SAMPLE CONTENT

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# MHT-CET

## 10 FULL MOCK TESTS with Solutions

Physics | Chemistry | Mathematics

- 10 Full-length practice papers
- Smart keys:
  - Shortcut
  - Thinking Hatke
  - Caution
- Self-Assessment Score Card

For MHT-CET EXAM 2025

Based on latest paper pattern

Target Publications® Pvt. Ltd.

Written in accordance with the latest MHT-CET Paper Pattern prescribed by
State Common Entrance Test Cell, Maharashtra State

Academic ace

# MHT-CET

# 10 FULL MOCK TESTS *with Solutions*

**PHYSICS | CHEMISTRY | MATHEMATICS**

## Salient Features

- **10 Full-Length Practice Papers**
  - A complete set of 10 question papers covering Physics, Chemistry and Mathematics
  - Designed in line with the latest MHT-CET exam pattern
- **Comprehensive Solutions**
  - Detailed solutions are provided for challenging Multiple Choice Questions (MCQs)
  - Solutions are crafted to ensure easy comprehension, with special focus on complex questions
- **Smart Keys to Enhance Learning and Problem-Solving Skills**
  - *Shortcut* - *Caution* - *Thinking Hatke*
- **Self-Assessment Score Card**
  - Scorecards for tracking progress with each paper
  - Enables self-evaluation after every paper to identify areas needing improvement

Printed at: **Print to Print,** Mumbai



Balbharati Registration No.: 2018MH0022 P.O. No. 15185

TEID: 4399

# PREFACE

In the ever-evolving journey of education, where curiosity shapes dreams and knowledge paves the way, we are excited to introduce **'MHT-CET: Full Mock Tests with Solutions (PCM)' -** a gateway to testing your readiness. This book is thoughtfully curated to evaluate the depth of understanding accumulated by students over two years of junior college.

Designed to reflect the rigor and scope of the MHT-CET examination, this collection of Mock Tests is your essential companion. Each test is crafted in harmony with the official exam pattern, ensuring comprehensive coverage of the core concepts in **Physics, Chemistry** and **Mathematics.**

To aid students, detailed solutions are provided to difficult MCQs. **Smart Keys** (Shortcut, Caution and Thinking Hatke) are provided, which offer supplemental explanations for the tricky questions and are intended to help students approaching problems in novel ways in the shortest possible time with accuracy.

*Smart Keys*

- **Shortcut** incorporates important theoretical or formula based short tricks, beneficial in solving MCQs.
- **Caution** apprises students about mistakes often made while solving MCQs.
- **Thinking Hatke** reveals quick witted approach to crack the specific question.

The book features a **Self-Assessment Score Card** at the end, thoughtfully designed to help you collectively record and evaluate your scores across all 10 mock tests for comprehensive self-evaluation.

We hope that this book will enable students to optimize their time-management abilities to achieve high scores in the examination.

They say, *'With the right tools, even ordinary men achieve extraordinary results'*. This book is designed to be the perfect tool that will help students to launch their careers in the most extraordinary way possible.

Publisher
**Edition:** First

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.

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# MHT-CET PAPER PATTERN

- There will be three papers of Multiple Choice Questions (MCQs) in 'Mathematics', 'Physics and Chemistry' and 'Biology' of 100 marks each.
- Duration of each paper will be 90 minutes.
- Questions will be based on Syllabus of State Council of Educational Research and Training, Maharashtra with approximately 20% weightage given to Std. XI and 80% weightage will be given to Std. XII curriculum.
- Difficulty level of questions will be at par with JEE (Main) for Mathematics, Physics, Chemistry and at par with NEET for Biology.
- There will be no negative marking.
- Questions will be mainly application based.
- Details of the papers are as given below:

| Paper | Subject(s) | No. of MCQs based on | | Mark(s) Per Question | Total Marks | Duration in Minutes |
|---|---|---|---|---|---|---|
| | | Std XI | Std XII | | | |
| Paper I | Mathematics | 10 | 40 | 2 | 100 | 90 |
| Paper II | Physics | 10 | 40 | 1 | 100 | 90 |
| | Chemistry | 10 | 40 | | | |
| Paper III | Biology | 20 | 80 | 1 | 100 | 90 |

- Questions will be set on
  i. the entire syllabus of Std. XII of Physics, Chemistry, Mathematics and Biology subjects prescribed by State Council of Educational Research and Training, Maharashtra and
  ii. chapters / units from Std. XI curriculum as mentioned below:

| Sr.no | Subject | Chapters/Units of Std. XI |
|---|---|---|
| 1 | Physics | Motion in a Plane, Laws of Motion, Gravitation, Thermal Properties of Matter, Sound, Optics, Electrostatics, Semiconductors |
| 2 | Chemistry | Some Basic Concepts of Chemistry, Structure of Atom, Chemical Bonding, Redox Reactions, Elements of Group 1 and Group 2, States of Matter (Gaseous and Liquid States), Adsorption and Colloids (Surface Chemistry), Hydrocarbons, Basic Principles of Organic Chemistry |
| 3 | Mathematics | Trigonometry II, Straight Line, Circle, Measures of Dispersion, Probability, Complex Numbers, Permutations and Combinations, Functions, Limits, Continuity |
| 4 | Biology | Biomolecules, Respiration and Energy Transfer, Human Nutrition, Excretion and Osmoregulation |

- **Language of Question Paper:**
  The medium for examination shall be English / Marathi / Urdu for Physics, Chemistry and Biology. Mathematics paper shall be in English only.

- **Duration of Online Computer Based Test (CBT):**
  The duration of the examination for PCB is 180 minutes and PCM is 180 minutes.
  a. **For PCM -** This paper is having 2 Groups of Physics-Chemistry and Mathematics with total 180 Minutes Duration, first 90 minutes Physics and Chemistry will be enabled and only after completion of first 90 minutes' time Physics-Chemistry group will be auto submitted and Mathematics group will be enabled with 90 minutes' duration.
  b. **For PCB -** This paper is having 2 Groups of Physics-Chemistry and Biology with total 180 Minutes Duration, first 90 minutes Physics and Chemistry will be enabled and only after completion of time response for Physics-Chemistry group will be auto submitted and Biology group will be enabled with 90 minutes' duration.

**[Note :** Candidate should note that if he/she appearing for both the groups i.e. PCM and PCB, the Percentile / Percentage score of Physics or Chemistry will not be interchanged among the groups.**]**

# INDEX

# 01 MHT-CET MOCK TEST

Time: 180 Minutes | Physics, Chemistry and Mathematics | Total Marks: 200

Physics and Chemistry

Time: 90 Minutes | Total Marks: 100

## PHYSICS

**1.** In a diesel engine the cylinder compresses air from S.T.P. to about $\frac{1}{14}$ the original volume and a pressure of 40 atmosphere. The temperature of compressed air is
(A) 780 K (B) 580 K
(C) 853 K (D) 1126 K

**2.** When a particle carrying a charge of 100 μC moves at an angle 30° to a uniform magnetic field of induction $6 \times 10^{-5}$ Wb/m$^2$ with a speed of $2 \times 10^5$ m/s. The force acting on the particle is
(A) $6 \times 10^{-4}$ N (B) $10^{-3}$ N
(C) $2 \times 10^{-4}$ N (D) $10^{-4}$ N

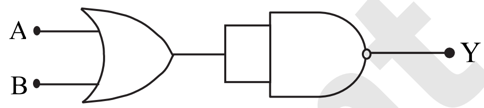
**3.** The magnetic susceptibility is given by
(A) $\chi = \frac{1}{H}$ (B) $\chi = \frac{B}{H}$
(C) $\chi = \frac{M_{net}}{V}$ (D) $\chi = \frac{M_z}{H}$

**4.** The coefficient of self inductance of a solenoid is 0.20 mH. If a core of soft iron of relative permeability 900 is inserted, then the coefficient of self inductance will become nearly
(A) 1.8 mH (B) 180 mH
(C) 0.018 mH (D) 0.18 mH

**5.** An alternating voltage $e = 200\sqrt{2}\sin(100\ t)$ volt is connected to 1 μF capacitor through a.c. ammeter. The reading of ammeter is
(A) 5 mA (B) 10 mA
(C) 15 mA (D) 20 mA

**6.** The radius of the orbit of a geostationary satellite is (mean radius of earth is 'R', angular velocity about own axis is 'ω' and acceleration due to gravity on earth's surface is 'g')
(A) $\left(\frac{gR^2}{\omega^2}\right)^{\frac{1}{3}}$ (B) $\left(\frac{gR^2}{\omega^2}\right)^{\frac{2}{3}}$
(C) $\left(\frac{gR^2}{\omega^2}\right)^{\frac{1}{2}}$ (D) $\frac{gR^2}{\omega^2}$

**7.** The following logic circuit is equivalent to

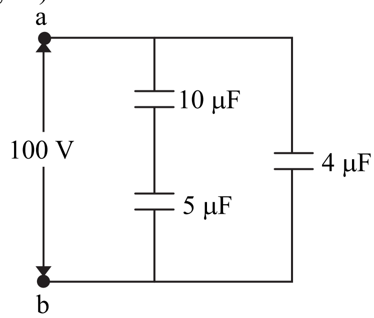



(A) AND gate (B) NAND gate
(C) NOR gate (D) OR gate

**8.** The phase difference between the following two waves $y_2$ and $y_1$ is:
$y_1 = a\sin(\omega t - kx)$
$y_2 = b\cos\left(\omega t - kx + \frac{\pi}{3}\right)$
(A) $\frac{\pi}{6}$ (B) $\frac{5\pi}{6}$
(C) $\frac{\pi}{3}$ (D) $\pi$

**9.** A particle is executing a simple harmonic motion. Its maximum acceleration is α and maximum velocity is β. Then, its time period of vibration will be
(A) $\frac{2\pi\beta}{\alpha}$ (B) $\frac{\beta^2}{\alpha^2}$ (C) $\frac{\alpha}{\beta}$ (D) $\frac{\beta^2}{\alpha}$

**10.** The charge on the capacitor of capacitance 4μF in the circuit (figure) is




(A) 300 μC
(B) 100 μC
(C) 200 μC
(D) 400 μC

**11.** A person travelling in a straight line moves with a constant velocity $v_1$ for certain distance 'x' and with a constant velocity $v_2$ for next equal distance. The average velocity v is given by the relation.
(A) $v = \sqrt{v_1 v_2}$ (B) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
(C) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$ (D) $\frac{v}{2} = \frac{v_1 + v_2}{2}$

**12.** A green light is incident from the water to the air-water interface at the critical angle (θ). Select the correct statement
(A) The entire spectrum of visible light will come out of the water at an angle of 90° to the normal.
(B) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium.
(C) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.
(D) The entire spectrum of visible light will come out of the water at various angles to the normal.

**13.** A water-proofing agent changes the angle of contact
(A) from obtuse to acute.
(B) from acute to obtuse.
(C) from obtuse to π/2.
(D) from acute to π/2.

**14.** Among the amount of heat absorbed and the amount of work done by a system,
(A) both depend on only its initial and final states, but not on path.
(B) the first depends on the path but the latter depends only on the initial and final states.
(C) the first only depends on initial and final states but the second, on the path.
(D) both depend on the path.

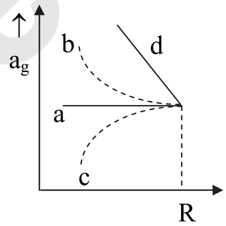
**15.** In Young's double slit experiment, in an interference pattern, second minimum is observed exactly in front of one slit. The distance between the two coherent sources is 'd' and the distance between source and screen is 'D'. The wavelength of light source used is
(A) $\frac{d^2}{D}$ (B) $\frac{d^2}{2D}$
(C) $\frac{d^2}{3D}$ (D) $\frac{d^2}{4D}$

**16.** A toroid has a core (non-ferromagnetic) of inner radius 25 cm and outer radius 26 cm, around which 2,000 turns of a wire are wound. If the current in the wire is 10 A, the magnetic field inside the core of the toroid will be
(A) $31.4 \times 10^{-2}$ T (B) $31.4 \times 10^{-3}$ T
(C) $15.7 \times 10^{-2}$ T (D) $15.7 \times 10^{-3}$ T

**17.** Lenz's law obeys the principle of _______ conservation.
(A) charge. (B) momentum.
(C) mass. (D) energy.

**18.** In an LC circuit
(A) The energy stored in L as well as in C is magnetic energy
(B) The energy stored in L is magnetic but in C it is electrical.
(C) The energy stored in L is electrical but in C it is magnetic.
(D) The energy stored in L as well as in C is electrical energy

**19.** A (non-rotating) star collapses onto itself from an initial radius $R_i$, its mass remaining unchanged. Which curve in the figure best gives the gravitational acceleration $a_g$ on the surface of the star as a function of radius of star during collapse?
(A) a
(B) b
(C) c
(D) d



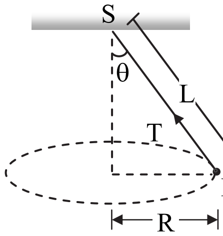

**20.** In the case of insulators, a band gap and conduction band is respectively
(A) very high, empty.
(B) very low, partially filled
(C) very high, completely filled
(D) very low, empty.

**21.** **Assertion:** Two points in adjacent loops of a string wave in the case of standing wave formation attain their maximum kinetic energy simultaneously.
**Reason:** The two points in the adjacent loops of standing wave are out of phase exactly by π.
(A) Assertion is true and Reason is correct explanation of Assertion.
(B) Assertion is true and Reason is false
(C) Assertion and Reason both are false
(D) Assertion is false but Reason is true.

**22.** The total energy of the body executing S.H.M. is E. The kinetic energy of the body, when the displacement is half of the amplitude is
(A) $\frac{E}{2}$ (B) $\frac{E}{4}$
(C) $\frac{3E}{4}$ (D) $\sqrt{\frac{3}{4}}E$

**23.** A string of length L is fixed at one end and carries a mass M at the other end. The string makes $2/\pi$ revolutions per second around the vertical axis through the fixed end as shown in the figure, then tension in the string is

(A) ML
(B) 2 ML
(C) 4 ML
(D) 16 ML

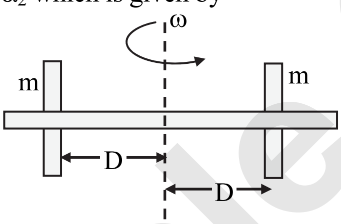



**24.** Three capacitors of capacity $C_1$, $C_2$, $C_3$ in ratio 1 : 3 : 5, are connected in series. The charges on these capacitors will be in ratio

(A) 1 : 3 : 5 (B) $1 : \frac{1}{3} : \frac{1}{5}$
(C) 1 : 1 : 1 (D) 1 : 9 : 25

**25.** Two identical masses are connected to a horizontal thin (massless) rod as shown in the figure. When their distance from the pivot is D, a torque $\tau$ produces an angular acceleration of $\alpha_1$. The masses are now repositioned so that they are 2D from the pivot. The same torque produces an angular acceleration $\alpha_2$ which is given by

(A) $\alpha_2 = 4\alpha_1$
(B) $\alpha_2 = \alpha_1$
(C) $\alpha_2 = \frac{1}{2}\alpha_1$
(D) $\alpha_2 = \frac{1}{4}\alpha_1$




**26.** A cylindrical tube open at both ends, has a fundamental frequency f in air. The tube is dipped vertically into water such that half of its length is inside water. The fundamental frequency of the air column now is

(A) $\frac{f}{2}$ (B) f (C) 3f/4 (D) 2f

**27.** When light falls on a metal surface, the maximum kinetic energy of the emitted photo-electrons depends upon

(A) the time for which light falls on the metal.
(B) frequency of the incident light.
(C) intensity of the incident light.
(D) velocity of the incident light.

