

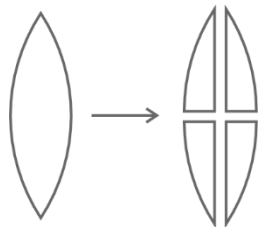
**PHYSICS**

**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 equiconvex lens of focal length  $f$ , is cut into four parts as shown in the diagram. The focal length of each part is



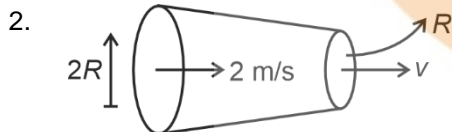
- (1)  $f$  (2)  $2f$   
(3)  $f/2$  (4)  $4f$

**Answer (2)**

**Sol.**  $f = \frac{R}{2(\mu - 1)}$  (equiconvex lens)

$f' = \frac{R}{(\mu - 1)}$  (plans convex lens)

$f = 2f'$



Radius of a tube decreases from  $2R$  to  $R$  in which ideal liquid is flowing at same level.

Speed at one end is  $2 \text{ m/s}$  as shown, find speed  $v$  at other end

- (1)  $4 \text{ m/s}$  (2)  $1 \text{ m/s}$   
(3)  $2 \text{ m/s}$  (4)  $8 \text{ m/s}$

**Answer (4)**

**Sol.**  $A_1 v_1 = A_2 v_2$

equation of continuity

$\pi(2R)^2 \cdot 2 = \pi R^2 v$

$v = 8 \text{ m/s}$

3. The dimensional formula of capacitance is

- (1)  $[M^{-1}L^2T^2A^{-3}]$  (2)  $[M^{-1}L^{-2}T^4A^3]$   
(3)  $[M^{-1}L^{-2}T^4A^2]$  (4)  $[M^{-1}L^{-2}T^2A^2]$

**Answer (3)**

**Sol.** The energy stored in capacitor in term of charge

$E = \frac{Q^2}{2C}$

$C = \frac{Q^2}{2E}$

$[C] = \frac{[A^2T^2]}{[ML^2T^{-2}]}$   
 $= [M^{-1}L^{-2}T^4A^2]$

4. A proton is moving with uniform velocity of  $2 \times 10^8 \text{ m/s}$  in uniform magnetic and electric fields which are perpendicular to each other. If electric field is switched off then proton moves in circular path of radius  $1.6 \times 10^{-5} \text{ m}$ . Then magnetic field is  $B$

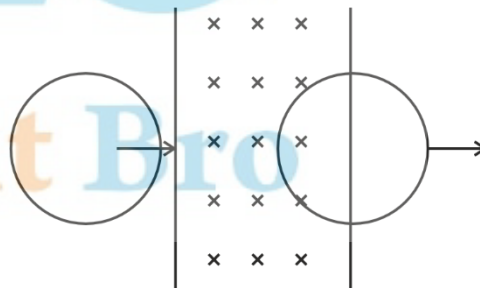
- (1)  $5 \times 10^{-5} \text{ T}$  (2)  $1.2 \times 10^5 \text{ T}$   
(3)  $2.5 \times 10^4 \text{ T}$  (4)  $2.5 \times 10^2 \text{ T}$

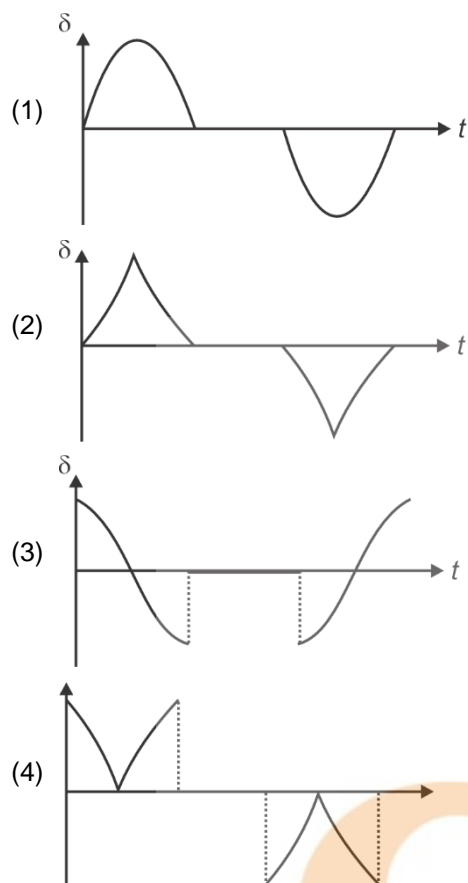
**Answer (2)**

**Sol.**  $r = \frac{mv}{qB} \Rightarrow 1.6 \times 10^{-5} = \frac{1.6 \times 10^{-27} \times 2 \times 10^8}{1.6 \times 10^{-19} \times B}$

