27/06/2022
Evening

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Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2022 (Online) Phase-1

(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.

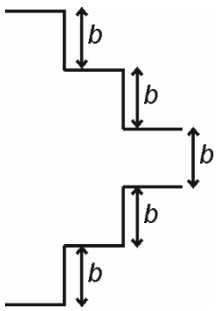
PHYSICS

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.



Six capacitor plates are arranged as shown. The area of each of the plates is A. The capacitance of the arrangement is _____.

(1) $\frac{15}{28}\frac{\varepsilon_0 A}{d}$

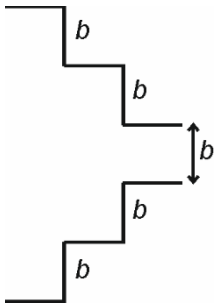
(2) $\frac{23}{15}\frac{\varepsilon_0 A}{b}$

(3) $\frac{15}{22}\frac{\varepsilon_0 A}{d}$

(4) $\frac{17}{23}\frac{\varepsilon_0 A}{d}$

Answer (2)

Sol.



$$C = \frac{\varepsilon_0 A}{5b} + \frac{\varepsilon_0 A}{3b} + \frac{\varepsilon_0 A}{b}$$

$$= \frac{\varepsilon_0 A}{b}\left[\frac{1}{5} + \frac{1}{3} + \frac{1}{1}\right]$$

$$= \frac{\varepsilon_0 A}{b} \times \left(\frac{3+5+15}{15}\right)$$

$$= \frac{23}{15}\frac{\varepsilon_0 A}{b}$$

2. Deuteron and proton enter a magnetic field perpendicularly having equal kinetic energy.

Find $\frac{R_d}{R_p}$ (R_d radius of circular trajectories.)

(1) $\sqrt{2}$

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

(3) 2

(4) $\frac{1}{2}$

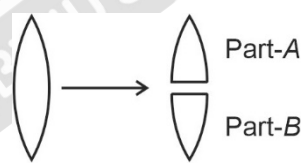
Answer (1)

Sol. $R = \frac{\sqrt{2mKE}}{qB}$

or $R \propto \frac{\sqrt{m}}{q}$

So $\frac{R_d}{R_p} = \sqrt{\frac{m_d}{m_p}} \times \frac{q_d}{q_p}$

3. A thin lens of focal length f (in metres) is cut into two parts symmetrically as shown:



Then the power of part A is

(1) $\frac{1}{f}$

(2) $\frac{1}{2f}$

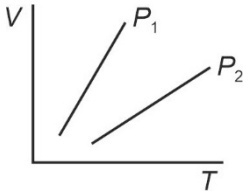
(3) $\frac{2}{f}$

(4) $\frac{1}{3f}$

Answer (1)

Sol. As the radius of surfaces and refractive index has not changed focal length will also not change. So $P = \frac{1}{f}$.

4. For the V-T graph we can say that



(1) $P_1 < P_2$
(2) $P_1 > P_2$
(3) $P_1 = P_2$
(4) No relationship can be obtained

Answer (1)

Sol. From $PV = nRT$

$$V = \frac{nR}{P}T$$

So, higher the pressure lesser the slope.

So, $P_2 > P_1$

5. An ideal diatomic gas is expanded isobarically and work done in the process is 400 J. Find the heat given to the gas in this process.

(1) 160 J
(2) 700 J
(3) 320 J
(4) 1400 J

Answer (4)

Sol. $W = nR\Delta T$ for isobaric process.

$\Rightarrow$ $400 = nR\Delta T$

And, $Q = nC_p\Delta T$

$$= n \times \left(\frac{7R}{2}\right) \cdot \Delta T; \quad C_p = \frac{7}{2} \text{ for diatomic gas}$$

$$= \frac{7}{2} \times (400)$$

= 1400 J

6. A wave propagates from one medium to another medium. Out of the parameters: wavelength, frequency and speed of the wave, the parameters that change are

(1) Wavelength and frequency
(2) Frequency and speed
(3) Wavelength and speed
(4) All the three

Answer (3)

Sol. In refraction from one medium to another, the speed and wavelength get changed.

The frequency remains unchanged.

7. A spring with spring constant k and length l was attached to mass m and rotated about its axis at other end with ω. Find elongation

(1) $\dfrac{k - m\omega_0^2 l}{m\omega_0^2}$

(2) $\dfrac{k + m\omega_0^2 l}{m\omega_0^2}$

(3) $\dfrac{m\omega_0^2 l}{k - m\omega_0^2}$

(4) $\dfrac{m\omega_0^2 l}{k + m\omega_0^2}$

Answer (3)

Sol. Spring force is providing centrepetal acceleration thus

$$kx = m\omega_0^2 (l + x)$$

$$\Rightarrow x = \frac{m\omega_0^2 l}{k - m\omega_0^2}$$

8. Non conducting hemisphere with a charge q at centre flux through curved surface is

(1) $\dfrac{q}{\varepsilon_0}$

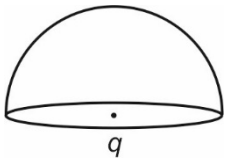
(2) $\dfrac{q}{2\varepsilon_0}$

(3) $\dfrac{2q}{\varepsilon_0}$

(4) $\dfrac{\pi q}{4\varepsilon_0}$

Answer (2)

Sol.



Flux through hemispherical surface $= \dfrac{1}{2} \times \left(\dfrac{q}{\varepsilon_0}\right)$

$$= \frac{q}{2\varepsilon_0}$$

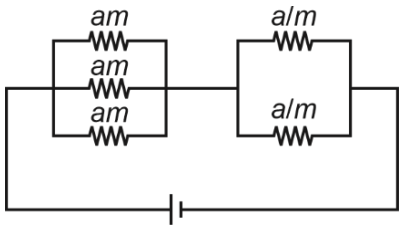
9. When does a transistor act as a switch.

(1) Saturation only
(2) Cut off
(3) Active
(4) Cut off + Saturation

Answer (4)

Sol. Transistor acts as a switch in cut off and saturation condition.

10. A network of resistors is shown



Find the value of m for minimum resistance of the network.

(1) $\sqrt{\frac{3}{2}}$

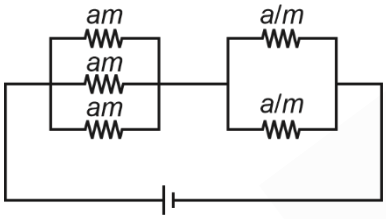
(2) $\sqrt{\frac{2}{3}}$

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

(4) $\sqrt{\frac{4}{5}}$

Answer (1)

Sol.



