

22/01/2025

Evening



Aakash

Medical | IIT-JEE | Foundations

Corporate Office : AESL, 3rd Floor, Incuspaze Campus-2, Plot-13, Sector-18, Udyog Vihar,
Gurugram, Haryana-122018

Memory Based Answers & Solutions

Time : 3 hrs.

for

M.M. : 300

JEE (Main)-2025 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

- (1) The test is of **3 hours** duration.
- (2) This test paper consists of 75 questions. Each subject (PCM) has 25 questions. The maximum marks are 300.
- (3) This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is **Mathematics**. Each part has only two sections: **Section-A** and **Section-B**.
- (4) **Section - A** : Attempt all questions.
- (5) **Section - B** : Attempt all questions.
- (6) **Section - A (01 – 20)** 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.
- (7) **Section - B (21 – 25)** contains 5 **Numerical value** based questions. The answer to each question should be rounded off to the **nearest integer**. Each question carries **+4 marks** for correct answer and **-1 mark** for wrong answer.

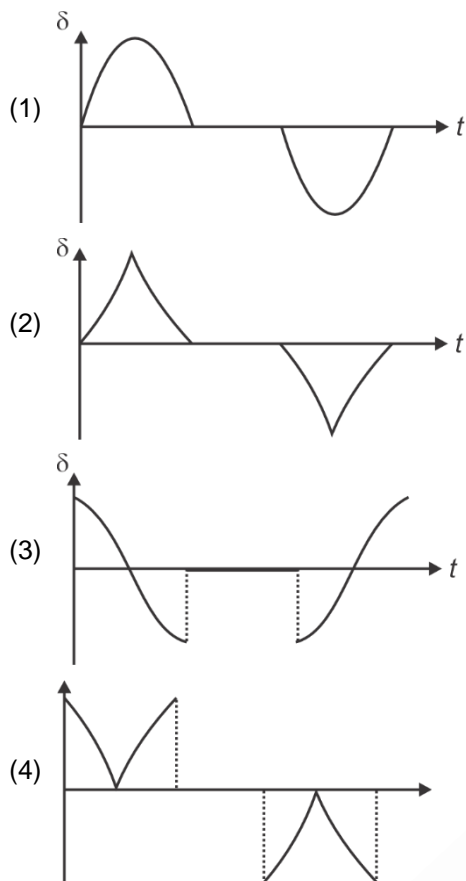
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JEE (Advanced) 2024

AIR	Name	Classroom
25	Rishi Shekher Shukla	2 Year Classroom
67	Krishna Sai Shishir	2 Year Classroom
78	Abhishek Jain	2 Year Classroom
93	Hardik Aggarwal	2 Year Classroom
95	Ujjwal Singh	2 Year Classroom
98	Rachit Aggarwal	2 Year Classroom

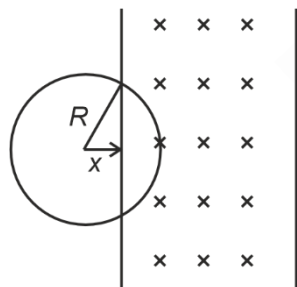
JEE (Main) 2024

AIR	Name	Classroom	State
1	Sarvvi Jais	2 Year Classroom	Karnataka
15	M Sai Divya Teja Reddy	2 Year Classroom	Telangana
19	Rishi Shekher Shukla	2 Year Classroom	Telangana



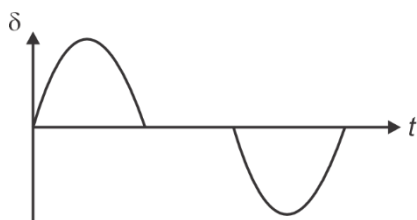
Answer (1)

Sol.



$$\delta = 2Bv\sqrt{R^2 - x^2} \text{ (Equation of an ellipse)}$$

$$x = R - vt$$



6. The displacement of a particle moving under the action of a force $\vec{F} = 2\hat{i} + b\hat{j} + \hat{k}$ is $\vec{d} = \hat{i} + \hat{j} + \hat{k}$. Find the value of b if the work done by the force is zero.

- (1) 0
- (2) +3
- (3) -3
- (4) -1

Answer (3)

Sol. Work = $\vec{F} \cdot \vec{s} = (2\hat{i} + b\hat{j} + \hat{k}) \cdot (\hat{i} + \hat{j} + \hat{k})$
 $= 2 + 1 + 1 = 3 + b = 0$
 $\Rightarrow b = -3$

7. In a series LCR circuit the maximum amplitude of current is I_0 when the resistance is R . What is the maximum amplitude of current if the resistor is replaced by a resistor of resistance $\frac{R}{2}$.

- (1) I_0
- (2) $2I_0$
- (3) $\frac{I_0}{2}$
- (4) $\frac{2I_0}{3}$

Answer (2)

Sol. Current has maximum amplitude at resonance.

$$I_0 = \frac{\xi_0}{R}$$

$$\Rightarrow I_0' = \frac{\xi_0}{R/2} = \frac{2\xi_0}{R} = 2I_0$$

8. **Statement-I** : Fringe width of red light is more than fringe width of violet light.

Statement-II : Fringe width is directly proportional to the wavelength of light used.

Choose the correct option.