$B = \frac{5}{4} \times 10^5 = 1.25 \times 10^5 \text{ T}$

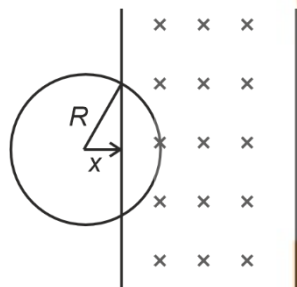
5. A conducting circular ring is moving with a constant velocity in a uniform magnetic field as shown. Identify the correct graph between induced emf vs time





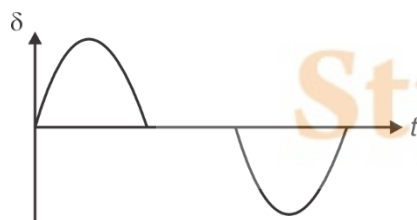
**Answer (1)**

**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 ( $\beta$ ) =  $\frac{\lambda D}{d}$

9. For non-vibrating diatomic gas has adiabatic constant of  $\gamma_1$  & for vibrating diatomic gas has adiabatic constant of  $\gamma_2$  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  $\gamma_1 > \gamma_2$

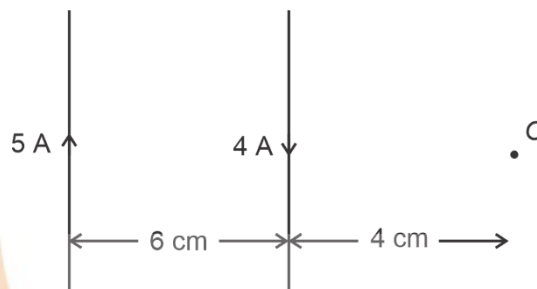
10. A force  $\vec{F} = (\hat{i} + 2\hat{j} - 3\hat{k})N$  acts on point whose position vector is given as  $\vec{r} = (2\hat{i} - 3\hat{j} + 7\hat{k})m$ . Find torque about origin.

- (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.

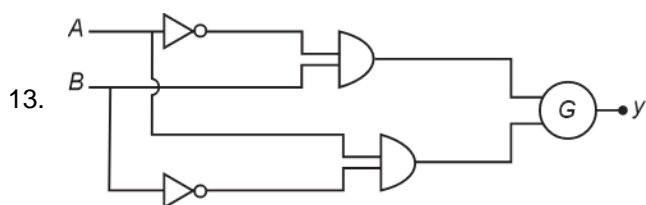
- (1) Statement I is true but statement II is false.  
(2) Statement II is true but statement I is false.  
(3) Both statements are false.  
(4) Both statements are true.

**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  $l$ .



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

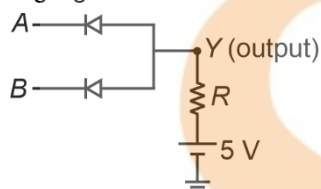
**Answer (2)**

**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.

$\therefore$  AND Gate.

15. Displacement current in capacitor of area  $16 \text{ cm}^2$  is 6 A at an instant. Find displacement current across area  $3.2 \text{ cm}^2$



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

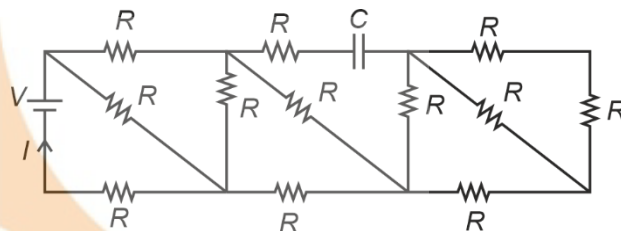
**Answer (1)**

**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)  $0.500 \mu\text{m}$  (2)  $0.250 \mu\text{m}$   
(3)  $0.125 \mu\text{m}$  (4)  $1.00 \mu\text{m}$

