06/04/2023
Morning

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

Memory Based
Answers & Solutions
for
JEE (Main)-2023 (Online) Phase-2

(Physics, Chemistry and Mathematics)

Time : 3 hrs. M.M. : 300

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. Kinetic energy of electron, proton and α-particle is given as k, $2k$ and $4k$ respectively then which of the following gives the correct order of de-Broglie wavelength of electron, proton and α-particle?

(1) $\lambda_p > \lambda_\alpha > \lambda_e$ (2) $\lambda_\alpha > \lambda_p > \lambda_e$

(3) $\lambda_e > \lambda_p > \lambda_\alpha$ (4) $\lambda_e > \lambda_\alpha > \lambda_p$

Answer (3)

Sol. $\lambda = \dfrac{h}{\sqrt{2m\,K\cdot E\cdot}}$

$\Rightarrow \lambda_e : \lambda_p : \lambda_\alpha = \dfrac{1}{\sqrt{m_e}} : \dfrac{1}{\sqrt{2m_p}} : \dfrac{1}{\sqrt{16m_p}}$

$\Rightarrow \lambda_e > \lambda_p > \lambda_\alpha$

2. If the height of a tower used for LOS communication is increased by 21%. The percentage change in range is

(1) 5% (2) 10%

(3) 15% (4) 12%

Answer (2)

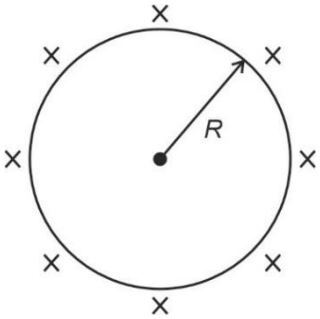
Sol. New range is $\sqrt{2R(h+0.21h)}$

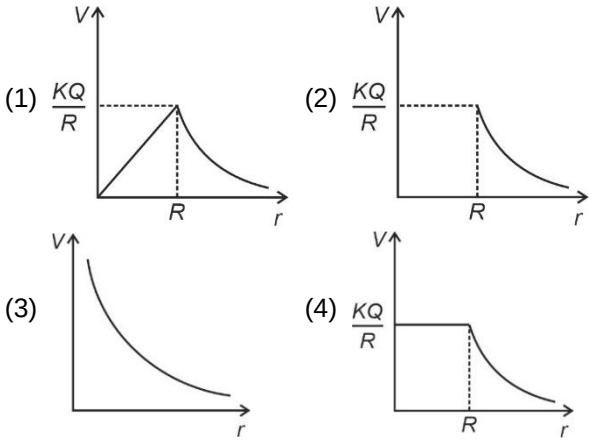
$= \sqrt{2R(1.21)h}$

$= 1.1\sqrt{2Rh}$

% increase in range = 10%

3. Pick the correct graph between potential V at distance r from centre for the uniformly charged spherical shell of radius R.



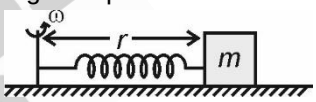


Answer (4)

Sol. $V = \dfrac{KQ}{R}$ for $r \le R$

$V = \dfrac{KQ}{r}$ for $r > R$

4. A block of mass m is connected to one end of a spring and kept on a smooth surface. The other end of the spring is connected to fixed shaft rotating with constant angular speed ω. Find tension in spring.

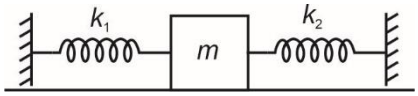


(1) $\dfrac{m\omega^2 r}{2}$ (2) $2m\omega^2 r$

(3) $m\omega^2 r$ (4) $\dfrac{3}{2}m\omega^2 r$

Answer (3)

Sol. $T = m\omega^2 r$

5. 

For the oscillations exhibited by the spring block system, on smooth surface, along the springs, the time period is equal to

(1) $2\pi\sqrt{\dfrac{m(k_1+k_2)}{k_1k_2}}$ (2) $2\pi\sqrt{\dfrac{m(k_1+k_2)}{2k_1k_2}}$

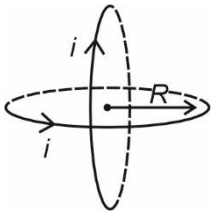
(3) $2\pi\sqrt{\dfrac{m}{k_1+k_2}}$ (4) $\pi\sqrt{\dfrac{m}{k_1+k_2}}$

Answer (3)

Sol. Both springs can be considered equivalent to a parallel combination of springs

$\Rightarrow k_{eq} = k_1 + k_2$

$\Rightarrow T = 2\pi\sqrt{\dfrac{m}{k_1+k_2}}$

6. 

Two identical current carrying coils with same centre are placed with their planes perpendicular to each other as shown.

If $i = \sqrt{2}A$ and radius of coils is R = 1 m then magnetic field at centre C is equal to

(1) μ_0 (2) $\frac{\mu_0}{2}$

(3) $2\mu_0$ (4) $\sqrt{2}\,\mu_0$

Answer (1)

Sol. $i = \sqrt{2}A$

$B_{net} = \sqrt{B_1^2 + B_2^2}$

$= \sqrt{\left(\frac{\mu_0 i}{2R}\right)^2 + \left(\frac{\mu_0 i}{2R}\right)^2}$

$= \mu_0$

7. A ball of mass m and radius r and density ρ is dropped in a liquid of density ρ_0. After moving for some time, the speed of the ball becomes constant, equal to v_0. The coefficient of viscosity of the liquid is

(1) $\frac{mg}{6\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$ (2) $\frac{mg}{6\pi r v_0}\left(1+\frac{\rho_0}{\rho}\right)$

(3) $\frac{mg}{3\pi r v_0}\left(1+\frac{\rho_0}{\rho_0}\right)$ (4) $\frac{mg}{3\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$

Answer (1)

Sol. $6\pi\eta r v_0 = v\rho g - v\rho_0 g$

$= vg(\rho - \rho_0)$

$= \frac{m}{\rho} g(\rho - \rho_0)$

$\therefore \quad \eta = \frac{mg}{6\pi r v_0}\left(1-\frac{\rho_0}{\rho}\right)$

8. **Assertion (A):** Earth has atmosphere and moon doesn't.

Reason (R): Escape speed on moon is less than that of earth.

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

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

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

(4) (A) and (R), both are false

Answer (1)

Sol. Both (A) and (R), are true and escape speed on moon is less due to its small radius and acceleration due to gravity as compared to earth.

9. The amount of heat supplied to a gas in a system is equal to 1000 J, the system in return does 200 J of work on the surrounding. Find charge in internal energy of the gas.