- (1) Statement-I is correct and statement-II is incorrect
- (2) Both statement-I and statement-II are correct
- (3) Statement-I is incorrect and statement-II is correct
- (4) Both statement-I and statement-II are incorrect

Answer (2)

Sol. Fringe width (β) = $\frac{\lambda D}{d}$

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JEE (Advanced) 2024						JEE (Main) 2024		
AIR 25	AIR 67	AIR 78	AIR 93	AIR 95	AIR 98	100 PERCENTILE	100 PERCENTILE	100 PERCENTILE
Rishi Shekher Shukla 2 Year Classroom	Krishna Sai Shishir 2 Year Classroom	Abhishek Jain 2 Year Classroom	Hardik Aggarwal 2 Year Classroom	Ujjwal Singh 2 Year Classroom	Rishabh Aggarwal 2 Year Classroom	Kannataka Topper	Telangana Topper	Telangana Topper

9. For non-vibrating diatomic gas has adiabatic constant of γ_1 & for vibrating diatomic gas has adiabatic constant of γ_2 then

- (1) $\gamma_1 > \gamma_2$ (2) $\gamma_1 < \gamma_2$
(3) $\gamma_1 = \gamma_2$ (4) None of these

Answer (1)

Sol. $\gamma_1 = 1 + \frac{2}{5} = \frac{7}{5} = 1.4$

$\gamma_2 = 1 + \frac{2}{7} = \frac{9}{7} = 1.28$

Therefore $\gamma_1 > \gamma_2$

10. A force $\vec{F} = (\hat{i} + 2\hat{j} - 3\hat{k})N$ acts on point whose position vector is given as $\vec{r} = (2\hat{i} - 3\hat{j} + 7\hat{k})m$. Find torque about origin.

- (1) $(+5\hat{i} - 12\hat{j} + 7\hat{k})N.m$
(2) $(-5\hat{i} - 12\hat{j} + 8\hat{k})N.m$
(3) $(-5\hat{i} + 13\hat{j} + 7\hat{k})N.m$
(4) $(-5\hat{i} + 13\hat{j} - 7\hat{k})N.m$

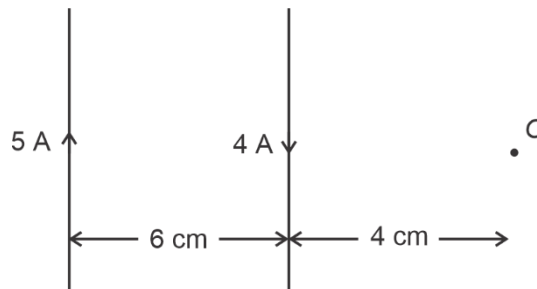
Answer (3)

Sol. $\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 7 \\ 1 & 2 & -3 \end{vmatrix}$

$= \hat{i}(9 - 14) - \hat{j}(-6 - 7) + \hat{k}(4 + 3)$

$= (-5\hat{i} + 13\hat{j} + 7\hat{k}) N.m$

11. The net magnetic field at point O due to the two infinite current carrying wires shown in the figure is



- (1) $1 \times 10^{-5} T$
(2) $1.2 \times 10^{-5} T$
(3) $1.5 \times 10^{-5} T$
(4) $2 \times 10^{-5} T$

Answer (1)

Sol. $B_{\text{net}} = \left| \frac{\mu_0(5 A)}{2\pi(10 \text{ cm})} - \frac{\mu_0(4 A)}{2\pi(4 \text{ cm})} \right|$
 $= \frac{25\mu_0}{\pi} = 10^{-5} T$

12. Read the statements and select the correct option.

Statement I : A pendulum is taken from Earth to another planet having mass four times and radius double than earth, then time period of pendulum remain same as on earth.

Statement II : The time period of pendulum only depends on the gravity of the planet.

- (1) Statement I is true but statement II is false.
(2) Statement II is true but statement I is false.
(3) Both statements are false.
(4) Both statements are true.

Answer (1)

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

On other planet, $g' = \frac{G(4M)}{(2R)^2} = g$

So, time period will remain same and her T depends on g as well as l.

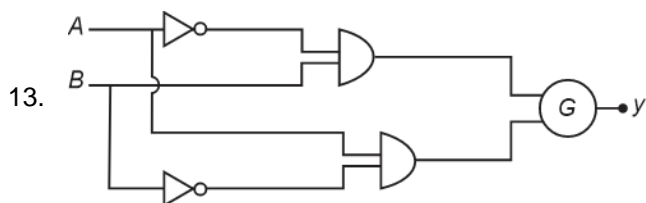
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JEE (Main) 2024

Karnataka Topper 100 PERCENTILE Sarvi Jain 2 Year Classroom	Telangana Topper 100 PERCENTILE M Sai Divya Tuja Reddy 2 Year Classroom	Telangana Topper 100 PERCENTILE Rishi Shekher Shukla 2 Year Classroom
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For a given logic circuit truth table is given identify the gate G.

A	B	y
0	0	1
1	0	0
0	1	0
1	1	1

- (1) AND (2) NOR
(3) NAND (4) OR

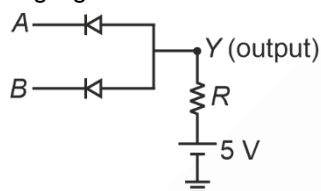
Answer (2)

Sol. From truth table we know its XNOR gate

$$i.e. y = \overline{AB} + A\overline{B}$$

therefore gate G must be NOR gate.

14. Name the logic gate



- (1) OR (2) AND
(3) NOT (4) NAND

Answer (2)

Sol. If both A and B are high only then Y is high, otherwise Y is low.

∴ AND Gate.

