

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**SPACE FOR ROUGH WORK**

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