(1) 800 J (2) 1200 J

(3) 1000 J (4) 1100 J

Answer (1)

Sol. Using first law of thermodynamics

$\Delta Q = \Delta U + W$

$\Delta U = 1000 - 200$

$= 800$ J

10. On a planet ρ (mass density) is same as that of earth while mass of planet is twice than that of earth. Ratio of weight of a body on surface of planet to that on earth is equal to

(1) 1 (2) $(2)^{1/3}$

(3) $(2)^{-1/3}$ (4) 2

Answer (2)

Sol. $\frac{g_p}{g_e} = \frac{GM_p/R_p^2}{GM_e/R_e^2} = \frac{\left(M_p/\rho_p^2\right)^{1/3}}{\left(M_e/\rho_e^2\right)^{1/3}}$

$= \left(M_p/M_e\right)^{1/3}$

$= (2)^{1/3}$

11. **Assertion (A):** Range of a horizontal projectile is maximum when angle of projection is $\theta = 45°$.

Reason (R): Range is maximum when $\sin(2\theta) = 1$.

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

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

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

(4) Both (A) and (R) are false

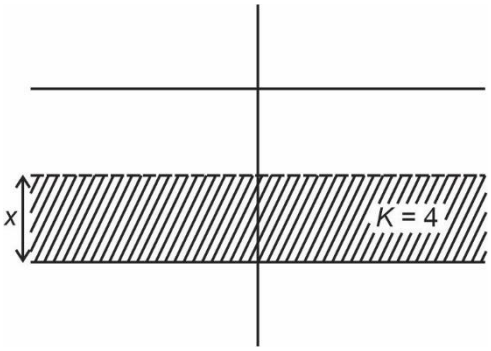
Answer (1)

Sol. $R = \frac{u^2 \sin 2\theta}{g}$

$\Rightarrow$ For R_{max}, $\sin(2\theta) = 1$

$\Rightarrow$ $\theta = 45°$

12. The capacitance of capacitor can be varied by filling dielectric constant $K = 4$ as shown in figure. As x varies, the capacitance changes. For $x = \frac{d}{3}$, the equivalent capacitance is C_2 and for $x = \frac{2d}{3}$, the equivalent capacitance is 2 μF. Find the value of C_1 in μF



(1) 4 (2) 3

(3) $\frac{4}{3}$ (4) $\frac{3}{2}$

Answer (3)

Sol. $C_2 = \dfrac{\frac{3\varepsilon_0 A}{d} \times \frac{4\varepsilon_0 A \times 3}{2d}}{\frac{3\varepsilon_0 A}{d} + \frac{6\varepsilon_0 A}{d}}$

$= \dfrac{\varepsilon_0 A}{d}\left(\dfrac{3 \times 6}{9}\right)$

$= \left(\dfrac{2\varepsilon_0 A}{d}\right) = 2\ \mu F$

$C_1 = \dfrac{\frac{3\varepsilon_0 A}{2d} \times \frac{3 \times 4\varepsilon_0 A}{d}}{\frac{3\varepsilon_0 A}{2d} + \frac{12\varepsilon_0 A}{d}}$

$= \dfrac{\varepsilon_0 A}{d} \dfrac{\left(\frac{3}{2} \times 12\right)}{\left(\frac{3}{2} + 12\right)}$

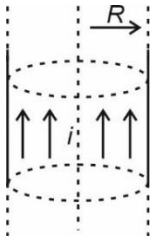
$= \dfrac{\varepsilon_0 A}{d} \times \dfrac{18 \times 2}{27}$

$= \dfrac{12}{9}\left(\dfrac{\varepsilon_0 A}{d}\right)$

$= \left(\dfrac{12}{9}\right) \mu F$

$= \left(\dfrac{4}{3}\right) \mu F$

13. The given figure shows a long cylindrical shell having current I flowing uniformly along the wall. The graph showing the variation of magnetic field (B) with the perpendicular distance(r) from the axis of the shell is



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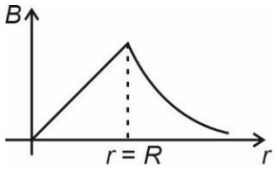

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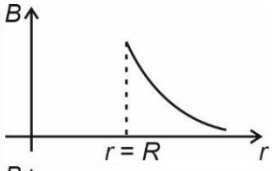

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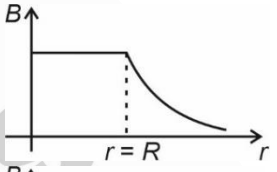

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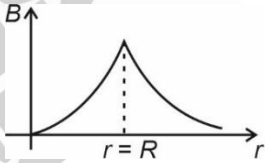


Answer (2)

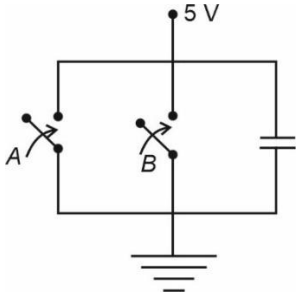
Sol. Using Ampere's circuital law

$B_{inside} = 0$

$B_{outside} = \dfrac{\mu \cdot i}{2\pi r}$

$\therefore \quad B_{outside} \propto \dfrac{1}{r}$

14. Which of the following logic gate is correct according to given circuit?



(1) OR gate (2) NAND gate

(3) AND gate (4) NOR gate

Answer (1)

Sol. Output = $A + B \Rightarrow OR$ gate

15. Find the radius of the orbit corresponding to the 4th excited state in Li^{++}. (a_0 is the radius of first orbit in H-atom)

(1) $\frac{25}{3}a_0$

(2) $\frac{16}{3}a_0$

(3) $25a_0$

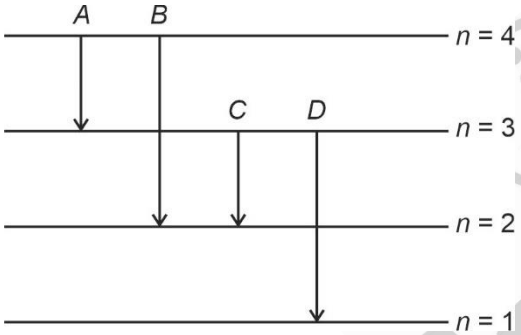
(4) $12a_0$

Answer (1)

Sol. $r_n = \frac{a_0 n^2}{z}$

$= a_0\left(\frac{25}{3}\right)$

16. In the given diagram, different type of transition of is named as *A*, *B*, *C* and *D*, then which transition emits shortest wavelength.



(1) A (2) B

(3) C (4) D

Answer (D)

Sol. For particular atom

$\lambda \propto \frac{1}{\Delta E}$

$\Delta E \propto \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For A $\Delta E \propto \left(\frac{1}{9} - \frac{1}{16}\right) = K\left(\frac{7}{144}\right) \approx K \times 0.486$

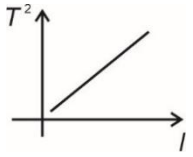
For B $\Delta E \propto \left(\frac{1}{4} - \frac{1}{16}\right) = K\left(\frac{3}{16}\right) \approx K \times 0.1875$

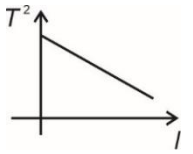
For C, $\Delta E \propto \left(\frac{1}{4} - \frac{1}{9}\right) = K\left(\frac{5}{36}\right) \approx K \times 0.1388$

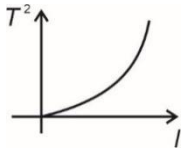
For D, $\Delta E \propto \left(1 - \frac{1}{4}\right) = K\frac{3}{4} \approx K \times 0.75$

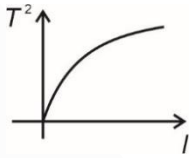
So, for D, ΔE is high, so λ_D is shortest.