15. Displacement current in capacitor of area 16 cm² is 6 A at an instant. Find displacement current across area 3.2 cm²



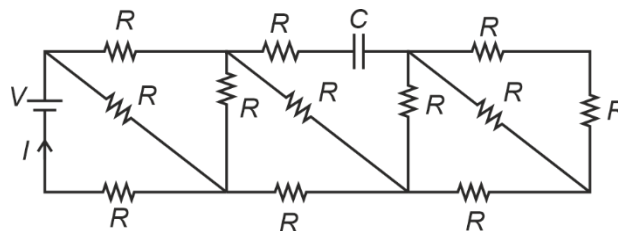
- (1) 1.2 A (2) 1.6 A
(3) 2.1 A (4) 0.5 A

Answer (1)

Sol. $id = \epsilon_0 \frac{d\phi_E}{dt} = \epsilon_0 A \frac{dE}{dt} \Rightarrow id \propto A$

$$\Rightarrow i' = \left(\frac{3.2}{16}\right) id = 1.2 \text{ A}$$

16. In the RC circuit shown, find I.



- (1) $\frac{V}{5R}$ (2) $\frac{5V}{3R}$
(3) $\frac{8V}{13R}$ (4) $\frac{3V}{R}$

Answer (3)

Sol. At steady state, C behaves as open-circuit

$$R_{eq} = \frac{13}{8}R$$

$$I = \frac{V}{R_{eq}} = \frac{8V}{13R}$$

17. A glass slab of refractive index $\mu_g = 1.44$ is coated with a thin film of refractive index $\mu_f = 2$. The minimum thickness of the film so that maximum transmission of green light of wavelength $\lambda = 5000 \text{ \AA}$ (incident normally) takes place is

- (1) 0.500 μm (2) 0.250 μm
(3) 0.125 μm (4) 1.00 μm

Answer (3)

Sol. For maximum transmission of light incident normally

$$2\mu_f t = n\lambda \quad (n = 1, 2, 3, \dots)$$

$$t_{min} = \frac{\lambda}{2\mu_f} = \frac{5000 \times 10^{-10}}{2(2)} \text{ m} = 0.125 \mu\text{m}$$

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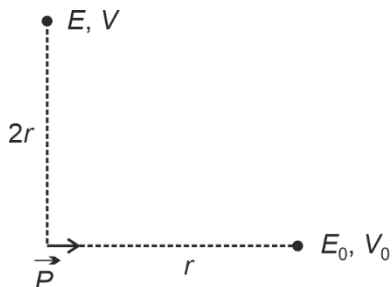
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- AIR 67 Krishna Sai Shishir (2 Year Classroom)
- AIR 78 Abhishek Jain (2 Year Classroom)
- AIR 93 Hardik Aggarwal (2 Year Classroom)
- AIR 95 Ujjwal Singh (2 Year Classroom)
- AIR 98 Rachit Aggarwal (2 Year Classroom)

JEE (Main) 2024

- Karnataka Topper: AIR 1 Sarvi Jais (100 Percentile Score)
- Telangana Topper: AIR 15 M Sai Divya Tuja Reddy (100 Percentile Score)
- Telangana Topper: AIR 19 Rishi Shekher Shukla (100 Percentile Score)

18. For the electric dipole shown in the figure, the electric field and the electric potential are E_0, V_0 at a distance r on the axis. Then what is the electric field and the electric potential at a point on the equatorial plane at a distance $2r$.



- (1) $\frac{E_0}{16}, 0$
 (2) $\frac{E_0}{4}, 0$
 (3) E_0, V_0
 (4) $\frac{E_0}{8}, 0$

Answer (1)

Sol. $E_{\text{axis}} = \frac{2kP}{r^3} = E_0$

$$E_{\text{equatorial}} = \frac{kP}{(2r)^3} = \frac{kP}{8r^3} = \frac{E_0}{16}$$

$$V = \frac{kP \cos \theta}{r^2}$$

$$V_{\text{axis}} = \frac{kP \cos 0^\circ}{r^2} = \frac{kP}{r^2} = V_0$$

$$V_{\text{equatorial}} = \frac{kP \cos 90^\circ}{(2r)^3} = 0$$

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

Choose the correct answer:

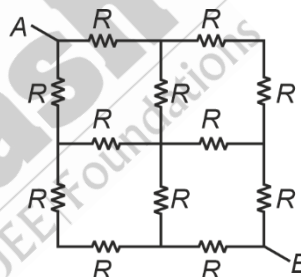
21. A projectile is fired with speed of 20 m/s at angle of 60° with horizontal. The speed at highest point of trajectory is x m/s then x is

Answer (10)

Sol. $V_H = 4 \cos \theta$

$$= 20 \cos 60^\circ = 10 \text{ m/s}$$

22. If equivalent resistance across AB is $\frac{NR}{2}$, find N



Answer (3)

Sol. Line of symmetry problem

$$R_{\text{eq}} = \frac{3R}{4} \times 2 = \frac{3R}{2}$$

23.

24.

25.

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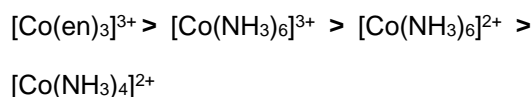
Karnataka Topper AIR 1 Sanyal Jais 2 Year Classroom	Telangana Topper AIR 15 M Sai Divya Teja Reddy 2 Year Classroom	Telangana Topper AIR 19 Rishi Shekher Shukla 2 Year Classroom
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Sol. Crystal Field Splitting Energy (CFSE)

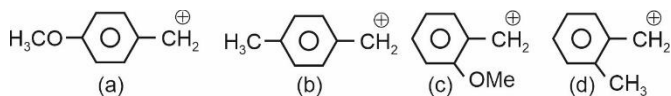
\propto Charge on central metal ion

\propto Ligand field strength

On this basis the correct decreasing order of CFSE



4. What is correct order of stability of carbocation.



- (1) $a > b > c > d$
- (2) $c > a > d > b$
- (3) $a > c > d > b$
- (4) $c > b > a > d$

Answer (3)

Sol. Solution stability of $\text{C}^{\oplus} \propto +M, \text{HC}, +I$

$$\propto \frac{1}{-M, -Z}$$

5. Which of the following anion will not undergo disproportionation?

- (1) ClO_4^-
- (2) ClO_3^-
- (3) ClO_2^-
- (4) ClO^-

Answer (1)

Sol. In $\text{ClO}_4^- \rightarrow$ chlorine is in its highest oxidation state i.e., +7.

