03/04/2025
Morning

Aakash
Medical | IIT-JEE | Foundations

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Memory Based
Answers & Solutions
for
JEE (Main)-2025 (Online) Phase-2

(Physics, Chemistry and Mathematics)

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

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.

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. An ideal gas with an adiabatic exponent 1.5, initially at 27°C is compressed adiabatically from 800 cc to 200 cc. The final temperature of the gas is

(1) 600 K

(2) 300 K

(3) 450 K

(4) 273 K

Answer (1)

Sol. T_i = 27°C or 300 K

$T_f V_f^{\gamma-1} = T_i V_i^{\gamma-1}$

$T_f = T_i\left(\frac{V_i}{V_f}\right)^{\gamma-1}$

$T_f = (300\text{ K})\left(\frac{800\text{ cc}}{200\text{ cc}}\right)^{1.5-1}$

= 300 K $(4)^{0.5}$

= 600 K

2. In YDSE, light of intensity of 4I and 9I passes through two slits respectively. Difference of maximum and minimum intensity of interference pattern is

(1) 5I (2) 10I

(3) 24I (4) 26I

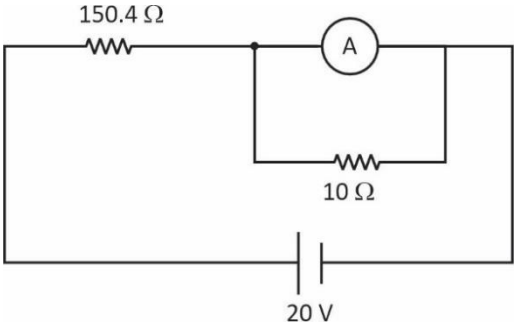
Answer (3)

Sol. $I_{max} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2 = 25I$

$I_{min} = \left(\sqrt{I_1}+\sqrt{I_2}\right)^2 = I$

$\Delta I = 24I$

3. An ammeter having resistance 240 Ω is connected in the given circuit as shown. Find current through the ammeter.



(1) 1 mA

(2) 5 mA

(3) 100 mA

(4) 2.5 mA

Answer (2)

Sol. $R_{eq} = 150.4 + \frac{10\times240}{250}$

= 160 Ω

$I = \frac{20}{160} = \frac{1}{8}$

$I_A = \frac{10}{250} I = \frac{1}{25\times8} = \frac{1}{200}$

I_A = 5 mA

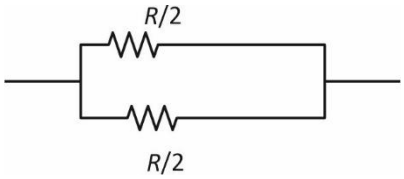
4. A thin uniform wire of length 25 m and area of cross-section 5mm^2 has resistivity 2 × 10^{-6} Ω – m. If the wire is bent to form a circle, the resistance across diametrically opposite points is

(1) 5 Ω (2) 2.5 Ω

(3) 10 Ω (4) 12.5 Ω

Answer (2)

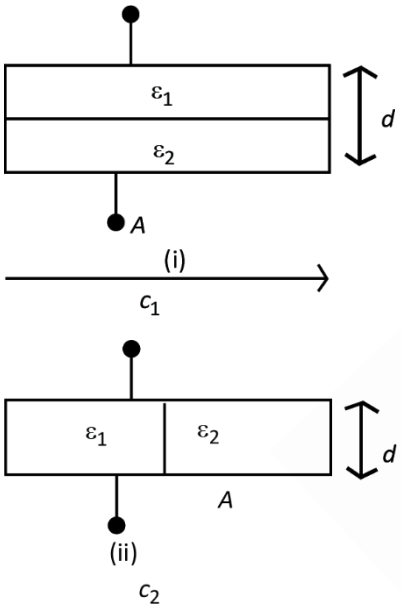
Sol. $R = \rho\frac{l}{A} = \frac{\left(2\times10^{-6}\,\Omega\,\text{m}\right)\left(25\,\text{m}\right)}{5\times10^{-6}\,\text{m}^2}$



$R = 10\,\Omega$

Resistance across diametrically point is $\frac{R}{4} = 2.5\,\Omega$

5. Capacitors with dielectric are shown in figure (symmetric situation).



Find $\frac{C_1}{C_2}$

(1) $\frac{4\varepsilon_1\varepsilon_2}{\left(\varepsilon_1+\varepsilon_2\right)^2}$ (2) $\frac{4\varepsilon_1\varepsilon_2}{\varepsilon_1+\varepsilon_2}$

(3) $\frac{2\varepsilon_1\varepsilon_2}{\left(\varepsilon_1+\varepsilon_2\right)^2}$ (4) $\frac{\left(\varepsilon_1\varepsilon_2\right)^2}{\left(\varepsilon_1+\varepsilon_2\right)^2}$

Answer (1)

Sol. $\frac{1}{c_1} = \frac{d}{2A\varepsilon_1} + \frac{d}{2A\varepsilon_2}$

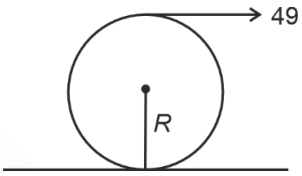
$\Rightarrow c_1 = \frac{2A}{d}\frac{\varepsilon_1\varepsilon_2}{\left(\varepsilon_1+\varepsilon_2\right)^2}$

$c_2 = \frac{A\varepsilon_1}{2d} + \frac{A\varepsilon_2}{2d}$

$c_2 = \frac{A}{2d}\left(\varepsilon_1+\varepsilon_2\right)$

$\frac{c_1}{c_2} = \frac{4\varepsilon_1\varepsilon_2}{\left(\varepsilon_1+\varepsilon_2\right)^2}$

6. A sphere of mass 20 kg is pulled with force of 49 N as shown in diagram. Acceleration of sphere assuming no slipping.



(1) 2.5 m/s^2 (2) 2.8 m/s^2

(3) 1.4 m/s^2 (4) 3.5 m/s^2

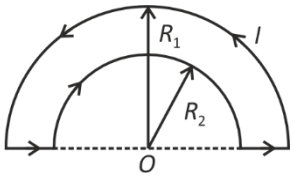
Answer (4)

Sol. $\tau = F2R = \frac{7}{5}MR^2\alpha = \frac{7}{5}MRa$

$2F = \frac{7}{5}Ma$

$a = \frac{10F}{7M} = \frac{10\times49}{7\times20} = 3.5\ \text{m/s}^2$

7. A current carrying wire is bent as shown in the figure. Find magnetic field at centre 'O' of the semi-circles. (take $R_1 = 4\pi$ and $R_2 = 6\pi$)



(1) $8.3I \times 10^{-6}$ T (2) $8.3I \times 10^{-9}$ T

(3) $4\pi I \times 10^{-7}$ T (4) $6I \times 10^{-8}$ T

Answer (2)

Sol. $B=\frac{\mu_0 I}{4R_1}-\frac{\mu_0 I}{4R_2}$

$=\frac{4\pi\times10^{-7}I}{4}\left(\frac{1}{4\pi}-\frac{1}{6\pi}\right)$

$=\frac{1}{12}\times10^{-7}I$

$=8.3I\times10^{-9}$ T

8. A biconvex lens is having the radius of curvature of 10 cm and 15 cm. If focal length of the lens is 12 cm find refractive index of material of the lens.