**28.** Point masses of 2 kg, 3 kg, 5 kg and 7 kg are placed at the corners of a square ABCD respectively whose each side is 1 m long. The position of the centre of mass of the system is

(A) $\frac{14}{17}$ m, $\frac{8}{17}$ m (B) $\frac{12}{17}$ m, $\frac{10}{17}$ m
(C) $\frac{15}{17}$ m, $\frac{10}{17}$ m (D) $\frac{12}{17}$ m, $\frac{8}{17}$ m

**29.** Which of the following statements is incorrect?

(A) For $\theta < 90°$, shape of liquid meniscus is concave
(B) For $\theta = 90°$, shape of liquid meniscus is plane
(C) For $\theta > 90°$, shape of liquid meniscus is convex
(D) For $\theta = 90°$, the liquid wets the solid surface

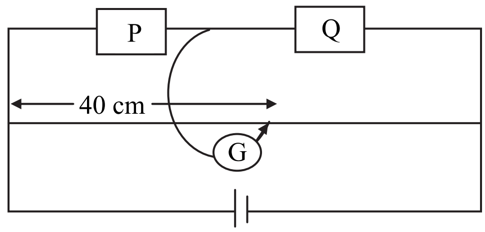
**30.** Total random kinetic energy of the one molecule of a gas at a temperature of 600 K is ($k_B = 1.38 \times 10^{-23}$ J/K)

(A) $6.21 \times 10^{-20}$ J (B) $3.28 \times 10^{-24}$ J
(C) $1.24 \times 10^{-20}$ J (D) $4.2 \times 10^{-21}$ J

**31.** When a 10 μC charge is enclosed by a closed surface, the flux passing through the surface is $\phi$. Now another 10 μC charge is placed inside the closed surface, then the flux passing through the surface is ________.

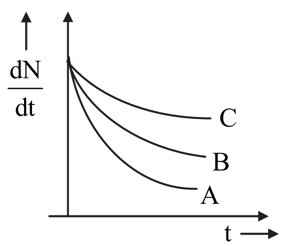
(A) $4\phi$ (B) $\phi$
(C) $2\phi$ (D) zero

**32.** In a metre bridge, the gaps are closed by two resistances P and Q and the balance point is obtained at 40 cm. When Q is shunted by a resistance of 10 Ω, the balance point shifts to 50 cm. The values of P and Q are




(A) (10/3) Ω, 5 Ω (B) 20 Ω, 30 Ω
(C) 10 Ω, 15 Ω (D) 5 Ω, (15/2) Ω

**33.** Which one of the following nuclei has shorter mean life?




(A) C (B) A
(C) Same for all (D) B

**34.** The momentum of a photon of energy 1 MeV in kg m/s will be

(A) $5 \times 10^{-22}$ (B) $0.33 \times 10^{6}$
(C) $7 \times 10^{-24}$ (D) $10^{-22}$

**35.** The ratio of densities of nitrogen and oxygen is 14:16. The temperature at which the speed of sound in nitrogen will be same as that in oxygen at 79 °C is

(A) 35 °C (B) 48 °C
(C) 65 °C (D) 14 °C

**36.** A mercury drop continues to be spherical inside the water which proves that as compared to the adhesive force between water and mercury molecules, the cohesive forces between mercury molecules are

(A) stronger (B) weaker
(C) equal (D) negligible

**37.** Temperature of an ideal gas, initially at 27 °C, is raised by 12 °C. The rms velocity of the gas molecules will,

(A) increase by nearly 2%
(B) decrease by nearly 2%
(C) increase by nearly 1%
(D) decrease by nearly 1%

**38.** An object is kept in front of a concave mirror of focal length 15 cm. The image formed is three times the size of the object. The two possible distances of the object are

(A) u = – 20 cm and u = – 10 cm
(B) u = – 15 cm and u = – 10 cm
(C) u = – 20 cm and u = – 30 cm
(D) u = – 15 cm and u = – 30 cm

**39.** A vertical straight conductor carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west at the same distance. The magnetic field at P is

(A) greater than at Q.
(B) same as at Q.
(C) less than at Q.
(D) greater or less than at Q depending upon the strength of the current.

**40.** Gyromagnetic ratio of the electron revolving in a circular orbit of hydrogen atom is $8.8 \times 10^{10}$ C $kg^{-1}$. What is the mass of the electron? (Given charge of the electron $= 1.6 \times 10^{-19}$ C.)

(A) $1 \times 10^{-29}$ kg (B) $0.1 \times 10^{-29}$ kg
(C) $1.1 \times 10^{-29}$ kg (D) $\frac{1}{11} \times 10^{-29}$ kg

**41.** In an A.C. circuit, peak value of voltage is 320 volt. Its effective voltage is

(A) 220 volt (B) 160 volt
(C) 320 volt (D) 226 volt

**42.** When a gas is heated at constant pressure, its volume changes and hence

(A) less heat is required when the same gas is heated at constant volume under similar conditions.
(B) more heat is required when the same gas is heated at constant volume under similar conditions.
(C) same heat is required, when the same gas is heated at constant volume under similar conditions.
(D) half of the heat is required when same gas is heated at constant volume under similar conditions.

**43.** Solar cell is based on the principle of

(A) formation of electron-hole pairs with incident light.
(B) formation of electron-hole pairs with heating.
(C) formation of electron-hole pairs with potential.
(D) all of these

**44.** A vibrating tuning fork produces concentric circular waves on the surface of water. The distance between 11 crests is 1 m and the velocity of the wave on the surface of water is 30 m/s. The frequency of the tuning fork is

(A) 200 Hz (B) 250 Hz
(C) 300 Hz (D) 400 Hz

**45.** The resultant amplitude of two waves $y_1 = a \sin(\omega t + \pi/6)$ and $y_2 = a \cos \omega t$ will be

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

**46.** The radius of gyration of a thin rod of mass 100 gm and length 1 m about an axis passing through its centre of gravity and perpendicular to its length is

(A) $\frac{1}{2\sqrt{3}}$ m (B) $\frac{1}{6\sqrt{2}}$ m
(C) $\frac{1}{3\sqrt{2}}$ m (D) $\frac{1}{4\sqrt{3}}$ m

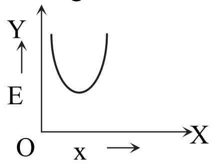
**47.** Match List – I with List – II.

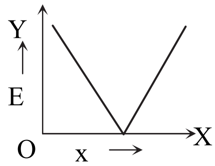
| | List – I | | List – II |
|---|---|---|---|
| i. | Radius of Bohr orbit | a. | Directly proportional to $n^3$ |
| ii. | Velocity of electron in Bohr orbit | b. | Inversely proportional to $n^2$ |
| iii. | Period of revolution of electron in Bohr orbit | c. | Directly proportional to $n^2$ |
| iv. | Energy of electron in Bohr orbit | d. | Inversely proportional to n |

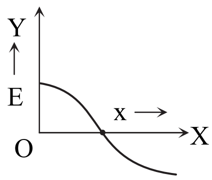
Where, n is the principal quantum number.

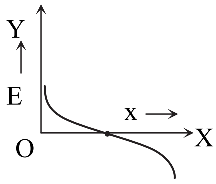
(A) (i – d), (ii – a), (iii – b), (iv – c)
(B) (i – a), (ii – c), (iii – d), (iv – c)
(C) (i – b), (ii – d), (iii – a), (iv – c)
(D) (i – c), (ii – d), (iii – a), (iv – b)

**48.** Two identical point charges are placed at a separation of d. P is a point on the line joining the charges, at a distance x from any one of the charges. The field at P is E. E is plotted against x for values of x from close to zero to slightly less than d. Which of the following represents the resulting curve?

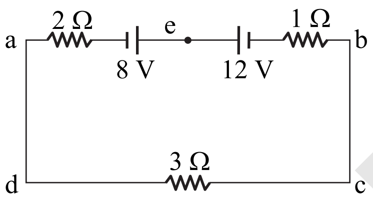
(A) 


(B) 


(C) 


(D) 


**49.** The magnitude and direction of the current in the circuit shown will be




(A) $\frac{2}{3}$ A from a to b through e.
(B) $\frac{2}{3}$ A from b to a through e.
(C) 3 A from b to a through e.
(D) $\frac{10}{3}$ A from a to b through e.

**50.** If the radius of the innermost Bohr orbit is 0.53 Å, the radius of the $4^{th}$ orbit is
(A) 8.48 Å (B) 16 Å
(C) 81 Å (D) 4 Å

## CHEMISTRY

**1.** Identify the last step in wet chemical synthesis of nanomaterial.
(A) Formation of oxide or alcohol-bridged network
(B) Dehydration
(C) Aging of the gel
(D) Drying of the gel

**2.** Which of the following is a mixed ketone?
(A) Pentan-3-one (B) Acetone
(C) Benzophenone (D) Butanone

**3.** The number of moles of chlorine required to oxidise 1 mol of sulfur dioxide to sulfur trioxide in presence of water is ______.
(A) 1 (B) 1.5
(C) 2 (D) 3

**4.** What is the expected value of $\Delta T_f$ for 1 m NaCl solution if 1 m glucose solution has $\Delta T_f$ value x K?
(A) 2x K (B) xK
(C) $\frac{x}{2}$ K (D) 3x K

**5.** What is the molar mass of the amine formed when acetamide undergoes Hofmann bromamide degradation?
(A) 31 g/mol (B) 35 g/mol
(C) 45 g/mol (D) 59 g/mol

**6.** What is the product of the following reaction?
$CH_3 - CH_2 - CH_2 - OH \xrightarrow[\Delta]{conc.H_2SO_4}$
(A) Ethene (B) Propene
(C) But-1-ene (D) But-2-ene

**7.** The three electrons have the following set of quantum numbers:

$X = 6, 1, -1, +\frac{1}{2}$ $Y = 6, 0, 0, +\frac{1}{2}$

$Z = 5, 1, 0, +\frac{1}{2}$

Identify the CORRECT statement.
(A) Y and Z have same energy.
(B) Y has greater energy than X.
(C) Z has greater energy than X and Y.
(D) X has greater energy than Y and Z.

**8.** The number of particles in 1 g of a metallic crystal is equal to _______.
(A) $\frac{1}{\rho a^3}$ (B) $\frac{n}{\rho a^3}$
(C) $\frac{n^2}{\rho a^3}$ (D) $\frac{a^3 N_A}{n}$

**9.** At a certain temperature, the solubility product of MX is $6.4 \times 10^{-5}$. The solubility of salt in mol $L^{-1}$ is _______.
(A) $8 \times 10^{-5}$ (B) $8 \times 10^{-2}$
(C) $8 \times 10^{-3}$ (D) $8 \times 10^{-4}$

**10.** How many of the following molecules have non-zero dipole moments?
HBr, $CO_2$, $NF_3$, $CH_4$, $H_2S$, $CHCl_3$, $F_2$.
(A) 2 (B) 3
(C) 4 (D) 5

**11.** What is the entropy change (in $JK^{-1}mol^{-1}$) when one mole of ice is converted into water at 0 °C? (The enthalpy change for the conversion of ice to liquid water is 6.0 kJ $mol^{-1}$ at 0 °C)
(A) 21.98 (B) 20.13
(C) 2.013 (D) 2.198

**12.** What is the density of a crystal if an element having bcc structure and edge length of unit cell 400 pm? (Molar mass of element = 170 g $mol^{-1}$)
(A) 6.6 g $cm^{-3}$ (B) 7.7 g $cm^{-3}$
(C) 8.8 g $cm^{-3}$ (D) 9.4 g $cm^{-3}$

**13.** What is the oxidation number of underlined species in $\underline{P}F_6^-$ and $\underline{V}_2O_7^{-4}$ ions respectively?
(A) +5 and −5 (B) 5 and +5
(C) −5 and +5 (D) 3 and +3

**14.** The standard electrode potential (E°) values of $Al^{3+}/Al$, $Au^{3+}/Au$ and $Pb^{2+}/Pb$ are −1.66 V, 1.50 V and −0.126 V, respectively. The CORRECT increasing order of reducing power of the metal is:
(A) Au < Pb < Al (B) Pb < Au < Al
(C) Au < Al < Pb (D) Al < Pb < Au

**15.** The vacant space in simple cubic lattice is ______.
(A) 68% (B) 52.36%
(C) 32% (D) 47.64%

**16.** In how many of the following, ΔS is positive?
i. Melting of ice
ii. Sublimation of iodine
iii. Dissolution of $CuSO_4$ in water
iv. Condensation of water vapour
v. Dissociation of $H_2$ molecule into atoms
vi. Conversion of carbon dioxide gas to dry ice
vii. Vaporization of acetone
(A) 2 (B) 3
(C) 4 (D) 5

**17.** **Statement I:** Ionic radii of transition elements are larger than ionic radii of representative elements of same period.
**Statement II:** Transition elements are more electropositive than elements of group 1 and group 2.
Choose the most appropriate 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.

**18.** Identify the reagent used in the following reaction:
$CH_3 - CH_2 - Br \xrightarrow{?} CH_3 - CH_2 - OH$
(A) Pyridine
(B) $Ag_2O/ H_2O$
(C) NaBr + $H_2SO_4$
(D) $ZnCl_2$

**19.** Which of the following polymers is used in the manufacture of lenses and LCD screens?
(A) Perspex
(B) Polycarbonate
(C) Glyptal
(D) Polyacrylamide

**20.** The energy difference between $t_{2g}$ and $e_g$ level in an octahedral crystal field is _______.
(A) 4 Dq (B) 6 Dq
(C) 8 Dq (D) 10 Dq

**21.** Cumene is used in the commercial method for the manufacture of _______.
(A) phenol
(B) ethanol
(C) dimethyl ether
(D) methanol

**22.** Identify $EO_2$ type oxide of group 16 elements from following.
(A) $SeO_3$ (B) $SO_3$
(C) $O_3$ (D) $TeO_3$

**23.** Which of the following statements is CORRECT?
(A) The oil in water emulsion is miscible with oil.
(B) The water in oil emulsion is miscible with water.
(C) The oil in water emulsion can be diluted with water.
(D) Electrical conductance of water in oil emulsion increases on addition of small amount of electrolyte.