17. During simple harmonic motion of a pendulum, the square of time period (T^2) can be plotted against length of pendulum (l) by

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

$\boxed{T^2 \propto l}$

18. In an EM wave ratio of average electric field and magnetic field energy density in a region of wave is equal to

(1) $\frac{2\varepsilon_0}{\mu_0 C^2}$

(2) $\frac{C^2\varepsilon_0}{\mu_0}$

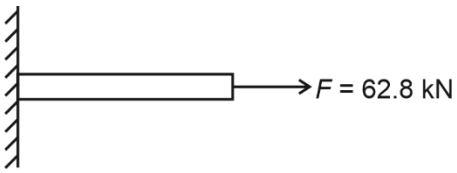
(3) 1 : 1

(4) $\frac{\varepsilon_0}{2\mu_0 C^2}$

Answer (3)

Sol. Average energy density contained with electric and magnetic field component of an EM wave is equal.

19. A rod is fixed at one end and other end is pulled with force F = 62.8 kN, Young's modulus of rod is 2×10^{11} N/m^2. If the radius of cross-section of rod is 20 mm the strain produced in rod is



(1) 2.5×10^{-3} (2) 2.5×10^{-4}

(3) 2×10^{-3} (4) 2×10^{-4}

Answer (2)

Sol. $\text{Strain} = \left(\frac{F}{AY}\right) = \frac{62.8 \times 10^3}{3.14 \times (0.02)^2 \times 2 \times 10^{11}} = 2.5 \times 10^{-4}$

20. A ray undergoes refraction at boundary of a medium such that incident angle is 45° while refraction angel is 30°. Wavelength and frequency of incident ray are λ_1 and ν_1 while for refracted ray are λ_2 and ν_2, then

(1) $\lambda_1 = \lambda_2, \nu_1 = \frac{\nu_2}{\sqrt{2}}$ (2) $\lambda_1 = \lambda_2, \nu_2 = 2\nu_1$

(3) $\lambda_1 = \sqrt{2}\lambda_2, \nu_1 = \nu_2$ (4) $\lambda_1 = \frac{\lambda_2}{\sqrt{2}}, \nu_1 = \nu_2$

Answer (3)

Sol. $i = 45°, r = 30°$

$\mu = \sqrt{2}$

$\Rightarrow C_2 = \frac{C_2}{\sqrt{2}}$

$\Rightarrow \lambda_2 = \frac{\lambda_1}{\sqrt{2}}$

and $\nu_1 = \nu_2$

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 100 gm is placed on smooth surface, moves with acceleration of $a = 2x$, then the change is kinetic energy can be given as $\left(\frac{x^n}{10}\right)$.

Find the value of n

Answer (2)

Sol. $\frac{v\,dv}{dx} = 2x$

$\int v\,dv = \int 2x\,dx$

$\Rightarrow \frac{1}{2}\left(v_f^2 - v_i^2\right) = x^2$

$\Rightarrow \frac{1}{2}m\left(v_f^2 - v_i^2\right) = mx^2$

$\Delta k = \left(0.1x^2\right) = \left(\frac{x^2}{10}\right)$

22. A car is moving with speed of 15 m/s towards a stationary wall. A person in the car press the horn and experience the change in frequency of 40 Hz due to reflection from stationary wall. Find the frequency of horn.

(Use v_{sound} = 330 m/s)

Answer (420 Hz)

Sol.

$f' = \left(\frac{c+v}{c-v}\right) f_0$

$\frac{f'}{f_0} = \left(\frac{c+v}{c-v}\right) = \frac{1+\left(\frac{v}{c}\right)}{1-\left(\frac{v}{c}\right)} = \frac{345}{315}$

$\Rightarrow \frac{f'}{f_0} - 1 = \frac{345}{315} - 1 = \frac{30}{315}$

$\Rightarrow \frac{f' - f_0}{f_0} = \frac{30}{315}$

$\Rightarrow \frac{40 \times 315}{30} = f_0$

$f_0 = (4 \times 105)$

$= 420$ Hz

23. If the length of a conductor is increased by 20 percent and cross-sectional area is decreased by 4 percent, then calculate the percentage change in resistance of a conductor.

Answer (25.00)

Sol. $R = \left(\frac{\rho l}{A}\right)$

$R' = \frac{\rho l'}{A'} \Rightarrow l' = 1.2l$

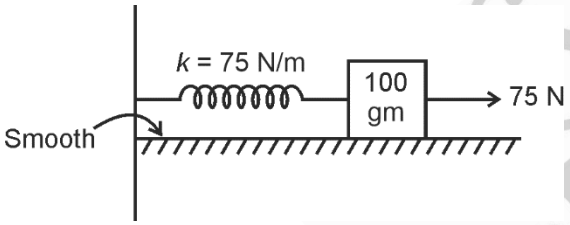
$A' = 0.96A$

$R' = \frac{\rho \times 1.2l}{0.96A} = \frac{10}{8}\left(\frac{\rho l}{A}\right)$

$\frac{R' - R}{R} = \left(\frac{1}{4}\right)$

$\Rightarrow$ 25 percent

24.



At equilibrium position a 75 N force starts acting on the block attach with the spring as shown. Maximum extension in spring in meter is

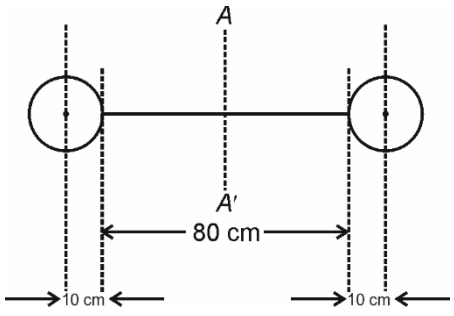
Answer (2)

Sol. $X\,max = \frac{2F}{k_{max}}$

$= \frac{2 \times 75}{75}$

= 2 m

25.