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

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

Answer (1)

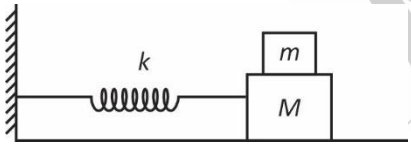
Sol. $\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$\frac{1}{12}=(\mu-1)\left(\frac{1}{10}+\frac{1}{15}\right)$

$\mu-1=\frac{1}{2}$

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

9. The figure below shows an oscillating system of two blocks and a spring. The horizontal surface is smooth and the contact between the blocks is rough with coefficient of static friction μ.



Considering that the blocks of mass *m* is always stationary relative to *M*, choose the correct option regarding the statements below:

(A) Maximum frictional force between blocks is μmg.

(B) Time period of oscillation is $2\pi\sqrt{\frac{m+M}{k}}$

(C) Friction between the blocks at any instant is $\mu(m+M)g$

(1) Only A is correct

(2) Only B is correct

(3) A, B and C all three are correct

(4) Only C is correct

Answer (2)

Sol. $f\le\mu N$

$\Rightarrow \quad f\le\mu mg$

$T=2\pi\sqrt{\frac{m+M}{k}}$ for no shipping between the blocks.

10. A point source of power 450 W is emitting light in all direction. Radiation pressure at distance of 2m from the source is nearly

(1) 3×10^{-8} Pa (2) 2×10^{-8} Pa

(3) 2×10^{-9} Pa (4) 4×10^{-7} Pa

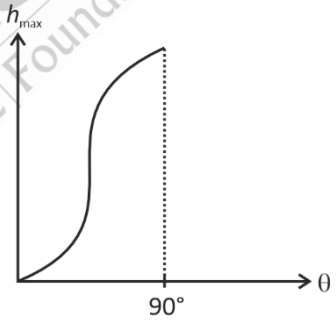
Answer (1)

Sol. $p=\frac{I}{C}=\frac{P}{AC}=\frac{450}{4\times3.14\times2^2\times3\times10^8}=\frac{450}{48\times3.14}\times10^{-8}$

$\approx3\times10^{-8}$ Pa

11. From a horizontal surface a particle is projected with a speed *u*. Which of the following graph correctly represent the variation of maximum height above the surface attained by the particle as the angle of projection is varied?

(1)



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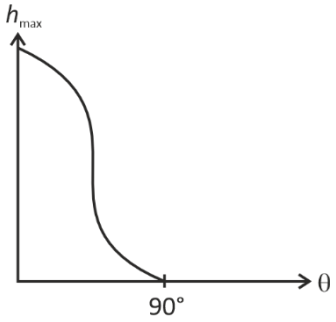
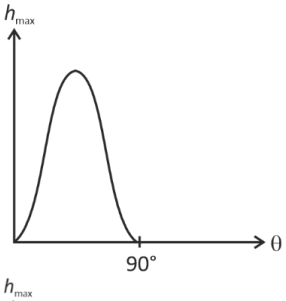
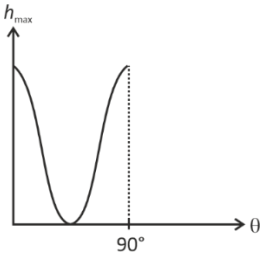


(3)



(4)



Answer (1)

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

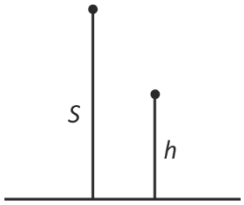
12. An object is dropped from height S. At a point its kinetic energy is three times its potential energy. Find its height from ground and speed at that point.

(1) $\frac{3S}{4}, \sqrt{\frac{3gS}{2}}$ (2) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$

(3) $\frac{S}{2}, \sqrt{gS}$ (4) $\frac{S}{4}, \sqrt{\frac{3gS}{4}}$

Answer (2)

Sol.



KE + PE = mgS

3PE + PE = mgS

$4mgh = mgS$

$h = \frac{S}{4}$

$v = \sqrt{2g \cdot \left(\frac{3S}{4}\right)}$

$v = \sqrt{\frac{3gS}{2}}$

13. The electric potential at the surface of a shell of radius 10 cm is 120 V. Find the potential at its centre, at r = 5 cm from centre and at r = 15 cm from centre.

(1) 0 V, 0 V, 80 V (2) 120 V, 120 V, 80 V

(3) 120 V, 0 V, 80 V (4) 80 V, 0 V, 120 V

Answer (2)

Sol. $V_{inside} = V_{surface}$

$\Rightarrow V_{centre} = V(r = 5\text{ cm}) = 120\text{ V}$

$$V_{outside} = \frac{(V_{surface})(R)}{r}$$

$$\Rightarrow V(r = 15\text{ cm}) = \frac{(120\text{ V})(10\text{ cm})}{(15\text{ cm})}$$

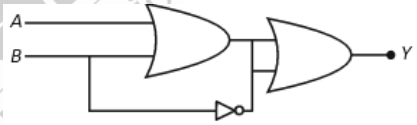
$$= 80\text{ V}$$

14. Truth table of logical circuit is given

A	B	Y
0	0	0
1	1	1
0	1	0
1	0	0

Then identify the correct circuit.

(1)



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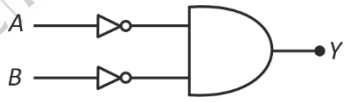

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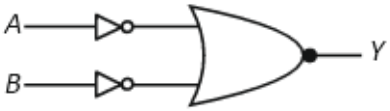
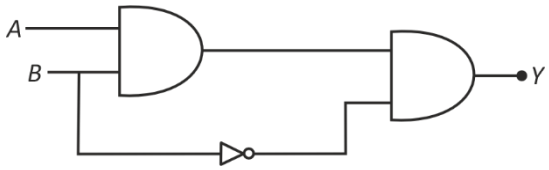


(4)



Answer (3)

Sol. Truth table is of AND gate

$A \cdot B = \overline{\overline{A} + \overline{B}}$

15. Find the colour corresponding to photons of energy 3 eV.

(1) Violet

(2) Yellow

(3) Green

(4) Blue

Answer (4)

Sol. $\lambda = \frac{12400}{E(eV)}\text{ Å} = \frac{12400}{3} = 4133\text{ Å}$

V I B G Y O R

3800Å 5500Å 7600Å

16. Choose the correct option.

a.	Gravitational potential	(i)	$M^{-1}L^3T^{-2}$
b.	Gravitational constant	(ii)	ML^2T^{-2}
c.	Acceleration due to gravity	(iii)	$M^0L^2T^{-2}$
d.	Potential energy	(iv)	M^0LT^{-2}

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

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

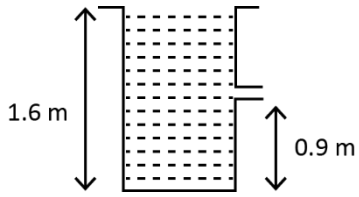
(3) a(ii), b(i), c(iv), d(iii)

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

Answer (2)

Sol. Conceptual

17. A container of height 1.6 m is having a small hole at height of 0.9 m from ground then find speed of efflux from the hole [use $g = 9.8\text{ m/s}^2$]



(1) 3.71 m/s

(2) 2.97 m/s

(3) 4.12 m/s

(4) 5.79 m/s

Answer (1)

Sol. $u = \sqrt{2gh} = \sqrt{2\times9.8\times0.7} = \sqrt{2\times14\times0.7\times0.7} = 0.7\sqrt{28}$

$= 0.7 \times 5.3$

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. Find force (in millinewton) on current carrying wire of length $l = 4$ m, and current of 8 A placed perpendicular to the magnetic field of $\beta = 0.15$ T.

