Memory Based
Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2023 (Online) Phase-2

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

   (i)   **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

   (ii)   **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. If the height of the tower used for L.O.S is increased by 21% then percentage change in range is
   - (1) 10%
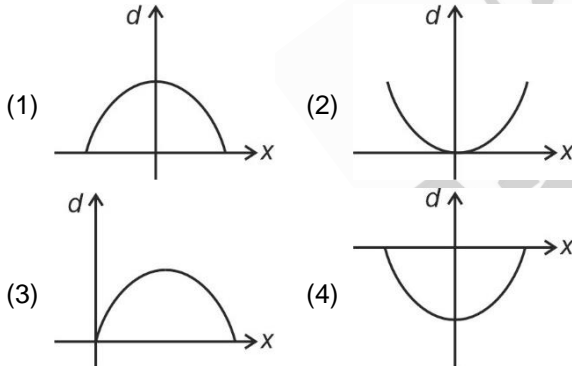   - (2) 21%
   - (3) 19%
   - (4) 42%

   Answer (1)

   Sol. $l = \sqrt{2Rh}$

   $l' = \sqrt{2R(1.21h)} = 1.1\sqrt{2Rh}$

   $\dfrac{l'-l}{l} = (0.1) = 10\%$

2. Select the correct graph showing the difference (d) between total energy and potential energy of a particle in linear SHM with position x of the particle ($x = 0$ is the mean position)

   Answer (1)

   Sol. $d = T.E - P.E$

   $= K.E$ (∵ Total energy is conserved)

   $= \dfrac{1}{2}m\omega^2(A^2 - x^2)$

3. A dipole of charge 0.01 C and separation 0.4 mm, is placed in an electric field of strength 10 dyne/C. Find the maximum torque exerted on the dipole in the field.
   - (1) 4×10^{-9} Nm
   - (2) 2×10^{-10} Nm
   - (3) 4×10^{-10} Nm
   - (4) 2×10^{-9} Nm

   Answer (3)

   Sol. $P = 0.01 \times 0.4 \times 10^{-3} = 4 \times 10^{-6}$ cm

   $E = 10 \times 10^{-5}$ N

   $|\tau| = |\vec{P} \times \vec{E}| = 4 \times 10^{-6} \times 10 \times 10^{-5} = 4 \times 10^{-10}$ Nm

4. Two bodies having same linear momentum have ratio of kinetic energy as 16 : 9. Find the ratio of masses of these bodies.
   - (1) $\dfrac{9}{16}$
   - (2) $\dfrac{4}{3}$
   - (3) $\dfrac{3}{4}$
   - (4) $\dfrac{16}{9}$

   Answer (1)

   Sol. $\dfrac{P^2}{2m} = K$

   $\Rightarrow \dfrac{K_1}{K_2} = \left(\dfrac{m_2}{m_1}\right) = \dfrac{16}{9} = \left(\dfrac{m_2}{m_1}\right)$

   $\left(\dfrac{m_1}{m_2}\right) = \dfrac{9}{16}$

5. What is the centre of gravity of semi-circular disc of radius (R)?
   - (1) $\dfrac{2R}{\pi}$
   - (2) $\dfrac{4R}{3\pi}$
   - (3) $\dfrac{R}{2}$
   - (4) $\dfrac{3R}{8}$

   Answer (2)

   Sol. $y_{cm} = \displaystyle\int_0^R \dfrac{dm\,y}{M} = \int_0^R \dfrac{\dfrac{M(\pi r dr)}{\left(\dfrac{\pi R^2}{2}\right)} \cdot \dfrac{2r}{\pi}}{M} = \dfrac{4}{\pi R^2}\int_0^R r^2 dr = \dfrac{4R}{3\pi}$
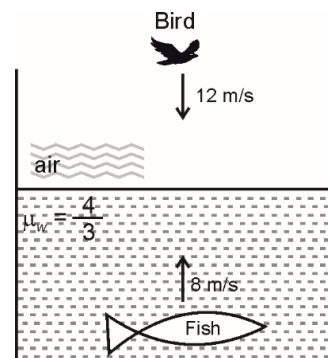
6. The work function for two metals are 9 eV and 4.5 eV. Find the approx. difference between their threshold wavelengths. (Use $hC = 1240$ eV–nm)
   - (1) 138 nm
   - (2) 130 nm
   - (3) 112 nm
   - (4) 145 nm

   Answer (1)

   Sol. $\Delta\lambda = \left[\dfrac{1240}{4.5} - \dfrac{1240}{9}\right]$ nm

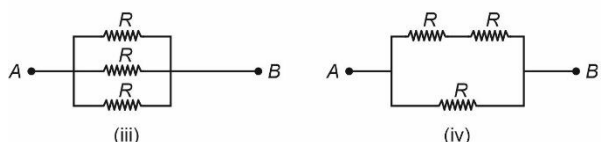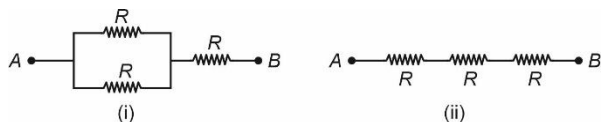7. In the given figure, find the speed of bird as seen by fish.

(1) 24 m/s   (2) 16 m/s

(3) 20 m/s   (4) 12 m/s

Answer (1)

Sol. $\dfrac{v_{b/f}}{\dfrac{4}{3}} = \dfrac{-8}{\dfrac{4}{3}} + \dfrac{(-12)}{1}$

8. Select increasing order of power consumption.

(1) $P_1 < P_2 < P_4 < P_3$

(2) $P_3 < P_4 < P_1 < P_2$

(3) $P_4 < P_3 < P_1 < P_2$

(4) $P_2 < P_1 < P_4 < P_3$

Answer (4)

Sol. Suppose battery of emf ε is applied across each circuit.

$\therefore \quad P_1 = \dfrac{\varepsilon^2}{R_{eq}} = \dfrac{\varepsilon^2}{\left(\dfrac{3R}{2}\right)} = 0.67\dfrac{\varepsilon^2}{R}$

$P_2 = \dfrac{\varepsilon^2}{R_{eq}} = \dfrac{\varepsilon^2}{3R} = 0.33\dfrac{\varepsilon^2}{R}$

$P_3 = \dfrac{\varepsilon^2}{R_{eq}} = \dfrac{\varepsilon^2}{\left(\dfrac{R}{3}\right)} = 3\dfrac{\varepsilon^2}{R}$

$P_4 = \dfrac{\varepsilon^2}{R_{eq}} = \dfrac{\varepsilon^2}{\left(\dfrac{2R}{3}\right)} = 1.5\dfrac{\varepsilon^2}{R}$

Increasing order is → $P_2 < P_1 < P_4 < P_3$

9. Pressure for polytropic process P varies with volume V as $P = aV^{-3}$, find out the bulk modulus.
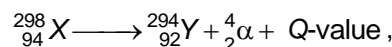
(1) $3V$ (2) $3P$

(3) P (4) V

Answer (2)

Sol. $P = aV^{-3}$

$\dfrac{dP}{dV} = -3aV^{-4}$

$\Rightarrow -V\dfrac{dP}{dV} = \left(3aV^{-3}\right) = (3P)$

10. For the given radioactive decay

$^{298}_{94}X \longrightarrow {}^{294}_{92}Y + {}^4_2\alpha + Q\text{-value}$,

binding energy per nucleon of X, Y and α are a, b and c. The Q-value is equal to

(1) $(294b + 4c - 298a)$ (2) $(92b + 2c - 94a)$

(3) $(294b + 4c + 298a)$ (4) $(92b + 2c + 94a)$

Answer (1)