Two solid spheres of mass $m = \frac{1}{2}$ kg each are connected at the ends of a light rod as shown in the figure. The assembly rotates about axis AA'. Then moment of inertia of the assembly is equal to $\frac{x}{5}$ kgm^2 value of x is equal to

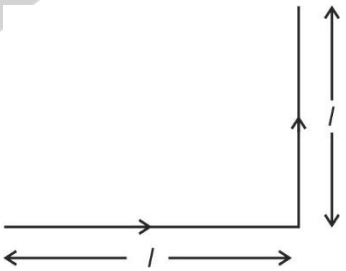
Answer (01.27)

Sol. $MI = \left[\left(\frac{2}{5}Mr^2\right) + \left(MR^2\right)\right] \times 2$

$= \left[\frac{2}{5} \times \frac{1}{2} \times (0.1)^2 + \frac{1}{2} \times (0.5)^2\right] \times 2$

$= \frac{0.02}{5} + \frac{1.25}{5}$

26. The path of an object moving with constant speed is shown in figure. The ratio of magnitude of average velocity to instantaneous speed is equal to $\sqrt{x}$ find x.



Answer (2)

Sol. |Average velocity| = $\sqrt{2}v$

Instantaneous speed = v

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. Polymer which is named as Orlon is
   (1) Polyamide
   (2) Polyacrylonitrile
   (3) Polycarbonate
   (4) Polyethene

Answer (2)

Sol. Orlon is the commercial name of polyacrylonitrile

2. We are given with some diseases in Column-II. Column-I contains name of some vitamins and their deficiencies will cause :

Column-I (Deficiency)		Column-II	
(A)	Vitamin A	(p)	Scurvy
(B)	Vitamin B_2 (Riboflavin)	(q)	Xerophthalmia
(C)	Vitamin B_1 (Thiamine)	(r)	Cheilosis
(D)	Vitamin C	(s)	Beri Beri

   (1) A(q); B(r); C(s); D(p)
   (2) A(r); B(q); C(p); D(s)
   (3) A(q); B(r); C(p); D(s)
   (4) A(p); B(r); C(s); D(q)

Answer (1)

Sol. Vitamin A $\rightarrow$ Xerophthalmia

Vitamin B_2 $\rightarrow$ Cheilosis

Vitamin B_1 $\rightarrow$ Beri Beri

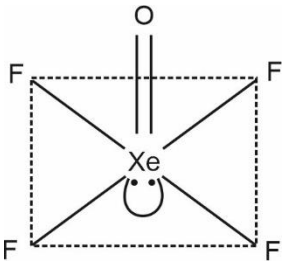
Vitamin C $\rightarrow$ Scurvy

(NCERT ref. : Pg. No. 426, Class XII, Part-II)

3. Which of the following have square pyramidal structure
   (1) $XeOF_4$
   (2) BrF_4
   (3) XeF_4
   (4) XeO_3

Answer (1)

Sol. $XeOF_4$ has sp^3d^2 hybridisation



Shape $\rightarrow$ square pyramidal

5.

Column-I (Compound)		Column-II (Type of Bond)	
A	N_2O	P	(N—N) Bond
B	N_2O_4	Q	(N—O—N) Bond
C	N_2O_5	R	(N=N) or (N≡N) Bond
D	NO_2	S	(N=O)

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

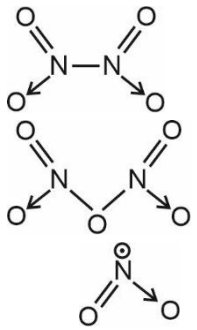
Answer (3)

Sol. A. N_2O $N\equiv N \rightarrow O$

B. N_2O_4

C. N_2O_5

D. NO_2



6. We are given with a reaction

$$R-CH_2-Br+NaI \xrightarrow{\text{Acetone}} R-I+NaBr$$

Which of the following statement is correct?
   (1) This reaction can also take place in acetic acid
   (2) This reaction is called Swarts reaction
   (3) This reaction shifts in forward direction using principle of Le-Chatelier's principle
   (4) This Reaction will take place even if Br is replaced with F.

Answer (3)

Sol. $R-CH_2-X+NaI \xrightarrow{\text{Acetone}} R-CH_2-I+NaX$

X = Cl, Br

Above reaction is called Finkelstein reaction.

NaCl and NaBr are insoluble in acetone and hence this shifts in forward reaction using Le-Chatelier's principle.

7. **Assertion:** Magnetic moment of $[Fe(H_2O)_6]^{3+}$ is 5.92 BM and that of $[Fe(CN)_6]^{3-}$ is 1.73 BM

Reason: Oxidation state of Fe in both the complexes is +3.

(1) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion

(2) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion

(3) Reason is correct but Assertion is not correct

(4) Reason is incorrect but Reason is correct

Answer (2)

Sol. $[Fe(H_2O)_6]^{3+}$ – O.S. of Fe = +3

$Fe^{3+}: 3d^5,\ t_{2g}^3e_g^2;\ \mu=\sqrt{35}=5.92\ BM$

$[Fe(CN)_6]^{3-}$ – O.S. of Fe = +3

$Fe^{3+}: 3d^5,\ t_{2g}^5e_g^0;\ \mu=\sqrt{3}=1.73\ BM$

8. Consider the following reaction

$A_2B_3(g) \rightleftharpoons 2A(g) + 3B(g)$

If initial concentration of $A_2B_3(g)$ is C, find α

(1) $\left(\frac{k_{eq}}{27\,C^4}\right)^{1/5}$ (2) $\left(\frac{k_{eq}}{C^4}\right)^{1/5}$

(3) $\left(\frac{k_{eq}}{108\,C^4}\right)^{1/5}$ (4) $\left(\frac{k_{eq}}{4\,C^4}\right)^{1/5}$

Answer (3)

Sol. $\underset{C(1-\alpha)}{A_2B_3} \rightleftharpoons \underset{2C\alpha}{2A} + \underset{3C\alpha}{3B}$

$$k_{eq}=\frac{4C^2\alpha^2\times 27C^3\alpha^3}{C(1-\alpha)}$$

$$k_{eq}=\frac{108\,C^5\,\alpha^5}{C(1-\alpha)}$$

$$\alpha=\left(\frac{k_{eq}}{C^4(108)}\right)^{1/5}$$

(Assuming $1-\alpha \ll 1$)

9. Which compound is added to cement to increase its setting time?

(1) Gypsum

(2) Lime stone

(3) Clay

(4) Calcium carbonate

Answer (1)

Sol. Gypsum is added to cement to increase its setting time.

10. Which reaction is correct with its correct enzyme used?

(1) Sucrose → glucose + fructose
enzyme : Invertase

(2) Glucose → CO_2 + ethanol
enzyme : maltase

(3) Protein → Amino acid
enzyme : Zymase

(4) Starch → Maltose
enzyme : Pepsin

Answer (1)

Sol. Sucrose $\xrightarrow{\text{Invertase}}$ glucose + fructose

Glucose $\xrightarrow{\text{zymase}} CO_2 + C_2H_5OH$

Protein $\xrightarrow{\text{pepsin}}$ Amino acids

Sucrose $\xrightarrow{\text{diastase}}$ maltose

11. Compound P with molecular formula $C_{14}H_{13}ON$ is hydrolysed to give Q and R Compound Q give effervescence with $NaHCO_3$ while compound R react with Hinsberg reagent to give oily liquid which react with NaOH.