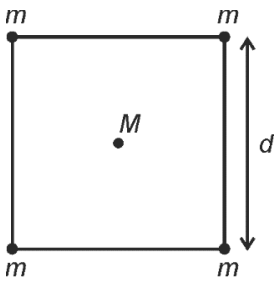
$$R = \frac{am}{3} + \frac{a}{2m}$$

$$\Rightarrow \frac{dR}{dm} = \frac{a}{3} + \frac{a(-1)}{2m^2} = 0$$

$$\Rightarrow \frac{a}{3} = \frac{a}{2m^2}$$

$$\Rightarrow m = \sqrt{\frac{3}{2}}$$

11. Four point masses each of mass "m" are placed at the corners of square at side "d" and a mass 'M' is placed at the centre. The gravitational potential energy of system is



(1) $-\frac{Gm}{d}\left[4\sqrt{2}M + \left(4+\sqrt{2}\right)m\right]$

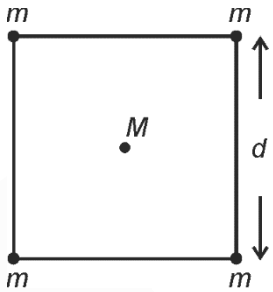
(2) $-\frac{Gm}{d}\left[4\sqrt{2}m + \left(4+\sqrt{2}\right)M\right]$

(3) $-\frac{GM}{d}\left[4\sqrt{2}M + \left(4+\sqrt{2}\right)m\right]$

(4) $-\frac{GM}{d}\left[4\sqrt{2}m + \left(4+\sqrt{2}\right)M\right]$

Answer (1)

Sol.



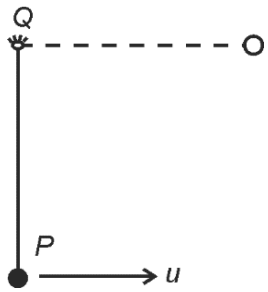
Gravitational PE of system

$$= 4 \times \frac{-GMm}{\left(\frac{d}{\sqrt{2}}\right)} + 4 \times \frac{-Gm^2}{d} + 2 \times \frac{-Gm^2}{\sqrt{2}d}$$

$$= -\frac{GMm}{d} \times \left(4\sqrt{2}\right) - \left(4+\sqrt{2}\right)\frac{Gm^2}{d}$$

$$= -\frac{Gm}{d}\left[4\sqrt{2}\,M + \left(4+\sqrt{2}\right)m\right]$$

12. A bob P is suspended by the means of a thread from point Q. Length of thread is l. Bob is given a velocity u as shown. The change in velocity of bob till thread becomes horizontal



(1) $\sqrt{u^2 + gl}$

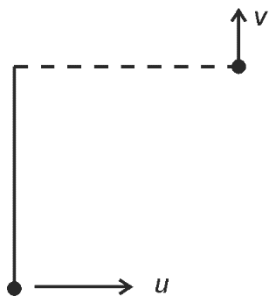
(2) $\sqrt{2u^2 - 2gl}$

(3) $\sqrt{u^2 - gl}$

(4) $\sqrt{u^2 - 2gl}$

Answer (2)

Sol.



$\vec{v} = \sqrt{u^2 - 2gl}\ \hat{j}$

$\vec{v} = u\hat{i}$

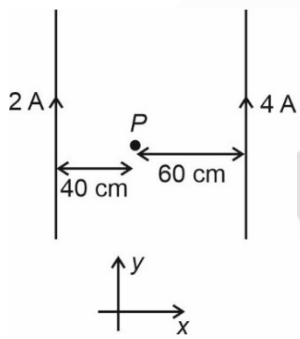
$\therefore\ \Delta\vec{v} = \vec{v} - \vec{u}$

$= \sqrt{u^2 - 2gl}\ \hat{j} - u\hat{i}$

$\Rightarrow\ |\Delta\vec{v}| = \sqrt{u^2 - 2gl + u^2}$

$= \sqrt{2u^2 - 2gl}$

13. A point charge $q = 2C$ is projected with the velocity of $\vec{v} = 2\hat{i} + 3\hat{j}$ from point P. The magnetic force acting on the charge at this moment is

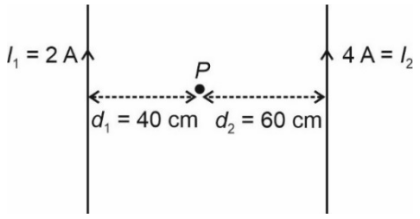


(1) 2.4×10^{-6} N (2) 3.2×10^{-6} N

(3) 4.2×10^{-6} N (4) 3.6×10^{-6} N

Answer (1)

Sol.



$\vec{B}_1 = \frac{\mu_0 I_1}{2\pi d_1}(-\hat{k})$

$\vec{B}_2 = \frac{\mu_0 I_2}{2\pi d_2}(\hat{k})$

$\therefore\ \vec{B}_P = \vec{B}_1 + \vec{B}_2$

$= \frac{\mu_0}{2\pi}\left(\frac{I_2}{d_2} - \frac{I_1}{d_1}\right)\hat{k}$

$= 2 \times 10^{-7}\left(\frac{4}{0.6} - \frac{2}{0.4}\right) = \frac{10}{3} \times 10^{-7}$ T

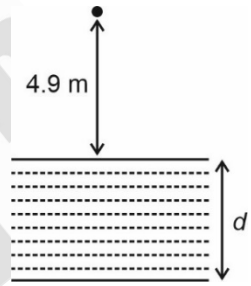
$\therefore\ F_m = qvB$ as $\vec{v} \perp \vec{B}$

$= 2 \times \sqrt{4+9} \times \frac{10}{3} \times 10^{-7}$

$= 2 \times \sqrt{13} \times \frac{10}{3} \times 10^{-7}$

$= 2.4 \times 10^{-6}$ N

14. A particle is released from a height of 4.9 m above the surface of water as shown. The particle enters the water and moves with constant velocity and reaches bottom of tank in 4 sec after the release the value of d is (g = 9.8 m/s^2)

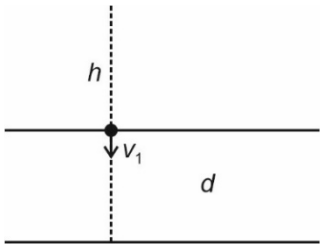


(1) 34.3 m (2) 19.8 m

(3) 38.2 m (4) 29.4 m

Answer (4)

Sol.



$v_1 = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 4.9}$

$= 2 \times 4.9$ m/s

$t_1 = \sqrt{\frac{2h}{g}}$

$= \sqrt{\frac{2 \times 4.9}{9.8}} = 1$ s

$\therefore\ t_2 = 4 - 1 = 3$ s

$\therefore\ d = t_2 \times v_1 = 3 \times 9.8 = 29.4$ m

15. **Statement-1 :** An electron jumps from lower energy state E_1 to higher energy state E_2 then the photon absorbed is given as $h\nu = E_1 - E_2$.