**Answer (3)**

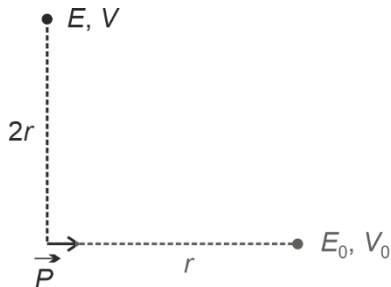
**Sol.** For maximum transmission of light incident normally

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

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



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

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

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

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

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

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:**

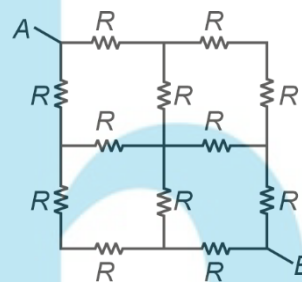
21. A projectile is fired with speed of 20 m/s at angle of  $60^\circ$  with horizontal. The speed at highest point of trajectory is x m/s then x is

**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.

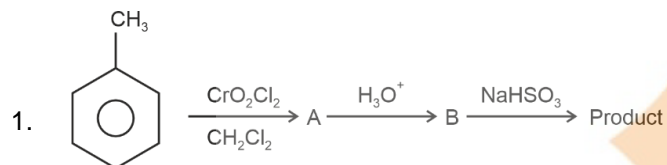
25.

# CHEMISTRY

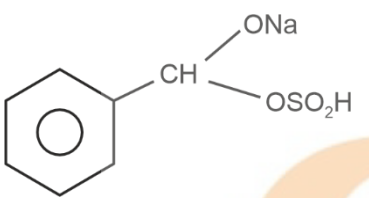
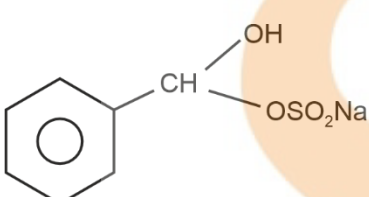
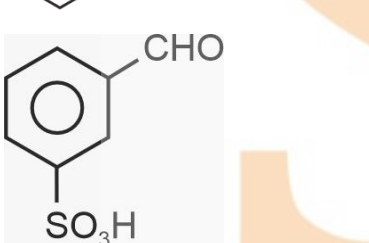
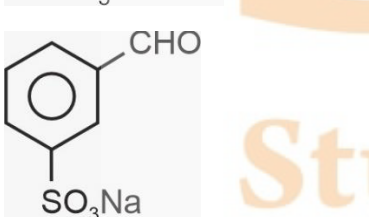
## SECTION - A

**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 :**

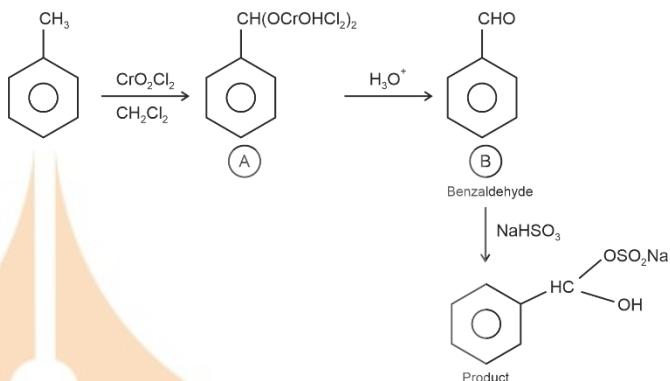


The product is

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

**Answer (2)**

**Sol.**



2. Density of 3 M NaOH is 1.25 g/ml. Molality of solution is

- (1) 2.65 (2) 2.5  
(3) 2.8 (4) 3

**Answer (1)**

**Sol.** 
$$M = \frac{1000 M}{1000 d - M \times M_0}$$

$$= \frac{3 \times 1000}{1250 - 3 \times 40}$$

$$= \frac{3 \times 1000}{1130} = 2.65$$

3. Arrange according to CFSE.

- (i)  $[\text{Co}(\text{NH}_3)_4]^{2+}$   
(ii)  $[\text{Co}(\text{NH}_3)_6]^{3+}$   
(iii)  $[\text{Co}(\text{NH}_3)_6]^{2+}$   
(iv)  $[\text{Co}(\text{en})_3]^{3+}$
- (1) (iv) > (ii) > (iii) > (i)  
(2) (iv) > (iii) > (ii) > (i)  
(3) (i) > (iii) > (ii) > (iv)  
(4) (i) > (ii) > (iii) > (iv)