**24.** If molality of the dilute solution is doubled, the value of molal depression constant ($K_f$) will be _______.
(A) halved (B) tripled
(C) unchanged (D) doubled

**25.** Which of the following statements are CORRECT for NICAD cell and mercury battery?

I. Both can be recharged.
II. Both cannot be recharged.
III. Both are secondary voltaic cells.
IV. Both cells work using an acidic electrolyte.

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

**26.** Which of the following represents the structure of isopropyl methyl ketone?

(A) $CH_3 - CH_2 - CH_2 - \overset{\overset{O}{\|}}{C} - CH_3$

(B) $CH_3 - \underset{\underset{CH_3}{|}}{CH} - \overset{\overset{O}{\|}}{C} - CH_3$

(C) $CH_3 - CH_2 - \overset{\overset{O}{\|}}{C} - CH_2 - CH_3$

(D) $CH_3 - CH_2 - CH_2 - CH_2 - \overset{\overset{O}{\|}}{C} - H$

**27.** How many amino acids are linked together by $(n-1)$ amide bonds?

(A) $n-1$ (B) $n$
(C) $n+1$ (D) $2n$

**28.** Calculate the pH of buffer solution containing 0.2 M acetic acid and 0.5 M acetate ion. ($pK_a$ for $CH_3COOH$ = 4.744)

(A) 2.08 (B) 2.60
(C) 3.95 (D) 5.14

**29.** Which of the following is CORRECT for the atomic and ionic radii of alkali metals?

(A) $Li^+$ is larger than Li
(B) Li is smaller than Na
(C) Na is smaller than $Na^+$
(D) K is smaller than Na

**30.** Which of the following is CORRECT for a salt of weak acid and weak base?

(I) If $K_a = K_b$, the solution is neutral.
(II) If $K_a > K_b$, the solution is basic.
(III) If $K_a < K_b$, the solution is acidic.

(A) Only (I)
(B) Both (I) and (II)
(C) Both (II) and (III)
(D) Only (III)

**31.** Acetone + Methyl magnesium iodide $\xrightarrow[\text{ii. HOH/H}^+]{\text{i. Dry ether}}$ P

'P' in above reaction is _______.

(A) 2-methylpropan-1-ol
(B) butan-2-ol
(C) 2-methylpropan-2-ol
(D) propan-2-ol

**32.** Identify the CORRECT statement about d block elements.

(A) They are good oxidizing agents.
(B) They exhibit variable valencies.
(C) They form water soluble oxides and hydroxides.
(D) They are poor electrical and thermal conductors.

**33.** The molar conductivities at zero concentration for $Ca^{2+}$ and $CaCl_2$ are 104 and 256.8 $\Omega^{-1}$ $cm^2$ $mol^{-1}$ respectively. The molar conductivity at zero concentration for $Cl^-$ is _______.

(A) 76.4 $\Omega^{-1}$ $cm^2$ $mol^{-1}$
(B) 152.8 $\Omega^{-1}$ $cm^2$ $mol^{-1}$
(C) 180.4 $\Omega^{-1}$ $cm^2$ $mol^{-1}$
(D) 305.6 $\Omega^{-1}$ $cm^2$ $mol^{-1}$

**34.** Identify the product 'B' in the following reaction.

Benzamide $\xrightarrow{Br_2/KOH}$ A $\xrightarrow[298K]{Br_2 \text{ water}}$ B

(A) 2,4,6-Tribromoaniline
(B) 4-Bromoacetanilide
(C) 4-Bromoaniline
(D) 2-Bromoaniline

**35.** The products of the following reaction are ______.

$CH_{4(g)} + H_2O_{(g)} \xrightarrow[Ni]{1270K}$

(A) $CO_2$ and $H_2$
(B) $CO_2$, $O_2$ and $H_2$
(C) CO and $H_2$
(D) CO, $O_2$ and $H_2$

**36.** The CORRECT decreasing order for the stability of carbanion is_______.

(A) $CH \equiv \bar{\ddot{C}} > CH_2 = \bar{\ddot{C}}H > CH_3 - \bar{\ddot{C}}H_2$

(B) $CH_2 = \bar{\ddot{C}}H > CH \equiv \bar{\ddot{C}} > CH_3 - \bar{\ddot{C}}H_2$

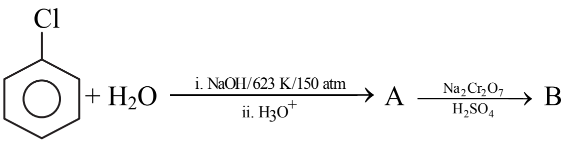
(C) $CH_3 - \bar{\ddot{C}}H_2 > CH_2 = \bar{\ddot{C}}H > CH \equiv \bar{\ddot{C}}$

(D) $CH_3 - \bar{\ddot{C}}H_2 > CH \equiv \bar{\ddot{C}} > CH_2 = \bar{\ddot{C}}H$

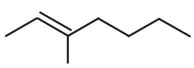
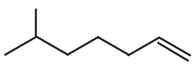
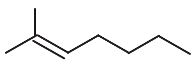
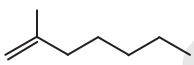
**37.** Sea water is a homogeneous mixture of _______ type of solution.
(A) solid in solid
(B) solid in gas
(C) solid in liquid
(D) gas in solid

**38.** Find increase in temperature for a gas when first its pressure and then volume both are doubled at 400 K.
(A) 400 K (B) 800 K
(C) 1200 K (D) 1600 K

**39.** Identify 'A' and 'B' in the following series of reactions.




(A) A ⇒ Phenol, B ⇒ Salicyclic acid
(B) A ⇒ Benzoic acid, B ⇒ Benzene
(C) A ⇒ Benzaldehyde, B ⇒ Benzoquinone
(D) A ⇒ Phenol, B ⇒ Benzoquinone

**40.** A + HBr $\xrightarrow{\text{Peroxide}}$ 1-Bromo-2-methylheptane.
Identify A.
(A)

(B)

(C)

(D)


**41.** The total number of electrons present in 20 mL of water is _______. (Density = 1 g $mL^{-1}$)
(A) $6.684 \times 10^{24}$
(B) $6.022 \times 10^{24}$
(C) $4.684 \times 10^{23}$
(D) $1.022 \times 10^{24}$

**42.** $S + \frac{3}{2}O_2 \longrightarrow SO_3 + 2x \text{ kcal}$ ….(i)

$SO_2 + \frac{1}{2}O_2 \longrightarrow SO_3 + y \text{ kcal}$ ….(ii)

The heat of formation of $SO_2$ is _______.
(A) $2x - y$ (B) $2x + y$
(C) $x + y$ (D) $y - 2x$

**43.** A reaction proceeds in three steps. The first step is a fast reaction and is a first order reaction. The second step is slow and is a second order reaction. The third step is a fast and is a second order reaction. The reaction is of _______ order.
(A) first (B) second
(C) fifth (D) zero

**44.** Identify the pair of elements from following so that both members of it exhibit same value of calculated magnetic moment in their respective oxidation states.
(A) $Zn^{2+}$ and $Cu^{2+}$
(B) $Ti^{3+}$ and $Cu^{2+}$
(C) $Cr^{3+}$ and $Zn^{2+}$
(D) $Sc^{3+}$ and $Cr^{3+}$

**45.** The IUPAC name of pyrogallol is _______.
(A) benzene-1,2,4-triol
(B) benzene-1,2,3-triol
(C) benzene-1,3,5-triol
(D) 3,5-dihydroxybenzoic acid

**46.** Which among the following has the highest boiling point?
(A) $C_2H_5N(CH_3)_2$
(B) n-$C_4H_9NH_2$
(C) $(C_2H_5)_2NH$
(D) $C_2H_5CH(CH_3)_2$

**47.** Which of the following is CORRECT stability order according to Irving-William order?
(A) $Cu^{2+} > Ni^{2+} > Fe^{2+} > Cd^{2+}$
(B) $Cd^{2+} > Ni^{2+} > Fe^{2+} > Cu^{2+}$
(C) $Cu^{2+} > Ni^{2+} > Cd^{2+} > Fe^{2+}$
(D) $Cu^{2+} > Cd^{2+} > Fe^{2+} > Ni^{2+}$

**48.** In a first order reaction, the concentration of the reactant, decreases from 0.8 mol $dm^{-3}$ to 0.4 mol $dm^{-3}$ in 15 minutes. The time taken for the concentration to change from 0.1 mol $dm^{-3}$ to 0.025 mol $dm^{-3}$ is _______.
(A) 60 minutes
(B) 15 minutes
(C) 7.5 minutes
(D) 30 minutes

**49.** What product is formed when $R - C \equiv N$ is hydrolysed?
(A) $R - \underset{\underset{O}{\|}}{C} - OH$ (B) $R - \underset{\underset{O}{\|}}{C} - H$
(C) $R - \underset{\underset{O}{\|}}{C} - R$ (D) $R - \underset{\underset{O}{\|}}{C} - O - R$

**50.** 171 g of sucrose on hydrolysis gives _______ mole(s) of glucose.
(Atomic wt: C = 12, H = 1, O = 16)
(A) 0.5 (B) 1
(C) 1.5 (D) 2

## Mathematics

Time: 90 Minutes

Total Marks: 100

**1.** In Δ ABC, P is the mid point of BC, Q divides CA internally in the ratio 2 : 1 and R divides AB externally in the ratio 1 : 2, then
(A) R divides PQ externally in the ratio 2:1
(B) P,Q, R are collinear
(C) P divides QR externally in the ratio 3:2
(D) Q divides PR internally in the ratio 3:2

**2.** If the line $\frac{x+1}{2} = \frac{y-5}{3} = \frac{z-p}{6}$ lies in the plane $3x - 14y + 6z + 49 = 0$, then the value of p is
(A) 2 (B) 4
(C) 3 (D) –4

**3.** If $A = \begin{bmatrix} 2 & 1 \\ 7 & 4 \end{bmatrix}$ then $\left(A^2 - 5A\right)^{-1}$ is
(A) $\left(-\frac{1}{4}\right)\begin{bmatrix} -3 & 1 \\ 7 & -1 \end{bmatrix}$ (B) $\left(\frac{1}{4}\right)\begin{bmatrix} -3 & 1 \\ 7 & -1 \end{bmatrix}$
(C) $\left(\frac{1}{4}\right)\begin{bmatrix} 3 & 1 \\ 7 & 1 \end{bmatrix}$ (D) $\left(\frac{1}{-4}\right)\begin{bmatrix} 3 & -1 \\ 7 & -1 \end{bmatrix}$

**4.** $\int e^x \frac{(x^2+1)}{(x+1)^2} dx =$
(A) $e^x\left(\frac{x-1}{x+1}\right) + c$ (B) $e^x\left(\frac{x+1}{x-1}\right) + c$
(C) $e^x (x+1)(x-1) + c$ (D) $\frac{e^x}{(x+1)^2} + c$

**5.** The equation of the circle which has its centre at the point (3, 4) and touches the line $5x + 12y - 11 = 0$ is
(A) $x^2 + y^2 - 6x - 8y + 9 = 0$
(B) $x^2 + y^2 - 6x - 8y + 25 = 0$
(C) $x^2 + y^2 - 6x - 8y - 9 = 0$
(D) $x^2 + y^2 - 6x - 8y - 25 = 0$

**6.** The acute angle between $\bar{r} = \left(-\hat{i} + 3\hat{k}\right) + \lambda\left(2\hat{i} + 3\hat{j} + 6\hat{k}\right)$ and $\bar{r} \cdot \left(10\hat{i} + 2\hat{j} - 11\hat{k}\right) = 3$ is
(A) $\sin^{-1}\left(\frac{8}{21}\right)$ (B) $\cos^{-1}\left(\frac{8}{21}\right)$
(C) $\sin^{-1}\left(\frac{5}{21}\right)$ (D) $\cos^{-1}\left(\frac{5}{21}\right)$

**7.** Inverse of the function $y = 5 - 10x$ is
(A) $\frac{5-x}{10}$ (B) $\frac{x-5}{10}$
(C) $\frac{1}{5-10x}$ (D) $\frac{5}{x+3}$

**8.** If $y = \sin^{-1}\left(x\sqrt{1-x} + \sqrt{x}\sqrt{1-x^2}\right)$, then $\frac{dy}{dx} =$
(A) $\frac{-2x}{\sqrt{1-x^2}} + \frac{1}{2\sqrt{x-x^2}}$
(B) $\frac{-1}{\sqrt{1-x^2}} - \frac{1}{2\sqrt{x-x^2}}$
(C) $\frac{1}{\sqrt{1-x^2}} + \frac{1}{2\sqrt{x-x^2}}$
(D) None of these

**9.** If ${}^{n-1}P_4 : {}^{n}P_5 = 1 : 6$, then n =
(A) 6 (B) $\frac{1}{6}$
(C) 12 (D) $\frac{1}{12}$

**10.** A cupboard contains 3 pink, 3 black and 5 blue shirts well mixed. A person pulls out 2 shirts at random from cupboard. The probability that they match is
(A) $\frac{5}{8}$ (B) $\frac{16}{55}$
(C) $\frac{39}{55}$ (D) $\frac{41}{81}$

**11.** If $f(x) = x^{\frac{3}{2}} (3x - 10)$, $x \geq 0$, then $f(x)$ is increasing in
(A) $(-\infty, -1) \cup (1, \infty)$
(B) $[2, \infty)$
(C) $(-\infty, -1) \cup [2, \infty)$
(D) $(-\infty, 0] \cup (2, \infty)$

**12.** The variance of α, β and γ is 8, then variance of 4α, 4β and 4γ is
(A) 32 (B) $\frac{1}{2}$
(C) 2 (D) 128

**13.** $\lim_{x \to 0} \frac{15^x - 3^x - 5^x + 1}{x \tan x}$ is equal to
(A) $\log\sqrt{3} \cdot \log 5$
(B) $\log 5 \cdot \log 3$
(C) $\log \sqrt{5} \cdot \log 3$
(D) $\log\sqrt{1} \cdot \log 2$

**14.** The derivative of $\sin^{-1}\left(2x\sqrt{1-x^2}\right)$ w.r.t. $\sin^{-1}\left(3x - 4x^3\right)$ is
(A) $\frac{2}{3}$ (B) $\frac{1}{2}$ (C) $\frac{3}{2}$ (D) 1

**15.** The minimum value of z = $7x + 9y$ subject to $3x + y \le 6$, $5x + 8y \le 40$, $x \ge 0$, $y \ge 2$ is
(A) 45 (B) 18
(C) 9 (D) $\frac{82}{3}$

**16.** A random variable X has the following probability distribution:

| $X = x_i$ | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| $P(X = x_i)$ | 0.2 | 0.15 | 0.3 | 0.35 |

The mean and the variance are respectively
(A) 3.8 and 1.26 (B) 2.8 and 1.26
(C) 3.8 and 1 (D) 2.8 and 1

**17.** Minimum number of times a fair coin must be tossed, so that the probability of getting at least one head, is more than 99% is
(A) 5 (B) 6 (C) 7 (D) 8