P → Q (give effervescence with $NaHCO_3$) + K (React with Hinsberg reagent)

The products Q and R are respectively

(1) C_6H_5COOH and $C_6H_{13}NH_2$

(2) C_6H_5COOH and $C_6H_5CH_2NH_2$

(3) $CH_3(CH_2)_4COOH$ and $CH_3(CH_2)_6NH_2$

(4) $CH_3(CH_2)_4CONH_2$ and $CH_3(CH_2)_5COOH$

Answer (2)

Sol. $C_6H_5CONH-CH_2C_6H_5 \xrightarrow{\text{Hydrolysis}} \underset{Q}{C_6H_5COOH} + \underset{R}{C_6H_5CH_2NH_2}$

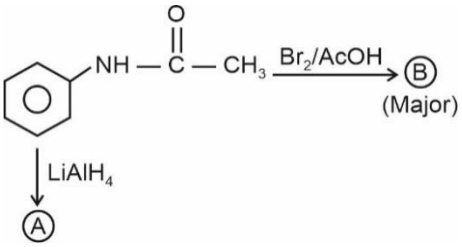
$C_6H_5SO_2Cl + C_6H_5-CH_2NH_2 \longrightarrow C_6H_5SO_2NH-CH_2C_6H_5$

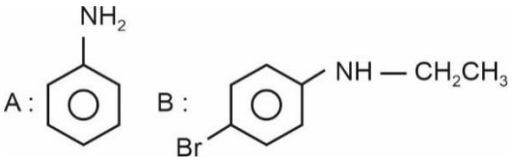
Hinsberg reagent

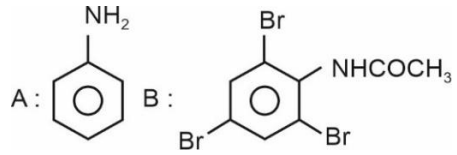
↓

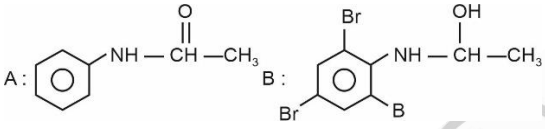
Soluble in NaOH

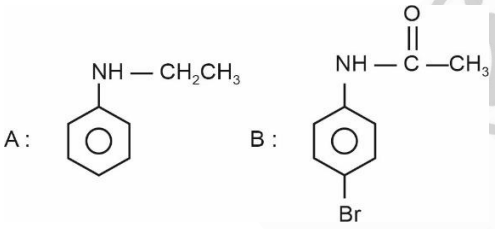
12. In following sequence of reaction, identify A and B



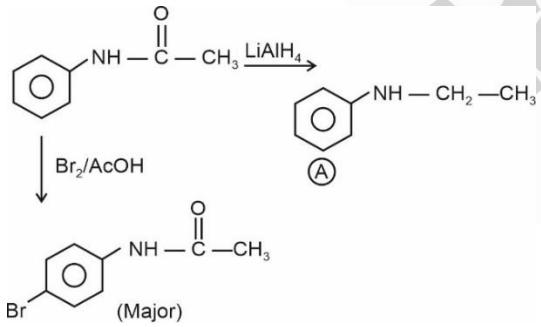
(1) 

(2) 

(3) 

(4) 

Answer (4)

Sol. 

13. Column-I contains some elements and column-II contains final product obtained during their qualitative analysis.

Column-I	Column-II
(A) Nitrogen	(P) AgX
(B) Sulphur	(Q) $(NH_4)_3PO_4 \cdot 12MoO_3$
(C) Phosphorous	(R) $Fe(SCN)_3$
(D) Halogens	(S) $Fe_4\left[Fe(CN)_6\right]_3$

(1) A(P), B(R), C(Q), D(S)

(2) A(Q), B(R), C(Q), D(P)

(3) A(S), B(R), C(Q), D(P)

(4) A(Q), B(R), C(P), D(S)

Answer (3)

Sol. Nitrogen: $Fe_4\left[Fe(CN)_6\right]_3$

Prussian Blue

Sulphur: $[Fe(SCN)]^{2+}$ or $Fe(SCN)_3$

Phosphorous: $(NH_4)_3PO_4 \cdot 12MoO_3$

Halogen: AgCl; AgBr; AgI

14. For the given elements:

Ne, F, Cl, Ar

Which of the following pair of element has highest difference of electronegativity?

(1) Ne — Cl (2) Ne — F

(3) Ne — He (4) Ne — Ar

Answer (2)

Sol. The electronegativity of F (Fluorine) is highest among all the elements of periodic table. Hence highest difference of E.N. arises between Ne and F.

15. Photochemical smog is most likely to be found in which of the following industrial areas?

(1) Marshy areas

(2) Himalayan valley in winters

(3) Warm moist climates

(4) Sunny dessert areas

Answer (4)

Sol. Photochemical smog occurs in warm, dry and sunny climate. Hence the option 4 is most appropriate.

16. A binary compound has Y-atoms forming FCC unit cell and another type of X-atoms occupying 1/3rd of tetrahedral voids. Find out the molecular formula of the compound

(1) XY (2) X_2Y_3

(3) X_3Y_2 (4) XY_2

Answer (2)

Sol. Y-atoms of a binary compound form FCC unit cell.

$\therefore$ No. of Y-atoms per unit = 4

X-atoms of the same compound occupy 1/3rd of tetrahedral voids.

$\therefore$ No. of X-atoms per unit cell = $\frac{8}{3}$

$\therefore$ Formula of the compound $X_{\frac{8}{3}}Y_4$ as X_2Y_3

17. The M^+/M of an element doesn't depend on

(1) $\Delta H_{hyd.}$

(2) $\Delta H_{Sub.}$

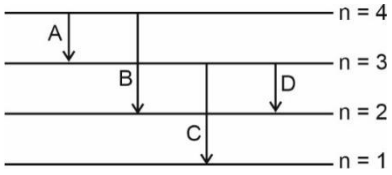
(3) Ionisation enthalpy of gas

(4) Ionisation enthalpy of solid

Answer (4)

Sol. Ionisation enthalpy is calculated for isolated gaseous atom

18. Shortest wavelength will be there for which of the following transition?



(1) Transition A (2) Transition B

(3) Transition C (4) Transition D

Answer (3)

Sol. Shortest $\lambda \Rightarrow$ maximum ΔE

$(\Delta E)_C > (\Delta E)_B$

Energy difference decreases while we move in higher energy levels.

19. Strong reducing & oxidizing agent among the following respectively.

(1) Ce^{+3} & Ce^{+4} (2) Eu^{+2} & Ce^{+4}

(3) Ce^{+4} & Tb^{+4} (4) Ce^{+4} & Eu^{+2}

Answer (2)

Sol. The most stable oxidation state of lanthanides is +3.

$\therefore$ Eu^{+2} is a reducing agent & Ce^{+4} is an oxidising agent.