Statement-2: An electron jumps from higher energy state E_2 to lower energy state E_2 then the photon released is given by $h\nu = E_2 - E_1$.

(1) Both statements are true

(2) Statement-1 is true, Statement-2 is false

(3) Statement-1 is false, Statement-2 is true

(4) Both statements are false

Answer (3)

Sol. For statement-1, $h\nu = E_2 - E_1$, but given one is $h\nu = E_1 - E_2$.

So, it is incorrect.

Statement-2 is true.

16. For a particle, position is given by

$$x = 1\sin\left[\pi\left(t+\frac{1}{3}\right)\right]$$

Then find the velocity of the particle at $t = 1$.

(1) $\frac{1}{2}$ units

(2) $-\frac{1}{2}$ units

(3) $\frac{\pi}{2}$ units

(4) $-\frac{\pi}{2}$ units

Answer (4)

Sol. $\because\ x = 1\sin\left[\pi\left(t+\frac{1}{3}\right)\right]$

$$\Rightarrow v = \frac{dx}{dt} = 1\cos\left[\pi\left(t+\frac{1}{3}\right)\right]\times\pi$$

$\therefore$ At $t = 1$,

$$v = 1\times\cos\left(\pi\times\frac{4}{3}\right)\times\pi$$

$$= -\frac{\pi}{2}\text{ units}$$

17. Time period of oscillation is t = 6 sec when the amplitude $A = x$. The time period, when $A = \frac{x}{2}$ is

(1) $\sqrt{6}$ sec

(2) 3 sec

(3) 6 sec

(4) 9 sec

Answer (3)

Sol. $\therefore$ Time period of oscillation is independent of amplitude.

$\Rightarrow T_2 = T_1$

$\Rightarrow T_2 = 6$ s

18. Which of the following expressions does not have the dimension of $[M^0L^0T^1]$?

(1) $\frac{L}{C}$

(2) $\sqrt{LC}$

(3) RC

(4) $\frac{L}{R}$

Answer (1)

Sol. $\because [RC] = [\text{Time}] = \left[\frac{L}{R}\right] = [LC]$

$$\Rightarrow \left[\frac{L}{C}\right] \neq [\text{Time}]$$

19. Three charged particle having change q each are suspended by the means of thread from a common point. In equilibrium they make an equilateral triangle of edge l. The electrostatic force on one of the charge is

(1) $\frac{2\sqrt{3}q^2}{4\pi\varepsilon_0 l^2}$

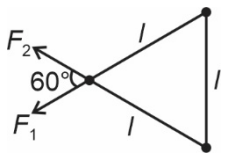
(2) $\frac{2q^2}{4\pi\varepsilon_0 l^2}$

(3) $\frac{q^2}{8\pi\varepsilon_0 l^2}$

(4) $\frac{\sqrt{3}q^2}{4\pi\varepsilon_0 l^2}$

Answer (4)

Sol. $F = \sqrt{F_1 + F_2 + 2F_1F_2\cos 60°}$



and, $F_1 = F_2 = \dfrac{q^2}{4\pi\varepsilon_0 l^2}$

$\Rightarrow \quad F = \sqrt{3} \times \dfrac{q^2}{4\pi\varepsilon_0 l^2}$

20. Which of the following statements is true about kinetic theory of gases?

(1) Mean free path increases with increase in density

(2) Mean free path decreases with decrease in temperature, keeping volume constant

(3) Average kinetic energy per degree of freedom $= \dfrac{3}{2}k_bT$

(4) Average kinetic energy per degree of freedom $= \dfrac{1}{2}k_bT$

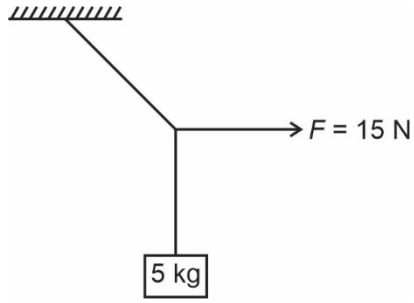
Answer (4)

Sol. From KTG, average kinetic energy per degree of freedom is $\dfrac{1}{2}k_bT$.

SECTION - B

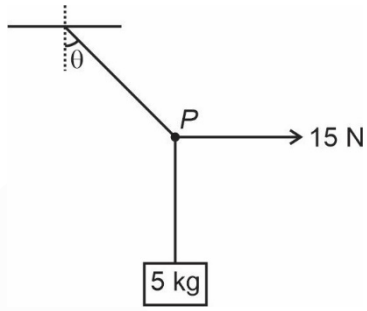
Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 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. A block of mass 5 kg is hanging vertically with the help of a rope. A force 15 N is applied at the centre of the rope horizontally as shown. The angle made by the upper portion of the rope with the vertical in equilibrium is given by $\tan^{-1}\left(\dfrac{x}{10}\right)$. The value of x is___

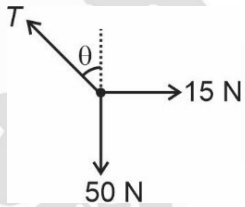


Answer (3)

Sol.



At point P FBD will look like



$\Rightarrow$ $T\cos\theta = 50$ and $T\sin\theta = 15$

$\Rightarrow \quad \tan\theta = \dfrac{3}{10}$

$\Rightarrow \quad \theta = \tan^{-1}\left(\dfrac{3}{10}\right)$

22.

23.

24.

25.

26.

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. Arrange the following species in increasing order of their radii.

(1) $Na^+ < Mg^{2+} < F^- < O^{2-} < N^{3-}$

(2) $Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

(3) $Mg^{2+} < F^- < Na^+ < O^{2-} < N^{3-}$

(4) $F^- < Na^+ < Mg^{2+} < O^{2-} < N^{3-}$

Answer (2)

Sol. For isoelectronic species, more the number of protons, less the size of the species.

Hence, correct order is

$Mg^{2+} < Na^+ < F^- < O^{2-} < N^{3-}$

2. Chlorine nitrate on hydrolysis produces X along with HNO_3 and chlorine nitrate on reaction with HCl produces Y along with HNO_3. X and Y are respectively

(1) HOCl, $HClO_2$ (2) HOCl, Cl_2

(3) HCl, Cl_2 (4) HOCl, $HClO_3$

Answer (2)

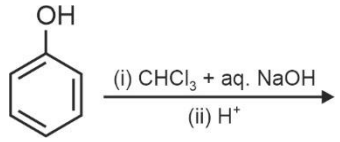
Sol. The reactions are

$$ClONO_2(g) + H_2O(g) \longrightarrow HOCl(g) + HNO_3(g)$$

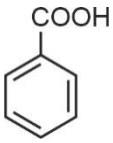
$$ClONO_2(g) + HCl(g) \longrightarrow Cl_2(g) + HNO_3(g)$$

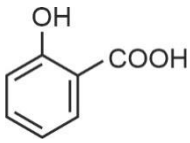
So, X and Y are HOCl and Cl_2.