Sol. Q-value = (B.E.)$_{\text{product}}$ − (B.E.)$_{\text{reaction}}$

11. Energy of He⁺ in 2ⁿᵈ orbit is –13.6 eV then energy of Be⁺⁺⁺ in $n = 4$.

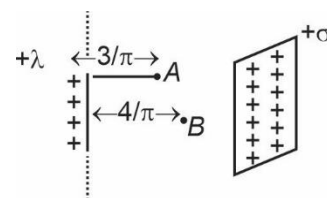(1) − 3.4 eV   (2) − 27.2 eV

(3) − 13.6 eV   (4) − 54.4 eV

Answer (3)

Sol. $E = -13.6\dfrac{Z^2}{n^2}$ eV

For He⁺ ($Z = 2$, $n = 2$), $E = -13.6\left(\dfrac{2^2}{2^2}\right)$ eV

$= -13.6$ eV

For Be⁺⁺⁺ ($Z = 4$, $n = 4$), $E = -13.6\left(\dfrac{4^2}{4^2}\right)$ eV

$= - 13.6$ eV

12. A line charge of linear charge density λ and a large non-conducting sheet of charge density σ are placed parallel to each other as shown. Find ratio of electric field at A to that at B.

(1) $\dfrac{3}{4}\left(\dfrac{\lambda - 3\sigma}{\lambda + 4\sigma}\right)$ (2) $\dfrac{4}{3}\left(\dfrac{\lambda - 3\sigma}{\lambda - 4\sigma}\right)$

(3) $\dfrac{2}{3}\left(\dfrac{\lambda - 4\sigma}{\lambda - 3\sigma}\right)$ (4) $\dfrac{3}{2}\left(\dfrac{\lambda - 4\sigma}{\lambda - 3\sigma}\right)$
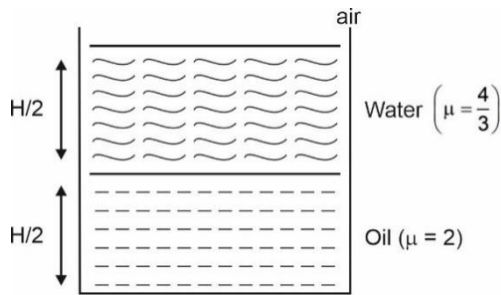
Answer (2)

Sol. $\dfrac{E_A}{E_B} = \dfrac{\dfrac{\lambda}{2\pi\varepsilon_0\left(\dfrac{3}{\pi}\right)} - \dfrac{\sigma}{2\varepsilon_0}}{\dfrac{\lambda}{2\pi\varepsilon_0\left(\dfrac{4}{\pi}\right)} - \dfrac{\sigma}{2\varepsilon_0}}$

13. Which of the following show time varying magnetic field?

    (1) Linearly varying

    (2) Permanent magnet

    (3) Antenna signal

    (4) Constant electric field

Answer (3)

Sol. Antenna signal carries sinusoidal EM wave where $\vec{E}$ and $\vec{B}$ both varying with time.

14. Find the apparent depth of bottom of beaker shown in figure, filled with water and oil.

    (1) $\dfrac{5H}{8}$

    (2) $\dfrac{4H}{5}$

    (3) $\dfrac{3H}{4}$

    (4) $\dfrac{7H}{8}$

Answer (1)

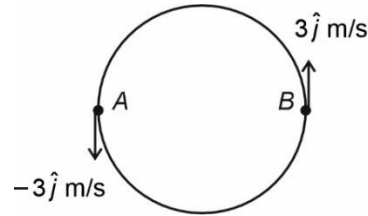**Sol.** $d_{app} = \dfrac{H/2}{4/3} + \dfrac{H/2}{2} = \dfrac{5H}{8}$

15. If a particle is moving in a uniform circular motion of radius 1 m, is having velocity $3\hat{j}$ m/s at point *B*. What are the velocity ($\vec{v}$) and acceleration ($\vec{a}$) at diametrically opposite point *A*.

    (1) $\vec{v}_A = 3\hat{j}$ m/s

    $\vec{a}_A = -9\hat{i}$ m/s^2

    (2) $\vec{v}_A = -3\hat{j}$ m/s

    $\vec{a}_A = 9\hat{i}$ m/s^2

    (3) $\vec{v}_A = -3\hat{i}$ m/s

    $\vec{a}_A = +9\hat{j}$ m/s^2

    (4) $\vec{v}_A = +3\hat{i}$ m/s
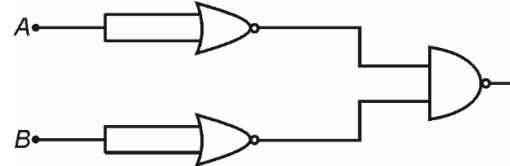
    $\vec{a}_A = +9\hat{j}$ m/s^2

Answer (2)
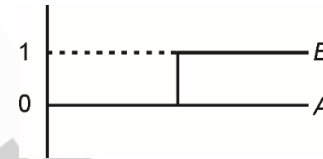
Sol. $\vec{v}_A = -3\hat{j}$ m/s

$\vec{a}_A = 9\hat{i}$ m/s^2

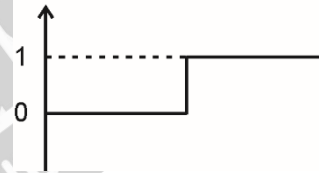16. The input signal is given below for the circuit

Input graph of A and B is
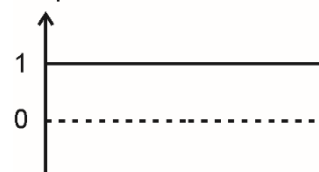

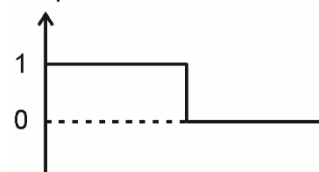Pick the correct output graph for the circuit.

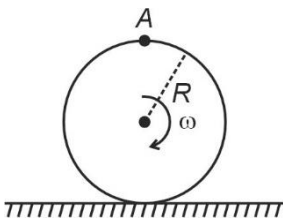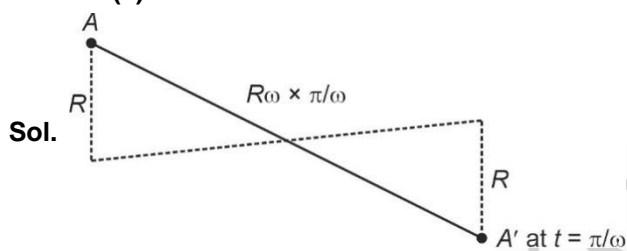(1) Output

(2) Output

(3) Output

(4) Output

Answer (1)

Sol. $\overline{(\overline{A} \cdot \overline{B})} = \overline{\overline{A} + \overline{B}} = (A + B)$ = OR gate

17. Find the displacement of point A on the top of the disc rolling without slipping on horizontal surface with angular speed ω, in half rotation.