Chlorine can exhibit -1 to +7 oxidation state.

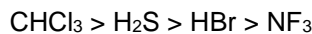
The oxidation states of chlorine which can undergo disproportionation are : 0, +1, +3 and +5.

6. Compare dipole moment of
 - (I) NF_3
 - (II) CHCl_3
 - (III) H_2S
 - (IV) HBr
 - (1) $\text{I} > \text{II} > \text{III} > \text{IV}$
 - (2) $\text{II} > \text{III} > \text{I} > \text{IV}$
 - (3) $\text{II} > \text{III} > \text{IV} > \text{I}$
 - (4) $\text{III} > \text{I} > \text{IV} > \text{II}$

Answer (3)

Sol. NH_3 CHCl_3 H_2S HBr
 \Rightarrow 0.230 1.04 0.95 0.79

So, order is



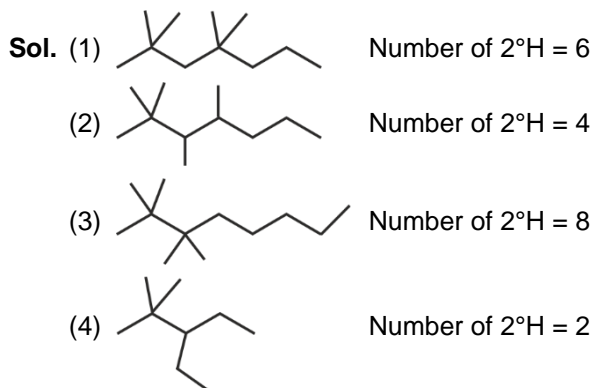
7. Given below are two statements
 S-I: Lassaigne test is used for detection of Nitrogen, phosphorous, sulphur and Halogens.
 S-II: Lassaigne extract is made with magnesium metal.
 - (1) Both S-I and S-II are correct.
 - (2) Both S-I and S-II are incorrect.
 - (3) S-I is correct but S-II is incorrect.
 - (4) S-I is incorrect but S-II is correct

Answer (3)

Sol. Lassaigne extract is made with sodium metal, and not with magnesium metal.

8. Which one has two secondary Hydrogen atoms?
 - (1) 2, 2, 4, 4-tetramethylheptane
 - (2) 2, 2, 3, 4-tetramethylheptane
 - (3) 2, 2, 3, 3-tetramethyloctane
 - (4) 3-ethyl-2, 2-dimethylpentane

Answer (4)



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100 PERCENTILE	100 PERCENTILE	100 PERCENTILE
Sanvi Jain 2 Year Classroom	M Sai Divya Teja Reddy 2 Year Classroom	Rishi Shekher Shukla 2 Year Classroom

Sol. The E – E bond energies of the elements of group-15 are

N – N	167 kJ mol ⁻¹
P – P	201 kJ mol ⁻¹
As – As	146 kJ mol ⁻¹
Sb – Sb	121 kJ mol ⁻¹

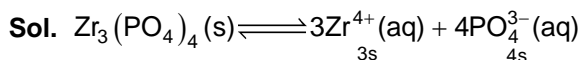
Antimony (Sb) has the weakest E – E bond and its maximum covalency is 5.

14. What is the relation between K_{sp} and S of $Zr_3(PO_4)_4$

$$(1) S = \left(\frac{K_{sp}}{6912}\right)^{\frac{1}{7}} \quad (2) S = \left(\frac{K_{sp}}{144}\right)^{\frac{1}{7}}$$

$$(3) S = \frac{K_{sp}}{6912} \quad (4) \text{None}$$

Answer (1)



$$K_{sp} = (3s)^3(4s)^4$$

$$= 27 \times 256 S^7$$

$$K_{sp} = 6912 S^7$$

$$S = \left(\frac{K_{sp}}{6912}\right)^{\frac{1}{7}}$$

15. Match the column and choose the correct option

(A)	$\left(\frac{\partial H}{\partial T}\right)_P$	(P)	C_p
(B)	$\left(\frac{\partial G}{\partial P}\right)_T$	(Q)	C_v
(C)	$\left(\frac{\partial U}{\partial T}\right)_V$	(R)	$-S$
(D)	$\left(\frac{\partial G}{\partial T}\right)_P$	(S)	V

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

Answer (1)

Sol. Heat exchanged at constant pressure is ΔH

Heat exchanged at constant volume is ΔU

16. Consider the following statements S-1 and S-2 and choose the correct option.

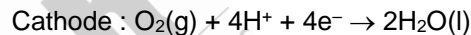
S-1 : During corrosion pure metal acts as anode and impure metal acts as cathode.

S-2 : Rate of corrosion is more in alkaline medium than in acidic medium.

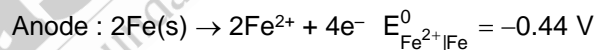
- (1) Both S-1 and S-2 are correct
 (2) Both S-1 and S-2 are incorrect
 (3) S-1 is correct but S-2 is incorrect
 (4) S-1 is incorrect but S-2 is correct

Answer (2)

Sol. In corrosion, a metal is oxidised by loss of electrons to oxygen. Electron released at anodic spot move through the same metal and go to another spot on the metal and reduce oxygen in the presence of H^+ (which is believed to be available from H_2CO_3 formed due to dissolution of CO_2 from air into water.



$$E^0_{H^+|O_2|H_2O} = 1.23 V$$



\therefore Both the statements S-1 and S-2 are incorrect.

17.
18.
19.
20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. In Ru and Nb, if in Ru, $4d$ electrons are x and in Nb, $4d$ electrons are y then find the sum of x and y .