Hence, correct answer is 2.

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 Radius of Ground State Hydrogen atom is 51 pm. Find out Radius of 5^{th} orbit of Li^{2+} ions (in pm). (Closest Integer)

Answer (425.00)

Sol. $r_5 = 51 \times \frac{(5)^2}{(3)} = \frac{51 \times 25}{3} = 425$ pm

22. Some amount of urea is added to 1000 gm of H_2O due to which vapour pressure decreases by 25% of the original vapour pressure. Find out mass of urea added (Round off to two decimal places)

Answer (18.52)

Sol.

100

↓

75

$\Rightarrow \frac{25}{75} = \frac{n_{urea}}{\left(\frac{1000}{18}\right)}$

$\Rightarrow n_{urea} = \frac{1}{3} \times \frac{1000}{18} = 18.52$

23. Find logk if $\Delta H° = -54.07$ kJ/mol and T = 298 k, $\Delta S° = 10$ J/mol k

Also given 2.303 × 298 = 5705

Answer (01.20)

Sol. $\Delta G° = \Delta H° - T\Delta S°$

$-2.303\ RT \log k = -54070 - 298 \times 10$

$\log k = 1.2027$

$\Rightarrow$ 1.20

24. Oxidation state of Mo in Ammonium phosphomolybdate is

Sol. Ammonium phosphomolybdate is

$(NH_4)_3PO_4 \cdot 12MoO_3$

Oxidation state of Mo

$\underset{(NH_4^+)}{3(+1)} + \underset{PO_4^{3-}}{(-3)} + \underset{Mo}{12x} + \underset{Oxygen}{36(-2)} = 0$

Calculation gives x = +6

25.

26.

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 number of ways to distribute 20 chocolates among three students such that each student will get atleast one chocolate is

(1) $^{22}C_2$ (2) $^{19}C_2$

(3) $^{19}C_3$ (4) $^{22}C_3$

Answer (2)

Sol. $x + y + z = 20$

$x \geq 1, y \geq 1, z \geq 1$

$x_1 + y_1 + z_1 = 17$ $\begin{cases} \text{where } x_1 = x+1 \\ y_1 = y+1 \\ z_1 = z+1 \end{cases}$

Number of ways $= {}^{17+3-1}C_{3-1}$

$= {}^{19}C_2$

2. The coefficient of x^{18} in the expansion of $\left(x^4 - \frac{1}{x^3}\right)^{15}$

(1) $^{14}C_7$ (2) $^{15}C_8$

(3) $^{15}C_6$ (4) $^{14}C_8$

Answer (3)

Sol. $T_{r+1} = {}^{15}C_r (x^4)^{15-r}\left(-\frac{1}{x^3}\right)^r$

$= {}^{15}C_r\, x^{60-4r-3r}(-1)^r$

Now, $60 - 7r = 18$

$r = 6$

$\therefore$ coefficient of x^{18} is $^{15}C_6$

3. Sum of first 20 turns of the series 5, 11, 19, 29, 41, …… is

(1) 3130 (2) 3520

(3) 2790 (4) 1880

Answer (2)

Sol.
$$\begin{array}{l} S = 5 + 11 + 19 + 29 + \ldots\ldots T_n \\ S = \quad 5 + 11 + 19 + \ldots\ldots T_{n-1} + T_n \\ \hline 0 = 5 + \underbrace{6 + 8 + 10 \ldots\ldots}_{n-1 \text{ turns}} - T_n \end{array}$$

$T_n = 5 + \frac{n-1}{2}(12 + (n-2)2)$

$T_n = 5 + 6(n-1) + (n-1)(n-2)$

$T_n = n^2 + 3n + 1$

$\sum T_n = \frac{(n)(n+1)(2n+1)}{6} + \frac{3(n)(n+1)}{2} + n$

$n = 20$

$S_{20} = \frac{20 \times 21 \times 41}{6} + \frac{3 \times 20 \times 21}{2} + 20$

$= 2870 + 630 + 20 = 3520$

4. Mean of first 15 numbers is 12 and variance is 14. Mean of next 15 numbers is 14 and variance is a. If variance of all 30 numbers is 13, then a is equal to

(1) 12 (2) 14

(3) 10 (4) 3

Answer (3)

Sol. $\sigma^2 = \frac{\Sigma x_i^2}{n} - (\bar{x})^2$

$13 = \frac{(14+144)\times 15 + (a+196)\times 15}{30} - (13)^2$

$\Rightarrow \quad a = 10$

5. If the image of point $P(1, 2, 3)$ about the plane $2x - y + 3y = 2$ is Q, then the area of triangle PQR, where coordinates of R is (4, 10, 12)

(1) $\frac{\sqrt{1531}}{2}$

(2) $\frac{\sqrt{1675}}{2}$

(3) $\frac{\sqrt{2443}}{2}$

(4) $\frac{\sqrt{1784}}{2}$

Answer (1)

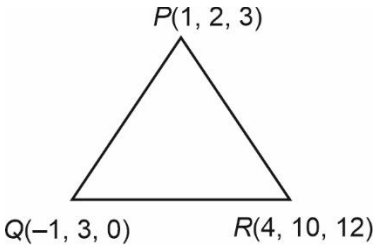
Sol. Image formula

$$\frac{x-1}{2}=\frac{y-2}{-1}=\frac{z-3}{3}=-2\left(\frac{2-2+9-2}{14}\right)$$

$\Rightarrow$ $x=-1$

$y=3$

$z=0$



$\overrightarrow{PQ}=-2i+j-3k$

$\overrightarrow{PR}=3i+8j+9k$

$$\text{Area}=\frac{1}{2}\left|\overrightarrow{PQ}\times\overrightarrow{PR}\right|$$

$$=\frac{1}{2}\left|33i+9j-19k\right|$$

$$=\frac{\sqrt{1531}}{2}$$

6. If $5f(x)+4f\left(\frac{1}{x}\right)=\frac{1}{x}+3$, then $18\int_1^2 f(x)dx$ is

(1) $10\log 2+6$ (2) $10\log 2-6$

(3) $5\log 2+6$ (4) $5\log 2-6$

Answer (2)

$$5\left(5f(x)+4f\left(\frac{1}{x}\right)=\frac{1}{x}+3\right) \quad ...(i)$$

Sol. $x\to\frac{1}{x}$

$$4\left(5f\left(\frac{1}{x}\right)+4f(x)=x+3\right) \quad ...(ii)$$

$$9f(x)=\frac{5}{x}+15-4x-12$$

$$9f(x)=\frac{5}{x}-4x+3$$

$$\int_1^2 f(x)dx=\frac{1}{9}\int_1^2\left(\frac{5}{x}-4x+3\right)dx$$

$$=\frac{1}{9}\left[5\log x-2x^2+3x\right]_1^2$$

$$=\frac{1}{9}\left[5\log 2-6+3\right]$$

$$=\frac{1}{9}\left[5(\log 2)-3\right]$$

$$18\int_1^2 f(x)dx=10\log 2-6$$

7. The sum of roots of $\left|x^2-8x+15\right|-2x+7=0$ is

(1) $11+\sqrt{3}$

(2) $11-\sqrt{3}$

(3) $9+\sqrt{3}$

(4) $9-\sqrt{3}$

Answer (3)