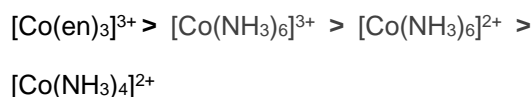
**Answer (1)**



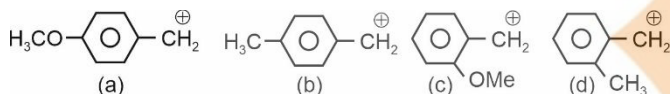


**Sol.** Crystal Field Splitting Energy (CFSE) $\propto$  Charge on central metal ion $\propto$  Ligand field strength

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  $\text{C}^+ \propto +M, \text{HC}, +I$ 

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

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

- (1)  $\text{ClO}_4^-$  (2)  $\text{ClO}_3^-$   
 (3)  $\text{ClO}_2^-$  (4)  $\text{ClO}^-$

**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.

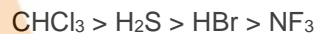
6. Compare dipole moment of

- (I)  $\text{NF}_3$  (II)  $\text{CHCl}_3$   
 (III)  $\text{H}_2\text{S}$  (IV)  $\text{HBr}$   
 (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.	$\text{NH}_3$	$\text{CHCl}_3$	$\text{H}_2\text{S}$	$\text{HBr}$
$\Rightarrow$	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.

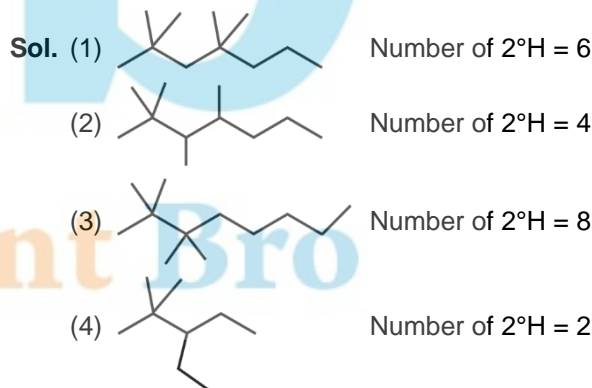
S-II: Lassaigne extract is made with magnesium metal.

- (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

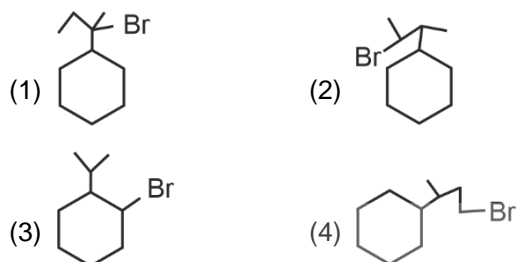
**Answer (3)****Sol.** Lassaigne extract is made with sodium metal, and not with magnesium metal.

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

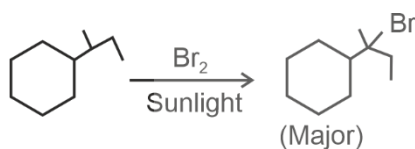
**Answer (4)**

9. Secondary butyl cyclohexane when reacts with  $\text{Br}_2$  in presence of sunlight produce



**Answer (1)**

**Sol.**



10. 200 mL of 0.2 M solution of NaOH is mixed with 400 mL of 0.5 M NaOH solution. Molarity of mixture is