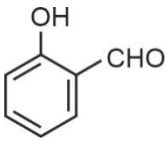
3. Consider the following reaction :

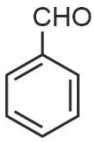


The major product formed in the above reaction is

(1) 

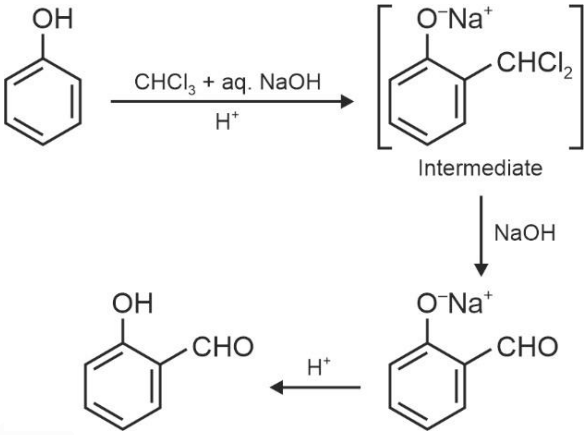
(2) 

(3) 

(4) 

Answer (3)

Sol.



4. Match the acidic radicals present in Column-I with their characteristic observations in Column-II

	Column-I		Column-II
(i)	CO_3^{2-}	(P)	Brisk Effervescence
(ii)	NO_3^-	(Q)	White precipitate
(iii)	SO_4^{2-}	(R)	Brown Ring
(iv)	S^{2-}	(S)	Rotten egg smell

(1) (i) - (S), (ii) - (R), (iii) - (Q), (iv) - (P)

(2) (i) - (P), (ii) - (Q), (iii) - (R), (iv) - (S)

(3) (i) - (P), (ii) - (R), (iii) - (Q), (iv) - (S)

(4) (i) - (P), (ii) - (R), (iii) - (S), (iv) - (Q)

Answer (3)

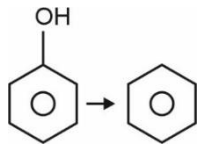
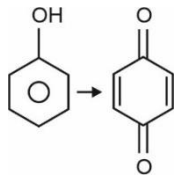
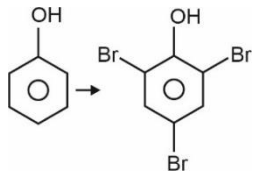
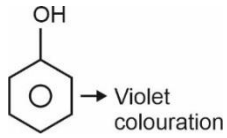
Sol. CO_3^{2-} — Produces Brisk Effervescence due to evolution of CO_2 gas on treatment with dil. H_2SO_4

NO_3^- — Brown Ring formation during confirmatory Test

SO_4^{2-} — White precipitate on addition of $BaCl_2$

S^{2-} — Produces Rotten Egg smell due to evolution of H_2S gas on addition of dil. acid.

5. Match the reagent with the organic conversion

	Column-I		Column-II
(i)		(P)	$Na_2Cr_2O_7/H^+$
(ii)		(Q)	Zn
(iii)		(R)	$FeCl_3$
(iv)		(S)	Br_2/H_2O

(1) (i) - (Q), (ii) - (P), (iii) - (S), (iv) - (R)

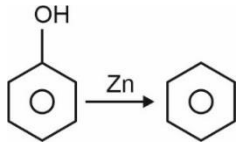
(2) (i) - (P), (ii) - (Q), (iii) - (R), (iv) - (S)

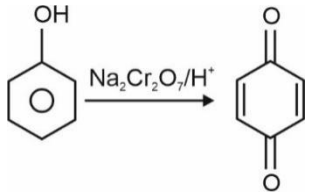
(3) (i) - (Q), (ii) - (R), (iii) - (S), (iv) - (P)

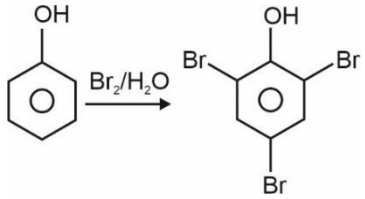
(4) (i) - (R), (ii) - (S), (iii) - (P), (iv) - (Q)

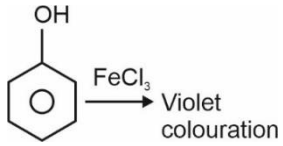
Answer (1)

Sol.









6. Arrange the following coordination complexes in increasing order of their magnetic moments

I = $[Fe(CN)_6]^{3-}$

II = $[Fe(F)_6]^{3-}$

III = $[Mn(Cl)_6]^{3-}$

IV = $[Mn(CN)_6]^{3-}$

(1) I < III < II < IV (2) I < IV < III < II

(3) IV < II < I < III (4) II < I < IV < III

Answer (2)

Sol. $[Fe(CN)_6]^{3-}$: Fe^{3+} : $3d^5$; n = 1 $\mu = \sqrt{3}$ BM

$[Fe\ F_6)]^{3-}$: Fe^{3+} : $3d^5$; n = 5 $\mu = \sqrt{35}$ BM

$[Mn\ Cl_6]^{3-}$: Mn^{3+} : $3d^4$; n = 4 $\mu = \sqrt{24}$ BM

$[Mn\ (CN)_6]^{3-}$: Mn^{3+} : $3d^4$; n = 2 $\mu = \sqrt{8}$ BM

Increasing order of magnetic moment

I < IV < III < II.

7. **Statement 1 :** In extraction of gold, the oxidation state of gold in the cyanide complex formed is +3

Statement 2 : When the cyanide complex is treated with zinc, Zn gets oxidised to +2 state

(1) Statement 1 and 2 both are correct

(2) Statement 1 is correct but statement 2 is wrong

(3) Statement 1 wrong but statement 2 is correct

(4) Statement 1 and 2 both are wrong

Answer (3)

Sol. $4Au(s) + 8C\bar{N} + 2H_2O(aq) + O_2 \longrightarrow 4[Au(CN)_2]^-(aq) + 4O\bar{H}(aq)$

$2[Au(CN)_2]^-(aq.) + Zn(s) \longrightarrow 2Au_{(s)} + [Zn(CN)_4]^{2-}(aq)$

8. Arrange the following compounds in increasing order of H-Bonding

HCN, NH_3, CH_4

(1) $CH_4 < NH_3 < HCN$

(2) $HCN < NH_3 < CH_4$

(3) $NH_3 < CH_4 < HCN$

(4) $CH_4 < HCN < NH_3$

Answer (1)