Answer (4800)

Sol. $F = Id\vec{\ell}\times\vec{B}$

$\Rightarrow \left|\vec{F}\right| = 8\times4\times0.15 = 4.8\text{ N}$

$\Rightarrow \left|\vec{F}\right| = 4800(\text{milli Newton})$

22.

23.

24.

25.

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. Which of the following ions has spin only magnetic moment of 4.9 BM?

(1) Mn^{2+} (2) Cr^{2+}

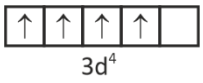
(3) Fe^{3+} (4) Co^{2+}

Answer (2)

Sol. $\mu_{spin\ only} = \sqrt{n(n+2)}$ BM

n = number of unpaired electrons

$Cr^{2+} = 3d^4 4s^0$



$3d^4$

n = 4

$\mu_{spin\ only} = \sqrt{4(4+2)}$ BM

$= \sqrt{24}$ BM

= 4.9 BM

Cr^{2+} has spin only magnetic moment = 4.9 BM

2. Which among the following element has highest atomic number.

(1) Po (2) Pt

(3) Pr (4) Pb

Answer (1)

Sol. Po $\rightarrow$ Polonium (Z = 84)

Pt $\rightarrow$ Platinum (Z = 78)

Pr $\rightarrow$ Praseodymium (Z = 59)

Pb $\rightarrow$ Lead (Z = 82)

$\therefore$ Of the given metals Po has the highest atomic number

3. Match the following List-I with List-II and choose the correct option.

	List-I (Compounds)		**List-II (Shape and Hybridisation)**
(A)	PF_5	(I)	Tetrahedral and sp^3
(B)	SF_6	(II)	Square planar and dsp^2
(C)	$Ni(CO)_4$	(III)	Octahedral and sp^3d^2
(D)	$[PtCl_4]^{2-}$	(IV)	Trigonal bipyramidal and sp^3d

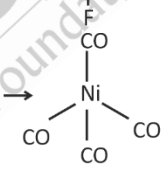
(1) A-IV, B-III, C-I, D-II (2) A-III, B-IV, C-I, D-II

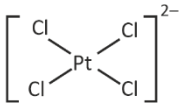
(3) A-III, B-IV, C-II, D-I (4) A-IV, B-III, C-II, D-I

Answer (1)

Sol. $PF_5 \rightarrow$  Trigonal bipyramidal and sp^3d

$SF_6 \rightarrow$  $\rightarrow$ Octahedral and sp^3d^2

$Ni(CO)_4 \rightarrow$  $\rightarrow$ Tetrahedral and sp^3

$[PtCl_4]^{2-} \rightarrow$  $\rightarrow$ Square planar and dsp^2

4. 2 moles each of ethylene glycol and glucose are mixed with 500 g of water. Find the boiling point of solution. (K_b = 0.52 K kg/mol)

(1) 377.16 K (2) 368.84 K

(3) 376.16 K (4) 369.84 K

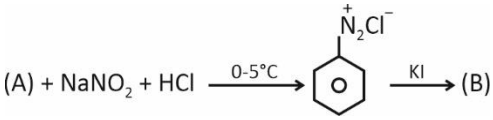
Answer (1)

Sol. $\Delta T_b = i \times K_b \times m$

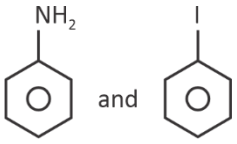
$$= 0.52 \times \left[(2+2) \times \frac{1000}{500}\right] = 4.16 \text{ K}$$

$\therefore$ Boiling point of solution = 377.16 K

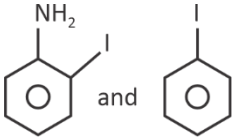
5. Observe the following reaction sequence.

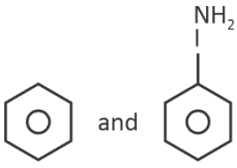


Which of the following options has correct structure of (A) and (B) respectively.

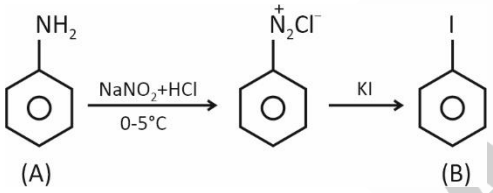
(1)  and

(2)  and

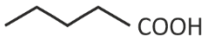
(3)  and

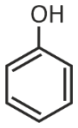
(4)  and

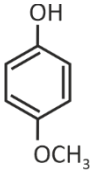
Answer (1)

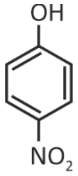
Sol. 

6. Which one of the following compounds is most acidic?

(1) 

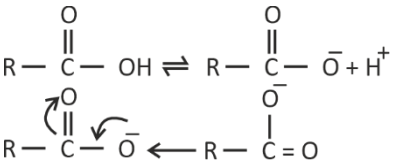
(2) 

(3) 

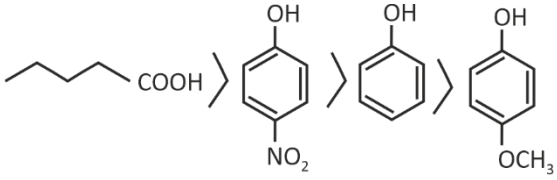
(4) 

Answer (1)

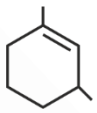
Sol. Carboxylic acid is more acidic than phenol and the given phenol derivatives because carboxylate anion has two equi-energetic resonating structures

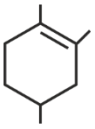


The correct acidic strength order is

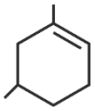


7. 3-methyl-6-oxoheptanal, will be formed after ozonolysis of

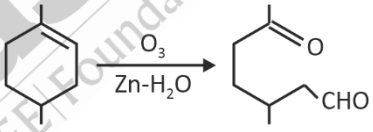
(1) 

(2) 

(3) 

(4) 

Answer (3)

Sol. 

(3-methyl-6-oxoheptanal)

8. The following reaction is at equilibrium starting with only PCl_5

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$,

when Xe gas is added to the above system at constant pressure, then which of the following is correct?

(1) Concentration of PCl_3 will become more than Cl_2

(2) PCl_3 and Cl_2 will have same concentration at new equilibrium.

(3) Concentration of Cl_2 will be more than PCl_3

(4) PCl_3 will be 30% and Cl_2 will be 70% at new equilibrium

Answer (2)

Sol. Addition of inert gas at constant pressure will result in increase in volume, which will increase gaseous moles and hence equilibrium will shift in forward direction.

Same amount of $PCl_3(g)$ and $Cl_2(g)$ will be formed.

9. Consider the following statements

Statement I: N–N has less bond strength than P–P

Statement II: All group-15 elements in +3 oxidation state undergo disproportionation.

In the light of above statements, choose the correct option.