(1) $R\sqrt{\pi^2+2}$

(2) $R\sqrt{\pi^2+\dfrac{1}{4}}$

(3) $R\sqrt{\pi^2+4}$

(4) $R\sqrt{\dfrac{\pi^2}{2}+1}$

Answer (3)

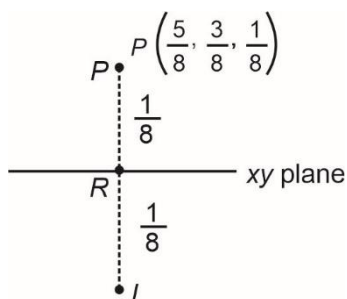**Sol.**

$$AA' = \sqrt{(2R)^2+(\pi R)^2}$$

$$= R\sqrt{\pi^2+4}$$

18. A point R is at $\left(\dfrac{5}{8},\dfrac{3}{8},\dfrac{1}{8}\right)$ and a plane mirror is placed on xy plane such that normal to the plane mirror from R intersect at point P on mirror. Find distance of image formed by the mirror and object.

(1) $\dfrac{1}{2}$ m

(2) $\dfrac{1}{4}$ m

(3) $\dfrac{1}{8}$ m

(4) 1 m

Answer (2)

Sol. Distance between object and image is

$$= PR+RI = 2\left(\dfrac{1}{8}\right) = \dfrac{1}{4} \text{ m}$$

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g., 06.25, 07.00, −00.33, −00.30, 30.27, −27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. If a wire of resistance R is connected across V_0, then power is P_0. The wire is cut into two equal parts and connected with V_0 individually, then sum of power dissipated is P_1 then $\dfrac{P_0}{P_1}$ is $\dfrac{1}{x}$ find the value of x.

Answer (4)

Sol. $P_0 = \left(\dfrac{V_0^2}{R}\right)$

$$P_1 = \dfrac{V_0^2}{\dfrac{R}{2}} + \dfrac{V_0^2}{\dfrac{R}{2}} = \dfrac{4V_0^2}{R}$$

$$\dfrac{P_0}{P_1} = \dfrac{1}{4}$$

22. A particle is performing SHM having position $x = A\cos(30°)$, and $A = 40$ cm. If its kinetic energy at this position is 200 J. The value of force constant in $\left(\dfrac{kN}{m}\right)$ is

Answer (10)

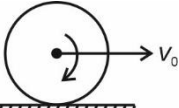**Sol.** $x = 40 \times \dfrac{\sqrt{3}}{2} = 20\sqrt{3}$ cm as $\omega = \sqrt{\dfrac{K}{m}}$

$$\dfrac{1}{2}mv^2 = \dfrac{1}{2}m\omega^2\left(A^2-x^2\right) = 200$$

$$\Rightarrow \dfrac{1}{2} \times m \times \dfrac{K}{m}(0.16-0.12) = 200$$

$$K = \dfrac{400}{0.04} = 10000 \text{ N/m}$$

23. Solid sphere rolls on horizontal plane. Ratio of angular momentum about COM to total energy is $\dfrac{\pi}{22}$. Find $\omega = ?$

Answer (4)

Sol.

$L = I_{COM}\,\omega$ and $K = \dfrac{1}{2}I_{COM}\omega^2 + \dfrac{1}{2}Mv_0^2$

$L = \dfrac{2}{5}MR^2\dfrac{v_0}{R}$ $\qquad K = \dfrac{1}{2}\left(\dfrac{2}{5}MR^2\right)\dfrac{v_0^2}{R^2} + \dfrac{1}{2}Mv_0^2$

$L = \dfrac{2MRv_0}{5}$ $\qquad\qquad K = \dfrac{7}{10}Mv_0^2$

Ratio $\dfrac{L}{K} = \dfrac{4}{7}\dfrac{R}{v_0} = \dfrac{\pi}{22} \Rightarrow \omega = \dfrac{4}{7}\times\dfrac{22}{22}\times 7 = 4$

24. If $m = 5 \pm 0.2$ and $v = 20 \pm 0.4$, calculate error in measurement of K.E.

Answer (8)

Sol. % error in $m = \dfrac{0.2}{5}\times 100 = 4\%$

% error in $v = \dfrac{0.4}{20}\times 100 = 2\%$

% error in $\dfrac{1}{2}mv^2$ = (% error in m) + 2 (% error in v)

$= 4 + 2\,(2) = 8\%$

25. Water is flowing inside the conical type tube having ratio of area of cross-section 6 : 1. If the speed of water outlet through smaller area is 60 m/s, then the pressure difference across these two cross-section is $x \times 10^4$ Pa, find the value of x. (Assume incompressible fluid, density of water = 1000 kg/m^3)
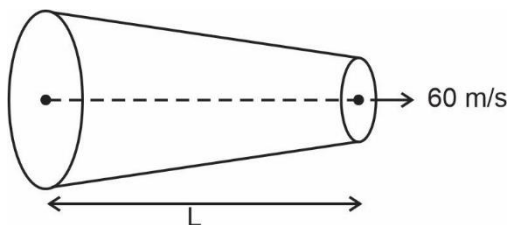
Answer (175)

Sol. $A_1v_1 = A_2v_2$

$\Rightarrow\quad 6v_1 = 60$

$v_1 = 10$ m/s

$\Delta P = \dfrac{1}{2}\rho\left(60^2 - 10^2\right)$

$= \dfrac{1}{2}\times 1000\left(3600 - 100\right)$

$= \dfrac{3500}{2}\times 1000$

$= 175 \times 10^4$

26. Train A of length l is moving with speed 108 km/hr. Another train B of length $4l$ is moving parallel to train A with speed 72 km/hr. They both move through a tunnel of length $60l$ and train B takes 35 s more time than train A to pass through the tunnel, if they enter the tunnel simultaneously. Find the length (in m) of tunnel.

Answer (1575)

Sol. $t_A = \dfrac{2l + 60l}{30}$, $t_B = \dfrac{8l + 60l}{20}$

Also, $t_B - t_A = 35$

$\dfrac{68l}{20} - \dfrac{62l}{30} = 35$

$l = \dfrac{105}{4}$ m

$\therefore$ Length of tunnel $= 60\left(\dfrac{105}{4}\right) = 1575$ m

27.

28.

29.

30.

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.
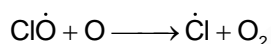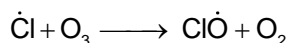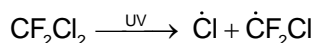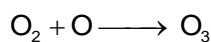
Choose the correct answer:

1. In which of the following free radical helps in depletion of ozone layer?

   (1) $\overset{\bullet}{N}O$

   (2) $\overset{\bullet}{C}l$

   (3) $O\overset{\bullet}{H}$

   (4) $\overset{\bullet}{C}H_3$

Answer (2)

Sol. $O_2 \xrightarrow{UV} O + O$

$O_2 + O \longrightarrow O_3$

$CF_2Cl_2 \xrightarrow{UV} \overset{\bullet}{C}l + \overset{\bullet}{C}F_2Cl$

$\overset{\bullet}{C}l + O_3 \longrightarrow Cl\overset{\bullet}{O} + O_2$

$Cl\overset{\bullet}{O} + O \longrightarrow \overset{\bullet}{C}l + O_2$

2. In which of the following option the species changes from paramagnetic to diamagnetic and bond order increases?

   (1) $N_2 \rightarrow N_2^+$

   (2) $O_2 \rightarrow O_2^{2-}$

   (3) $NO \rightarrow NO^+$

   (4) $O_2 \rightarrow O_2^+$

Answer (3)