Sol. The correct order of H-bonding is

$CH_4 < NH_3 < HCN$

The degree of H-Bonding is highest in HCN as N atom is *sp* hybridised resulting in higher polarity

However, CH_4 does not show H-Bonding

9. Match column I with column II

Column I	Column II
(i) Tranquilizers	(a) Relieve pain
(ii) Analgesics	(b) Lowers body temperature
(iii) Antipyretic	(c) Control acidity
(iv) Antacids	(d) Reduce stress

Choose the correct option

(1) (i)-d, (ii)-a, (iii)-b, (iv)-c

(2) (i)-b, (ii)-c, (iii)-d, (iv)-a

(3) (i)-c, (ii)-d, (iii)-b, (iv)-a

(4) (i)-b, (ii)-d, (iii)-a, (iv)-c

Answer (1)

Sol. Tranquilizers are a class of chemical compound used for the treatment of stress, and mild or even severe mental diseases. Example-chlordiazepoxide

Analgesics reduce or abolish pain without causing impairment of consciousness, mental confusion or some other disturbances of nervous system.

Antipyretics are used to reduce body temperature

Example : Paracetamol

Antacids control acidity in the stomach Ex-Ranitidine

10. The gas releases in the following reaction is

$PCl_5 + NH_4Cl \rightarrow$ Gas + side product

(1) NCl_3 (2) PCl_3

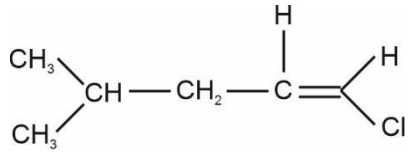
(3) HCl (4) N_2

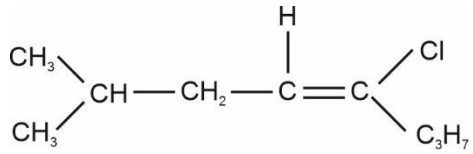
Answer (3)

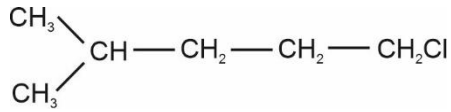
Sol. $3PCl_5 + 2NH_4Cl \xrightarrow{\Delta} [Cl_3P = N - PCl_2 = N - PCl_3]^+ Cl^- + 8HCl(g)$

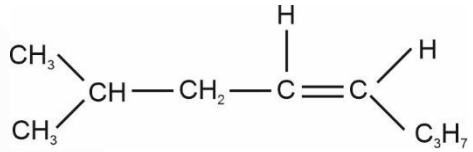
11. The product of the following reaction is

$CH_3 - CH(CH_3) - CH_2 - C \equiv CH \xrightarrow[\text{2. } C_3H_7-Cl \text{ 3. } H_2|Pd|BaSO_4]{\text{1. R–Li}} \text{Product}$

(1) 

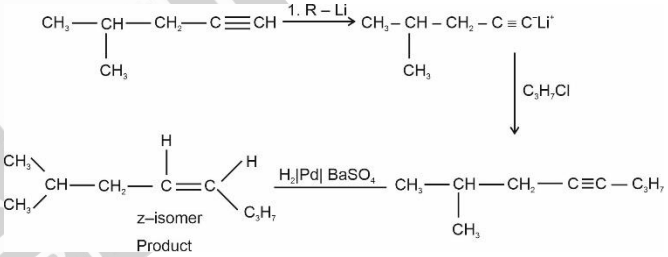
(2) 

(3) 

(4) 

Answer (4)

Sol.



12. Which of the following is correct statement about buna–N

(1) Monomer of Buna–N are styrene and Butadiene

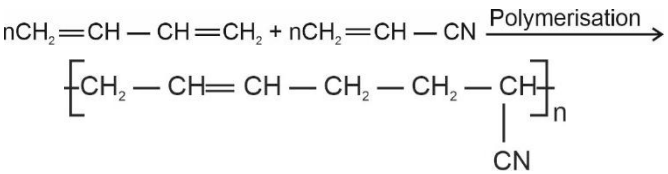
(2) Monomers of Buna–N are Butadiene and vinyl cyanide

(3) Buna–N is a condensation polymer

(4) Buna–N is natural rubber

Answer (2)

Sol. Buna–N is formed by the polymerisation of butadiene and vinyl cyanide



13. **Assertion (A) :** Fluorine forms only one oxoacid known as Hypofluorous acid

Reason (R) : Fluorine has small size and high electronegativity

(1) Both (A) and (R) are true and (R) is the correct explanation of (A)

(2) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(3) (A) is true but (R) is false

(4) (A) is false but (R) is true

Answer (1)

Sol. Due to high electronegativity and small size fluorine forms only one oxoacid, HOF known as fluoric acid (1) or hypofluorous acid. Other halogens form several oxoacids

14. **Statement-I :** Maltose is composed of two α-D-glucose units in which C-1 of one glucose is linked to C-4 of another glucose unit

Statement-II : Maltose is composed of α-D-glucose and β-D-glucose in which C-1 of α-D-glucose is linked to C-6 of β-D-glucose

(1) Statement-(I) is correct and Statement-(II) is incorrect

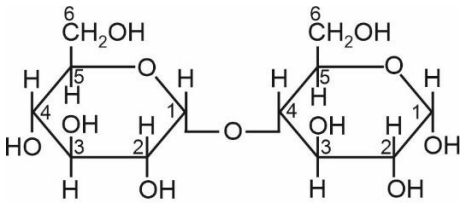
(2) Statement-(I) is incorrect and Statement-(II) is correct

(3) Both the statements are correct

(4) Both the statements are incorrect

Answer (1)

Sol. Maltose is composed of two α-D-glucose units in which C-1 of one glucose is linked to C-4 of another glucose.



Maltose

Therefore, statement-I is correct and statement-II is incorrect

15. Calculate the pH of 0.001 M NaOH

(1) 11 (2) 10

(3) 9 (4) 6

Answer (1)

Sol. pOH $= -\log[OH^-]$

$= -\log 10^{-3}$

$= 3\log 10$

pOH = 3

$\because$ pH + pOH = 14

pH = 14 – 3

pH = 11

16. Among the following most stable species is

(1) 

(2) 

(3) 

(4) 

Answer (4)

Sol.  $\Rightarrow$ Aromatic, so most stable

17. Correct statement about PCl_5 is/are

a. PCl_5 has TBP geometry

b. Axial bonds are stronger than equatorial bond

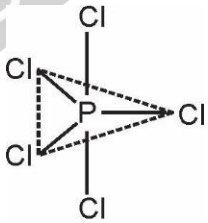
c. All equatorial bonds are in same plane

d. PCl_5 shows sp^3d hybridisation

(1) a, b, c (2) a, b, d

(3) a, c, d (4) b, c, d

Answer (3)

Sol. 

sp^3d hybridization

Axial bonds are longer than equatorial bonds.