(1) Statement I and statement II both are correct

(2) Statement I and statement II both are incorrect

(3) Statement I is correct, statement II is incorrect

(4) Statement I is incorrect, statement II is correct

Answer (3)

Sol. Due to small size of nitrogen interelectronic repulsion takes place and N–N bond strength is less than P–P bond strength. Statement I is correct.

Not all group-15 elements undergo disproportionation in +3 oxidation state. Statement II is incorrect.

10. Which of the following property shows irregular trend in group 16?

(1) Electronegativity (2) Atomic radius

(3) Electron affinity (4) Ionisation enthalpy

Answer (3)

Sol. Down the group electron affinity decreases, but O has the lowest value due to $e^- - e^-$ repulsion.

Electron gain enthalpy

O	S	Se	Te	Po	
–141	–200	–195	–190	–174	$\left(\frac{kJ}{mol}\right)$

11. Which of the following statement(s) is/are incorrect?

I. NO_2 dimerises easily

II. NF_5 does not exist but PF_5 exists

III. The oxides N_2O_3 and P_2O_3 are purely acidic but As_2O_3 and Sb_2O_3 are basic

IV. Nitrogen cannot form $d\pi$-$p\pi$ bond as the heavier elements can

(1) Only I, II and IV (2) Only III

(3) Only III and IV (4) Only I and II

Answer (2)

Sol. N_2O_3 and $P_2O_3 \Rightarrow$ Purely acidic

As_2O_3 and $Sb_2O_3 \Rightarrow$ Amphoteric

$Bi_2O_5 \rightarrow$ Basic

All other statements are correct.

12. Consider the following complex ions

(a) $[Co(NH_3)_6]^{3+}$ (b) $[Co(NH_3)_5Cl]^{3+}$

(c) $[Co(NH_3)_5H_2O]^{3+}$ (d) $[Co(CN)_6]^{3-}$

Choose the correct order of wavelength absorbed by complex ions

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

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

Answer (2)

Sol. More the crystal field splitting energy (Δ_o) more will be energy absorbed by complex.

$\Delta_o \propto$ ligand filed strength

Order of ligand filed strength

$CN^- > NH_3 > H_2O > Cl^-$

Order of Δ_o for complex ions

d > a > c > b

Order of wavelength absorbed

b > c > a > d

13. Arrange the following metal ions in the decreasing order of their molar conductivity in aqueous solution.

Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}

(1) $Na^{+} > K^{+} > Ca^{2+} > Mg^{2+}$

(2) $Mg^{2+} > Ca^{2+} > Na^{+} > K^{+}$

(3) $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$

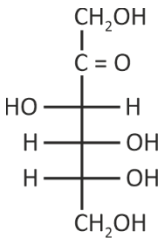
(4) $Mg^{2+} > Ca^{2+} > K^{+} > Na^{+}$

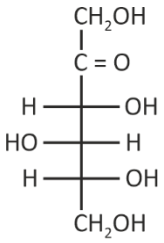
Answer (3)

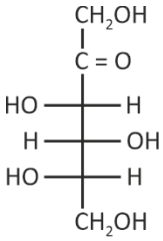
Sol. Molar conductivity of a metal ion in aqueous solution is directly proportional to charge on the ion and inversely proportional to the size of hydrated ion. Molar conductivity of M^{2+} is expected to be higher than that of M^{+}. The extent of hydration of Mg^{2+} will be higher than that of Ca^{2+}, so its mobility will be slower and hence molar conductivity of Mg^{2+}(aq) will be lower than that of Ca^{2+}(aq). Similarly, molar conductivity of K^{+}(aq) will be higher than that of Na^{+}(aq). The correct order of molar conductivity of the given metal ions in aqueous solution is

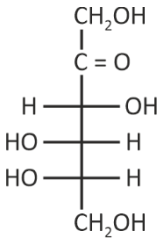
$Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$

14. Which of the following represents the L-form of fructose?

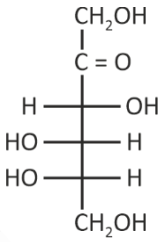
(1)


(2)


(3)


(4)


Answer (4)

Sol. L-form of fructose is


15. Which of the following is/are correct?

(a) $CH_3CH_2CH_2–COCH_3$ and $CH_3–CH_2–COCH_2CH_3$ metamers

(b) $CH_3CH_2CH_2CH_2OH$ and $CH_3CH_2CH_2–CH(OH)–CH_3$ position isomers

(c) $CH_3CH_2CH_2CH_2NH_2$ and $CH_3–CH_2NH–CH_2CH_3$ homologues

(d) $CH_3CH_2CH_2CH_2CN$ and $CH_3CH_2CH_2CH_2NC$ functional isomers

(1) (a) and (d)

(2) (a) and (c)

(3) (b) and (c)

(4) (b) and (d)

Answer (1)

Sol.

(1) $CH_3-CH_2-CH_2-\overset{\overset{O}{\|}}{C}-CH_3$ $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-CH_2-CH_3$ are metamers.

(2) $CH_3CH_2CH_2-CH_2-OH$ and $CH_3-CH_2-CH_2-\underset{\underset{OH}{|}}{CH}-CH_3$ are different compounds (homologues)

(3) $CH_3-CH_2-CH_2-\underset{\underset{NH_2}{|}}{CH_2}$ and $CH_3-CH_2-\overset{\overset{H}{|}}{N}-CH_2-CH_3$ are functional isomers

(4) $CH_3CH_2CH_2-CH_2-CN$ and $CH_3CH_2-CH_2-CH_2-NC$ are functional isomers.

16. Correct set of four quantum numbers for last electron of Cr^{3+} ion is

(1) $n = 4, l = 1, m = 0, s = +\frac{1}{2}$

(2) $n = 4, l = 2, m = 0, s = +\frac{1}{2}$

(3) $n = 3, l = 2, m = 0, s = +\frac{1}{2}$

(4) $n = 3, l = 2, m = -1, s = 0$

Answer (3)

Sol. Chromium = Atomic number 24.

$\therefore$ It has 24 protons and 24 electrons.

$Cr = 24e^-$, $\therefore$ $Cr^{3+} = 21e^-$

$Cr^{3+} \Rightarrow$ electronic configuration

$\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^3$

Four Quantum numbers decided on the basis of $3d^3 \Rightarrow$ | 1 | 1 | 1 | | |

n = 3

l = 2

m = 0

$S = +\frac{1}{2}$

17. Given below are two statements about X-ray spectra of elements:

Statement (I) : A plot of $\sqrt{v}$ (v = frequency of X-rays emitted) vs atomic mass is a straight line

Statement (II): A plot of v (v = frequency of X-rays emitted) vs atomic number is a straight line.

In the light of the above statements, choose the correct answer from the options given below.

(1) **Statement I** is true but **Statement II** is false

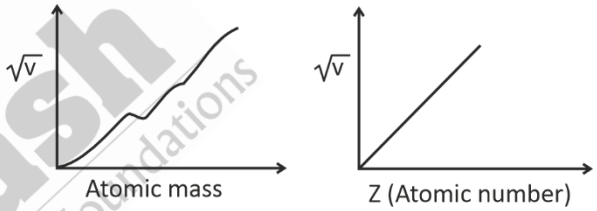
(2) **Statement I** is false but **Statement II** is true

(3) Both **Statement I** and **Statement II** are false

(4) Both **Statement I** and **Statement II** are true

Answer (3)

Sol.