- (1) 0.4 (2) 0.6  
 (3) 4 M (4) 0.8 M

**Answer (1)**

**Sol.**  $M_1 = 0.2 \text{ M}$

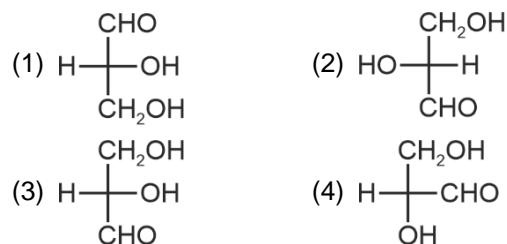
$M_2 = 0.5 \text{ M}$

$V_1 = 200 \text{ mL}$

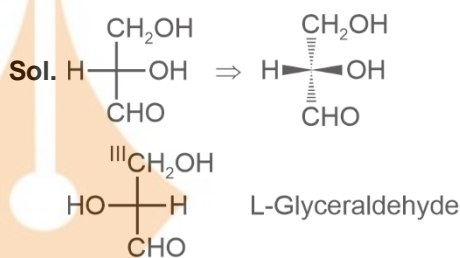
$V_2 = 400 \text{ mL}$

$$\begin{aligned} \text{Molarity of mixture} &= \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2} \\ &= \frac{0.2 \times 200 + 0.5 \times 400}{600} \text{ M} \\ &= \frac{40 + 200}{600} \\ &= \frac{240}{600} = 0.4 \text{ M} \end{aligned}$$

11. Correct structure of L-Glyceraldehyde is



**Answer (3)**



12. Identify the extensive and intensive property?

- (1) Mass, volume, conductivity – Intensive property  
 (2) Mass, temperature, heat, volume – Extensive property  
 (3) Mass, volume, internal energy – Extensive property  
 (4) Density, temperature, moles, internal energy – Intensive property

**Answer (3)**

**Sol.** The properties which do not depend upon amount of substance is known as intensive property and the properties which depend upon amount of substance are extensive properties of matter.

Mass, volume and internal energy depend on amount of substance.

13. Among Group-15 elements, what is the maximum covalency of an element having weakest E–E bond

(E = element)

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

**Answer (3)**



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

N – N 167 kJ mol<sup>-1</sup>

P – P 201 kJ mol<sup>-1</sup>

As – As 146 kJ mol<sup>-1</sup>

Sb – Sb 121 kJ mol<sup>-1</sup>

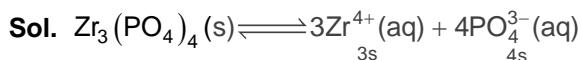
Antimony (Sb) has the weakest E – E bond and its maximum covalency is 5.

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  $\Delta H$

Heat exchanged at constant volume is  $\Delta U$

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.

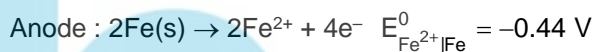
- (1) Both S-1 and S-2 are correct  
 (2) Both S-1 and S-2 are incorrect  
 (3) S-1 is correct but S-2 is incorrect  
 (4) S-1 is incorrect but S-2 is correct

**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.



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



$\therefore$  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)**

**Sol.**  ${}_{44}\text{Ru} \Rightarrow [\text{Kr}] 4d^7 5s^1$

$$x = 7$$

${}_{41}\text{Nb} \Rightarrow [\text{Kr}] 4d^4 5s^1$

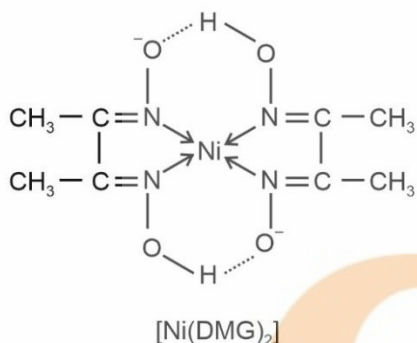
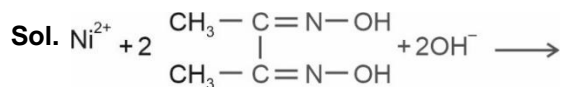
$$y = 4$$

$$x + y = 11$$

22.  $\text{Ni}^{2+} + 2\text{DMG} \longrightarrow \text{Complex}$

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

**Answer (2)**



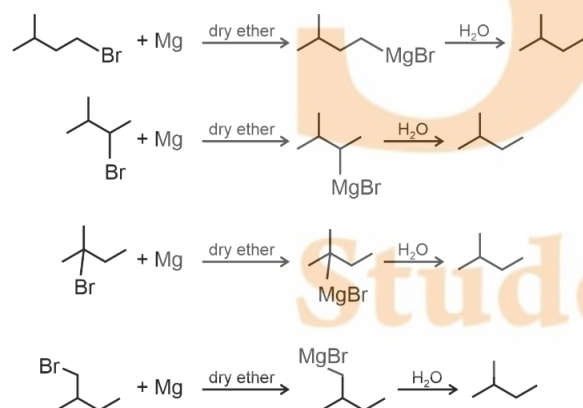
Number of H-bonds in a molecule of  $[\text{Ni}(\text{DMG})_2]$  = 2



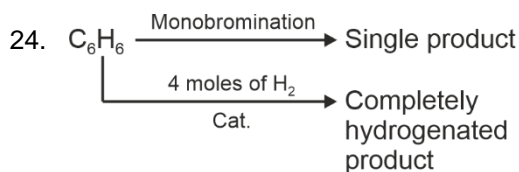
How many  $\text{R} - \text{Br}$  can form isopentane?