18. Which of the following elements has the highest value of $E^\circ_{M^{+2}/M}$?

(1) Ni (2) Mn

(3) Cu (4) Fe

Answer (3)

Sol. $E^\circ_{Cu^{+2}/Cu} = +0.34$ V $E^\circ_{Fe^{+2}/Fe} = -0.44$ V

$E^\circ_{Ni^{+2}/Ni} = -0.25$ V

$E^\circ_{Mn^{+2}/Mn} = -1.18$ V

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. When BeO reacts with HF in the presence of ammonia, a compound A is formed. On heating, a compound B is formed along with ammonium fluoride. The oxidation state of Be in compound B is

Answer (02.00)

Sol. $BeO + 2NH_3 + 4HF \longrightarrow \underset{(A)}{(NH_4)_2[BeF_4]} \xrightarrow{Heat} \underset{(B)}{BeF_2} + 2NH_4F$

In BeF_2, oxidation of Be is +2.

22. Among the elements with atomic number 57 to 70, the number of elements with half filled configuration are x and fully filled configuration are y. The sum of x and y is,

Answer (04.00)

Sol. The elements with half filled and fully filled configurations are,

Eu = $4f^7\ 6s^2$

Gd = $4f^7\ 5d^1\ 6s^2$

Yb = $4f^{14}\ 6s^2$

Lu = $4f^{14}\ 5d^1\ 6s^2$

23. In Carious method of estimation of halogen, 0.25 g of an organic compound gave 0.40 g of AgCl. Find out the percentage of chlorine in the compound.

Answer (39.58)

Sol. Mass of organic compound = 0.25 gm

Mass of AgCl formed = 0.40 gm

Mass of Cl in the organic compound = $\frac{0.40x}{143.5}$

Percentage of Cl in the organic compound

$$= \frac{0.40 \times 35.5 \times 100}{143.5 \times 0.25}$$

= 39.58%

24. Consider an electrochemical cell

$Pt, H_2 \mid H^+ \parallel Ag^+ \mid Ag$

Given, $E^\circ_{Ag^+|Ag} = +0.80$ V

the value of $\Delta G°$ for the cell represented above is –x kJ, then the value of x in nearest integer is

Answer (77)

Sol. $\Delta G° = -nFE°$

$= -1 \times 96500 \times 0.80$

$= -77200$ J

$= -77.2$ kJ

$\simeq -77$ kJ

25. How many of the following set of quantum numbers possible?

	n	l	m
(i)	3	3	3
(ii)	2	1	1
(iii)	3	2	2
(iv)	2	2	2

Answer (02.00)

Sol. Only those quantum numbers are possible in which n > l

Therefore, only set (ii) and (iii) are possible

26. The boiling point of pure water is 373.15 K. It changes to 373.535 K, when 2.5×10^{-3} kg of a non-volatile and non-electrolyte solute has been added to 75×10^{-3} kg water. Find the molecular mass of solute in g/mol. $K_b(H_2O) = 0.52$ K kg mol^{-1}

[Round off to the nearest integer]

Answer (45)

Sol. Since,

$\Delta T_b = ik_b m$

$m = \frac{2.5}{M} \times \frac{1000}{75}$

$\Delta T_b = 373.535 - 373.15 = 0.385$ K

$0.385 = 1 \times 0.52 \times \frac{2.5 \times 1000}{M \times 75}$

M = 45 g/mol

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. The value of $\cot\left(\sum_{n=1}^{50}\tan^{-1}\left(\frac{1}{1+n+n^2}\right)\right)$ is equal to

(1) $\frac{25}{26}$ (2) $\frac{3}{25}$

(3) $\frac{26}{25}$ (4) $\frac{3}{26}$

Answer (3)

Sol. $\because \sum_{n=1}^{50}\tan^{-1}\left(\frac{1}{1+n+n^2}\right)=\sum_{n=1}^{50}\tan^{-1}\left(\frac{(n+1)-n}{1+n-(n+1)}\right)$

$$=\sum_{n=1}^{50}\left(\tan^{-1}(n+1)-\tan^{-1}n\right)$$

$$=\tan^{-1}51-\tan^{-1}1$$

$$=\tan^{-1}\left(\frac{51-1}{1+51\cdot 1}\right)$$

$$=\tan^{-1}\left(\frac{50}{52}\right)$$

$$=\tan^{-1}\left(\frac{25}{26}\right)=\cot^{-1}\left(\frac{26}{25}\right)$$

$$\therefore \cot\left(\sum_{n=1}^{50}\tan^{-1}\left(\frac{1}{1+n+n^2}\right)\right)=\frac{26}{25}$$

2. If $S=2+\frac{6}{7}+\frac{12}{7^2}+\frac{20}{7^3}+.....\infty$, then find $4S$

(1) $\left(\frac{7}{2}\right)^2$ (2) $\left(\frac{7}{3}\right)^3$

(3) $\frac{7}{3}$ (4) $\left(\frac{7}{3}\right)^4$

Answer (2)

Sol.

$$S=2+\frac{6}{7}+\frac{12}{7^2}+\frac{20}{7^3}+.....\infty$$

$$\frac{1}{7}S=\quad\frac{2}{7}+\frac{6}{7^2}+\frac{12}{7^3}+\frac{20}{7^4}+.....\infty$$

$$-\qquad -\qquad -\qquad -\qquad -$$

$$\frac{6}{7}S=2+\frac{4}{7}+\frac{6}{7^2}+\frac{8}{7^3}+.....\infty$$

$$\frac{6}{49}S=\quad+\frac{2}{7}+\frac{4}{7^2}+\frac{6}{7^3}+.....\infty$$

$$-\qquad -\qquad -\qquad -\qquad -$$

$$\left(\frac{6}{7}-\frac{6}{49}\right)S=2+\frac{2}{7}+\frac{2}{7^2}+\frac{2}{7^3}+.....\infty$$

$$\frac{36}{49}S=2\left(1+\frac{1}{7}+\frac{1}{7^2}+.....\infty\right)$$

$$S=2\cdot\frac{1}{1-\frac{1}{7}}\cdot\frac{49}{36}$$

$$4S=\left(\frac{7}{3}\right)^3$$

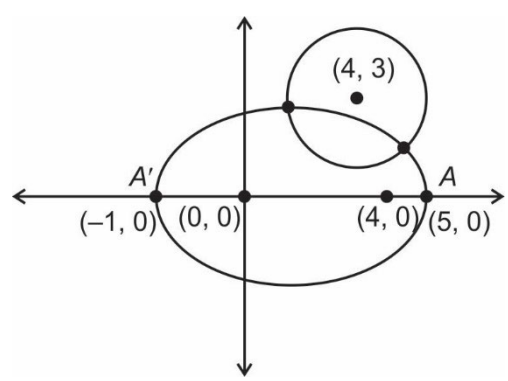
3. The number of complex numbers z satisfying $|z-(4+3i)|=2$ and $|z|+|z-4|=6$ is

(1) 1 (2) 2

(3) 3 (4) 4

Answer (2)

Sol. $|z-(4+3i)|=2$ it represents a circle with centre (4, 3) and radius 2 and $|z|+|z-4|=6$ it represents an ellipse with foci (0, 0) and (4, 0) and length of its major axis is 6



So, by graphs of the curves, here exist two complex numbers which satisfy both the given curves.