Answer (11)

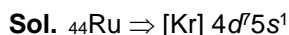
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JEE (Main) 2024

Kannada Topper AIR 1 Sarvi Jain 2 Year Classroom	Telangana Topper AIR 15 M Sai Divya Teja Reddy 2 Year Classroom	Telangana Topper AIR 19 Rishi Shekher Shukla 2 Year Classroom
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$$x = 7$$



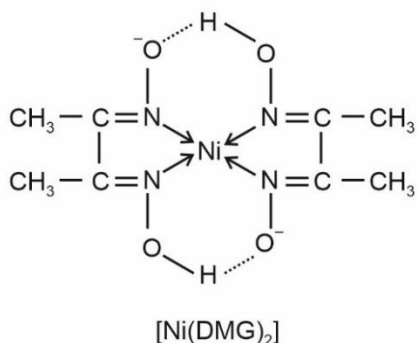
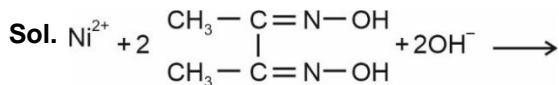
$$y = 4$$

$$x + y = 11$$

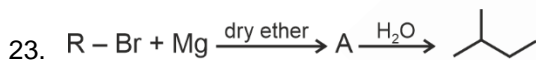


How many hydrogen bonds are present in a molecule of the complex?

Answer (2)



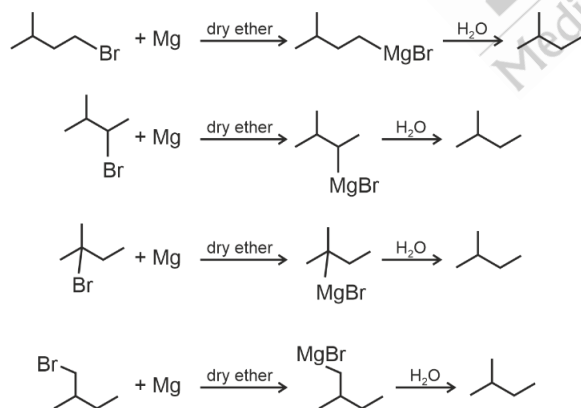
Number of H-bonds in a molecule of $[\text{Ni}(\text{DMG})_2]$ = 2



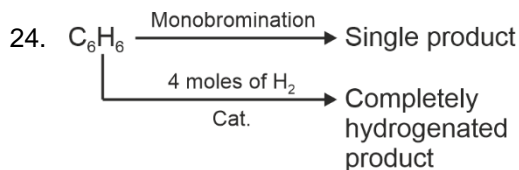
How many R - Br can form isopentane?

Answer (4)

Sol.



\therefore Total 4 R-Br can form isopentane in this reaction.

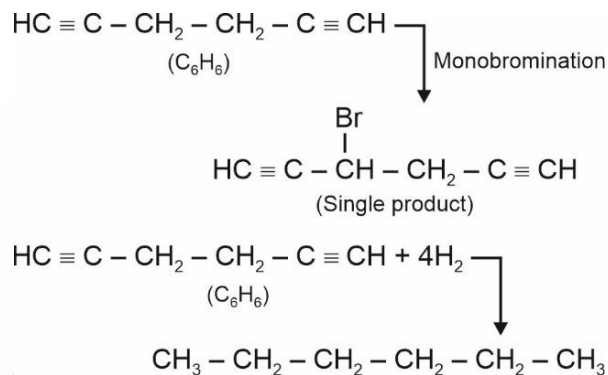


Find the number of π -electrons in C_6H_6 .

Answer (8)

Sol. Degree of unsaturation of $\text{C}_6\text{H}_6 = 4$

C_6H_6 is a symmetrical dialkyne.



Number of π -electrons in $\text{C}_6\text{H}_6 = 8$

25. Calculate the radius of first excited state of He^+ ion (in Å)

Answer (1)

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

$$n = 2$$

$$z = 2$$

$$r = a_0 \frac{4}{2}$$

$$= 2a_0$$

$$= 2 \times 0.529$$

$$= 1.058$$

$$\approx 1$$

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- AIR 25 Rishi Shekher Shukla (2 Year Classroom)
- AIR 67 Krishna Sai Shishir (2 Year Classroom)
- AIR 78 Abhishek Jain (2 Year Classroom)
- AIR 93 Harshik Aggarwal (2 Year Classroom)
- AIR 95 Ujjwal Singh (2 Year Classroom)
- AIR 98 Raahit Aggarwal (2 Year Classroom)

JEE (Main) 2024

- Kannataka Topper: AIR 1 Sarvi Jain (2 Year Classroom)
- Telangana Topper: AIR 15 M Sai Divya Teja Reddy (2 Year Classroom)
- Telangana Topper: AIR 19 Rishi Shekher Shukla (2 Year Classroom)

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. If $2x^2 + (\cos\theta)x - 1 = 0$, $\theta \in [0, 2\pi]$ has roots α and β . Then the sum of maximum and minimum value of $\alpha^4 + \beta^4$.

- (1) $\frac{25}{16}$
- (2) $\frac{9}{16}$
- (3) $\frac{41}{16}$
- (4) $\frac{8}{17}$

Answer (1)

Sol. $\alpha + \beta = \frac{-\cos\theta}{2}$

$\alpha\beta = \frac{-1}{2} \Rightarrow \alpha^2\beta^2 = \frac{1}{4}$

$\Rightarrow \alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$

$= \frac{\cos^2\theta + 1}{4}$

$\alpha^4 + \beta^4 = (\alpha^2 + \beta^2)^2 - 2\alpha^2\beta^2$

$= \left(\frac{\cos^2\theta + 1}{4}\right)^2 - \frac{1}{2}$

For minimum, $\cos\theta = 0$

For maximum, $\cos\theta = 1$

$\Rightarrow \text{Minimum} = 1 - \frac{1}{2} = \frac{1}{2}$

Maximum $= \frac{25}{16} - \frac{1}{2} = \frac{17}{16}$

$\Rightarrow \text{Sum} = \frac{1}{2} + \frac{17}{16} = \frac{25}{16}$

2. If $\theta \in [0, 2\pi]$ satisfying the system of equations $2\sin^2\theta = \cos 2\theta$ and $2\cos^2\theta = 3\sin\theta$. Then the sum of all real values of θ is