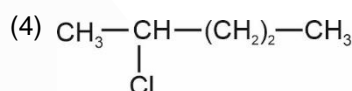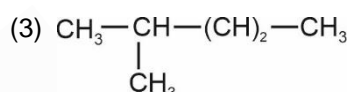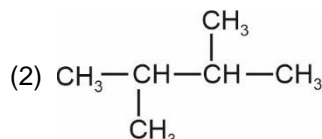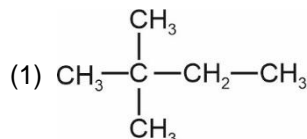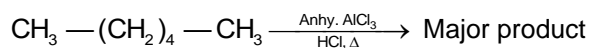**Sol.** NO is paramagnetic with BO = 2.5 NO$^+$ is diamagnetic with BO = 3.0

3. What happens when lyophilic sol is added to lyophobic sol?
   (1) Prevention from coagulation
   (2) Precipitation
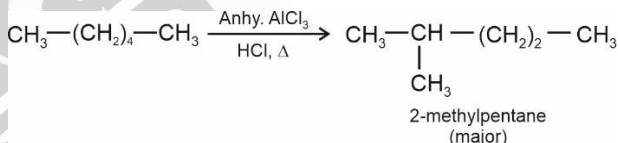   (3) Emulsion
   (4) Electrophoresis

Answer (1)

Sol. On addition of lyophilic sol to lyophobic sol, prevention from coagulation takes place in the sense that more amount of electrolyte is needed to cause coagulation of same colloidal sol.

4. What is the major product formed in the following reaction

   $$CH_3-(CH_2)_4-CH_3 \xrightarrow[HCl, \Delta]{Anhy. AlCl_3} \text{Major product}$$

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

   (2) $CH_3-CH-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}H}-CH_3$

   (3) $CH_3-\underset{\underset{CH_3}{|}}{C}H-(CH)_2-CH_3$

   (4) $CH_3-\underset{\underset{Cl}{|}}{C}H-(CH_2)_2-CH_3$

Answer (3)

Sol. n-Alkanes on heating in this presence of anhydrous AlCl₃ and hydrogen chloride gas isomerise to branched chain alkanes. The major product has one methyl side chain.

$$CH_3-(CH_2)_4-CH_3 \xrightarrow[HCl, \Delta]{Anhy. AlCl_3} CH_3-\underset{\underset{CH_3}{|}}{C}H-(CH_2)_2-CH_3$$

2-methylpentane (major)
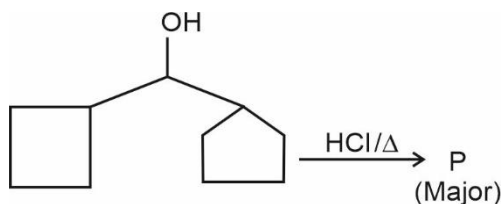
5. Which one of the following shows incorrect method of refining?
   (1) Zinc : Liquation
   (2) Copper : Electrolysis
   (3) Titanium : Van Arkel Method
   (4) Nickel : Mond's Process

Answer (1)

Sol. Zinc is refined by distillation, method used for metals having low boiling point.
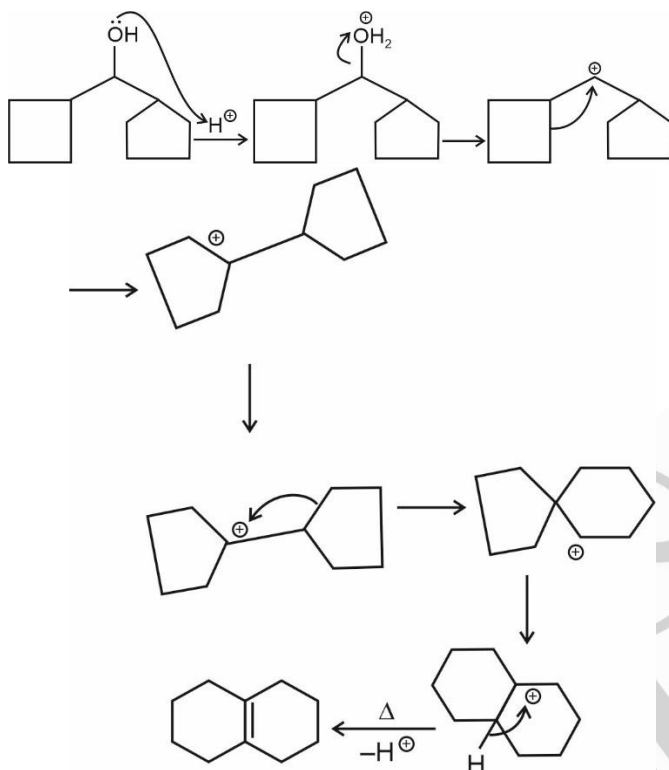
6. Consider a reaction

   Which of the following conclusions is correct about the product P?

(1) Both ring will be 5-membered

(2) Both ring will be 6-membered

(3) One ring is 5-membered and other is 6-membered

(4) One of the rings is 4-membered

Answer (2)

Sol.

7. The pair of lanthanoids with exceptionally high 3rd ionisation enthalpy than neighbour elements.

(1) Lu and Yb

(2) Eu and Gb

(3) Eu and Yb

(4) Dy and Yb

Answer (3)

Sol. $Eu : [Xe]\ 4f^7\ 6s^2$ ⎫ Exceptionlly high IE due to half
$Yb : [Xe]\ 4f^{14}\ 6s^2$ ⎭ filled & fully filled configurations

8. ClF$_5$ exist in which state at room temperature?

(1) Gaseous state and square pyramidal, colourless

(2) Liquid state and trigonal bipyramidal, colourless

(3) Gaseous state and trigonal bipyramidal, colourless

(4) Liquid state and square pyramidal, colourless

Answer (4)

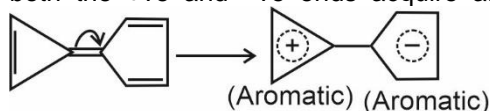**Sol.** ClF$_5$ is a colourless liquid with square pyramidal structure. Hence the correct option is (4).

[Reference : NCERT]

9. Which one of the following compounds has the highest dipole moment?

(1)

(2)

(3)

(4)
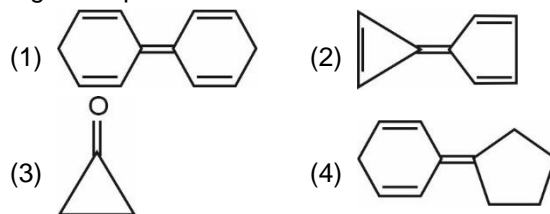
Answer (2)

Sol. Among the given compounds, the following compound has the highest dipole moment because both the +ve and –ve ends acquire aromaticity.

10. Identify the product formed in the following reaction
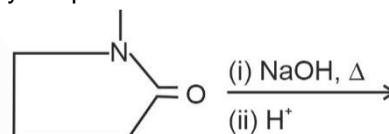
(1) $H_2N - (CH_2)_3 - CHO$

(2) $CH_3 - NH - (CH_2)_3 - CH_2OH$

(3) $CH_3 - NH - (CH_2)_3 - COOH$

(4) $H_2N - \underset{\underset{CH_3}{|}}{CH} - (CH_2)_2 - COOH$

Answer (3)

Sol.
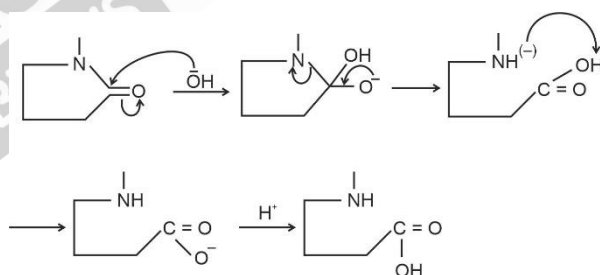
11. Incorrect statement about Borazine is

(1) It has Banana shape bonds

(2) It has electron delocalisation

(3) It reacts with water

(4) Cyclic in nature

Answer (1)

Sol. Borazine is $B_3N_3H_6$

Banana bonds are not present in $B_3N_3H_6$.