4. If f is differentiable function such that

$\int_{\cos x}^{1} t^2 f(t)dt = \sin^3 x + \cos x$. Then the value of

$\frac{1}{\sqrt{3}} f'\left(\frac{1}{\sqrt{3}}\right)$ is

(1) $6 - \frac{21}{\sqrt{2}}$ (2) $6 + \frac{9}{\sqrt{2}}$

(3) $6 - \frac{9}{\sqrt{2}}$ (4) $3 - \sqrt{21}$

Answer (3)

Sol. $\because \int_{\cos x}^{1} t^2 f(t)dt = \sin^3 + \cos x$ ...(i)

On differentiating both sides w.r.t. x we get :

$\sin x.\cos^2 x\, f(\cos x) = 3\sin^2 x.\cos x - \sin x$

$\therefore \cos^2 x.f(\cos x) = 3\sin x.\cos x - 1$ ...(ii)

When $\cos x = \frac{1}{\sqrt{3}}$ then $\sin x = \frac{\sqrt{2}}{\sqrt{3}}$, if $x \in \left(0, \frac{\pi}{2}\right)$

$\therefore f\left(\frac{1}{\sqrt{3}}\right) = 3\left(\sqrt{2} - 1\right)$ ...(iii)

Again on differentiating both sides of equation (ii) w.r.t. x we get

$-2\sin x.\cos x.\, f(\cos x) + \cos^2 x\, f'(\cos x)\,(-\sin x) = 3\cos 2x$

On replacing the values we get :

$$-2\sqrt{2}\left(\sqrt{2} - 1\right) - \frac{\sqrt{2}}{3\sqrt{3}} f'\left(\frac{1}{\sqrt{3}}\right) = -1$$

$$\therefore \frac{1}{\sqrt{3}} f'\left(\frac{1}{\sqrt{3}}\right) = \frac{3}{\sqrt{2}}\left(2\sqrt{2} - 3\right)$$

$$= 6 - \frac{9}{\sqrt{2}}$$

5. Which of the following is a tautology?

(1) $(\sim p \wedge q) \vee (p \vee \sim p)$ (2) $(p \to q) \vee q$

(3) $(p \leftrightarrow q) \vee (p \wedge q)$ (4) $p \vee (p \leftrightarrow q)$

Answer (1)

Sol. $\because$ $p \vee \sim p$ is a tautology.

So $(\sim p \wedge q) \vee (p \vee \sim p)$ will be a tautology.

6. The equation of parabola whose vertex is (5, 4) and equation of directrix is $3x + y - 29 = 0$ is $x^2 + ay^2 + bxy + cx + dy + e = 0$. The value of $(a + b + c + d + e)$ is

(1) 711 (2) –711

(3) 576 (4) –576

Answer (4)

Sol. Let focus be (α, β)

Foot of perpendicular from (5, 4) on $3x + y - 29 = 0$ is (8, 5)

$\Rightarrow \frac{\alpha + 8}{2} = 5, \frac{\beta + 5}{2} = 4 \Rightarrow (\alpha, \beta) = (2, 3)$

$\because$ focus is (2, 3) & directrix $3x + y - 29 = 0$

Applying $PS = PL$ we get

$$(x - 2)^2 + (y - 3)^2 = \frac{(3x + y - 29)^2}{10}$$

$\Rightarrow x^2 + 9y^2 - 6xy + 134x - 2y - 711 = 0$

Comparing we get

$(9 - 6 + 134 - 2 - 711) = -576$

7. The shortest distance between the lines $\frac{x-1}{4} = \frac{y-2}{2} = \frac{z-3}{3}$ and $\frac{x-5}{5} = \frac{y-3}{6} = \frac{z-2}{7}$ is

(1) $\sqrt{43}$ (2) $\frac{43}{\sqrt{381}}$

(3) $\frac{43}{\sqrt{391}}$ (4) $\sqrt{381}$

Answer (2)

Sol. $L_1 : \frac{x-1}{4} = \frac{y-2}{2} = \frac{z-3}{3}$

$L_2 : \frac{x-5}{5} = \frac{y-3}{6} = \frac{z-2}{7}$

$\vec{a_1} = \hat{i} + 2\hat{j} + 3\hat{k}, \quad \vec{p} = 4\hat{i} + 2\hat{j} + 3\hat{k}$

$\vec{a_2} = 5\hat{i} + 3\hat{j} + 2\hat{k}, \quad \vec{q} = 5\hat{i} + 6\hat{j} + 7\hat{k}$

Now, $\vec{a_2} - \vec{a_1} = 4\hat{i} + \hat{j} - \hat{k}$

$$\vec{p} \times \vec{q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & 2 & 3 \\ 5 & 6 & 7 \end{vmatrix} = -4\hat{i} - 13\hat{j} + 14\hat{k}$$

$\therefore$ Shortest distance between L_1 and L_2

$$= \left| \frac{(\vec{a_2} - \vec{a_1}) \cdot (\vec{p} \times \vec{q})}{\vec{p} \times \vec{q}} \right|$$

$$= \left| \frac{43}{\sqrt{381}} \right|$$

8. The value of $\int_0^1 \frac{dx}{7^{\left[\frac{1}{x}\right]}}$ is (where [·] denotes the greatest integer function)

(1) $1 - 6\ln\left(\frac{6}{7}\right)$

(2) $1 + 6\ln\left(\frac{6}{7}\right)$

(3) $1 - 7\ln\left(\frac{6}{7}\right)$

(4) $1 + 7\ln\left(\frac{6}{7}\right)$

Answer (1)