[Graphs plotted by Henry Moseley]

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. 0.5 g of an organic compound gives 1.46 g CO_2 and 0.9 g H_2O. What is the % of carbon in organic sample?

Answer (80)

Sol. $n_{CO_2} = \frac{1.46}{44} = n_C = 0.033 \text{ mol}$

Mass of carbon = $0.033 \times 12 = 0.398$ g

% of carbon = $\frac{0.398}{0.5} \times 100$

= 79.6 %

≈ 80%

22. In two first order reactions initial concentration of $[A]_0 = 8[B]_0$. Find the time after which concentration of A and B become equal. Given that $(t_{1/2})_A = 20$ min and $(t_{1/2})_B = 80$ min.

Answer (80)

Sol. Let initial concentration of [B] = 1 mol/L

$\therefore$ Initial concentration of [A] = 8 mol/L

	A	$\xrightarrow{20'}$	A	$\xrightarrow{20'}$	A	$\xrightarrow{20'}$	A	$\xrightarrow{20'}$ A
mol/L	8		4		2		1	0.5

	B	$\xrightarrow{80'}$	B
mol/L	1		0.5

$\therefore$ After 80 min, both (A) and (B) will have same concentrations.

23. How many of the following statements are correct?

(a) First ionisation energy of Boron is more than that of Beryllium.

(b) Lithium is strongest reducing agent.

(c) Electronegativity of carbon is 2.5 (approx.) in CCl_4.

(d) Removal of electron from isolated gaseous atom is endothermic and addition of electron to isolated gaseous atom is generally exothermic.

Answer (3)

Sol. IE_1 of Be > B

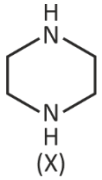
Li is strongest reducing agent.

Electronegativity of 'C' in CCl_4 is 2.5.

Removal of electron is endothermic and addition of electron is generally exothermic.

Statements (b), (c) and (d) are correct.

24. 0.42 g of the following compound (X) is subjected to analysis for estimation of volume of N_2 gas by Duma's method



(X)

What is the volume of N_2 gas evolved in mL at STP (1 atm pressure and 273 K temperature) to the nearest integer

Answer (109)

Sol. Mass of (X) = 0.42 g

No of moles of (X) $\frac{0.42}{86}$

Volume of N_2 gas at STP

$= \frac{0.42}{86} \times 22.400 \text{ mL}$

= 109.4

≃ 109 mL

25.

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. Let A be 3 × 3 matrix such that det(A) = 5. If det(3 adj(2A adj(2A))) = $2^{\alpha}\cdot 3^{\beta}\cdot 5^{\gamma}$, then $(\alpha+\beta+\gamma)$ is equal to

(1) 25 (2) 26

(3) 27 (4) 28

Answer (3)

Sol. $|3\text{adj}(2A\ \text{adj}(2A))| = 3^3|\ 2A(\text{adj}\ 2A)|^2$

$= 3^3(2^3)^2|A|^2|\text{adj}(2A)|^2$

$= 3^3\cdot 2^6\cdot 5^2(|(2A)|^2)^2$

$= 3^3\cdot 2^6\cdot 5^2\cdot\ |2A|^4$

$= 3^3\cdot 2^6\cdot 5^2\cdot\ (2^3)^4\cdot|A|^4$

$= 2^{18}\cdot 3^3\cdot 5^6 = 2^{\alpha}\cdot 3^{\beta}\cdot 5^{\gamma}$

$\Rightarrow\ \alpha = 18$

$\beta = 3$

$\gamma = 6$

$\Rightarrow\ \alpha+\beta+\gamma = 27$

2. The sum of all rational numbers in $\left(2+\sqrt{3}\right)^8$ is

(1) 18117 (2) 18817

(3) 17280 (4) 1800

Answer (2)

Sol. $S = {}^8C_0(2)^8 + {}^8C_1 2^7\left(\sqrt{3}\right)+\ldots+{}^8C_8\left(\sqrt{3}\right)^8$

Sum of rational terms

$= {}^8C_0(2)^8 + {}^8C_2 2^6\left(\sqrt{3}\right)^2 + {}^8C_4(2)^4\left(\sqrt{3}\right)^4 +$

$\qquad {}^8C_6(2)^2\left(\sqrt{3}\right)^2 + {}^8C_8\left(\sqrt{3}\right)^8$

= 18,817

3. If the sum $\sum_{r=1}^{9}\left(\frac{r+3}{2^r}\right)\cdot{}^9C_r = \alpha\cdot\left(\frac{3}{2}\right)^9-\beta$, then the value of $(\alpha+\beta)^2$ is equal to

(1) 9 (2) 81

(3) 27 (4) 36

Answer (2)

Sol. $\sum_{r=1}^{9}\left(\frac{r+3}{2^r}\right)\cdot{}^9C_r = \sum_{r=1}^{9}\frac{r}{2^r}\cdot\frac{9}{r}\cdot{}^8C_{r-1}+\sum_{r=1}^{9}3\cdot{}^9C_r\left(\frac{1}{2}\right)^r$

$= \frac{9}{2}\sum_{r=1}^{9}{}^8C_{r-1}\left(\frac{1}{2}\right)^{r-1}+3\sum_{r=1}^{9}{}^9C_r\left(\frac{1}{2}\right)^r$

$= \frac{9}{2}\sum_{r=0}^{8}{}^8C_{r-1}\left(\frac{1}{2}\right)^{r}+3\sum_{r=1}^{9}{}^9C_r\left(\frac{1}{2}\right)^r$

$= \frac{9}{2}\left(1+\frac{1}{2}\right)^8+3\left[\left(1+\frac{1}{2}\right)^9-{}^9C_0\left(\frac{1}{2}\right)^0\right]$

$= \frac{9}{2}\cdot\frac{3^8}{2^8}+3\left[\frac{3^9}{2^9}-1\right]$

$= \frac{3^{10}}{2^9}+\frac{3^{10}}{2^9}-3 = 4\cdot\frac{3^{10}}{2^{10}}-3$

$= 4\left(\frac{3}{2}\right)^{10}-3$

$= 6\left(\frac{3}{2}\right)^9-3$

$\alpha = 6, \beta = 3 \Rightarrow (\alpha+\beta)^2 = 81$

4. Let S_n = 1 + 3 + 11 + 25 + 45 + ... Then sum upto 20th term equals

(1) 6200 (2) 7200

(3) 7240 (4) 6240

Answer (3)

Sol. $S = 1+3+11+25+....+T_n$

$T_n = 1+2+8+14+....+(T_n - T_{n-1})$

$S = 1+3+11+....T_{n-1}+T_n$

$T_n = 1+\frac{n-1}{2}[4+(n-2)6]$

$=1+\left(\frac{n-1}{2}\right)[6n-8]$

$= 1 + (n-1)(3n-4)$

$= 1 + 3n^2 - 4n - 3n + 4$

$T_n = 3n^2 - 7n + 5$

$S_n = \sum Tn = 3\sum n^2 - 7\sum n + \sum 5$

$=\frac{3n(n+1)(2n+1)}{6}-\frac{7n(n+2)}{2}+5n$

now $n = 20$

$=\frac{3\times20\times21\times41}{6}-\frac{7\times20\times21}{2}+5\times20=7240$