- (1) $\frac{3\pi}{2}$
- (2) π
- (3) $\frac{\pi}{2}$
- (4) $\frac{5\pi}{6}$

Answer (2)

Sol. $2\sin^2\theta = \cos 2\theta$

$2\cos^2\theta = 3\sin\theta$

\Rightarrow Adding,

$2 = 1 - 2\sin^2\theta + 3\sin\theta$

$\Rightarrow 2\sin^2\theta - 3\sin\theta + 1 = 0$

$2\sin^2\theta - 2\sin\theta - \sin\theta + 1 = 0$

$2\sin\theta(\sin\theta - 1) - 1(\sin\theta - 1) = 0$

$\sin\theta = 1, \frac{1}{2}$ but $2\sin^2\theta = \cos 2\theta = 2$

but not is not possible

$\Rightarrow \theta = \frac{\pi}{6}, \left(\pi - \frac{\pi}{6}\right)$

$\Rightarrow \text{Sum of all values} = \frac{\pi}{6} + \pi - \frac{\pi}{6} = \pi$

3. Let $A = \{1, 2, 3, 4\}$ and $B = \{1, 4, 9, 16\}$.

If $f: A \rightarrow B$, number of many-one functions from A to B are

- (1) 24
- (2) 232
- (3) 256
- (4) 252

Answer (2)

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$$P(A/B) + P(B/A) = \frac{7}{12}$$

$$\text{and } P(A/B) \cdot P(B/A) = \frac{1}{12}$$

$$\frac{P(A \cup B)}{P(B)} \cdot \frac{P(A \cap B)}{P(A)} = \frac{1}{12}$$

$$\Rightarrow P(A) \cdot P(B) = 12 \left(\frac{1}{12} \right)^2 = \frac{12}{100}$$

$$P(A \cap B) \left[\frac{1}{P(A)} + \frac{1}{P(B)} \right] = \frac{7}{12}$$

$$P(A) + P(B) = \frac{7}{10}$$

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$= \frac{7}{10} - \frac{1}{10} = \frac{6}{10}$$

$$\frac{P(\overline{A \cup B})}{P(\overline{A \cap B})} = \frac{P(\overline{A \cap B})}{P(\overline{A \cup B})} = \frac{1 - P(A \cap B)}{1 - P(A \cup B)}$$

$$\frac{1 - \frac{1}{10}}{1 - \frac{6}{10}} = \frac{\frac{9}{10}}{\frac{4}{10}} = \frac{9}{4}$$

8. Number of terms in an arithmetic progression is $2n$. Sum of terms occurring at even places is 40 and sum of terms occurring at odd places is 55. If the first term exceeds the last term by 27, then n equals to

- (1) 3 (2) 5
(3) 7 (4) 4

Answer (2)

Sol. Let the AP be

$$a, a + d, a + 2d, \dots, a + (2n - 1)d$$

Now given that

$$(a + d) + (a + 3d) + \dots + (a + (2n - 1)d) = 40$$

$$na + n^2d = 40 \quad \dots(1)$$

$$\text{Also } a + (a + 2d) + (a + 4d) + \dots + (a + (2n - 2)d) = 55$$

$$na + dn(n - 1) = 55 \quad \dots(2)$$

$$\text{Also } a - (a + (2n - 1)d) = 27$$

$$-(2n - 1)d = 27 \quad \dots(3)$$

$$d = \frac{-27}{2n - 1}$$

$$(2) - (1)$$

$$dn(n - 1) - n^2d = 15$$

$$d[n^2 - n - n^2] = 15$$

$$\left(\frac{-27}{2n - 1} \right) (-n) = 15$$

$$27n = 30n - 15$$

$$15 = 3n$$

$$n = 5$$

9. The perpendicular distance of point $P(3, 4, 5)$ from the line

$$\vec{r} = 2\hat{i} - \hat{j} + \hat{k} + \lambda(4\hat{i} - \hat{j} + 5\hat{k}) \text{ is}$$

(1) $\sqrt{\frac{19}{42}}$ (2) $\sqrt{\frac{19}{21}}$

(3) $\sqrt{\frac{42}{19}}$ (4) $\sqrt{\frac{21}{19}}$

Answer (1)

Sol. $P(3, 4, 5)$

$$L: \vec{r} = \vec{r} = 2\hat{i} - \hat{j} + \hat{k} + \lambda(4\hat{i} - \hat{j} + 5\hat{k})$$

Any point on L can be. $A(2 + 4\lambda, -1 - \lambda, 1 + 5\lambda)$

$$\text{Now } \overline{AP} \cdot (4\hat{i} - \hat{j} + 5\hat{k}) = 0$$

$$((4\lambda - 1)\hat{i} - (\lambda + 5)\hat{j} + (5\lambda - 4)\hat{k}) \cdot (4\hat{i} - \hat{j} + 5\hat{k}) = 0$$

$$16\lambda + 4 + \lambda + 5 + 25\lambda - 20 = 0$$

$$42\lambda = 19$$

$$\lambda = \frac{19}{42}$$

$$\text{Now } |AP| = \sqrt{(4\lambda - 1)^2 + (\lambda + 5)^2 + (5\lambda + 4)^2}$$

$$= \sqrt{\frac{19}{42}}$$

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10. In the expansion of $(x + \sqrt{x^3 - 1})^5 + (x - \sqrt{x^3 - 1})^5$, where α, β, γ and δ are the coefficient of x, x^3, x^5 and x^7 respectively. If $\alpha u - \beta v = 18, \gamma u + \delta v = 20$ then $u + v$ equal to.