Sol. $I = \int_0^1 \frac{dx}{7^{\left[\frac{1}{x}\right]}}$ let $x = \frac{1}{t}$

$$I = \int_1^\infty \frac{dt}{7^{[t]} \cdot t^2}$$

Let $I_n = \int_n^{n+1} \frac{dt}{7^{[t]} \cdot t^2} = \frac{1}{7^n}\left[-\frac{1}{t}\right]_n^{n+1} = \frac{1}{7^n}\left[\frac{1}{n} - \frac{1}{n+1}\right]$

$$= \frac{1}{n.7^n} - \frac{7}{(n+1)7^{n+1}}$$

So, $I = \sum_{n=1}^{\infty}\left(\frac{1}{n \cdot 7^n} - \frac{7}{(n+1)7^{n+1}}\right)$

$$= -\ln\left(1 - \frac{1}{7}\right) + 7\left[\ln\left(1 - \frac{1}{7}\right) + \frac{1}{7}\right]$$

$$= -\ln\left(\frac{6}{7}\right) + 7\ln\left(\frac{6}{7}\right) + 1$$

$$= 1 - 6\ln\left(\frac{6}{7}\right)$$

9. If $a_1, a_2, \ldots a_3$ and $b_1, b_2, \ldots$ are two A.P's and $a_1 = 2$, $a_{10} = 3$ if $a_1 b_1 = 1 = a_{10} b_{10}$. Find $a_4 b_4$

(1) $\frac{27}{28}$ (2) $\frac{28}{27}$

(3) $\frac{9}{16}$ (4) $\frac{16}{9}$

Answer (2)

Sol. Let $a_1, a_2, a_3 \ldots a_{10}$ are in A.P. with common difference d_1

So $9d_1 = a_{10} - a_1 = 1 \Rightarrow d_1 = \frac{1}{9}$

Hence $a_4 = a_1 + 3d_1 = 2 + \frac{3}{9} = \frac{7}{3}$

Let $b_1, b_2, b_3, \ldots b_{10}$ are in A.P. with common difference d_2. Here, $b_1 = \frac{1}{2}$ and $b_{10} = \frac{1}{3}$

So, $9d_2 = b_{10} - b_1 = -\frac{1}{6} \Rightarrow d_2 = -\frac{1}{54}$

$b_4 = b_1 + 3d_2 = \frac{1}{2} - \frac{1}{18} = \frac{4}{9}$

So, $a_4 \cdot b_4 = \frac{28}{27}$.

10. A and B are two 3 × 3 matrices such that $AB = I$, $|A| = \frac{1}{8}$, then find $|\text{adj}\,(B\,\text{adj}\,2A)|$

(1) 128 (2) 32

(3) 64 (4) 102

Answer (3)

Sol. $\because AB = I$ and $|A| = \frac{1}{8}$

$|AB| = |I| \Rightarrow |A|\,|B| = 1$

$\therefore |B| = 8$

Now, $|\text{adj}\,B\,\text{adj}(2A)| = |B\,\text{adj}(2A)|^2$

$$= |B|^2\,|\text{adj}(2A)|^2$$

$$= |B|^2\,|2^2\,(\text{adj}\,A)|^2$$

$$= 4^6 \cdot |B|^2 |A|^4$$

$$= 2^{12} \cdot 8^2 \cdot \left(\frac{1}{8}\right)^4$$

$$= 2^6$$

$$= 64$$

11. If the curve satisfying the differential equation $\left(\tan^{-1}y - x\right)dy = \left(1+y^2\right)dx$ passes through (1, 0), then find x at $y = 1$.

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

(2) $e^{-\frac{\pi}{4}}$

(3) $\left(\frac{\pi}{4}-1\right)+2e^{-\frac{\pi}{4}}$

(4) $\left(\frac{\pi}{4}+1\right)+2e^{\frac{\pi}{4}}$

Answer (3)

Sol. $\left(\tan^{-1}y - x\right)dy = (1+y^2)dx$

$$\therefore \quad \frac{dx}{dy}+\frac{x}{1+y^2}=\frac{\tan^{-1}y}{1+y^2}$$

$$\text{I.f} = e^{\int\frac{1}{1+y^2}dy} = e^{\tan^{-1}y}$$

$\therefore$ Solution

$$xe^{\tan^{-1}y} = \int\frac{\tan^{-1}y}{1+y^2}\cdot e^{\tan^{-1}y}dy$$

Let $\tan^{-1}y = t \Rightarrow \frac{1}{1+y^2}dy = dt$

$$\therefore \quad xe^{\tan^{-1}y} = \int te^t dt$$

$$xe^{\tan^{-1}y} = te^t - e^t + C$$

$$x = \left(\tan^{-1}y - 1\right) + Ce^{-\tan^{-1}y} \quad \text{....(i)}$$

$\because$ (i) passes (1, 0), $\therefore$ $C = 2$

$$\therefore \quad x = (\tan^{-1}y - 1) + 2e^{-\tan^{-1}y}$$

Now, put $y = 1$

$$x(1) = \left(\frac{\pi}{4}-1\right)+2e^{-\frac{\pi}{4}}$$

12.

13.

14.

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 A be a 2 × 2 matrix, whose entries are taken from the set {0, 1, 2, 3, 4, 5, 6} such that sum of all entries is a prime number between 2 and 6 (both excluded). Find number of possible matrices A.

Answer (76)

Sol. There will be two cases.

Case I : When sum of entries is 3

Entries will be (3, 0, 0, 0) or (2, 1, 0, 0)

or (1, 1, 1, 0)

Number of matrices formed $= \frac{\lfloor 4}{\lfloor 3}+\frac{\lfloor 4}{\lfloor 2}+\frac{\lfloor 4}{\lfloor 3}$

$= 20$

Case II : When sum of entries is 5

Entries will be (5, 0, 0, 0), (4, 1, 0, 0), (3, 2, 0, 0), (3, 1, 1, 0), (2, 2, 1, 0), (2, 1, 1, 1)

Number of matrices formed

$$= \frac{\lfloor 4}{\lfloor 3}+\frac{\lfloor 4}{\lfloor 2}+\frac{\lfloor 4}{\lfloor 2}+\frac{\lfloor 4}{\lfloor 2}+\frac{\lfloor 4}{\lfloor 2}+\frac{\lfloor 4}{\lfloor 3} = 56$$

Total number of matrices formed = 76

22. Consider elements 4, 5, 6, 6, 7, 8, x, y. If mean = 6 and variance $= \frac{9}{4}$. Find $x^2 + y^2$.

Answer (80)

Sol. Given data : 4, 5, 6, 6, 7, 8, x, y

Mean $(\bar{x}) = 6$, variance $= \frac{9}{4}$

$\therefore$ Variance $= \frac{\Sigma x_i^2}{n} - (\bar{x})^2$

$$\frac{9}{4} = \frac{226 + x^2 + y^2}{8} - 36$$

$$\therefore \quad x^2 + y^2 + 226 = \frac{153}{4} \times 8$$

$\therefore$ $x^2 + y^2 = 80$

23.

24.

25.

26.

27.

28.

29.

30.

❑ ❑ ❑