5. Evaluate $\int x^3\sqrt{1-x^2}dx$

(1) $\frac{-1}{15}\left(1-x^2\right)^{3/2}\left(3x^2+2\right)+C$

(2) $\frac{1}{3}\left(1+x^2\right)^{2/3}-\sqrt{1-x^2}+C$

(3) $\frac{2}{3}\left(1-x^2\right)^{3/2}\left(3x^2+2\right)+C$

(4) $\frac{1}{3}\left(1-x^2\right)^{2/3}+\sqrt{1-x^2}+C$

Answer (1)

Sol. $\int x^3\sqrt{1-x^2}dx$

Put $1 - x^2 = t^2$

$-2x\,dx = 2t\,dt$

$-\int t^2(1-t^2)dt = -\left[\frac{t^3}{3}-\frac{t^5}{5}\right]+C$

$\frac{t^5}{5}-\frac{t^3}{3}+C$

$=\frac{(1-x^2)^{5/2}}{5}-\frac{\left(1-x^2\right)^{3/2}}{3}+C$

$=\frac{\left(1-x^2\right)^{3/2}}{15}\left[3(1-x^2)-5\right]+C$

$=\frac{-\left(1-x^2\right)^{3/2}}{15}\left(3x^2+2\right)+C$

6. A relation $R = \{(x, y); x, y \in A = \{-3, -2, -1, 0, 1, 2, 3\}$ such that $x^2 + 2y \le 4\}$. If the number of ordered pairs in relation R be r and number of ordered pairs required to add in R so that it becomes reflexive relations is m, then $r + m$ is equal to

(1) 26 (2) 28

(3) 24 (4) 23

Answer (2)

Sol. $x^2 + 2y \le 4$

$A = \{-3, -2, -1, 0, 1, 2, 3\}$

$x^2 \le 4 - 2y$

For $y = -3$

$x^2 \le 4 - (2(-3))$

$x^2 \le 10$

$\Rightarrow x^2 \in \{-3, -2, -1, 0, 1, 2, 3\}$

For $y = -2$

$x^2 \le 4 - 2(-2)$

$x^2 \le 8$

$\Rightarrow x \in \{-2, -1, 0, 1, 2\}$

For $y = -1$

$x^2 \le 4 - (2(-1))$

$x^2 \le 6$

$\Rightarrow x \in \{-2, -1, 0, 1, 2\}$

For $y = 0$

$x^2 \le 4$

$\Rightarrow x \in \{-2, -1, 0, 1, 2\}$

For $y = 1$

$x^2 \le 2$

$\Rightarrow x \in \{-1, 0, 1\}$

For $y = 2$

$x^2 \le 0$

$\Rightarrow x \in \{0\}$

For $y = 3$

$x^2 \le -2 \Rightarrow$ No value of x

Tota number of ordered pair in relation R is, $r = 26$

For it to be reflexive we have to add $\{(3, 3), (2, 2)\}$

$\Rightarrow m = 2$

$\Rightarrow r + m = 28$

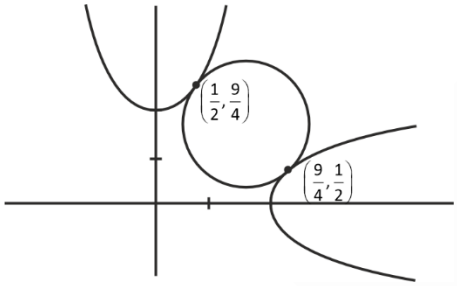
7. The radius of circle touching both parabolas $y = x^2 + 2$ and $x = y^2 + 2$ is

(1) $\frac{7\sqrt{2}}{2}$ (2) $\frac{7\sqrt{2}}{6}$

(3) $\frac{7\sqrt{2}}{8}$ (4) $\frac{7\sqrt{2}}{4}$

Answer (4)

Sol.



The circle will have its centre at $x = y$ line and since these parabolas are symmetric about the line $y = x$. The slope will be of tangents at closest points.

$\Rightarrow y^2 = x - 2 \quad \Rightarrow 2y\frac{dy}{dx} = 1 \quad \Rightarrow y = \frac{1}{2}$

$\Rightarrow$ Point will be $\left(\frac{9}{4}, \frac{1}{2}\right)$

Similarly on $x^2 = y - 2$

$\Rightarrow 2x = \frac{dy}{dx} = 1 \quad \Rightarrow x = \frac{1}{2}$

$\Rightarrow \left(\frac{1}{2}, \frac{9}{4}\right)$

Circle's diameter will be equal to shortest distance

$$2r = \sqrt{\left(\frac{9}{4} - \frac{1}{2}\right)^2 + \left(\frac{1}{2} - \frac{9}{4}\right)^2} = \sqrt{\frac{7}{4} \times 2} = \sqrt{\frac{7}{2}}$$

$$\Rightarrow r = \frac{1}{2}\sqrt{\frac{7}{2}} = \sqrt{\frac{7}{8}} = \frac{7\sqrt{2}}{4}$$

8. Let $3x + 2\tan x = \pi$, $x \in \left[-2\pi, 2\pi\right] - \left\{\pm\frac{\pi}{2}, \pm\frac{3\pi}{2}\right\}$

Then number of values of x satisfying the above condition is

(1) 4

(2) 5

(3) 6

(4) 7

Answer (2)

Sol. $3x + 2\tan x = \pi$

$2\tan x = \pi - 3x$

$\tan x = \frac{\pi - 3x}{2}$

5 solution

$\because$ in $\left(\frac{-\pi}{2}, \frac{\pi}{2}\right)$ well get 1 solution as $\tan x$ is increasing in $\left(\frac{-\pi}{2}, \frac{\pi}{2}\right)$

$$\Rightarrow \left.\begin{array}{l} \left(\frac{-3\pi}{2}, \frac{\pi}{2}\right) \to 1 \text{ solution} \\ \left(\frac{-\pi}{2}, \frac{\pi}{2}\right) \to 1 \text{ solution} \\ \left(\frac{\pi}{2}, \frac{3\pi}{2}\right) \to 1 \text{ solution} \\ \left(\frac{3\pi}{2}, 2\pi\right) \to 1 \text{ solution} \\ \left(-2\pi, \frac{-3\pi}{2}\right) \to 1 \text{ solution} \end{array}\right\} 5$$

9. Let $\int_0^x g(t)dt = x - \int_0^x tg(t)dt,\ x \geq 0$ and $\frac{dy}{dx} - y\tan x = 2(x+1)\sec x g(x)$ satisfying the condition $y(0) = 0$. Then $y\left(\frac{\pi}{3}\right)$ is

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

(3) π (4) 2π

Answer (2)

Sol. Differentiate both side w.r.t x

$g(x) = 1 - xg(x)$

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

$g(x) = \frac{1}{1+x}$

Also $\frac{dy}{dx} - y\tan x = 2(x+1)\sec x g(x)$

$I.F = e^{-\int \tan x dn.}$

$I.F = e^{-(-\ln\cos x)}$

$I.F = \cos x$

$y\cos x = \int 2(x+1)\sec x \frac{1}{(1+x)}\cos x dx$

$y\cos x = \int 2dx$

$y\cos x = 2x + c$ ...(i)

$y(0) = 0$

$\Rightarrow c = 0$

from (i)