12. Match the Column-I and Column-II

	Column-I		Column-II
A	Nylon-6	1	Caprolactum
B	Natural rubber	2	Chloroprene
C	Vulcanized rubber	3	Isoprene
D	Neoprene	4	Sulfur containing rubber

(1) A → 1; B → 3; C → 4; D → 2

(2) A → 1; B → 2; C → 4; D → 3

(3) A → 4; B → 3; C → 1; D → 2

(4) A → 2; B → 3; C → 4; D → 1

Answer (1)

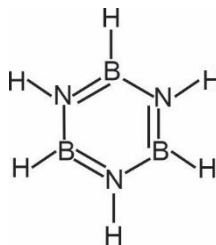**Sol.** Nylon-6 – Caprolactum

Natural rubber – Isoprene

Vulcanized rubber – Sulfur containing rubber

Neoprene – Chloroprene

13. Consider a reaction.

$Be(OH)_2 + Sr(OH)_2 \longrightarrow$ Product

Incorrect statement regarding the product is

(1) Be is tetrahedrally bonded in the product

(2) Be forms cationic part

(3) It is an acid-base reaction

(4) $Be(OH)_2$ acts as a Lewis acid

Answer (2)

Sol. $Be(OH)_2 + Sr(OH)_2 \longrightarrow Sr^{2+}[Be(OH)_4]^{2-}$

As Be is present in the anionic part, option (2) is incorrect.

14. Following two columns are given

Column I / Column II

(a) Troposphere — (p) From 10 to 50 km from sea level

(b) Stratosphere — (q) Upto 10 km from sea level

(c) **Mesosphere** — (R) From 85 km to 100 km from sea level

(d) Thermosphere — (s) From 50 km to 85 km from sea level

(1) a(p); b(q); c(r); d(s)

(2) a(r); b(s); c(p); d(q)

(3) a(q); b(p); c(s); d(r)

(4) a(s); b(r); c(p); d(q)

Answer (3)

Sol. Thermosphere : From 85 to ~ 700 km from sea level

Mesosphere : From 50 to 85 km from sea level

Stratosphere : From 10 – 50 km from sea level

Troposphere : Upto 10 km from sea level

15. Energy of first Bohr orbit E_1 is -2.18×10^{-18} J, then find energy of third Bohr orbit for hydrogen

(1) $3E_1$

(2) $9E_1$

(3) $\dfrac{E_1}{9}$

(4) $\dfrac{E_1}{27}$

Answer (3)

Sol. $E_3 = -2.18 \times 10^{-18} \times \dfrac{Z^2}{n^2}$

$E_3 = \dfrac{E_1}{(3)^2} = \dfrac{E_1}{9}$

16. Which one of the following is the best method for the removed of hardness of water?

(1) Boiling

(2) Treatment with washing soda

(3) Permutit process

(4) Synthetic resin method

Answer (4)

Sol. Boiling of hard water removes temporary harness only. Treatment with washing soda as well as permutit process are useful in removing Ca^{2+} and Mg^{2+} ions from hard water but do not remove Cl^- and SO_4^{2-} ions. Synthetic resin method enables us to remove Ca^{2+} and Mg^{2+} ions as well as Cl^- and SO_4^{2-} ions. Therefore, synthetic resin method is the best method to remove hardness of water.

17. Glyceraldehyde $\xrightarrow[\substack{ii.\ H_3O^+ \\ iii\ HNO_3}]{i.\ HCN} A + B$

Then select the correct option about the product A and B

(1) Both are optically active

(2) Both are optically inactive

(3) One is optically active and another is optically inactive

(4) None of these

Answer (3)

Sol

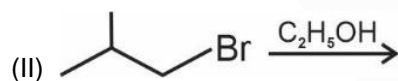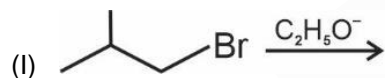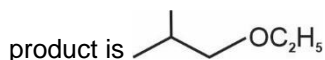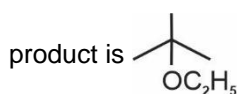D(+) Glyceraldehyde → (HCN) → (two products) → (H₃O⁺) → ... → (HNO₃) → Optically inactive / Optically active
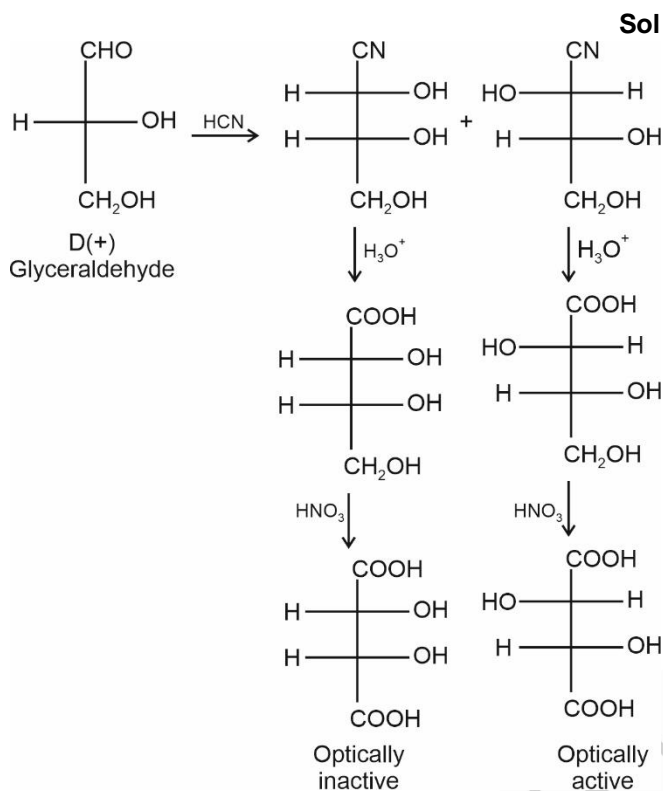
18. Consider the following reactions

(I) $\xrightarrow{C_2H_5O^-}$

(II) $\xrightarrow{C_2H_5OH}$

and identify the correct statement.

(1) In reaction (I), mechanism is S_N1 and the product is OC_2H_5

(2) In reaction (II), mechanism is S_N1 and the product is OC_2H_5

(3) In reaction (I), mechanism is S_N2 and the product is OC_2H_5

(4) In reaction (II), mechanism is S_N2 and the product is OC_2H_5

Answer (2)

Sol. (I) $\xrightarrow[S_N2]{C_2H_5O^-}$ ... OC_2H_5

(II) $\xrightarrow[S_N1]{C_2H_5OH}$ ...