- (1) $\frac{-14}{15}$ (2) $\frac{-13}{15}$
 (3) $\frac{-3}{5}$ (4) $\frac{-2}{3}$

Answer (1)

Sol. $(x + \sqrt{x^3 - 1})^5 + (x - \sqrt{x^3 - 1})^5$

$$\left[\int_0^3 (x)^5 + \int_1^5 x^4 \sqrt{x^3 - 1} + \int_2^5 x^3 (\sqrt{x^3 - 1})^2 + \dots \right] +$$

$$\left[\int_0^5 x^5 - \int_1^5 x^4 \sqrt{x^3 - 1} + \int_2^5 x^3 (\sqrt{x^3 - 1})^2 + \dots \right]$$

$$= 2 \left[x^5 + \int_2^5 x^3 (x^3 - 1) + \int_4^5 x (x^3 - 1)^2 \right]$$

$$= 2[x^5 + 10x^6 - 10x^3 + 5x(x^6 + 1 - 2x^3)]$$

$$= 10x^7 + 20x^6 + 2x^5 - 20x^4 - 20x^3 + 10x$$

Coefficient of $x = 10 = \alpha$
 Coefficient of $x^3 = -20 = \beta$
 Coefficient of $x^5 = 2 = \gamma$
 Coefficient of $x^7 = 10 = \delta$

$$10u + 20v = 18 \quad \dots(i)$$

$$2u + 10v = 20$$

$$u = \frac{-11}{3}$$

$$v = \frac{41}{15}$$

$$u + v = \frac{41}{15} - \frac{11}{3}$$

$$= \frac{-14}{15}$$

11. Let $A(6, 8), B(10 \cos \alpha, -10 \sin \alpha)$ and $C(-10 \sin \alpha, -10 \cos \alpha)$ be 3 points and if orthocentre of the triangle ABC is $(0, 9)$ then $100 \sin^2 \alpha$ is equal to

- (1) $\frac{25}{4}$ (2) 25
 (3) $\frac{15}{4}$ (4) $\frac{5}{4}$

Answer (1)

Sol. Notice, origin is equidistance form A, B and C

$\Rightarrow (0, 0)$ is circumcentre



Since centroid divides orthocentre and circumcentre in 2 : 1 ratio.

$$\Rightarrow \frac{6 + 10 \cos \alpha + (-10 \sin \alpha)}{3} = \frac{2(0) + 1(0)}{3} = 0$$

$$\Rightarrow 15 \sin \alpha - 10 \cos \alpha = 6$$

Alos $\frac{8 - 10 \sin \alpha - 10 \cos \alpha}{3} = \frac{2(0) + 1(9)}{3} = 3$

$$\Rightarrow 8 - 10 \sin \alpha - 10 \cos \alpha = 9$$

$$10(\sin \alpha + \cos \alpha) = -1$$

$$10(\sin \alpha - \cos \alpha) = -6$$

$$20 \sin \alpha = 5$$

$$10 \sin \alpha = \frac{5}{2}$$

$$100 \sin^2 \alpha = \frac{25}{4}$$

12. If z be a complex number such that $|z - 3| \leq 1$, then the equation of line with largest slope passing through origin and z

- (1) $x - 2\sqrt{2}y = 0$ (2) $x + 2\sqrt{2}y = 0$
 (3) $2\sqrt{2}x + y = 0$ (4) $2\sqrt{2}x - y = 0$

Answer (1)

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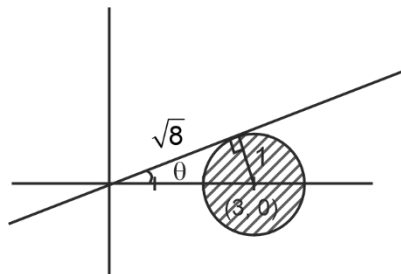
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Sol.



$$\tan\theta = \frac{1}{\sqrt{8}} = \frac{1}{2\sqrt{2}}$$

Therefore, equation of line with maximum slope is

$$(y - 0) = \frac{1}{2\sqrt{2}}(x - 0)$$

$$\Rightarrow y = \frac{x}{2\sqrt{2}}$$

13. A relation R is defined on set A , $A = \{1, 2, 3\}$ and $R = \{(1, 2), (2, 3)\}$. Elements are added such that R becomes reflexive and transitive but not symmetric. Find the number of such relations.

- (1) 3
(2) 4
(3) 2
(4) 9

Answer (1)

Sol. Transitivity

$$(1, 2) \in R, (2, 3) \Rightarrow (1, 3) \in R$$

$$(1, 1), (2, 2), (3, 3) \in R$$

$$(2, 1) \quad (3, 2) \quad (3, 1)$$

(3, 1) cannot be taken.

- (2, 1) taken and (3, 2) not taken.
- (3, 2) taken and (2, 1) not taken.
- Both not taken.

Therefore 3 relations are possible.