$y\cos x = dx$

Put $x = \frac{\pi}{3}$

$y \cdot \frac{1}{2} = \frac{2\pi}{3}$

$y = \frac{4\pi}{3}$

10. If $f(x) = \begin{vmatrix} \sin x & \cos x & \sin x + \cos x + 1 \\ 27 & 28 & 27 \\ 1 & 1 & 1 \end{vmatrix}$. Then, the value of $f'(x) + f(x)$ is

(1) -1

(2) 28

(3) 27

(4) 1

Answer (1)

Sol. $f(x) = \begin{vmatrix} \sin x & \cos x & \sin x + \cos x + 1 \\ 27 & 28 & 27 \\ 1 & 1 & 1 \end{vmatrix}$

$f(x) = \sin x(1) - \cos x(0) + (\sin x + \cos x + 1)(-1)$

$f(x) = \sin x - \sin x - \cos x - 1$

$f(x) = -\cos x - 1$

$f'(x) = \sin x$

$f''(x) - \cos x$

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

$= -1$

11. Let α, β are the roots of the equation $x^2 + \sqrt{3}x - 16 = 0$ and γ, δ are the roots of the equation $x^2 + 3x - 1 = 0$. If $Q_n = \alpha^n + \beta^n\ \forall\ n \in N$ and $P_n = \gamma^n + \delta^n\ \forall\ n \in N$ then the value of $\frac{Q_{25} + \sqrt{3}Q_{24}}{2Q_{23}} + \left(\frac{P_{25} - P_{23}}{P_{24}}\right)$ is

(1) 5 (2) 6

(3) 7 (4) 8

Answer (1)

Sol. $x^2 + 3x - 1 = 0 \begin{matrix} \nearrow \gamma \\ \searrow \delta \end{matrix}$ $\Rightarrow x^2 - 1 = -3x$

$\Rightarrow P^n = \gamma^n + \delta^n$

$P_{25} - P_{23} = (\gamma^{25} - \gamma^{23}) + (\delta^{25} - \delta^{23})$

$= \gamma^{23}(\gamma^2 - 1) + \delta^{23}(\delta^2 - 1)$

$= \gamma^{23}(-3\gamma) + \delta^{23}(-3\delta)$

$= -3[\gamma^{24} + \delta^{24}]$

$$\Rightarrow \frac{P_{25}-P_{23}}{P_{24}}=(-3)$$

Similarly

$x^2+\sqrt{3}x-16=0 \overset{\alpha}{\underset{\beta}{\rightleftarrows}} Q_n=\alpha^n+\beta^n$

$$\Rightarrow Q_{25}+\sqrt{3}Q_{24}=(\alpha^{25}+\sqrt{3}\alpha^{24})+(\beta^{25}+\sqrt{3}\beta^{24})$$

$$=\alpha^{23}(\alpha^2+\sqrt{3}\alpha)+\beta^{23}(\beta^2+\sqrt{3}\beta)$$

$= \alpha^{23}(16) + 16\beta^{23}$

$$\Rightarrow \frac{Q_{25}+\sqrt{3}Q_{24}}{2\cdot Q_{23}}=\frac{16(\alpha^{23}+\beta^{23})}{2(\alpha^{23}+\beta^{23})}=8$$

$$\Rightarrow \frac{Q_{25}+\sqrt{3}Q_{24}}{2Q_{23}}+\frac{(P_{25}-P_{23})}{P_{24}}=8+(-3)=5$$

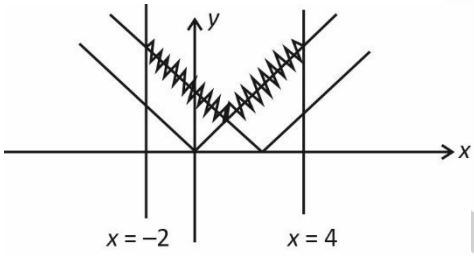
12. If $y=\max\{|x|, x, |x-2|\}$, then the area under the curve from $x = -2$ to $x = 4$ is (in sq. units)

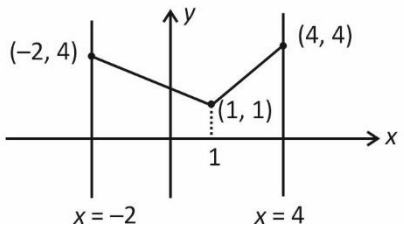
(1) 15 (2) 20

(3) 12 (4) 8

Answer (1)

Sol. $\max\{|x|, x, |x-2|\}$





Area = $\frac{1}{2}[(1+4)\times 3]+\frac{1}{2}[1+4]\times 3$

$$=\frac{15}{2}+\frac{15}{2}=15 \text{ sq. unit}$$

13. Let $\vec{a}=\hat{i}+\hat{j}+\hat{k}$ and $\vec{b}=2\hat{i}-\hat{j}+\hat{k}$. Let $\vec{c}$ is a unit vector such that $\vec{a}\times\vec{c}=\vec{b}\times\vec{c}$. If $\vec{c}=\lambda\hat{i}+\mu\hat{j}$ and $\vec{d}$ is a vector perpendicular to $\vec{c}$ and $\vec{a}$, then $|\lambda\vec{c}+\mu\vec{d}|^2$ is equal to

(1) $\frac{6}{25}$

(2) $\frac{61}{25}$

(3) $\frac{41}{25}$

(4) $\frac{36}{25}$

Answer (2)

Sol. $\vec{a}\times\vec{c}=\vec{b}\times\vec{c}$

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

$$\Rightarrow \vec{c}\,||\,(\vec{a}-\vec{b})=(-\hat{i}+2\hat{j})$$

$$\Rightarrow \vec{c}=\frac{-i}{\sqrt{5}}+\frac{2j}{\sqrt{5}}=\lambda\hat{i}+\mu\hat{j}$$

$$\Rightarrow \lambda=\frac{-1}{\sqrt{5}}, \mu=\frac{2}{\sqrt{5}}$$

$\vec{c}\cdot\vec{d}=0$

$$|\lambda\vec{c}+\mu\vec{d}|^2=\lambda^2|\vec{c}|^2+2\lambda\mu(0)+\mu^2|\vec{d}|^2$$

$$\vec{d}=\begin{vmatrix} i & j & k \\ 1 & 1 & 1 \\ \frac{-1}{\sqrt{5}} & \frac{2}{\sqrt{5}} & 0 \end{vmatrix}=\hat{i}\left(\frac{-2}{\sqrt{5}}\right)+\left(\frac{-1}{\sqrt{5}}\right)\hat{j}+\left(\frac{3}{\sqrt{5}}\right)\hat{k}$$

$$|\vec{d}|=\sqrt{\frac{4}{5}+\frac{1}{5}+\frac{9}{5}}=\sqrt{\frac{14}{5}}$$

$$\left(\frac{1}{5}\right)\times(1)+0+\left(\frac{4}{5}\right)\cdot\left(\frac{14}{5}\right)=\frac{5}{25}+\frac{56}{25}=\left(\frac{61}{25}\right)$$