$\xrightarrow[-H^+]{C_2H_5OH}$ ... OC_2H_5
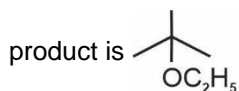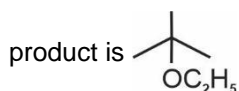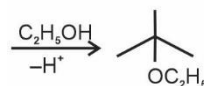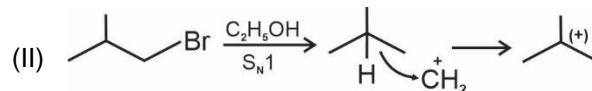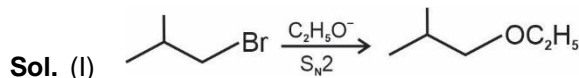
19. Identify the major product formed in the following reaction
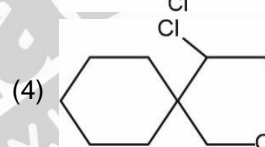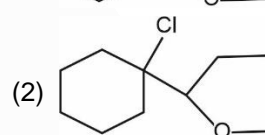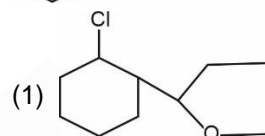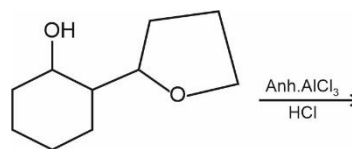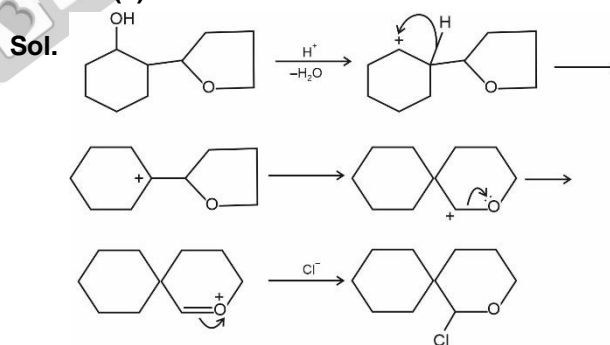
 $\xrightarrow[HCl]{Anh.AlCl_3}$

(1)

(2)

(3)

(4)

Answer (3)

Sol.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g., 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. Radius of 2nd orbit of $He^{\oplus}$ is r_0. Radius of 4th orbit of Be^{+3} is xr_0.

Find x.

Answer (02.00)

Sol. $r_0 = 0.529 \times \dfrac{(4)}{2}$

$= 0.529 \times 2$ Å

$r_{Be}^{+3} = 0.529 \times \dfrac{(4)^2}{4}$

$= 0.529 \times 4$

$= 2r_0$

$\Rightarrow \quad x = 2$

22. An organic compound on combustion gives 0.22 g of CO_2 and 0.126 g H_2O. It the percentage of C in given organic compound is 40%, the % of H will be?

Answer (9.34)

Sol. $C\% = \dfrac{12}{44} \times \dfrac{0.22}{\text{weight of sample}} \times 100$

$40 = \dfrac{12}{44} \times \dfrac{0.22}{\text{weight of sample}} \times 100$

$\therefore$ weight of sample $= \dfrac{6}{40} = 0.15$ g

$\therefore \quad H\% = \dfrac{2}{18} \times \dfrac{0.126}{0.15} \times 100$

$= 9.33\%$

23. For the 1st order reaction, the ratio of $t_{50\%}$ to $t_{87.5\%}$ will be:

Answer (3)

Sol. At 87.5% consumption, we have 3 half lives.

$\therefore \dfrac{t_{87.5}}{t_{50\%}} = 3$

24. If $\left(1+\dfrac{1}{x}\right)^{1/2} v_{av} = v_{rms}$, then x is (Nearest integer)

Answer (6)

Sol. $\left(1+\dfrac{1}{x}\right)^{1/2} \sqrt{\dfrac{8RT}{\pi M}} = \sqrt{\dfrac{3RT}{M}}$

$\left(1+\dfrac{1}{x}\right) \times \dfrac{8}{\pi} = 3$

$8x + 8 = 3\pi x$

$x = \dfrac{8}{(3\pi - 8)} = \dfrac{8}{1.42} \simeq 5.63$

25. A solution is isotonic with glucose having concentration 0.05 M at a certain temperature. If the volume of the solution is 1 L, find the molar mass of the solution if 12 g of the (in g/mol) solute is mixed to form the solution.

Answer (240)

Sol. $\dfrac{12}{X} = 0.05$

$\therefore \quad X = \dfrac{12}{0.05}$

$= \dfrac{1200}{5}$

$= 240$ g

26. Consider a reaction

$\underset{(g)}{A_2} + \underset{(g)}{B_2} \longrightarrow \underset{(g)}{2AB}$
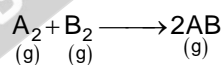
If ΔH_f^0 of A_2, AB and B_2 are in the ratio $1 : \dfrac{1}{2} : 1$ and ΔH of the reaction is –200 kJ/mol. Find ΔH_f^0 (A_2). (kJ mol^{-1})

Answer (200)

Sol. $\Delta H_{reaction} = 2\Delta H_f^0(AB) - \Delta H_f^0(A_2) - \Delta H_f^0(B_2)$

$-200 = 2k - 2k - 2k \Rightarrow k = 100$

$\therefore \Delta H_f^0(A_2) = 200$ kJ mol^{-1}

27.

28.

29.

30.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Find the sum of series

   $2 \times 2^2 - 2 \times 3^2 + 2 \times 4^2 \ldots\ldots$ (20 terms)

   (1) 462
   (2) −462
   (3) 460
   (4) −460

Answer (4)

Sol. $S = 2\left[2^2 - 3^2 + 4^2 \ldots\ldots + 20^2 - 21^2\right]$

$= 2\left[\left(2^2 + 4^2 + 6^2 + \ldots + 20^2\right) - \left(3^2 + 5^2 + \ldots + 21^2\right)\right]$

$= 2\left[2\left(2^2 + 4^2 + 6^2 + \ldots + 20^2\right) - \left(2^2 + 3^2 + 4^2 + \ldots + 21^2\right)\right]$

$= 2\left[2^3\left(1^2 + 2^2 + 3^2 + \ldots + 10^2\right) - \left(2^2 + 3^2 + 4^2 + \ldots + 21^2\right)\right]$

$= 2\left[\dfrac{8 \times 10 \times 11 \times 21}{6} - \dfrac{21 \times 22 \times 43}{6} + 1\right]$

$= 2[3080 - 3311 + 1]$

$= 2[-230]$

$= -460$

2. The number of seven digit numbers made using 1, 2, 3, 4 whose sum of digits is 12 is

   (1) 413
   (2) 311
   (3) 308
   (4) 393

Answer (1)

Sol.