**18.** The normal of the curve $x = a(\cos\theta + \theta\sin\theta)$ and $y = a(\sin\theta - \theta\cos\theta)$, at any point θ, is such that
(A) it makes a constant angle with X-axis
(B) it passes through the origin
(C) It is parallel to Y-axis
(D) it is at a constant distance from the origin

**19.** The solution of the equation $1 + \frac{dx}{dy} = \frac{2y}{x}$ is
(A) $(x - y)(x + 2y)^2 = c$
(B) $y = x + c$
(C) $(x + y)(x - 2y)^2 = c$
(D) $y = \frac{x}{2y - x} + c$

**20.** The diagonals of a parallelogram ABCD are along the lines $x + 3y = 4$ and $6x - 2y = 7$. Then ABCD must be a
(A) rectangle.
(B) square.
(C) rhombus.
(D) cyclic quadrilateral

**21.** Let $\bar{a} = \hat{i} + \hat{j} - 2\hat{k}$ and $\bar{b} = \hat{i} - \hat{j} + \hat{k}$ be two vectors. If $\bar{c}$ is a vector such that $\bar{b} \times \bar{c} + \bar{a} \times \bar{b} = 0$ and $\bar{b} \cdot \bar{c} = 0$, then $\bar{c} \cdot \bar{a}$ is
(A) $\frac{1}{3}$ (B) 0
(C) $\frac{-2}{3}$ (D) $\frac{-1}{3}$

**22.** The approximate value of cos (60° 0′ 10″) is (given that $\sqrt{3} = 1.732$, $1° = 0.0175^c$)
(A) 0.049996 (B) 0.00049996
(C) 0. 49996 (D) 0.0049996

**23.** $\sin^2(5°) + \sin^2(10°) + \sin^2(15°) + \ldots + \sin^2(85°) + \sin^2(90°) =$
(A) $\frac{9}{2}$ (B) $\frac{19}{2}$
(C) $\frac{39}{2}$ (D) $\frac{49}{2}$

**24.** $\int \frac{e^{7\log x} - e^{6\log x}}{e^{5\log x} - e^{4\log x}} dx =$
(A) $\frac{x^3}{3} + c$ (B) $\frac{1}{x} + c$
(C) $x^3 \log x + c$ (D) $\frac{3}{x^3} + c$

**25.** If $\bar{a}$ makes an acute angle with $\bar{b}$, $\bar{r} \cdot \bar{a} = 0$ and $\bar{r} \times \bar{b} = \bar{c} \times \bar{b}$, then $\bar{r} =$
(A) $\bar{a} \times \bar{c} - \bar{b}$ (B) $\bar{c} \times \bar{a}$
(C) $\bar{c} - \left(\frac{\bar{c} \cdot \bar{a}}{\bar{b} \cdot \bar{a}}\right)\bar{b}$ (D) $\bar{c} + \left(\frac{\bar{c} \cdot \bar{a}}{\bar{b} \cdot \bar{a}}\right)\bar{b}$

**26.** In ΔABC, with usual notations, $m\angle C = \frac{\pi}{4}$, if $\tan\left(\frac{A}{3}\right)$ and $\tan\left(\frac{B}{3}\right)$ are the roots of the equation $px^2 + qx + r = 0 (p \ne 0)$, then
(A) $p + q = r$ (B) $q + r = p$
(C) $p + r = q$ (D) $q = r$

**27.** In a ΔABC, if $a = \sqrt{2}x$ and $b = 2y$ and $\angle C = 135°$, then the area of triangle is
(A) $xy$ (B) $\sqrt{2}xy$
(C) $\frac{1}{2\sqrt{2}} xy$ (D) $2\sqrt{2}xy$

**28.** $\int \frac{\cos x}{\sqrt{1 + \sin x}} dx =$
(A) $\sin\left(\frac{x}{2}\right) - \cos\left(\frac{x}{2}\right) + c$
(B) $\sin\left(\frac{x}{2}\right) + \cos\left(\frac{x}{2}\right) + c$
(C) $2\left[\sin\left(\frac{x}{2}\right) - \cos\left(\frac{x}{2}\right)\right] + c$
(D) $2\left[\sin\left(\frac{x}{2}\right) + \cos\left(\frac{x}{2}\right)\right] + c$

**29.** The projection of a line segment on the co-ordinate axes are 2, 3, 6. Then, the length of the line segment is
(A) 7 (B) 5
(C) 1 (D) 11

**30.** The area of the region bounded by the curve $y = x|x|$, X-axis and the ordinates $x = 2, x = -2$ is

(A) 0 (B) $\frac{8}{3}$

(C) $\frac{16}{3}$ (D) 1

**31.** The statement pattern
$[p \wedge (q \vee r)] \vee [\sim r \wedge \sim q \wedge p]$ is equivalent to

(A) $q \vee r$ (B) $p \vee r$

(C) q (D) p

**32.** If $y(x)$ is the solution of the differential equation $(x+2)\frac{dy}{dx} = x^2 + 4x - 9, x \neq -2$ and $y(0) = 0$, then $y(-4)$ is equal to

(A) 0 (B) 1

(C) –1 (D) 2

**33.** $x^{5x}$ has a stationary point at

(A) $x = e$ (B) $x = \frac{1}{e}$

(C) $x = 1$ (D) $x = \sqrt{e}$

**34.** Let $\left(-2 - \frac{1}{3}i\right)^3 = \frac{x + iy}{27}, i = \sqrt{-1}$, where $x$ and $y$ are real numbers, then $(y - x)$ has the value

(A) –91 (B) –85

(C) 85 (D) 91

**35.** Negation of $(p \wedge q) \rightarrow (\sim p \vee r)$ is

(A) $(p \vee q) \wedge (p \wedge \sim r)$

(B) $(p \wedge q) \vee (p \wedge \sim r)$

(C) $(p \wedge q) \wedge (p \wedge \sim r)$

(D) $(p \vee q) \vee (p \wedge \sim r)$

**36.** If $\log(x + y) = \sin(x + y)$, then $\frac{dy}{dx}$ is

(A) 2 (B) 1

(C) 0 (D) –1

**37.** If $f(x) = \begin{cases} \frac{a}{2}(x - |x|) & , \text{ for } x < 0 \\ 0 & , \text{ for } x = 0 \\ bx^2 \sin\left(\frac{1}{x}\right) & , \text{ for } x > 0 \end{cases}$

is continuous at $x = 0$, then

(A) a is any real value and b is any real value

(B) a is only rational value and b is any real value

(C) a is only irrational value and b is any real value

(D) a is only rational value and b is only rational value

**38.** The differential equation for all the straight lines which are at the distance of 2 units from the origin is

(A) $\frac{1}{4}\left(y - x\frac{dy}{dx}\right)^2 = 1 - \left(\frac{dy}{dx}\right)^2$

(B) $\frac{1}{4}\left(y + x\frac{dy}{dx}\right)^2 = 1 + \left(\frac{dy}{dx}\right)^2$

(C) $\frac{1}{4}\left(y - x\frac{dy}{dx}\right)^2 = 1 + \left(\frac{dy}{dx}\right)^2$

(D) $\frac{1}{4}\left(y + x\frac{dy}{dx}\right)^2 = 1 - \left(\frac{dy}{dx}\right)^2$

**39.** The mean and standard deviation of random variable X are 10 and 5 respectively, then $E\left(\frac{X - 15}{5}\right)^2 =$ ________.

(A) 4 (B) 3

(C) 2 (D) 5

**40.** A vector $\bar{a}$ has components 3m and 1 with respect to a rectangular Cartesian system. This system is rotated through a certain angle about origin in the clock wise direction. If, with respect to the new system, $\bar{a}$ has components (m + 1) and 1, then

(A) $m = 1$ or $m = \frac{1}{2}$

(B) $m = -1$ or $m = \frac{-1}{2}$

(C) $m = \frac{-1}{2}$ or $m = 1$

(D) $m = \frac{1}{2}$ or $m = -1$

**41.** The value of $\sin^{-1}\left[\cos\left(\frac{\pi}{3}\right)\right] + \sin^{-1}\left[\tan\left(\frac{5\pi}{4}\right)\right]$ is

(A) $\frac{\pi}{3}$ (B) $\frac{\pi}{2}$

(C) $\frac{2\pi}{3}$ (D) $\pi$

**42.** If plane $x + ay + z = 4$ has equal intercepts on axes, then 'a' is equal to

(A) 1 (B) $\frac{1}{4}$

(C) 4 (D) $\frac{1}{5}$

**43.** The angle between the lines whose direction cosines satisfy the equations $l + m + n = 0$ and $l^2 = m^2 + n^2$ is

(A) $\frac{\pi}{6}$ (B) $\frac{\pi}{2}$

(C) $\frac{\pi}{3}$ (D) $\frac{\pi}{4}$

**44.** $\int_0^1 \sin^{-1}\left(\frac{2x}{1+x^2}\right)dx =$

(A) $\frac{\pi}{2} + \log 2$  (B) $\frac{\pi}{2} - \log 2$

(C) $\frac{\pi}{2} + \frac{1}{2}\log 2$  (D) $\frac{\pi}{2} - \frac{1}{2}\log 2$

**45.** The integral $\int \sec^{\frac{2}{3}} x \cdot \operatorname{cosec}^{\frac{4}{3}} x \, dx$ is equal to

(A) $3(\tan x)^{-\frac{1}{3}} + c$, (where c is the constant of integration)

(B) $-\frac{3}{4}(\tan x)^{-\frac{4}{3}} + c$, (where c is the constant of integration)

(C) $-3(\cot x)^{-\frac{1}{3}} + c$, (where c is the constant of integration)

(D) $-3(\tan x)^{-\frac{1}{3}} + c$, (where c is the constant of integration)

**46.** If equation $\tan\theta + \tan 2\theta + \tan\theta \tan 2\theta = 1$, $\theta =$

(A) $\frac{n\pi}{2} + \frac{\pi}{6}$  (B) $\frac{n\pi}{2} + 6$

(C) $\frac{n\pi}{3} + \frac{\pi}{12}$  (D) $\frac{n\pi}{2} + \frac{\pi}{12}$

**47.** The combined equation of two lines through the origin and making an angle of $45^\circ$ with the line $3x + y = 0$, is

(A) $2x^2 - 3xy - 2y^2 = 0$

(B) $2x^2 + 3xy + 4y^2 = 0$

(C) $2x^2 + 3xy - 2y^2 = 0$

(D) $2x^2 - 3xy + 2y^2 = 0$

**48.** Equation of the plane, through the points $(-1, 2, -2)$ and $(-1, 3, 2)$ and perpendicular to $yz$ - plane, is

(A) $4y + z = 10$  (B) $4y - z + 10 = 0$

(C) $4y - z = 10$  (D) $4y + z + 10 = 0$

**49.** In a $\Delta$ABC, if $\frac{b+c}{11} = \frac{c+a}{12} = \frac{a+b}{13}$, then cos C =

(A) $\frac{7}{5}$  (B) $\frac{5}{7}$

(C) $\frac{17}{16}$  (D) $\frac{a\sin\frac{5\pi}{8}}{\frac{1}{\sqrt{2}}}$

**50.** $\int \cos(\log x)dx = F(x) + c$, where c is an arbitrary constant. Here $F(x) =$

(A) $x[\cos(\log x) + \sin(\log x)]$

(B) $x[\cos(\log x) - \sin(\log x)]$

(C) $\frac{x}{2}[\cos(\log x) + \sin(\log x)]$

(D) $\frac{x}{2}[\cos(\log x) - \sin(\log x)]$

# ANSWERS AND SOLUTIONS

## Mock Test 01

Physics and Chemistry

### PHYSICS

**1.** **(A)**
At S.T.P.,
$T_1 = 273$ K and $P_1 = 1$ atm
Given that, $V_2 = \frac{V_1}{14}$ and $P_2 = 40$ atm
Being the same gas compressed, n = constant
Equation of state
$\Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$\therefore\ T_2 = \frac{P_2V_2}{P_1V_1} \times T_1 = \frac{40\times V_1}{14\times 1\times V_1} \times 273 = 780$ K

**2.** **(A)**
$F = qvB \sin\theta$
$= 100 \times 10^{-6} \times 2 \times 10^5 \times 6 \times 10^{-5} \times \sin 30°$
$F = 6 \times 10^{-4}$ N

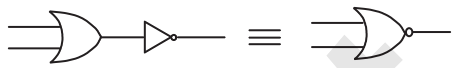
**3.** **(D)**

**4.** **(B)**
$L = \mu_0 nI$
$\therefore\ \frac{L_2}{L_1} = \frac{\mu}{\mu_0}$ ....($\because$ n and I are same)
$\therefore\ L_2 = \mu_r L_1 = 900 \times 0.20 = 180$ mH

**5.** **(D)**
Alternating voltage: $e = 200\sqrt{2}\ \sin(100\,t)$ volt
Comparing with $e = e_0 \sin \omega t$
$\omega = 100$ rad/s, $e_0 = 200\sqrt{2}$
Capacitive reactance,
$X_C = \frac{1}{\omega C} = \frac{1}{100\times 10^{-6}}\ \Omega = 10^4\ \Omega$
$I_0 = \frac{e_0}{X_C}$
$I_0 = \frac{200\sqrt{2}}{10^4}$
$I_0 = 2\sqrt{2} \times 10^{-2}$ A
$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{2\sqrt{2}\times 10^{-2}}{\sqrt{2}} = 2 \times 10^{-2}$ A = 20 mA

**6.** **(A)**
$mr\omega^2 = \frac{GMm}{r^2}$
$\omega^2 = \frac{GM}{r^3} = \frac{gR^2}{r^3}$ ....($\because g = \frac{GM}{R^2}$)
$\therefore$ Radius of the orbit of the satellite is:
$r = \left(\frac{gR^2}{\omega^2}\right)^{\frac{1}{3}}$

**7.** **(C)**
As NAND gate with shorted inputs behaves as a NOT gate, the given logic circuit is simplified as follows



Hence, the given circuit represents a NOR gate.

**8.** **(B)**
Given: $y_1 = a \sin(\omega t - kx)$ ....(i)
$y_2 = b \cos\left(\omega t - kx + \frac{\pi}{3}\right)$ ....(ii)
The equation (ii) can be written as,
$y_2 = b \sin\left(\frac{\pi}{2} + \omega t - kx + \frac{\pi}{3}\right)$
... $\left[\because \sin\left(\frac{\pi}{2} + \theta\right) = \cos\theta\right]$
$\therefore\ y_2 = b \sin\left(\omega t - kx + \frac{5\pi}{6}\right)$ ...(iii)
Comparing equation (i) and (iii),
The phase difference is $\frac{5\pi}{6}$ rad.