14.
15.
16.
17.
18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 5 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. Let \vec{a} and \vec{b} be two unit vectors such that angle between \vec{a} and \vec{b} is $\frac{\pi}{3}$. If $\lambda\vec{a} + 3\vec{b}$ and $2\vec{a} + \lambda\vec{b}$ are perpendicular to each other, then the product of all possible values of λ is _____

Answer (6)

Sol. $|\vec{a}| = 1, |\vec{b}| = 1$

$$\vec{a} \cdot \vec{b} = |\vec{a}| |\vec{b}| \cos \frac{\pi}{3} = \frac{1}{2}$$

$\lambda\vec{a} + 3\vec{b}$ and $2\vec{a} + \lambda\vec{b}$ are perpendicular

$$\Rightarrow (\lambda\vec{a} + 3\vec{b}) \cdot (2\vec{a} + \lambda\vec{b}) = 0$$

$$\Rightarrow 2\lambda + 3\lambda + (\lambda^2 + 6)\vec{a} \cdot \vec{b} = 0$$

$$\Rightarrow 5\lambda + (\lambda^2 + 6)\left(\frac{1}{2}\right) = 0$$

$$\Rightarrow 10\lambda + \lambda^2 + 6 = 0$$

$$\Rightarrow \lambda^2 + 10\lambda + 6 = 0$$

Product of possible values of $\lambda = 6$

22. If A is the 3×3 matrix of order 3×3 , such that $\det(A) = \frac{1}{2}$, $\text{tr}(A) = 10$ and B be another matrix of order 3×3 and defined as $B = \text{adj}(\text{adj}(2A))$, then $\det(B) + \text{tr}(B)$ is equal to (where $\text{tr}(A)$ denotes trace of matrix A)

Answer (336)

Sol. $B = \text{adj}(\text{adj}(2A))$

$$B = |2A|^{n-2} (2A), [\text{Using } \text{adj}(\text{adj } P) = |P|^{n-2} \cdot P],$$

for $n = 3$

$$= |2A|(2A)$$

$$= 2^3|A|(2A)$$

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$$= 8 \times \frac{1}{2}(2A)$$

$$= 4(2A)$$

$$B = 8A$$

$$|B| = |8A|$$

$$= 8^3|A|$$

$$|B| = 8^3 \times \frac{1}{2} = 256$$

$$B = 8A$$

[each element is multiplied 8 times]

$$\text{tr}(B) = 8\text{tr}(A)$$

$$= 80$$

$$|B| + \text{tr}(B) = 256 + 80$$

$$= 336$$

23. Consider two curves $E_1: \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ with eccentricity e_1 and $E_2: \frac{x^2}{A^2} + \frac{y^2}{B^2} = 1$ with eccentricity e_2 . If $\frac{e_1}{e_2} = \frac{1}{3}$ and distance between foci of both curves is $2\sqrt{3}$ and $a - A = 4$, then the sum of lengths of latus rectum of both curves is

Answer (12)

Sol. Since, distance between foci

$$\text{for } E_1 = 2ae_1, \text{ for } E_2 = 2Ae_2$$

$$\Rightarrow 2ae_1 = 2\sqrt{3} = 2Ae_2$$

$$\Rightarrow ae_1 = Ae_2$$

$$\Rightarrow \frac{e_1}{e_2} = \frac{A}{a} = \frac{1}{3} \Rightarrow a = 3A$$

$$\text{Also } a - A = 4 \Rightarrow A = 2, a = 6$$

$$\text{Now, } 2(6)e_1 = 2\sqrt{3} \Rightarrow e_1 = \frac{\sqrt{3}}{6}$$

$$2(2)e_2 = 2\sqrt{3} \Rightarrow e_2 = \frac{\sqrt{3}}{2}$$

$$e_1^2 = \frac{1-b^2}{a^2} = \frac{3}{36} = \frac{1-b^2}{36} \Rightarrow \frac{b^2}{36} = \frac{33}{36}$$

$$b^2 = 33$$

$$e_2^2 = \frac{1-B^2}{A^2} = \frac{3}{4} = \frac{1-B^2}{4} \Rightarrow B^2 = 1$$

$$\text{Length of latus rectum of } E_1 = \frac{2b^2}{a}$$

$$\text{Length of latus rectum of } E_2 = \frac{2B^2}{A}$$

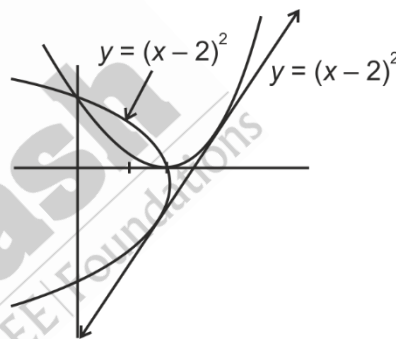
\Rightarrow Sum of lengths of latus rectum

$$= \frac{2(33)}{6} + \frac{2(1)}{2} = 11 + 1 = 12$$

24. The number of maximum number of common tangents to the curves $y = (x - 2)^2$ and $y^2 = 16 - 8x$ is

Answer (1)

Sol.



Clearly, one tangent is possible. Based on the graphs of these parabola.

25. Let $P(10, -2, -1)$ and Q be the point of perpendicular drawn from point $R(1, 7, 6)$ on the line joining the points $(2, -5, 11)$ and $(-6, 7, -5)$. Then the length PQ is

Answer (13)

$$\text{Sol. } L_1: \frac{x-2}{8} = \frac{y+5}{-12} = \frac{z-11}{16}$$

$$L_1: \frac{x-2}{2} = \frac{y+5}{-3} = \frac{z-11}{4}$$

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Avg point of L_1 be $A(2\lambda + 2, -3\lambda - 5, 4\lambda + 11)$

$R(1, 7, 6)$

$$RA \cdot (2\hat{i} - 3\hat{j} + 4\hat{k}) = 0$$

$$((2\lambda + 1)\hat{i} + (-3\lambda - 12)\hat{j} + (4\lambda + 5)\hat{k}) \cdot (2\hat{i} - 3\hat{j} + 4\hat{k}) = 0$$

$$4\lambda + 2 + 9\lambda + 36 + 16\lambda + 20 = 0$$

$$29\lambda = -58$$

$$\lambda = -2$$

\therefore Foot of perpendicular = $(-2, 1, 3)Q$

$$PQ = \sqrt{(10+2)^2 + (1+2)^2 + (3+1)^2}$$

$$= \sqrt{144 + 9 + 16}$$

$$= 13$$



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