**Answer (4)**

**Sol.**



$\therefore$  Total 4  $\text{R} - \text{Br}$  can form isopentane in this reaction.

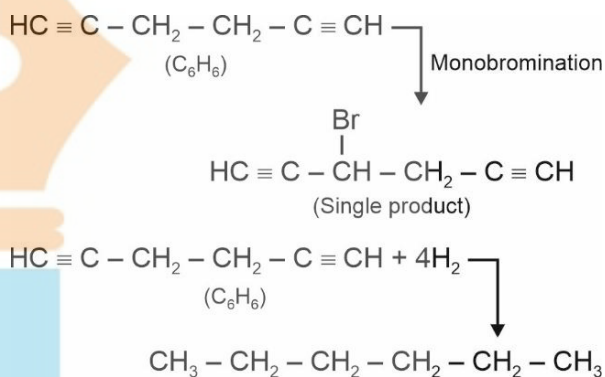


Find the number of  $\pi$ -electrons in  $\text{C}_6\text{H}_6$ .

**Answer (8)**

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

$\text{C}_6\text{H}_6$  is a symmetrical dialkyne.



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

25. Calculate the radius of first excited state of  $\text{He}^+$  ion (in Å)

**Answer (1)**

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

$$n = 2$$

$$z = 2$$

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

$$= 2a_0$$

$$= 2 \times 0.529$$

$$= 1.058$$

$$\approx 1$$

# 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  $\alpha$  and  $\beta$ . 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,  $\cos\theta = 1$

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

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

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

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  $\theta$  is

- (1)  $\frac{3\pi}{2}$  (2)  $\pi$   
(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,

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

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

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

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

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

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)**

**Sol.**  $n(A) = 4$

$n(B) = 4$

Number of many one functions =

Total functions – Number of one-one function  
 $= 4^4 - 4! = 232$

4. 4 boys and 3 girls are to be seated in a row such that all girls seat together and two particular boys  $B_1$  and  $B_2$  are not adjacent to each other. Then the number of ways in which this arrangement can be done.

- (1) 432 (2) 430  
 (3) 516 (4) 1002

**Answer (1)**

**Sol.** 4 boys and 3 girls.

All girls together  $\Rightarrow \boxed{G_1 G_2 G_3}$

3 girls and 2 boys can be seated in  $3! \cdot 3!$  ways

Now  $B_1$  and  $B_2$  go into spaces.

$\Rightarrow {}^4C_2 \times 2! \times 3! \times 3! = 432$

5. If the sum  $\sum_{r=0}^{30} \frac{r^2 \binom{30}{r}}{\binom{30}{r-1}} = \alpha \cdot 2^{29}$ , then  $\alpha$  is equal to
- (1) 225 (2) 465  
 (3) 345 (4) 425

**Answer (2)**

**Sol.**  $\frac{r^2 \cdot 30!}{(30-r)!r!} \cdot \frac{30!}{(30-r)!r!} \times \frac{(r-1)!(31-r)!}{30!}$   
 $= \frac{30!(31-r)}{(r-1)!(30-r)!}$   
 $= \frac{30(31-r)29!}{(r-1)!(30-r)!}$   
 $\Rightarrow \sum_{r=0}^{30} \frac{r^2 \binom{30}{r}}{\binom{30}{r-1}} = 30 \sum_{r=0}^{30} (31-r) 2^9 C_{r-1} = 30 \sum_{r=0}^{30} (31-r) 2^9 C_{30-r}$