$\underline{1}\ \ \underline{1}\ \ \underline{1}\ \ \underline{1}\ \ \underline{1}\ \ \underline{4}\ \ \underline{3} = \dfrac{7!}{5!} = 42$

$1\ \ 1\ \ 1\ \ 1\ \ 3\ \ 3\ \ 2 = \dfrac{7!}{4!\,2!} = 105$

$2\ \ 2\ \ 2\ \ 3\ \ \underline{1}\ \ 1\ \ 1 = \dfrac{7!}{3!\,3!} = 140$

$2\ \ 2\ \ 2\ \ 2\ \ 2\ \ \underline{1}\ \ \underline{1} = \dfrac{7!}{5!\,2!} = 21$

$1\ \ 1\ \ 1\ \ 1\ \ 4\ \ 2\ \ 2 = \dfrac{7!}{4!\,2!} = 105$

Total = $\overline{413}$

3. If $\dfrac{dy}{dx} = y + 7$ & $y(0) = 0$, then the value of $y(1) =$

   (1) $7(e - 1)$
   (2) $2(e - 1)$
   (3) $7e$
   (4) None of these

Answer (1)

Sol. $\dfrac{dy}{y + 7} = dx$

$\Rightarrow \ \log|y + 7| = x + c$

$y(0) = 0$

$\Rightarrow \ c = \log 7$

$\log|y + 7| = x + \log 7$

Now put $x = 1$

$\log|y + 7| = 1 + \log 7$

$|y + 7| = 7e$

$\therefore \ y = 7(e - 1)$

4. If $g(x) = \sqrt{x + 1}$ and $f(g(x)) = 3 - \sqrt{x + 1}$ then value of $f(0)$ is

   (1) 2
   (2) 3
   (3) 4
   (4) −4

Answer (2)

Sol. For $f(0)$, put $x = -1$ in $f(g(x))$

$\therefore \ f(g(-1)) = 3 + \sqrt{-1 + 1}$

$\Rightarrow \ f(0) = 3$

5. If $3f(x) + 2f\left(\dfrac{1}{x}\right) = \dfrac{1}{x} - 10$, then $f(3) =$

   (1) 2
   (2) −3
   (3) −4
   (4) None of these

Answer (2)

Sol. $3f(x) + 2f\left(\dfrac{1}{x}\right) = \dfrac{1}{x} - 10$ \qquad ...(i)

$x \to \dfrac{1}{x}$

$3f\left(\dfrac{1}{x}\right) + 2f(x) = x - 10$ \qquad ...(ii)

3(i) − 2(ii)

$9f(x) - 4f(x) = \dfrac{3}{x} - 30 - 2x + 20$
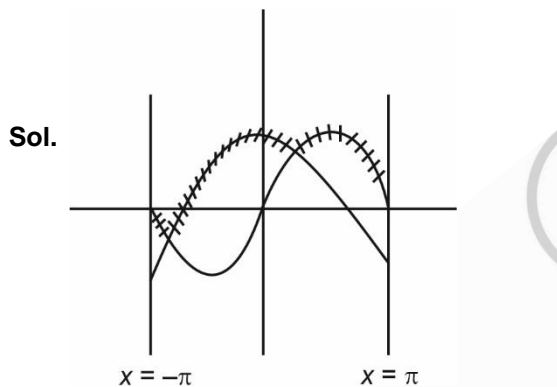
$\Rightarrow \quad 5f(x) = \dfrac{3}{x} - 2x - 10$

$x = 3$

$5f(3) = 1 - 6 - 10 = -15$

$f(3) = -3$

6. Find area bounded by the curves y = max {sin$x$, cos$x$} and x-axis between $x = -\pi$ and $x = \pi$

(1) $2 + \sqrt{2}$ (2) $\sqrt{2}$

(3) $1 + \sqrt{2}$ (4) $2\sqrt{2}$

Answer (4)

Sol.

$\displaystyle\int_{-\pi}^{-3\frac{\pi}{4}} \sin x \, dx + \int_{-3\frac{\pi}{4}}^{\frac{\pi}{4}} \cos x \, dx + \int_{\frac{\pi}{4}}^{\pi} \sin x \, dx$

$= -\cos x \Big|_{-\pi}^{-3\frac{\pi}{4}} + \sin x \Big|_{-\frac{3\pi}{4}}^{\pi/4} + -\cos x \Big|_{\frac{\pi}{4}}^{\pi}$

$= \left(\dfrac{1}{\sqrt{2}} - 1\right) + \left(\dfrac{1}{\sqrt{2}} + \dfrac{1}{\sqrt{2}}\right) + \left(1 + \dfrac{1}{\sqrt{2}}\right)$

$= 2\sqrt{2}$

7. The negation of $((A \cap (B \cup C)) \Rightarrow (B \cap C)) \Rightarrow A$ is equivalent to

(1) $\sim(A \cup B)$

(2) $\sim A$

(3) A

(4) None of these

Answer (2)

Sol. Let $P = (((A \cap (B \cup C)) \Rightarrow (B \cap C)) \Rightarrow A$

$P = \sim(((A \cap (B \cup C)) \Rightarrow (B \cap C)) \cup A$

$= \sim((\sim(A \cap (B \cup C)) \cup (B \cap C)) \cup A$

$= ((A \cap (B \cup C) \cap \sim(B \cap C)) \cup A$

$= A$

$P \equiv A$

$\sim P \equiv \sim A$

8. $f(x) = x - 2\sin x \cos x + \dfrac{1}{3}\sin 3x,\ x \in [0, \pi]$ then maximum value of $f(x)$ is

(1) $\dfrac{5\pi}{6} + \dfrac{\sqrt{3}}{2} + \dfrac{1}{3}$ (2) 0

(3) $\dfrac{5\pi}{6} + \dfrac{\sqrt{3}}{2} - \dfrac{1}{3}$ (4) $\dfrac{5\pi}{6}$

Answer (1)

Sol. $f(x) = x - \sin 2x + \dfrac{1}{3}\sin 3x$

$f'(x) = 1 - 2\cos 2x + \cos 3x = 0$

$x = \dfrac{5\pi}{6}, \dfrac{\pi}{6}$

$\therefore \quad f''(x) = 4\sin 2x - 3\sin 3x$

$f''(x)$ at $\dfrac{5\pi}{6}$ is < 0

$\Rightarrow \left(\dfrac{5\pi}{6}\right)$ is point of maxima

$f\left(\dfrac{5\pi}{6}\right) = \dfrac{5\pi}{6} + \dfrac{\sqrt{3}}{2} + \dfrac{1}{3}$

9. If $\vec{a} = 2\hat{i} + 3\hat{j} + 5\hat{k}$

$\vec{b} = 3\hat{i} + 3\hat{j} + 7\hat{k}$

$\vec{c} = 7\hat{i} + 8\hat{j} + 9\hat{k}$

If $\vec{a} \times \vec{b} = \vec{c} + \vec{d}$ then $|\vec{d}|$ is

(1) $\sqrt{174}$ (2) $8\sqrt{2}$

(3) $\sqrt{168}$ (4) $5\sqrt{5}$

Answer (1)

Sol. $\vec{a} \times \vec{b} = 6\hat{i} + \hat{j} - 3\hat{k}$

$\vec{d} = -\hat{i} - 7\hat{j} - 12\hat{k}$

$|\vec{d}| = \sqrt{174}$

10. **Statement 1 :** $\underset{x\to\infty}{\text{limit}} \dfrac{1}{n^2}(1+2+3+.....+n)=1$

Statement 2 : $\underset{x\to\infty}{\text{limit}} \dfrac{1}{n^{16}}\left(1^{15}+2^{15}+.....+n^{15}\right)=\dfrac{1}{16}$

(1) Statement 1 and statement 2 both are correct

(2) Only statement 1 is correct

(3) Only statement 2 is correct

(4) Both statement are incorrect

Answer (3)

Sol : Statement 1 : $\underset{x\to\infty}{\text{limit}} \dfrac{1}{n^2}(1+2+.....+n)$

$\underset{x\to\infty}{\text{limit}} \dfrac{n(n+1)}{2n^2}=\dfrac{1}{2}$

Statement 2 : $\because \underset{x\to\infty}{\text{limit}} \dfrac{\sum r^n}{n^{n+1}}=\dfrac{1}{n+1}$

Hence $n = 15$

$\therefore \underset{x\to\infty}{\text{limit}} \dfrac{\sum r^{15}}{n^{16}}=\dfrac{1}{16}$