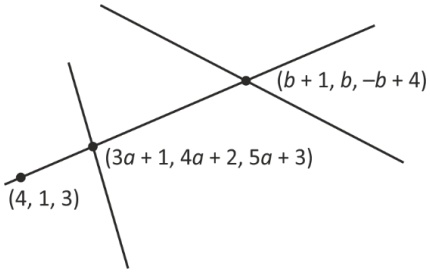
14. Let a line passing through (4, 1, 3) intersects the line $l_1 : \frac{x-1}{3} = \frac{y-2}{4} = \frac{z-3}{5}$ at (α, β, γ) and $l_2 : x - 1 = y = -z + 4$ at (a, b, c) then $\begin{vmatrix} 63 & 21 & -21 \\ \alpha & \beta & \gamma \\ a & b & c \end{vmatrix}$ is equal to

(1) 102 (2) 204

(3) 63 (4) 21

Answer (2)

Sol.



$$\frac{3a+1-4}{b+1-4} = \frac{4a+2-1}{b-1} = \frac{5a+3-3}{-b+4-3}$$

$$\frac{3a-3}{b-3} = \frac{4a+1}{b-1} = \frac{-5a}{b-1}$$

$$\Rightarrow \quad 4a+1 = -5a \Rightarrow a = \frac{-1}{9}$$

$$\Rightarrow \quad \frac{3\left(\frac{-1}{9}-1\right)}{b-3} = \frac{4\left(-\frac{1}{9}\right)+1}{b-1} = \frac{\frac{-10}{3}}{b-3} = \frac{\frac{5}{9}}{b-1}$$

$$\Rightarrow \quad b = \frac{9}{7}$$

$$\Rightarrow \quad l_1(\alpha, \beta, \gamma) = \left(\frac{2}{3}, \frac{14}{7}, \frac{22}{9}\right) \equiv \left(\frac{6}{9}, \frac{14}{9}, \frac{22}{9}\right)$$

$$l_2(a, b, c) = \left(\frac{16}{7}, \frac{9}{7}, \frac{19}{7}\right)$$

$$\Rightarrow \quad \begin{vmatrix} 63 & 21 & -21 \\ \frac{6}{9} & \frac{14}{9} & \frac{22}{9} \\ \frac{16}{7} & \frac{9}{7} & \frac{19}{7} \end{vmatrix} = 204$$

15. Let a_1, a_2, a_3....be the terms of an increasing G.P. such that $a_3 \cdot a_5 = 729$ and $a_3 + a_5 = \frac{111}{4}$, then $24(a_1 + a_2 + a_3)$ is equal to

(1) 139 (2) 129

(3) 125 (4) 119

Answer (2)

Sol. Let $a_3 + a_5 = \frac{111}{4}$

and $a_3 \cdot a_5 = 729$

$\Rightarrow (ar^2) \cdot (ar^4) = (27)^2$

$\Rightarrow ar^3 = 27, a_i > 0$

$a_4 = 27$

$\Rightarrow a_3 = \frac{27}{r}; a_5 = 27r$

$$27r + \frac{27}{r} = \frac{111}{4} = \frac{37 \times 3}{4}$$

$$\Rightarrow r + \frac{1}{r} = \frac{37}{36} \Rightarrow r \Rightarrow \frac{1}{6}, 6 \Rightarrow r = 6$$

$$24\left(a_1 + a_2 + a_3\right) = 24\left[\frac{27}{216} + \frac{27}{36} + \frac{27}{6}\right]$$

$$= 24\left[\frac{1}{8} + \frac{3}{4} + \frac{9}{2}\right]$$

$$= 3 + 18 + 108 = 129$$

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.

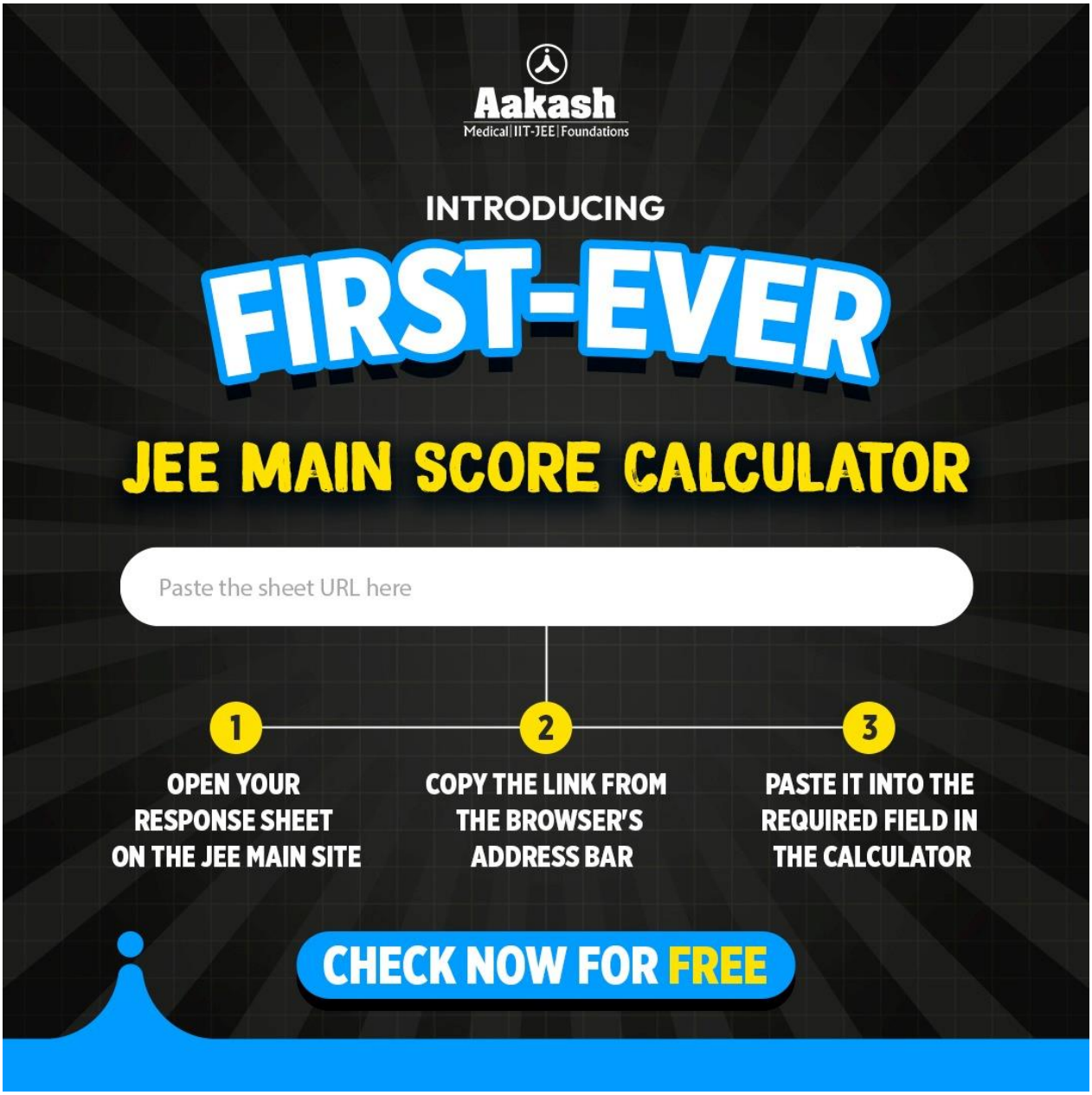
22.

23.

24.

25.

❑ ❑ ❑



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