$= 30 \sum_{r=0}^{30} [(30-r)+1]^{29} C_{30-r}$   
 $= 30 \sum_{r=0}^{30} \frac{29}{(30-r)} (30-r) \cdot 2^8 C_{29-r} + 30 \sum_{r=0}^{30} 2^9 C_{30-r}$   
 $= 30 \cdot 29 \cdot 2^{28} + 30 \cdot 2^{29}$   
 $= 30 \cdot 2^{28} (29 + 2) = (31 \times 15) \cdot 2^{29}$

6. Consider a function  $f(x) = \int_0^{x^2} \frac{t^2 - 8t + 15}{e^t} dt$ . The number of points of extrema are
- (1) 3 (2) 5  
 (3) 7 (4) 9

**Answer (2)**

**Sol.**  $\therefore f(x) = \int_0^{x^2} \frac{t^2 - 8t + 15}{e^t} dt$   
 $f'(x) = \frac{2x(x^4 - 8x^2 + 15)}{e^{x^2}}$   
 $= \frac{2x(x^2 - 5)(x^2 - 3)}{e^{x^2}}$

The extremum value of  $f(x)$  are  $x = 0, \pm\sqrt{5}, \pm\sqrt{3}$   
 $\therefore$  Number of extremum points are 5.

7. Let  $A$  and  $B$  are two events such that  $P(A \cap B) = \frac{1}{10}$  and  $P(A/B)$  and  $P(B/A)$  are the roots of the equation  $12x^2 - 7x + 1 = 0$ , then  $\frac{P(\bar{A} \cup \bar{B})}{P(\bar{A} \cap \bar{B})}$  is equal to
- (1)  $\frac{4}{9}$  (2)  $\frac{9}{4}$   
 (3)  $\frac{3}{2}$  (4)  $\frac{2}{3}$

**Answer (2)**

**Sol.**  $P(A \cap B) = \frac{1}{10}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**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.  $A(2 + 4\lambda, -1 - \lambda, 1 + 5\lambda)$

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

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

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

$$42\lambda = 19$$

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

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

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

10. In the expansion of  $\left(x + \sqrt{x^3 - 1}\right)^5 + \left(x - \sqrt{x^3 - 1}\right)^5$ , where  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$  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.**  $\left(x + \sqrt{x^3 - 1}\right)^5 + \left(x - \sqrt{x^3 - 1}\right)^5$

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

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

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

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

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

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 from A, B and C

$\Rightarrow (0, 0)$  is circumcentre



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

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

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

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

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

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

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

$$20 \sin \alpha = 5$$

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

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

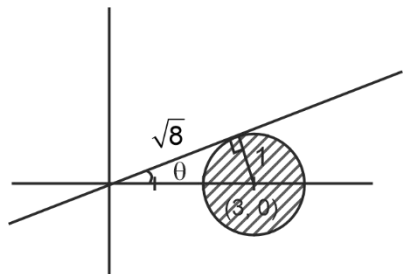
12. If  $z$  be a complex number such that  $|z - 3| \leq 1$ , then the equation of line with largest slope passing through origin and  $z$

- (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)**



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.

1.  $(2, 1)$  taken and  $(3, 2)$  not taken.
2.  $(3, 2)$  taken and  $(2, 1)$  not taken.
3. 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  $\lambda$  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  $3 \times 3$  matrix of order  $3 \times 3$ , such that  $\det(A) = \frac{1}{2}$ ,  $\text{tr}(A) = 10$  and  $B$  be another matrix of order  $3 \times 3$  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  $n = 3$

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

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

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

$$= 4(2A)$$

$$B = 8A$$

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

$$= 8^3|A|$$

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

$$B = 8A$$

[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

for  $E_1 = 2ae_1$ , for  $E_2 = 2Ae_2$

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

$$\Rightarrow ae_1 = Ae_2$$

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

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

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

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

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

$$b^2 = 33$$

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

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

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

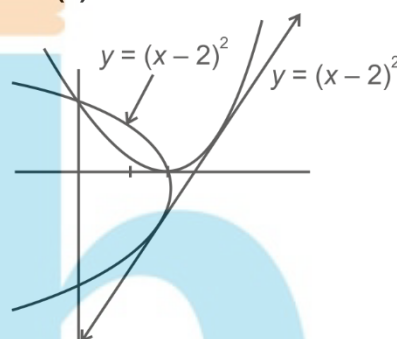
$\Rightarrow$  Sum of lengths of latus rectum

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

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)**

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

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

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 =  $(-2, 1, 3)Q$

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

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

$$= 13$$