**9.** **(A)**
For S.H.M.
Maximum acceleration = $\omega^2 A = \alpha$ ....(i)
Maximum velocity = $\omega A = \beta$ ....(ii)
Dividing (i) by (ii)
$\Rightarrow \omega = \frac{\alpha}{\beta} \Rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi\beta}{\alpha}$

**Thinking Hatke - 9**
Amongst the given options, only option (A) dimensionally equates to time.

**10.** **(D)**
$Q = CV = 4 \times 10^{-6} \times 100 = 400\ \mu C$

**11.** **(C)**
$t_1 = \frac{x/2}{v_1},\ t_2 = \frac{x/2}{v_2}$
Average speed $v = \frac{x}{t_1+t_2} = \frac{x}{\frac{x/2}{v_1}+\frac{x/2}{v_2}} = \frac{2v_1v_2}{v_1+v_2}$
$\therefore\ \frac{2}{v} = \frac{v_1+v_2}{v_1v_2} = \frac{1}{v_1} + \frac{1}{v_2}$

**12.** **(B)**
$\sin i_C = \frac{1}{n}$ and $n \propto \frac{1}{\lambda}$
For greater wavelength (i.e., lesser frequency) n is less. Hence, $i_C$ would be more. Thus, these wavelengths will not suffer internal reflection and come out at angles less than 90°.

13. (B)
Waterproofing agents are used so that the material is not wetted. It means that angle of contact is obtuse.

14. (D)

15. (C)
Second minimum is exactly in front of one slit indicates, $y'_2 = \frac{d}{2}$

But $y'_2 = \frac{(2n-1)\lambda D}{2d}$

For n = 2

$\therefore \quad \frac{d}{2} = \frac{(2\times 2-1)\lambda D}{2d}$

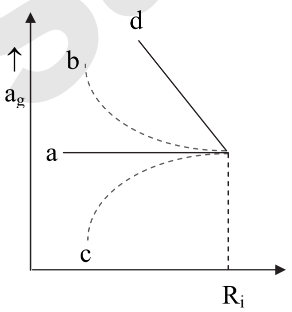
$\therefore \quad \lambda = \frac{d^2}{3D}$

16. (D)
I = 10 A;
Total number of turns = 2000
Mean radius of toroid,
$r = \frac{25+26}{2} = 25.5 \text{ cm} = 25.5 \times 10^{-2} \text{ m}$
Total length (circumference) of the toroid
$= 2\pi r = 2\pi \times 25.5 \times 10^{-2} = 51\,\pi \times 10^{-2}$ m
Therefore, number of turns per unit length,
$n = \frac{2000}{51\pi\times 10^{-2}}$
The field inside the core of the toroid,
$B = \mu_0 nI = 4\pi \times 10^{-7} \times \frac{2000}{51\pi\times 10^{-2}} \times 10$
$= 15.7 \times 10^{-3}$ T

17. (D)
The energy of the field increases with the magnitude of the field. Lenz's law infers that there is an opposite field created due to increase or decrease of magnetic flux around a conductor so as to hold the law of conservation of energy.

18. (B)

19. (B)




As the star collapses,
its mass remains the same and radius decreases.
$a_g = \frac{GM}{R^2} \propto \frac{1}{R_i^2}$
$a_g$ increases as radius decreases. This is depicted correctly by plot b.

20. (A)

21. (A)
String crosses mean position simultaneously.

22. (C)
$E = \frac{1}{2}\, m\omega^2 A^2 \Rightarrow K = \frac{1}{2} m\omega^2 (A^2 - \frac{A^2}{4})$
$= \frac{3}{4}\left(\frac{1}{2} m\omega^2 A^2\right) = \frac{3}{4}$ E

23. (D)
$n = \frac{2}{\pi}$ r.p.s.
$T \sin\theta = M\omega^2 R$ ....(i)
$T \sin\theta = M\omega^2 L \sin\theta$ ....(ii)
From (i) and (ii),
$T = M\omega^2 L = M\, 4\pi^2 n^2 L$
$= M\, 4\pi^2 \left(\frac{2}{\pi}\right)^2 L = 16$ ML

24. (C)
For series combination of capacitors the charge on each capacitor is same.
$\therefore \quad Q_1 = Q_2 = Q_3$
$\Rightarrow Q_1 : Q_2 : Q_3 = 1 : 1 : 1$

25. (D)
Torque producing acceleration $\alpha_1$,
$\tau = I_1\alpha_1 = 2mD^2\alpha_1$
Same torque produces $\alpha_2$
$\therefore \quad \tau = I_2\alpha_2 = 2m(2D)^2\alpha_2$
$\therefore \quad 4(2mD^2)\alpha_2 = 2mD^2\alpha_1$
$\therefore \quad \alpha_2 = \frac{1}{4}\,\alpha_1$

26. (B)
If an open tube of length '$l$' is in resonance with a tuning fork or string. It is dipped in water so that its $\left(\frac{l}{x}\right)^{th}$ part is above water, then the ratio of the frequency of tube to that of string or fork is $\frac{x}{2}$. Similarly, if a closed tube of length '$l$' in resonance with a fork or string, is filled with water so that its $\left(\frac{l}{x}\right)^{th}$ part is above water then the ratio of the frequency of tube to that of string/ fork is x.

$\therefore \quad$ Part of pipe above water $= \frac{l}{2}$

$\Rightarrow x = 2$
$\frac{f_c}{f_o} = \frac{2}{2} = 1$
$\Rightarrow f_o = f_c$

**27. (B)**

$K.E._{max} = h(\nu - \nu_0)$; $\nu$ = frequency of incident light.

**28. (D)**

$$x = \frac{(2\times0)+(3\times0)+(5\times1)+(7\times1)}{2+3+5+7} = \frac{12}{17}\ \text{m}$$

$$y = \frac{(2\times0)+(3\times1)+(5\times1)+(7\times0)}{2+3+5+7} = \frac{8}{17}\ \text{m}$$

**29. (D)**

**30. (C)**

$$K.E. = \frac{3}{2}k_BT = \frac{3}{2}\times 1.38\times10^{-23}\times 600$$

∴ $K.E. = 1.24 \times 10^{-20}$ J

**31. (C)**

Electric flux $(\phi) = \frac{q_{enc}}{\varepsilon_0}$

∴ $\phi = \frac{10}{\varepsilon_0}$

If additional charge of 10 μC is placed,

$\phi' = \frac{20}{\varepsilon_0} = 2\phi$

**32. (A)**

1st case: $R_P/R_Q = 2/3$

$R_p = \frac{2}{3}R_Q$ ….(i)

2nd case: Resistance, instead of $R_Q$ is

$R_Q \parallel 10 = (10R_Q/10+R_Q) = R'$

Now, $R_P/R' = \frac{50}{50} = 1$

∴ $R_P = R'$

$R_P = \frac{10R_Q}{10+R_Q}$ ….(ii)

From (i) and (ii),

$\frac{2}{3}R_Q = \frac{10R_Q}{10+R_Q}$

∴ $\frac{1}{3} = \frac{5}{10+R_Q}$

∴ $10 + R_Q = 15$

∴ $R_Q = 5\ \Omega$ and $R_P = 10/3\ \Omega$

**33. (B)**

Slope of the given curves gives the activity of those nuclei.

Also, mean life time varies inversely with the activity. Thus, higher the activity shorter is the mean life of the substance. Here, slope is highest for the nucleus A. Hence, nucleus A has shortest mean life amongst the three.

**34. (A)**

$$E = 1\ \text{MeV},\ p = \frac{E}{c} = \frac{1\times10^6\times1.6\times10^{-19}}{3\times10^8}$$

$= 0.53 \times 10^{-21}$

$= 5 \times 10^{-22}$ kg m/s

**35. (A)**

$v = \sqrt{\frac{\gamma RT}{M}}$

$\frac{T_N}{T_0} = \frac{M_N}{M_0}$

$\frac{T_N}{273+79} = \frac{14}{16}$

$T_N = 308\ K = 35\ °C$

**36. (A)**

**37. (A)**

$v_{rms} \propto \sqrt{T} \Rightarrow \frac{\Delta v}{v} = \frac{1}{2}\frac{\Delta T}{T} = \frac{1}{2}\times\frac{12}{300} = \frac{1}{50}$

∴ The rms velocity will increase nearly by 2%

**38. (A)**

When m = – 3 (real image)

$m = -3 = -\frac{v}{u}$

∴ $v = 3u$

Also $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

∴ $\frac{1}{u} + \frac{1}{3u} = \frac{1}{-15}$

∴ $u = -20$ cm

When m = + 3 (virtual image)

$m = +3 = -\frac{v}{u}$

∴ $v = -3u \Rightarrow \frac{1}{u} + \frac{1}{-3u} = \frac{1}{-15}$

∴ $u = -10$ cm

**Thinking Hatke – 38**

In case of concave mirror, the image formed is finitely magnified for two distances of object.

i. Object lies between F and P,
   i.e., $u < f \Rightarrow u < 15$ cm

ii. Object lies between C and F,
   i.e., $2f > u > f \Rightarrow 30\ \text{cm} > u > 15$ cm

Amongst given options, only option **(A)** depicts the correct values of object distance.

**39. (B)**

As $B = \frac{\mu_0}{4\pi}\frac{2I}{r}$, for the same distance, field will remain the same

**40. (D)**

Gyromagnetic ratio, $\frac{M}{L} = \frac{e}{2m}$

$\therefore$ $m = \frac{e}{2(M/L)} = \frac{1.6\times10^{-19}}{2\times8.8\times10^{10}} = \frac{1}{11}\times10^{-29}$ kg

**41. (D)**

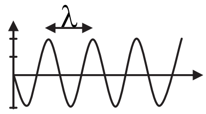
$e_{r.m.s.} = \frac{e_0}{\sqrt{2}} = \frac{320}{\sqrt{2}} \approx 226$ V

**42. (B)** **43. (A)**

**44. (C)**

Distance between 11 crests is 1 m,

$\Rightarrow \lambda = \frac{1}{10}$




Wave velocity is given by,

$v = n\lambda$

$n = \frac{v}{\lambda} = \frac{30}{\left(\frac{1}{10}\right)} = 300$ Hz

**Caution - 44**

Wavelength is distance between 2 crests. Hence, when N number of crests/ troughs are given, then wavelength $\lambda = \frac{1}{N-1}$.

**45. (C)**

The general equation of S.H.M. is given by

$y = a\sin(\omega t + \phi)$ ….(i)

Given that

$y_1 = a\sin(\omega t + \pi/6)$ ….(ii)

Comparing equation (ii) with equation (i), we get,

$a_1 = a$ ; $\phi_1 = \frac{\pi}{6}$

$y_2 = a\cos\omega t = a\sin(\omega t - \pi/2)$ ….(iii)

Comparing equation (iii) with equation (i), we get

$a_2 = a$ ; $\phi_2 = \frac{\pi}{2}$

So, phase difference $\Delta\phi = \phi_2 - \phi_1$

$= \frac{\pi}{2} - \frac{\pi}{6} = \frac{\pi}{3}$

Now, resultant amplitude of two waves is given by

$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

Substituting $a_1 = a$; $a_2 = a$; $\phi = \Delta\phi = \frac{\pi}{3}$, we get

$A = a\sqrt{3}$

**46. (A)**

M.I. of thin rod about axis passing through centre perpendicular to length is

Using, $I = MK^2 = \frac{ML^2}{12}$

$\therefore$ $K = \frac{L}{\sqrt{12}} = \frac{L}{2\sqrt{3}} = \frac{1}{2\sqrt{3}}$ m

**47. (D)**

**48. (D)**

At mid point, E = 0

Before mid point, E is positive. This is maximum near the charge and decreases towards mid point.

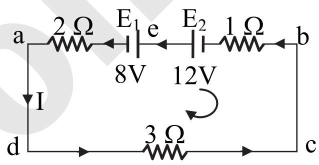
After mid point, E is negative, The curve crosses x-axis at x = d/2. From centre to end, E decreases.

The variation is shown by curve (D).

**49. (B)**

Since, $E_1$(8 V) < $E_2$ (12 V),

current in the circuit will be anticlockwise.




Applying Kirchhoff's voltage law to loop aebcda

$2I + 8 - 12 + I + 3I = 0$

$\therefore$ $I = \frac{2}{3}$ A (b to a via e)

**50. (A)**

$r_0 = 0.53$ Å

Since, $r_n \propto n^2$

$\therefore$ $\frac{r_n}{r_0} = \left(\frac{n}{1}\right)^2 = (4)^2 = 16$

$\therefore$ $r_n = 16 \times 0.53 = 8.48$ Å

## CHEMISTRY

**1. (B)**

**2. (D)**

In simple ketones, both alkyl or aryl groups attached to carbonyl carbon are identical. In mixed ketones, the two alkyl or aryl groups attached to the carbonyl carbon are different.

(A) $CH_3 - CH_2 - \underset{\displaystyle}{\overset{\displaystyle O \atop \|}{C}} - CH_2 - CH_3$

Pentan-3-one (simple or symmetrical ketone)

(B) $CH_3 - \overset{\displaystyle O \atop \|}{C} - CH_3$

Acetone (simple or symmetrical ketone)

(C) $C_6H_5 - \overset{O}{\overset{||}{C}} - C_6H_5$
Benzophenone (simple or symmetrical ketone)

(D) $CH_3 - \overset{O}{\overset{||}{C}} - CH_2 - CH_3$
Butanone (mixed or unsymmetrical ketone)

**3. (A)**

$SO_2 + 2H_2O + Cl_2 \longrightarrow H_2SO_4 + 2HCl$
(1 mol) (1 mol)

**4. (A)**

For non-electrolyte glucose:
$\Delta T_f = K_f m = xK$
For electrolyte NaCl:
$\Delta T_f = iK_f m$
$NaCl \rightarrow Na^+ + Cl^-$ (i = 2)
$\therefore \Delta T_f = iK_f m = 2xK$

**5. (A)**

$CH_3 - \overset{O}{\overset{||}{C}} - NH_2 + Br_2 + 4KOH_{(aq)}$
Acetamide

$\xrightarrow{\Delta} CH_3 - NH_2 + 2KBr + K_2CO_3 + 2H_2O$
Methylamine

Molar mass of methylamine
= (1 × 12 + 1 × 14 + 5 × 1) = 31 g/mol

**6. (B)**

n-Propyl alcohol on heating in the presence of conc sulphuric acid undergoes dehydration and forms propene.

$CH_3 - CH_2 - CH_2 - OH \xrightarrow[\Delta]{conc.H_2SO_4} CH_3 - CH = CH_2 + H_2O$
n-Propyl alcohol ... Propene

**7. (D)**

According to (n + *l*) rule, higher the value of (n + *l*), higher is the energy of the electron.
For same value of (n + *l*), higher the value of 'n', the greater is the energy.
For X; (n + *l*) = 6 + 1 = 7,
For Y; (n + *l*) = 6 + 0 = 6.
For Z; (n + *l*) = 5 + 1 = 6.
Thus, X has greater energy than Y and Z.

**8. (B)**

The number of particles in '*x*' g of a metallic crystal = $\frac{x\,n}{\rho a^3}$

Therefore, number of particles in 1 g of metallic crystal = $\frac{n}{\rho a^3}$

**9. (C)**

For MX,
$MX_{(s)} \rightleftharpoons M^+_{(aq)} + X^-_{(aq)}$
$\therefore$ $x = 1, y = 1$
$K_{sp} = x^x y^y S^{x+y} = (1)^1 (1)^1 S^{1+1} = S^2$
$\therefore$ $S = \sqrt{K_{sp}} = \sqrt{6.4 \times 10^{-5}} = 8 \times 10^{-3}$ mol $L^{-1}$

**10. (C)**

HBr, $NF_3$, $H_2S$ and $CHCl_3$ have non-zero dipole moments.