Sol. $\left|x^2-8x+15\right|-2x+7=0$

$\Rightarrow$ $\left|(x-3)(x-5)\right|-2x+7=0$

Let $x\le 3$ or $x\ge 5$, then

$x^2-8x+15-2x+7=0$

$x^2-10x+22=0$

$x=\frac{5\pm\sqrt{3}}{3}$ but $x\in(-\infty,3]\cup[5,\infty)$

$\therefore$ $x=5+\sqrt{3}$

Now,

$x\in(3,5)$, then

$-x^2+8x-15-2x+7=0$

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

$x=2,4$

$\therefore$ $x=4$

$\therefore$ Sum of roots $=9+\sqrt{3}$

8. $(P\Rightarrow Q)\vee(R\Rightarrow Q)$ is equivalent to

(1) $(P\wedge R)\Rightarrow Q$ (2) $(P\vee R)\Rightarrow Q$

(3) $(Q\Rightarrow R)\vee(P\Rightarrow R)$ (4) $(R\Rightarrow P)\wedge(Q\Rightarrow R)$

Answer (1)

Sol. $(P\Rightarrow Q)\vee(R\Rightarrow Q)$

$=(\sim P\vee Q)\vee(\sim R\vee Q)$

$=(\sim P\vee\sim R)\vee Q$

$=\sim(P\wedge R)\vee Q$

$=(P\wedge R)\Rightarrow Q$

9. Let $\vec{a}=2\hat{i}+3\hat{j}+4\hat{k}, \vec{b}=\hat{i}-2\hat{j}-2\hat{k}, \vec{c}=-\hat{i}+4\hat{j}+3\hat{k}$ and $\vec{d}$ is a vector perpendicular to both $\vec{b}$ and $\vec{c}$ and $\vec{a}\cdot\vec{d}=18$, then $|\vec{a}\times\vec{d}|^2$ is

(1) 720 (2) 640

(3) 680 (4) 760

Answer (1)

Sol. $\vec{b}\times\vec{c}=2\hat{i}-\hat{j}+2\hat{k}$

$\therefore \quad \vec{d}=\lambda(2\hat{i}-\hat{j}+2\hat{k})$

$\vec{a}\cdot\vec{d}=18$

$\Rightarrow \lambda = 2$

$\therefore \quad |\vec{a}\times\vec{d}|^2=|\vec{a}|^2\cdot|\vec{d}|^2-(\vec{a}\cdot\vec{d})^2$

$= 720$

10. The integration $\int\frac{x^2(x\sec^2 x+\tan x)}{(x\tan x+1)^2}dx$ is

(1) $\frac{x}{x\tan x+1}+\log|x\sin x+\cos x|+c$

(2) $\frac{x}{x\tan x+1}-\log|x\sin x+\cos x|+c$

(3) $\frac{-x^2}{x\tan x+1}+2\log|x\sin x+\cos x|+c$

(4) $\frac{x^2}{x\tan x+1}+2\log|x\sin x+\cos x|+c$

Answer (3)

Sol. $\int \underset{\text{I}}{x^2}\cdot\underset{\text{II}}{\frac{(x\sec^2 x+\tan x)}{(x\tan x+1)^2}}dx$

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

I

$I=2\int\frac{x}{x\tan x+1}dx$

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

Let $x\sin x + \cos x = t$

$(x\cos x + \sin x - \sin x)\,dx = dt$

$=2\int\frac{dt}{t}=2\log t+c'$

$=2\log|x\sin x+\cos x|+c'$

$\therefore \quad \int\frac{x^2(x\sec^2 x+\tan x)}{(x\tan x+1)^2}dx$

$=\frac{-x^2}{x\tan x+1}+2\log|x\sin x+\cos x|+c$

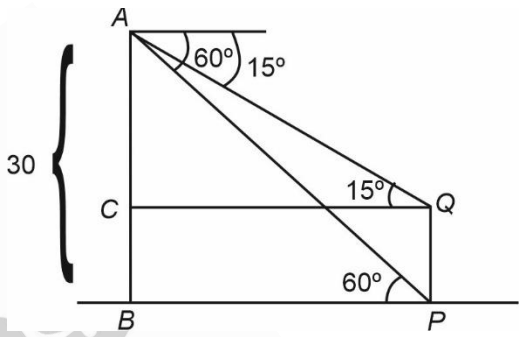
11. From the top of 30 m tower *AB* the angle of depression to another tower's *QP* base and top is 60º and 30º respectively. Another point *C* lies on tower *AB* such that *CQ* is parallel to *BP* (where *B* and *P* are the base of towers). Then the area of *BCQP* is

(1) $600\left(\sqrt{3}-1\right)$ (2) $600\left(\sqrt{3}+1\right)$

(3) 600 (4) $300\left(\sqrt{3}-1\right)$

Answer (1)

Sol.



$\tan 60^\circ=\frac{30}{BP}$

$BP=10\sqrt{3}$

$\tan 15^\circ=\frac{AC}{10\sqrt{3}}$

$\therefore AC=10\sqrt{3}\left(2-\sqrt{3}\right)$

$\therefore QP=30-10\sqrt{3}\left(2-\sqrt{3}\right)$

$=60-20\sqrt{3}$

Now area = $BP \times QP$

$=10\sqrt{3}\left(60-20\sqrt{3}\right)$

$=600\sqrt{3}-600$

$=600\left(\sqrt{3}-1\right)$

12. If $2y^x+3x^y=20$, then $\left(\frac{dy}{dx}\right)_{at(2,2)}$ is equal to

(1) $\frac{-(8+12\ln 2)}{(12+8\ln 2)}$ (2) $\frac{-(8\ln 2+12)}{(8+12\ln 2)}$

(3) 8ln + 12 (4) 8 + 12ln2

Answer (2)

Sol. $2y^x + 3x^y = 20$ …(i)

Let $u = y^x$

$\ln u = x \ln y$

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

Let $v = x^y$

$\ln v = y \ln x$

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

Now (i) differentiate w.r.t. x

$$2\frac{dy}{dx} + 3\frac{dv}{dx} = 0$$

$$2y^x\left[\frac{x}{y}\frac{dy}{dx} + \ln y\right] + 3\left[x^y\left[\frac{y}{x} + \frac{dy}{dx}\ln x\right]\right] = 0$$

Put $x = 2$, $y = 2$

$$8\left[\frac{dy}{dx} + \ln 2\right] + 12\left[1 + \frac{dy}{dx}\ln 2\right] = 0$$

13. Number of words with (or) without meaning using all the letters of the word ASSASSINATION such that all the vowels come together is

(1) 38004 (2) 38042

(3) 50400 (4) 60200

Answer (3)

Sol. $\underbrace{\text{SSSSNTN}}_{7}$ $\boxed{\text{A A I A I O}}$

Number of required words

$$\Rightarrow \frac{8!}{4!\,2!} \times \frac{6!}{3!\,2!} = 50400$$

14. If a cuboid has its sides along axes with lengths 3, 4 and 5, find the shortest distance between body diagonal and the side not containing the vertices of body diagonal.