11. If $\sin^{-1}\left(\dfrac{x+1}{\sqrt{x^2+2x+2}}\right)-\sin^{-1}\dfrac{x}{\sqrt{x^2+1}}=\dfrac{\pi}{4}$ (For $x \ge$

0) then $\sin\left(\left(x^2+x+5\right)\dfrac{\pi}{2}\right)-\cos\left(\left(x^2+x+5\right)\pi\right)$ is

(1) 0　　　　　　　(2) 2

(3) 1　　　　　　　(4) None of these

Answer (2)

Sol. $\tan^{-1}(x+1)-\tan^{-1}x=\dfrac{\pi}{4}$

$\tan^{-1}\dfrac{x+1-x}{1+x(x+1)}=\dfrac{\pi}{4}$

$1 = 1 + x(x+1)$

$x = 0$ or -1. rejected

$\therefore \quad x = 0$

$\sin\left(\left(x^2+x+5\right)\dfrac{\pi}{2}\right)-\cos\left(\left(x^2+x+5\right)\pi\right)$

$\sin\dfrac{5\pi}{2}-\cos5\pi=1-(-1)=2$

12. $\dfrac{dy}{dx}=6e^x+e^{2x}+e^{3x}$

then $y(2) - y(0)$ is

(1) $e^2+\dfrac{6e^4}{4}-\dfrac{e^6}{3}+\dfrac{15}{6}$　　(2) $6e^2+\dfrac{e^4}{3}+\dfrac{e^6}{2}-\dfrac{15}{6}$

(3) $6e^2+\dfrac{e^4}{2}+\dfrac{e^6}{3}-\dfrac{41}{6}$　　(4) $e^2+\dfrac{6e^4}{2}+\dfrac{e^6}{3}-\dfrac{15}{6}$

Answer (3)

Sol. $y(2)-y(0)=\int_0^2(6e^x+e^{2x}+e^{3x})dx$

$=6e^x+\dfrac{e^{2x}}{2}+\dfrac{e^{3x}}{3}\Big|_0^2$

$=6e^2+\dfrac{e^4}{2}+\dfrac{e^6}{3}-\dfrac{41}{6}$

13. The integral $\displaystyle\int_0^\infty \dfrac{6}{e^{3x}+6e^{2x}+11e^x+6}dx$

(1) ln 32　　　　　　　(2) ln 27

(3) $\ln\dfrac{32}{27}$　　　　　　(4) $\ln\dfrac{27}{32}$

Answer (3)

Sol. $I=\displaystyle\int_0^\infty \dfrac{6}{\left(e^x+1\right)\left(e^x+2\right)\left(e^x+3\right)}dx$

$=6\displaystyle\int_0^\infty\left(\dfrac{\frac{1}{2}}{e^x+1}+\dfrac{-1}{e^x+2}+\dfrac{\frac{1}{2}}{e^x+3}\right)dx$

$=3\displaystyle\int_0^\infty\dfrac{e^{-x}}{1+e^{-x}}dx-6\int_0^\infty\dfrac{e^{-x}dx}{1+2e^{-x}}+3\int_0^\infty\dfrac{e^{-x}}{1+3e^{-x}}dx$

$=3\left[-\ln\left(1+e^{-x}\right)\right]_0^\infty+6\dfrac{1}{2}\left[\ln\left(1+2e^{-x}\right)\right]_0^\infty$

$\quad\quad -\dfrac{3}{3}\left[\ln\left(1+3e^{-x}\right)\right]_0^\infty$

$= 3\ln2 - 3\ln3 + \ln4$

$= 3\ln\dfrac{2}{3}+\ln4$

$=\ln\dfrac{32}{27}$

14. Plane P_3 is passing through (1, 1, 1) and point of intersection of P_1 and P_2 where $P_1 : 2x - y + z = 5$ and $P_2 : x + 3y + 3z + 2 = 0$, then distance of (1, 1, 10) from P_3 is

(1) $\dfrac{53}{85}$

(2) $\sqrt{85}$

(3) $\dfrac{54}{\sqrt{85}}$

(4) 53

Answer (3)

Sol. $P_1 + \lambda P_2 = 0$

$(2x - y + z - 5) + \lambda(x + 3y + 3z + 2) = 0$

Passing though (1, 1, 1)

$(2 - 1 + 1 - 5) + \lambda(1 + 3 + 3 + 2) = 0$

$-3 + \lambda(9) = 0$

$\lambda = \dfrac{1}{3}$

$P_3 = 3(2x - y + z - 5) + (x + 3y + 3z + 2) = 0$

$7x + 6z = 13$

Distance of (1, 1, 10) is

$\left| \dfrac{7 \times 1 + 6 \times 10 - 13}{\sqrt{7^2 + 6^2}} \right| = \left| \dfrac{7 + 60 - 13}{\sqrt{49 + 36}} \right|$

$= \dfrac{54}{\sqrt{85}}$ unit

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g., 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. Let the number of matrices of order 3 × 3 are possible using the digits {0, 1, 2, 3, ……., 10} is m^n, then ($m + n$) is, (where m is a prime number)

Answer (20)

Sol. So, we have 9 places and 11 numbers

∴ Number of matrices = 11^9

∴ $m + n = 20$.

22. Remainder when 2^{2022} is divided by 15 is equal to

Answer (4)

Sol. $\left(2^8\right)^{252} \cdot 2^6$

$= (255 + 1)^{252} \cdot 64$

$= \left({}^{252}C_0(255)^{252} + {}^{252}C_1(255)^{251} + \ldots \right.$

$\left. + {}^{252}C_{252}(255)^0 \right) \cdot 64$

$= 64(15k + 1)$

Remainder = 4

23. Let 10 APs are there whose first terms are (1, 2, 3, ___, 10) respectively & common differences are (1, 3, 5, ___) respectively and S_i denotes sum of 10 terms of ith A.P then $\displaystyle\sum_{i=1}^{10} s_i$ is

Answer (5050)

Sol. $S_i = \dfrac{10}{2}\big[2i + (10-1)(2i-1)\big]$

$= 5[2i + 18i - 9]$

$= 5[20i - 9]$

$\therefore \displaystyle\sum_{i=1}^{10} S_i = 5\left[20 \times \dfrac{10 \times 11}{2} - 9 \times 10\right]$

$= 5[1100 - 90]$

$= 5 \times 1010 = 5050$

24. For the data

x_i	1	3	5	7	9
f_i	4	24	28	α	β

If mean of data is 5 and mean deviation about mean

is M and variance is σ^2 then $\dfrac{3\alpha}{M + \left(\sigma^2\right)}$ is

Answer (08)

Sol. $\overline{x} = \dfrac{4 + 72 + 140 + 7\alpha + 72}{(64 + \alpha)} = 5$

$\therefore \boxed{\alpha = 16}$

Now $M = \dfrac{4 \times 4 + 24 \times 2 + 28 \times 0 + 16 \times 2 + 8 \times 4}{80}$

$= \dfrac{8}{5}$

$\sigma^2 = \dfrac{4 \times 4^2 + 24 \times 2^2 + 28 \times 0^2 + 16 \times 2^2 + 8 \times 4^2}{80}$

$= \dfrac{22}{5}$

$\therefore \dfrac{3\alpha}{M + \sigma^2} = \dfrac{3 \times 16}{\dfrac{8}{5} + \dfrac{22}{5}} = 08$

25.

26.

27.

28.

29.

30.

❑ ❑ ❑