**11. (A)**

$\Delta S = \frac{Q_{rev}}{T} = \frac{6000}{273} = 21.98$ J $K^{-1}$ $mol^{-1}$

**12. (C)**

For bcc unit cell, n = 2.
a = 400 pm = $4 \times 10^{-8}$ cm

Density ($\rho$) = $\frac{n \times M}{a^3 \times N_A}$

$= \frac{2 \times 170}{(4 \times 10^{-8})^3 \times 6.022 \times 10^{23}} = 8.8$ g $cm^{-3}$

**13. (B)**

Let oxidation number of P in $PF_6^- = x$
$\therefore$ $x + (6 \times -1) = -1$
$x = +5$
Let oxidation number of V in $V_2O_7^{4-} = y$
$\therefore$ $2y + (-2 \times 7) = -4$
$y = +5$

**14. (A)**

Lower is the reduction potential, greater is the reducing power of the metal.
Hence, the increasing order of reducing power is Au < Pb < Al.

**15. (D)** **16. (D)**

**17. (B)**

Ionic radii of these elements are smaller than ionic radii of representative elements of same period. Hence, statement I is false.
Transition elements are less electropositive than elements of group 1 and group 2. Hence, statement II is false.

**18. (B)**

$Ag_2O + H_2O \longrightarrow 2AgOH$
$CH_3 - CH_2 - Br + AgOH \xrightarrow{\Delta} CH_3 - CH_2 - OH + AgBr$

**19. (A)** **20. (D)** **21. (A)**

**22. (C)**

Ozone ($O_3$) is an $EO_2$ type oxide whereas others are $EO_3$ type oxides.

**23. (C)**

**24. (C)**
$K_f$ is independent of solution concentration. $K_f$ depends only on the nature of the solvent.

**25. (C)**

**26. (B)**

$$CH_3COCH(CH_3)-CH_3$$

Isopropyl methyl ketone

**27. (B)**

**28. (D)**
Solution containing acetic acid and acetate ion forms an acidic buffer.

$$pH = pK_a + \log_{10}\frac{[Salt]}{[Acid]}$$

$$= 4.744 + \log_{10}\frac{(0.5)}{(0.2)}$$

$$= 4.744 + 0.3979 = 5.14$$

**Thinking Hatke - 28**
For an acidic buffer, if [Salt] > [Acid], then $pH > pK_a$ of acid. Hence, only option (D) is valid.

**29. (B)**
Ionic radii of alkali metals are smaller than the atomic radii of parent atoms. Atomic and ionic radii increase while moving down the group.

**30. (A)**

**31. (C)**

$$\underset{\text{Methyl magnesium iodide}}{CH_3-Mg-I} + \underset{\text{Propanone (Acetone)}}{CH_3-\overset{O}{\overset{||}{C}}-CH_3} \xrightarrow[-MgI(OH)]{\text{i. Dry ether, ii. } HOH/H^+} \underset{\text{2-Methylpropan-2-ol 'P'}}{CH_3-C(CH_3)_2-OH}$$

**Thinking Hatke - 31**
The addition of Grignard reagent to a ketone followed by acid hydrolysis results in the formation of a tertiary alcohol. Among the given options, only '2-methylpropan-2-ol' is a tertiary alcohol. Hence, the correct answer is option (C).

**32. (B)**

**33. (A)**

$$\Lambda_0 (CaCl_2) = \lambda^0_{Ca^{2+}} + 2\lambda^0_{Cl^-}$$

$256.8\ \Omega^{-1}\ cm^2\ mol^{-1} = 104\ \Omega^{-1}\ cm^2\ mol^{-1} + 2 \times x\ \Omega^{-1}\ cm^2\ mol^{-1}$

$x = 76.4\ \Omega^{-1}\ cm^2\ mol^{-1}$

**34. (A)**

$$\text{Benzamide} \xrightarrow{Br_2/KOH} \text{Aniline} \xrightarrow[298K]{Br_2\ water} \text{2,4,6-Tribromoaniline}$$

**35. (C)**
The reaction is as follows:

$$CH_{4(g)} + H_2O_{(g)} \xrightarrow[Ni]{1270K} CO_{(g)} + 3H_{2(g)}$$

**36. (A)**
The stability of carbanion increases with increase in percentage s-character.

$CH \equiv \ddot{C}$ (sp hybridization): % s-character: 50%

$CH_2 = \ddot{C}H$ ($sp^2$ hybridization): % s-character: 33.3%

$CH_3 - \ddot{C}H_2$ ($sp^3$ hybridization): % s-character: 25%

**37. (C)**

**38. (C)**
$P_2 = 2P_1;\ V_2 = 2V_1$

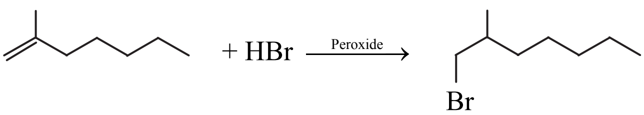
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2};\ \frac{P_1V_1}{T_1} = \frac{2P_1 \times 2V_1}{T_2}$$

$\therefore\ T_2 = 4T_1 = 4 \times 400 = 1600$ K

$\therefore$ The increase in temperature
$= T_2 - T_1 = 1600 - 400 = 1200$ K

**39. (D)**

**40. (D)**
In presence of peroxide, the addition of HBr to an unsymmetrical alkene follows the anti-Markovnikov's rule.




1-Bromo-2-methylheptane

**41. (A)**
20 mL $H_2O$ = 20 g $H_2O$

$$= \frac{20}{18}$$

= 1.11 mole of water

1 molecule of $H_2O$ contains 10 electrons.

$\therefore$ Total electrons in 20 mL
$= 1.11 \times 6.022 \times 10^{23} \times 10$
$= 6.684 \times 10^{24}$ electrons.

**42. (D)**
Reversing Equation (ii), we get,

$$SO_3 \longrightarrow SO_2 + \frac{1}{2}O_2\ ;\ \Delta H = y \text{ kcal} \ldots \text{(iii)}$$

Adding equation (i) and (iii)

$$S + \frac{3}{2}O_2 \longrightarrow SO_3\ ;\ \Delta H = -2x \text{ kcal}$$

$$SO_3 \longrightarrow SO_2 + \frac{1}{2}O_2\ ;\ \Delta H = y \text{ kcal}$$

$$S + O_2 \longrightarrow SO_2\ ;\ \Delta H = (y - 2x \text{ kcal})$$

**43. (B)**

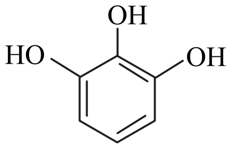
**44. (B)**

| Species | Outer E.C. | Number of unpaired electrons | Magnetic moment $\mu = \sqrt{n(n+2)}$ BM |
|---|---|---|---|
| $Zn^{2+}$ | $[Ar]3d^{10}$ | 0 | 0 |
| $Cu^{2+}$ | $[Ar]3d^{9}$ | 1 | 1.73 |
| $Ti^{3+}$ | $[Ar]3d^{1}$ | 1 | 1.73 |
| $Cr^{3+}$ | $[Ar]4d^{3}$ | 3 | 3.87 |
| $Sc^{3+}$ | $[Ar]4d^{0}$ | 0 | 0 |

$\therefore$ $Ti^{3+}$ and $Cu^{2+}$ exhibit same magnetic moment.

**45. (B)**

The structure of pyrogallol is




The IUPAC name is benzene-1,2,3-triol.

**46. (B)**

For compounds of comparable molar mass, boiling point of amines are higher than that of alkanes.

The observed order of boiling points of isomeric amines is primary amine > secondary amine > tertiary amine.

**47. (A)**

**48. (D)**

Half life period $t_{1/2}$ = 15 min.

Calculating the number of $t_{1/2}$ required to decrease the concentration from 0.1 mol $dm^{-3}$ to 0.025 mol $dm^{-3}$,

$0.1 \xrightarrow{t_{1/2}} 0.05 \xrightarrow{t_{1/2}} 0.025$

number of $t_{1/2}$ = 2

$\therefore$ time taken = 2 × 15 = 30 minutes

**49. (A)**

$$R-C\equiv N + H-OH \longrightarrow \left[\begin{array}{c} OH \\ | \\ R-C=NH \end{array}\right] \longrightarrow$$

Alkyl cyanide

$$R-\overset{\overset{O}{\|}}{C}-NH_2 \xrightarrow{H^+} R-\overset{\overset{O}{\|}}{C}-OH + NH_3$$

Carboxylic acid

**50. (A)**

The molecular weight of sucrose $C_{12}H_{22}O_{11}$ is 12 × 12 + 22 × 1 + 11 × 16 = 342 g/mol

Thus, 171 g of sucrose corresponds to 0.5 mole.

1 mole of sucrose on hydrolysis gives 1 mole of glucose and 1 mole of fructose.

$\therefore$ 0.5 mole of sucrose on hydrolysis gives 0.5 mole of glucose.

## Mathematics

**1. (B)**

$P(\bar{p})$ is midpoint of BC

$\therefore$ $\bar{p} = \dfrac{\bar{b}+\bar{c}}{2}$

$\Rightarrow 2\bar{p} = \bar{b} + \bar{c}$ ....(i)

$Q(\bar{q})$ divides CA internally in the ratio 2:1

$\therefore$ $\bar{q} = \dfrac{2\bar{a}+\bar{c}}{3}$

$\Rightarrow 3\bar{q} = 2\bar{a} + \bar{c}$ ....(ii)

$R(\bar{r})$ divides AB externally in the ratio 1:2

$\bar{r} = \dfrac{\bar{b}-2\bar{a}}{1-2}$

$= \dfrac{2\bar{p}-3\bar{q}}{-1}$ ....[From (i) and (ii)]

$\therefore$ $\bar{r} = -2\bar{p} + 3\bar{q}$

$\therefore$ points P, Q and R are collinear.

**2. (B)**

If line $\dfrac{x+1}{2} = \dfrac{y-5}{3} = \dfrac{z-p}{6}$ lies in the plane, then (–1, 5, p) should satisfy the equation of a plane $3x - 14y + 6z + 49 = 0$

$\therefore$ $3(-1) - 14(5) + 6(p) + 49 = 0$

$\Rightarrow 6p = 24$

$\Rightarrow p = 4$

**3. (B)**

$A = \begin{bmatrix} 2 & 1 \\ 7 & 4 \end{bmatrix}$

$\therefore$ $A^2 = \begin{bmatrix} 2 & 1 \\ 7 & 4 \end{bmatrix} \times \begin{bmatrix} 2 & 1 \\ 7 & 4 \end{bmatrix} = \begin{bmatrix} 11 & 6 \\ 42 & 23 \end{bmatrix}$

$\therefore$ $A^2 - 5A = \begin{bmatrix} 1 & 1 \\ 7 & 3 \end{bmatrix}$

$|A^2 - 5A| = 3 - 7 = -4$

$\therefore$ $(A^2 - 5A)^{-1} = \left(-\dfrac{1}{4}\right)\begin{bmatrix} 3 & -1 \\ -7 & 1 \end{bmatrix}$

$= \dfrac{1}{4}\begin{bmatrix} -3 & 1 \\ 7 & -1 \end{bmatrix}$

**4.** **(A)**

$$\int e^x \frac{(x^2+1)}{(x+1)^2}dx = \int \frac{e^x\left(x^2-1+2\right)}{\left(x+1\right)^2}dx$$

$$= \int e^x\left[\frac{x-1}{x+1} + \frac{2}{(x+1)^2}\right]dx$$

$$= e^x\left(\frac{x-1}{x+1}\right) + c$$

**5.** **(A)**

Radius = Distance of a point (3, 4) form $5x + 12y - 11 = 0$

$$= \left|\frac{5(3)+12(4)-11}{\sqrt{25+144}}\right|$$

$$= \left|\frac{15+48-11}{\sqrt{169}}\right| = \frac{52}{13} = 4$$

∴ Required equation is

$(x - 3)^2 + (y - 4)^2 = (4)^2$

$x^2 + y^2 - 6x - 8y + 9 = 0$

**6.** **(A)**

$$\sin\theta = \left|\frac{\left(2\hat{i}+3\hat{j}+6\hat{k}\right)\cdot\left(10\hat{i}+2\hat{j}-11\hat{k}\right)}{\sqrt{4+9+36}.\sqrt{100+4+121}}\right|$$

$$= \left|\frac{20+6-66}{7.15}\right| = \left|\frac{-8}{21}\right|$$

$$\Rightarrow \theta = \sin^{-1}\left(\frac{8}{21}\right)$$

**7.** **(A)**

$$y = 5 - 10x \Rightarrow x = \frac{5-y}{10}$$

$$\Rightarrow f^{-1}(y) = \frac{5-y}{10}$$

$$\Rightarrow f^{-1}(x) = \frac{5-x}{10}$$

**8.** **(C)**

Putting $x = \sin A$ and $\sqrt{x} = \sin B$, we get

$$y = \sin^{-1}\left(\sin A\sqrt{1-\sin^2 B} + \sin B\sqrt{1-\sin^2}\right)$$

$= \sin^{-1}(\sin A \cos B + \sin B \cos A)$

$= \sin^{-1}[\sin(A + B)] = A + B = \sin^{-1}x + \sin^{-1}\sqrt{x}$

$$\therefore \frac{dy}{dx} = \frac{1}{\sqrt{1-x^2}} + \frac{1}{\sqrt{1-\left(\sqrt{x}\right)^2}}\cdot\frac{1}{2\sqrt{x}}$$

$$= \frac{1}{\sqrt{1-x^2}} + \frac{1}{2\sqrt{x-x^2}}$$

**9.** **(A)**

${}^{n-1}P_4 : {}^nP_5 = 1 : 6$

$$\therefore \frac{1}{6} = \frac{{}^{n-1}P_4}{{}^nP_5} = \frac{(n-1)!}{n!} = \frac{(n-1)!}{n(n-1)!}$$

$\Rightarrow n = 6$

**10.** **(B)**

Total no. of ways in which 2 shirts can be drawn out of 11 is ${}^{11}C_2$. The two shirts match if either they are both pink or they are both black or they are both blue. So, two matching shirts can be drawn in ${}^3C_2 + {}^3C_2 + {}^5C_2$ ways.

$$\therefore \text{Required probability} = \frac{{}^3C_2 + {}^3C_2 + {}^5C_2}{{}^{11}C_2}$$

$$= \frac{3+3+10}{55} = \frac{16}{55}$$

**11.** **(B)**

$f(x) = x^{\frac{3}{2}}(3x - 10), x \geq 0$

$$\therefore f'(x) = \frac{3}{2}x^{\frac{1}{2}}(3x-10) + x^{\frac{3}{2}}(3) = \frac{15}{2}x^{\frac{1}{2}}(x-2)$$

For f(x) to be increasing,

$$f'(x) \geq 0 \Rightarrow \frac{15}{2}x^{\frac{1}{2}}(x-2) \geq 0$$

$\Rightarrow x \geq 2$

$\Rightarrow x \in [2, \infty)$

**12.** **(D)**

When each item of a data is multiplied by $\lambda$, variance is multiplied by $\lambda^2$.