(1) $\frac{20}{\sqrt{41}}$

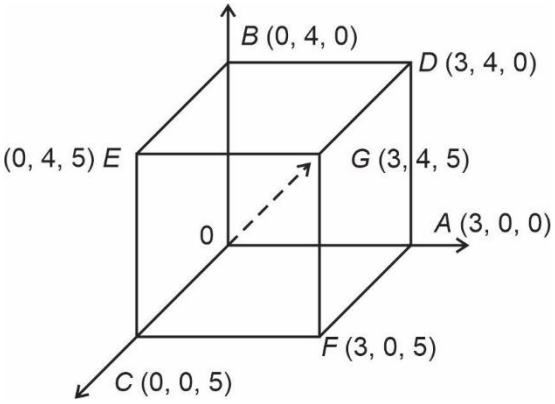
(2) $\frac{12}{5}$

(3) $\frac{15}{\sqrt{34}}$

(4) $\frac{18}{5}$

Answer (2)

Sol.



Equation of $\overrightarrow{OG}$:

$\vec{r} = \lambda\left(3\hat{i} + 4\hat{j} + 5\hat{k}\right)$

Equation of BE :

$\vec{r} = 4\hat{j} + \mu\left(5\hat{k}\right)$

$$SD = \frac{\begin{vmatrix} 0 & 4 & 0 \\ 3 & 4 & 5 \\ 0 & 0 & 5 \end{vmatrix}}{\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 4 & 5 \\ 0 & 0 & 5 \end{vmatrix}} = \frac{60}{\left|20i - 15\hat{j}\right|} = \frac{12}{5}$$

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 $a_1, a_2, a_3, \ldots a_n$ are in arithmetic progression having common difference as 'd'. The value of

$$\lim_{n\to\infty} \sqrt{\frac{d}{n}}\left(\frac{1}{\sqrt{a_1} + \sqrt{a_2}} + \frac{1}{\sqrt{a_2} + \sqrt{a_3}} + \ldots \frac{1}{\sqrt{a_{n-1}} + \sqrt{a_n}}\right)$$

is _____

Answer (1)

Sol. $\lim\limits_{n\to\infty}\sqrt{\frac{d}{n}}\left(\frac{1}{\sqrt{a_1}+\sqrt{a_2}}+\frac{1}{\sqrt{a_2}+\sqrt{a_3}}+\ldots\frac{1}{\sqrt{a_{n-1}}+\sqrt{a_n}}\right)$

$= \lim\limits_{n\to\infty}\sqrt{\frac{d}{n}}\left(\frac{\sqrt{a}_2-\sqrt{a_1}}{a_2-a_1}+\frac{\sqrt{a_3}-\sqrt{a_2}}{a_3-a_2}+\ldots\frac{\sqrt{a_n}-\sqrt{a_{n-1}}}{a_n-a_{n-1}}\right)$

$= \lim\limits_{n\to\infty}\sqrt{\frac{d}{n}}-\frac{1}{d}\left(\sqrt{a_n}-\sqrt{a_1}\right)$

$= \lim\limits_{n\to\infty}\frac{1}{\sqrt{d}}\left(\frac{\sqrt{a_1+(n-1)d}-\sqrt{a_1}}{\sqrt{n}}\right)$

$= \lim\limits_{n\to\infty}\left[\frac{1}{\sqrt{d}}\left(\sqrt{\frac{a_1}{n}+d-\frac{d}{n}}-\sqrt{\frac{a_1}{d}}\right)\right]$

$= 1$

22. Matrix A is 2 × 2 matrix and $A^2 = I$, no elements of the matrix is zero, let sum of diagonal elements is a and det(A) = b, then the value of $3a^2 + b^2$ is

Answer (1)

Sol. $\begin{bmatrix} u & v \\ w & x \end{bmatrix}\begin{bmatrix} u & v \\ w & x \end{bmatrix}$

$u^2 + vw = 1$

$uv + vx = 0 \Rightarrow u = -v$

$wu + wx = 0 \Rightarrow u = -x \Rightarrow u + x = 0 = a$

$wv + x^2 = 1$

$|A^2| = |I|$

$\det(A) = \pm 1$

$\Rightarrow b = \pm 1$

$\Rightarrow 3a^2 + b^2 = 3 \times 0 + 1 = 1$

23. Ratio of terms of 5th term from beginning and 5th term from end is $\sqrt{6}:1$ in $\left(2^{\frac{1}{4}}+\frac{1}{3^{\frac{1}{4}}}\right)^n$. The value of n is _____.

Answer (10)

Sol. $\frac{T_5}{T_{5'}} = \frac{{}^nC_4\left(2^{\frac{1}{4}}\right)^{n-4}\left(3^{-\frac{1}{4}}\right)^4}{{}^nC_4\left(3^{-\frac{1}{4}}\right)^{n-4}\left(2^{\frac{1}{4}}\right)^4} = \sqrt{6}$

$= \left(2^{\frac{1}{4}}\right)^{n-4-4}.\left(3^{\frac{1}{4}}\right)^{n-4-4} = (6)^{\frac{1}{2}}$

$\Rightarrow (6)^{\frac{n-8}{4}} = (6)^{\frac{1}{2}}$

$\Rightarrow \frac{n-8}{4} = \frac{1}{2}$

$\Rightarrow n - 8 = 2$

$\Rightarrow n = 10$

24. If $2n_{C_3} : n_{C_3} = 10$, then $\frac{n^2+3n}{n^2-3n+4}$ is equal to

Answer (02)

Sol. $\frac{2n!}{3!(2n-3)!}\times\frac{3!(n-3)!}{n!} = 10$

$\Rightarrow \frac{(2n)(2n-1)(2n-2)}{n(n-1)(n-2)} = 10$

$\Rightarrow 4(2n-1) = 10n - 20$

$\Rightarrow 2n = 16 \Rightarrow \boxed{n = 8}$

$\therefore \frac{n^2+3n}{n^2-3n+4} = \frac{64+24}{64-24+4} = \frac{88}{44} = 02$

25. The number of points of non-differentiability of the function $f(x) = [4 + 13\sin x]$ in $(0, 2\pi)$ is ____.

Answer (50)

Sol. Number of points of non-differentiability for 4 + [13 sin$x$] is 4 × 12 + 2 = 50 (by graph)

26.

27.

28.

29.

30.

❑ ❑ ❑