Hence, new variance = $4^2 \times 8 = 128$

**13.** **(B)**

$$\lim_{x\to 0}\frac{15^x - 3^x - 5^x + 1}{x\tan x}$$

$$= \lim_{x\to 0}\frac{(5\times 3)^x - 3^x - 5^x + 1}{x\tan x}$$

$$= \lim_{x\to 0}\frac{5^x(3^x-1) - 1(3^x-1)}{x\tan x}$$

$$= \lim_{x\to 0}\frac{(5^x-1)(3^x-1)}{x\tan x}$$

$$= \lim_{x\to 0}\frac{\left(\frac{5^x-1}{x}\right)\cdot\left(\frac{3^x-1}{x}\right)}{\frac{\sin x}{x}} = \log 5 \cdot \log 3$$

**14.** **(A)**

Let $y = \sin^{-1}\left(2x\sqrt{1-x^2}\right)$

and $z = \sin^{-1}(3x - 4x^3)$

Put $x = \sin\theta \Rightarrow \theta = \sin^{-1}x$

$\therefore y = \sin^{-1}\left(2\sin\theta\sqrt{1-\sin^2\theta}\right)$ and

$z = \sin^{-1}(3\sin\theta - 4\sin^3\theta)$

$\Rightarrow y = \sin^{-1}(\sin 2\theta)$ and $z = \sin^{-1}(\sin 3\theta)$

$\Rightarrow y = 2\theta = 2\sin^{-1}x$ and $z = 3\theta = 3\sin^{-1}x$

$$\therefore \frac{dy}{dx} = \frac{2}{\sqrt{1-x^2}} \text{ and } \frac{dz}{dx} = \frac{3}{\sqrt{1-x^2}}$$

$$\therefore \frac{dy}{dz} = \frac{\frac{dy}{dx}}{\frac{dz}{dx}} = \frac{2}{3}$$

**15. (B)**

Feasible region lies on origin side of lines $3x + y = 6$ and $5x + 8y = 40$ and above line $y = 2$, in first quadrant.

The corner points of the feasible region

$A(0, 2)$, $B\left(\frac{4}{3}, 2\right)$, $C\left(\frac{8}{19}, \frac{90}{19}\right)$ and $D(0, 5)$

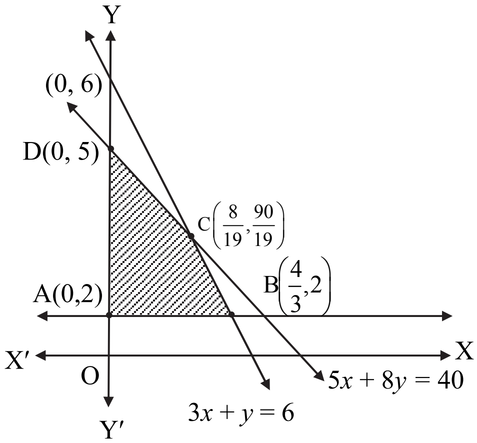
At A (0, 2), z = 18

At B $\left(\frac{4}{3}, 2\right)$, $z = \frac{82}{3}$

At C $\left(\frac{8}{19}, \frac{90}{19}\right)$, $z = \frac{866}{19}$

At D (0, 5), z = 45

∴ Minimum value of z is 18.




**16. (B)**

Mean = $E(X) = \sum x_i . P(x_i)$

$= 1(0.2) + 2(0.15) + 3(0.3) + 4(0.35)$

$= 2.8$

Var(X) = $E(X^2) - [E(X)]^2$

$= 1^2(0.2) + 2^2(0.15) + 3^2(0.3) + 4^2(0.35) - (2.8)^2$

$= 9.1 - 7.84$

$= 1.26$

**17. (C)**

Let the coin be tossed 'n' number of times.

Probability of getting head is $p = \frac{1}{2}$

∴ $q = 1 - \frac{1}{2} = \frac{1}{2}$

$P(X \geq 1) > \frac{99}{100}$

∴ $1 - P(X = 0) > \frac{99}{100}$

∴ $1 - \left(\frac{1}{2}\right)^n > \frac{99}{100}$

∴ $\left(\frac{1}{2}\right)^n < \frac{1}{100}$

∴ $100 < 2^n$

∴ Minimum value of n is 7.

**18. (D)**

$y = a(\sin\theta - \theta\cos\theta)$, $x = a(\cos\theta + \theta\sin\theta)$

∴ $\frac{dy}{d\theta} = a(\cos\theta - \cos\theta + \theta\sin\theta) = a\,\theta\sin\theta$ and

$\frac{dx}{d\theta} = a(-\sin\theta + \sin\theta + \theta\cos\theta) = a\,\theta\cos\theta$

∴ $\frac{dy}{dx} = \frac{\frac{dy}{d\theta}}{\frac{dx}{d\theta}} = \frac{a\theta\sin\theta}{a\theta\cos\theta} = \tan\theta$

∴ Slope of the normal $= \frac{-1}{\tan\theta} = -\cot\theta$

∴ Equation of the normal is

$y - a\sin\theta + a\theta\cos\theta$

$= -\frac{\cos\theta}{\sin\theta}(x - a\cos\theta - a\theta\sin\theta)$

$\Rightarrow y\sin\theta - a\sin^2\theta + a\theta\sin\theta\cos\theta$

$= -x\cos\theta + a\cos^2\theta + a\theta\sin\theta\cos\theta$

$\Rightarrow x\cos\theta + y\sin\theta = a(\sin^2\theta + \cos^2\theta)$

$\Rightarrow x\cos\theta + y\sin\theta = a$

∴ Distance from origin $= \left|\frac{-a}{\sqrt{\sin^2\theta + \cos^2\theta}}\right|$

$= a =$ constant

**19. (A)**

$1 + \frac{dx}{dy} = \frac{2y}{x}$

$\Rightarrow \frac{dx}{dy} = \frac{2y - x}{x}$

$\Rightarrow \frac{dy}{dx} = \frac{x}{2y - x}$ …(i)

Put $y = vx$ …(ii)

$\Rightarrow \frac{dy}{dx} = v + x\frac{dv}{dx}$ …(iii)

Substituting (ii) and (iii) in (i), we get

$v + x\frac{dv}{dx} = \frac{x}{2vx - x} = \frac{1}{2v - 1}$

$\Rightarrow x\frac{dv}{dx} = \frac{1}{2v - 1} - v = \frac{1 - 2v^2 + v}{2v - 1}$

$\Rightarrow x\frac{dv}{dx} = -\frac{(v - 1)(2v + 1)}{2v - 1}$

$\Rightarrow \frac{(2v - 1)}{(2v + 1)(v - 1)}dv = \frac{-dx}{x}$

$\Rightarrow \frac{1}{3(v - 1)} + \frac{4}{3(2v + 1)} = \frac{-dx}{x}$

Integrating on both sides, we get

$\frac{1}{3}\log(v - 1) + \frac{4}{3}.\frac{1}{2}\log(2v + 1)$

$= -\log x + \log c_1$

$\Rightarrow \log(v-1)^{1/3} + \log(2v+1)^{2/3} = \log \frac{c_1}{x}$

$\Rightarrow (v-1)^{1/3}(2v+1)^{2/3} = \frac{c_1}{x}$

$\Rightarrow \left(\frac{y-x}{x}\right)\left(\frac{2y+x}{x}\right)^2 = \frac{c_1^3}{x^3}$

$\Rightarrow (x-y)(x+2y)^2 = c$, where $c = -c_1^{\,3}$

**20. (C)**

Slope of $x + 3y = 4$ is $m_1 = -\frac{1}{3}$

Slope of $6x - 2y = 7$ is $m_2 = 3$

Here, $m_1 \cdot m_2 = -1$

∴ The diagonals are perpendicular to each other.

∴ Parallelogram ABCD is a rhombus.

**21. (B)**

Given, $\bar{b} \times \bar{c} + \bar{a} \times \bar{b} = 0$

$\Rightarrow \bar{b} \times \bar{c} - \bar{b} \times \bar{a} = 0$

$\Rightarrow \bar{b} \times (\bar{c} - \bar{a}) = \bar{0}$

$\Rightarrow \bar{b}$ is parallel to $(\bar{c} - \bar{a})$.

$\Rightarrow \bar{c} - \bar{a} = \lambda\bar{b}$, for some scalar $\lambda$

$\Rightarrow \bar{c} = \bar{a} + \lambda\bar{b}$ … (i)

$\Rightarrow \bar{b} \cdot \bar{c} = \bar{b} \cdot \bar{a} + \lambda(\bar{b} \cdot \bar{b})$

$\Rightarrow 0 = \bar{b} \cdot \bar{a} + \lambda\left(|\bar{b}|^2\right)$ …$[\because \bar{b} \cdot \bar{c} = 0 \text{ (given)}]$

$\Rightarrow 0 = -2 + 3\lambda$

$\Rightarrow \lambda = \frac{2}{3}$

Substituting the value of $\lambda$ in (i), we get

$\bar{c} = \left(\hat{i} + \hat{j} - 2\hat{k}\right) + \frac{2}{3}\left(\hat{i} - \hat{j} + \hat{k}\right)$

$= \frac{1}{3}\left(5\hat{i} + \hat{j} - 4\hat{k}\right)$

∴ $\bar{c} \cdot \bar{b} = \frac{1}{3}\left(5\hat{i} + \hat{j} - 4\hat{k}\right) \cdot \left(\hat{i} - \hat{j} + \hat{k}\right)$

$= \frac{1}{3}(5 - 1 - 4) = 0$

**22. (C)**

Let $f(x) = \cos x$

∴ $f'(x) = -\sin x$

Here, $a = 60°$ and

$h = 10'' = \left(\frac{1}{360}\right)^{\circ} = \frac{1}{360} \times 0.0175^c = 0.000049^c$

$f(a) = \cos(60°) = \frac{1}{2} = 0.5$

$f'(a) = -\sin(60) = -\frac{\sqrt{3}}{2} = -\frac{1.732}{2} = -0.866$

∴ $f(a + h) \approx f(a) + hf'(a)$

∴ $\cos(60°\ 0'\ 10'') \approx 0.5 - 0.000049 \times 0.866$
$\approx 0.49996$

**23. (B)**

$\sin^2(5°) + \sin^2(10°) + \sin^2(15°) + \ldots + \sin^2(85°) + \sin^2(90°)$

$= \sin^2(5°) + \sin^2(10°) + \ldots + \cos^2(10°) + \cos^2(5°) + \sin^2(90°)$ …$[\because \sin(90° - \theta) = \cos\theta]$

$= [\sin^2(5°) + \cos^2(5°)] + \ldots + [\sin^2(40°) + \cos^2(40°)] + \sin^2(30°) + \sin^2(45°) + \sin^2(60°) + \sin^2(90°)$

$= (1 + 1 + \ldots + 1) + \left(\frac{1}{2}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2 + (1)^2$

$= 7 + \frac{1}{4} + \frac{1}{2} + \frac{3}{4} + 1$

$= \frac{19}{2}$

**24. (A)**

$\int \frac{e^{7\log x} - e^{6\log x}}{e^{5\log x} - e^{4\log x}}\,dx = \int \frac{x^7 - x^6}{x^5 - x^4}\,dx$

$= \int \frac{x^6(x-1)}{x^4(x-1)}\,dx$

$= \int x^2\,dx$

$= \frac{x^3}{3} + c$

**25. (C)**

$\bar{r} \times \bar{b} = \bar{c} \times \bar{b}$

$\Rightarrow \bar{a} \times (\bar{r} \times \bar{b}) = \bar{a} \times (\bar{c} \times \bar{b})$

$\Rightarrow (\bar{a} \cdot \bar{b})\bar{r} - (\bar{a} \cdot \bar{r})\bar{b} = (\bar{a} \cdot \bar{b})\bar{c} - (\bar{a} \cdot \bar{c})\bar{b}$

$\Rightarrow (\bar{a} \cdot \bar{b})\bar{r} - 0 = (\bar{a} \cdot \bar{b})\bar{c} - (\bar{a} \cdot \bar{c})\bar{b}$

$\Rightarrow \bar{r} = \bar{c} - \left(\frac{\bar{c} \cdot \bar{a}}{\bar{b} \cdot \bar{a}}\right)\bar{b}$

**26. (A)**

In $\Delta ABC$,

$\angle A + \angle B + \angle C = \pi$

∴ $\angle A + \frac{\pi}{4} + \angle B = \pi$

∴ $\angle A + \angle B = \frac{3\pi}{4}$

$\therefore \quad \frac{\angle A}{3} + \frac{\angle B}{3} = \frac{\pi}{4}$

$\tan\left(\frac{A}{3}\right)$ and $\tan\left(\frac{B}{3}\right)$ are roots of equation

$px^2 + qx + r = 0$ …[Given]

$\therefore$ Sum of roots $= \frac{-q}{p}$

$\tan\left(\frac{A}{3}\right) + \tan\left(\frac{B}{3}\right) = \frac{-q}{p}$

Also, $\tan\left(\frac{A}{3}\right)\cdot\tan\left(\frac{B}{3}\right) = \frac{r}{p}$

Using $\tan\left(\frac{A}{3}+\frac{B}{3}\right) = \frac{\tan\frac{A}{3}+\tan\frac{B}{3}}{1-\tan\frac{A}{3}\tan\frac{B}{3}}$, we get

$\tan\left(\frac{\pi}{4}\right) = \frac{\frac{-q}{p}}{1-\frac{r}{p}}$

$1 = \frac{-q}{p-r}$

$p - r = -q$

$p + q = r$

**27. (A)**

$A(\Delta ABC) = \frac{1}{2}ab\sin C$

$= \frac{1}{2}\left(\sqrt{2}x\right)(2y)\sin 135°$

$= \frac{1}{2}\left(\sqrt{2}x\right)(2y)\sin(90° + 45°)$

$= \sqrt{2}xy \times \cos 45°$

$= \sqrt{2}xy \times \frac{1}{\sqrt{2}}$

$= xy$

**28. (D)**

$\int \frac{\cos x}{\sqrt{1+\sin x}}dx = 2\sqrt{1+\sin x} + c$

$= 2\sqrt{\left(\sin\frac{x}{2}+\cos\frac{x}{2}\right)^2} + c$

$= 2\left[\sin\left(\frac{x}{2}\right)+\cos\left(\frac{x}{2}\right)\right] + c$

**Shortcut - 28**

$\int \frac{f'(x)}{\sqrt{f(x)}}dx = 2\sqrt{f(x)} + c$

**29. (A)**

The projections on the co-ordinate axes are $lr$, $mr$, $nr$.

$\therefore$ $lr = 2$, $mr = 3$ and $nr = 6$

$\therefore$ $l^2r^2 + m^2r^2 + n^2r^2 = 4 + 9 + 36$

$\Rightarrow r^2(l^2 + m^2 + n^2) = 49$

$\Rightarrow r = 7$

**30. (C)**

Required area $= \int_{-2}^{2} x|x|\,dx$

$= \left|\int_{-2}^{0} -x^2\,dx\right| + \int_{0}^{2} x^2\,dx$

$= \left|\frac{-8}{3}\right| + \frac{8}{3}$

$= \frac{16}{3}$

**31. (D)**

$[p \wedge (q \vee r)] \vee [\sim r \wedge \sim q \wedge p]$

$\equiv [p \wedge (q \vee r)] \vee [p \wedge (\sim r \wedge \sim q)]$

…[Commutativity and associativity]

$\equiv [p \wedge (q \vee r)] \vee [p \wedge \sim(r \vee q)$

…[DeMorgan's Law]

$\equiv p \wedge [(q \vee r) \vee \sim(q \vee r)]$

…[Distributive and commutative Law]

$\equiv p \wedge T$ …[Absorption Law]

$\equiv p$ …[Identity Law]

**32. (A)**

$(x + 2)\frac{dy}{dx} = x^2 + 4x - 9$

$\therefore \quad dy = \frac{(x^2+4x+4)-4-9}{x+2}dx$

$\therefore \quad dy = \frac{(x+2)^2-13}{(x+2)}dx$

Integrating both sides, we get

$\int dy = \int(x+2)dx - 13\int\frac{1}{x+2}dx$

$y = \frac{(x+2)^2}{2} - 13\log|x+2| + c$ …(i)

Given that $y(0) = 0$

$\therefore$ from equation (i), we get

$0 = 2 - 13\log|0 + 2| + c$

$\therefore \quad c = 13\log(2) - 2$ …(ii)

$\therefore$ from (i) and (ii), we get

$y(-4) = 2 - 13\log(2) + 13\log(2) - 2 = 0$

**33.** **(B)**

Let $y = x^{5x} \Rightarrow \log y = 5x.\log x, (x > 0)$

Differentiating, $\frac{dy}{dx} = 5x^{5x}(1 + \log x)$;

$\therefore \quad \frac{dy}{dx} = 0$

$\Rightarrow \log x = -1 \Rightarrow x = e^{-1} = \frac{1}{e}$

$\therefore$ Stationary point is $x = \frac{1}{e}$

**34.** **(D)**

$\left(-2-\frac{1}{3}i\right)^3 = \frac{x+iy}{27}$

$\left(-2-\frac{1}{3}i\right)^3 = \frac{1}{27}(-6-i)^3$

Consider, $(-6 - i)^3$

$= (-6)^3 + 3(-6)^2(-i) + 3(-6)(-i)^2 + (-i)^3$

$= -216 - 108i + 18 + i$

$= -198 - 107i$

$\therefore \quad \left(-2-\frac{1}{3}i\right)^3 = \frac{-198-107i}{27}$

Comparing with $\frac{x+iy}{27}$, we get

$x = -198, y = -107$

$y - x = -107 + 198 = 91$

**35.** **(C)**

Since $\sim(p \to q) \equiv p \wedge \sim q$,

$\sim[(p \wedge q) \to (\sim p \vee r)]$

$\equiv (p \wedge q) \wedge \sim(\sim p \vee r)$

$\equiv (p \wedge q) \wedge (p \wedge \sim r)$ …[De Morgan's law]

**36.** **(D)**

$\log(x + y) = \sin(x + y)$

Differentiating both sides w.r.t. $x$, we get

$\frac{1}{x+y}\left(1+\frac{dy}{dx}\right) = \cos(x+y)\left[1+\frac{dy}{dx}\right]$

$\Rightarrow \frac{1}{x+y} + \frac{1}{x+y}\cdot\frac{dy}{dx} = \cos(x+y) + \cos(x+y)\frac{dy}{dx}$

$\Rightarrow \frac{dy}{dx}\left(\frac{1}{x+y} - \cos(x+y)\right) = \cos(x+y) - \frac{1}{x+y}$

$\Rightarrow \frac{dy}{dx} = -1$

**37.** **(A)**

$\lim_{x\to 0^-} f(x) = f(0) = \lim_{x\to 0^+} f(x)$

$\therefore \quad \lim_{x\to 0}\frac{a}{2}(x-|x|) = 0$

$\therefore \quad \lim_{x\to 0}\frac{a}{2}[x-(-x)] = 0$ …[$\because x < 0 \Rightarrow |x| = -x$]

$\therefore \quad \lim_{x\to 0} ax = 0$

Which is true for any real value of a.

$\lim_{x\to 0^+} f(x) = f(0)$

$\therefore \quad \lim_{x\to 0} bx^2\sin\left(\frac{1}{x}\right) = 0$

Note that $x \neq 0$

$\therefore \quad -1 \le \sin\left(\frac{1}{x}\right) \le 1$

$\therefore$ for any real value of b, above limit will be 0.

**38.** **(C)**

The equation of the family of lines which are at the distance of 2 units from the origin is

$x\cos\alpha + y\sin\alpha = 2$ …(i)

Differentiating w.r.t. $x$, we get

$\cos\alpha + \sin\alpha\frac{dy}{dx} = 0$ …(ii)

By (i) – $x$ × (ii), we get

$\sin\alpha\left(y - x\frac{dy}{dx}\right) = 2$

$\Rightarrow y - x\frac{dy}{dx} = 2\operatorname{cosec}\alpha$ …(iii)

From (ii), $\left(\frac{dy}{dx}\right)^2 = \cot^2\alpha = \operatorname{cosec}^2\alpha - 1$

$\therefore \quad \left(\frac{dy}{dx}\right)^2 = \frac{1}{4}\left(y - x\frac{dy}{dx}\right)^2 - 1$ …[From (iii)]

$\therefore \quad 1 + \left(\frac{dy}{dx}\right)^2 = \frac{1}{4}\left(y - x\frac{dy}{dx}\right)^2$

**39.** **(C)**

$\text{Var}(X) = \sigma^2 = 5^2 = 25$

$\text{Var}(X) = E(X^2) - [E(X)]^2$

$\Rightarrow 25 = E(X^2) - 10^2$

$\Rightarrow E(X^2) = 125$

$E\left(\frac{X-15}{5}\right)^2 = E\left(\frac{X^2-30X+225}{25}\right)$

$= \frac{1}{25}\left[E(X^2) - 30E(X) + 225\right]$

$= \frac{1}{25}(125 - 300 + 225)$

$= 2$

**40.** **(C)**

$\bar{a} = 3m\hat{i} + \hat{j}$

Let $\bar{b}$ be the vector obtained on rotation with components (m + 2) and 1. Then,

$\bar{b} = (m+2)\hat{i} + \hat{j}$

$|\bar{a}| = |\bar{b}|$

…[Magnitude remains unchanged after rotation]

$\Rightarrow |\bar{a}|^2 = |\bar{b}|^2$

$\Rightarrow (3m)^2 + 1 = (m + 2)^2 + 1$
$\Rightarrow 9m^2 = m^2 + 4m + 1$
$\Rightarrow 2m^2 - m - 1 = 0$
$\Rightarrow (2m + 1)(m - 1) = 0$
$\Rightarrow m = -\frac{1}{2}$ or $m = 1$

**41.** **(C)**

$\sin^{-1}\left[\cos\left(\frac{\pi}{3}\right)\right] + \sin^{-1}\left[\tan\left(\frac{5\pi}{4}\right)\right]$

$= \sin^{-1}\left(\frac{1}{2}\right) + \sin^{-1}(1)$

$= \frac{\pi}{6} + \frac{\pi}{2}$

$= \frac{2\pi}{3}$

**42.** **(A)**

$\frac{x}{4} + \frac{y}{\frac{4}{a}} + \frac{z}{4} = 1$

For equal intercepts,

$\frac{4}{a} = 4 \quad \Rightarrow a = 1$

**43.** **(C)**

Putting $l = -m - n$ in $l^2 = m^2 + n^2$, we get
$(-m - n)^2 = m^2 + n^2$
$\Rightarrow mn = 0 \Rightarrow m = 0$ or $n = 0$
If $m = 0$, then $l = -n$

$\therefore \quad \frac{l}{-1} = \frac{m}{0} = \frac{n}{1}$

If $n = 0$, then $l = -m$

$\therefore \quad \frac{l}{-1} = \frac{m}{1} = \frac{n}{0}$

$\therefore \quad a_1, b_1, c_1 = -1, 0, 1$ and
$a_2, b_2, c_2 = -1, 1, 0$
$\therefore$ The angle between the lines is given by

$\cos\theta = \frac{1+0+0}{\sqrt{1+0+1}\sqrt{1+1+0}} = \frac{1}{2}$

$\therefore \quad \theta = \frac{\pi}{3}$

**44.** **(B)**

Let $I = \int_0^1 \sin^{-1}\left(\frac{2x}{1+x^2}\right)dx$

Put $x = \tan\theta \Rightarrow dx = \sec^2\theta\, d\theta$

$\therefore \quad I = \int_0^{\frac{\pi}{4}} \sin^{-1}\left(\frac{2\tan\theta}{1+\tan^2\theta}\right)\sec^2\theta\, d\theta$

$= \int_0^{\frac{\pi}{4}} \sin^{-1}(\sin 2\theta)\ \sec^2\theta\, d\theta$

$= \int_0^{\frac{\pi}{4}} 2\theta \sec^2\theta\, d\theta$

$= 2\int_0^{\frac{\pi}{4}} \theta\sec^2\theta\, d\theta$

$= 2\left[\left[\theta\tan\theta\right]_0^{\pi/4} - \int_0^{\frac{\pi}{4}} 1\cdot\tan\theta\, d\theta\right]$

$= 2\left[\left(\frac{\pi}{4}\tan\frac{\pi}{4} - 0\right) - \left[\log|\sec\theta|\right]_0^{\pi/4}\right]$

$= 2\left[\frac{\pi}{4} - \left(\log\left|\sec\frac{\pi}{4}\right| - \log|\sec 0|\right)\right]$

$= 2\left[\frac{\pi}{4} - \left(\log\sqrt{2} - \log 1\right)\right]$

$= 2\left(\frac{\pi}{4} - \frac{1}{2}\log 2\right)$

$\therefore \quad I = \frac{\pi}{2} - \log 2$

**45.** **(D)**

Let $I = \int \sec^{\frac{2}{3}} x \operatorname{cosec}^{\frac{4}{3}} x\ dx$

$= \int \frac{1}{\cos^{\frac{2}{3}} x \sin^{\frac{4}{3}} x}\ dx$

$= \int \frac{1}{\left(\frac{\sin^{\frac{4}{3}} x}{\cos^{\frac{4}{3}} x}\right) \times \cos^2 x}\ dx$

$= \int \frac{\sec^2 x}{(\tan x)^{\frac{4}{3}}}\ dx$

Put $\tan x = t \Rightarrow \sec^2 x\, dx = dt$

$\therefore \quad I = \int \frac{dt}{t^{\frac{4}{3}}}\ dt = -3t^{-\frac{1}{3}} + c \ = -3(\tan x)^{\frac{-1}{3}} + c$

**46.** **(C)**

$\tan\theta + \tan 2\theta + \tan\theta \,.\, \tan 2\theta = 1$
$\Rightarrow \tan\theta + \tan 2\theta = 1 - \tan\theta \,.\, \tan 2\theta$

$\Rightarrow \frac{\tan\theta + \tan 2\theta}{1 - \tan\theta.\tan 2\theta} = 1$

$\Rightarrow \tan(\theta + 2\theta) = 1$

$\Rightarrow \tan(3\theta) = 1 = \tan\frac{\pi}{4}$

$\Rightarrow 3\theta = n\pi + \frac{\pi}{4}$

$\Rightarrow \theta = \frac{n\pi}{3} + \frac{\pi}{12}$

**47. (C)**

Given line $3x + y = 0 \Rightarrow$ slope $= -3$

Let the slope of required line be m

$\therefore$ $\tan 45^\circ = \left|\frac{m+3}{1-3m}\right|$

$\Rightarrow 1 = \left|\frac{m+3}{1-3m}\right|$

$\Rightarrow 2m^2 - 3m - 2 = 0$ …(i)

Since the line passes through origin, its equation is $y = mx$

$\Rightarrow m = \frac{y}{x}$

Substituting the value of m in equation (i), we get

$2\left(\frac{y}{x}\right)^2 - 3\left(\frac{y}{x}\right) - 2 = 0$

$\Rightarrow 2y^2 - 3xy - 2x^2 = 0$

$\Rightarrow 2x^2 + 3xy - 2y^2 = 0$

**48. (C)**

Equation of plane passing though (–1, 2, –2) and (–1, 3, 2) is

$\frac{x+1}{(-1+1)} = \frac{y-3}{2-3} = \frac{z-2}{-2-2}$

Above plane is perpendicular to $yz$ – plane

$\therefore$ $\frac{y-3}{-1} = \frac{z-2}{-4}$

$\Rightarrow 4(y - 3) = z - 2$

$\Rightarrow 4y - 12 - z + 2 = 0$

$\Rightarrow 4y - z = 10$

**49. (B)**

Let $\frac{b+c}{11} = \frac{c+a}{12} = \frac{a+b}{13} = k$

$\therefore$ $b + c = 11k$ ….(i)

$c + a = 12k$ ….(ii)

and $a + b = 13k$ ….(iii)

From (i) + (ii) + (iii), $2(a + b + c) = 36k$

$\therefore$ $a + b + c = 18\ k$ ….(iv)

Now, (iv) – (i) gives, $a = 7k$

(iv) – (ii) gives, $b = 6k$

(iv) – (iii) gives, $c = 5k$

Now,

$\cos C = \frac{a^2 + b^2 - c^2}{2ab} = \frac{(7k)^2 + (6k)^2 - (5k)^2}{2 \times (7k) \times (6k)}$

$= \frac{49k^2 + 36k^2 - 25k^2}{84k^2}$

$= \frac{60k^2}{84k^2}$

$= \frac{5}{7}$

**50. (C)**

Let $I = \int \cos(\log x)\,dx$

Put $\log x = t \Rightarrow x = e^t \Rightarrow dx = e^t\,dt$

$\therefore$ $I = \int e^t \cos t\,dt$

$= e^t \cos t - \int e^t(-\sin t)\,dt + c_1$

$= e^t \cos t + \int e^t \sin t\,dt + c_1$

$= e^t \cos t + e^t \sin t - \int e^t \cos t\,dt + c_2$

$= e^t \cos t + e^t \sin t - I + c_2$

$\Rightarrow 2I = e^t (\cos t + \sin t) + c_2$

$\Rightarrow I = \frac{e^t}{2}(\cos t + \sin t) + c$

$= \frac{x}{2}[\cos(\log x) + \sin(\log x)] + c$

Page no. **129** to **257** are purposely left blank.

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| **Physics** | | | 50 | | | 50 | | | 50 | | | 50 | | | 50 |
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*"Great things are not done by impulse, but by a series of small things brought together." — Vincent van Gogh*

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