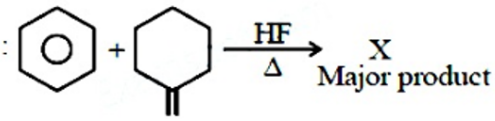
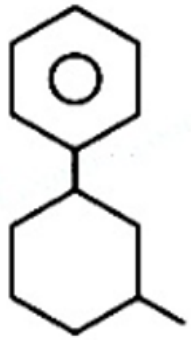
Max Marks: 300 | **SR_WEEK-1 (15-06-2026)** | **Time: 180 mins**

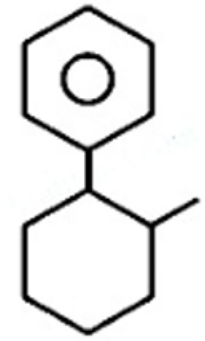
Chemistry

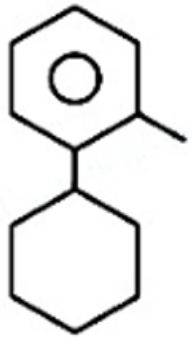
1.

'X' is : 

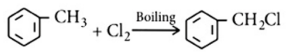
A) A) 

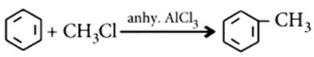
B) B) 

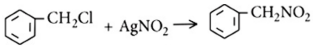
C) C) 

D) D) 

2. Which one of the following is a free-radical substitution reaction?

A) A) 

B) B) 

C) C) 

D) D) $CH_3CHO + HCN \rightarrow CH_3CH(OH)CN$

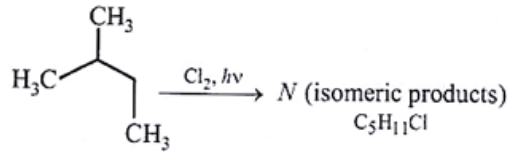
3. In Friedel-Crafts alkylation of aniline, one gets:

A) alkylated product with ortho and para substitution

B) secondary amine after acidic treatment

C) an amide product

D) positively charged nitrogen at benzene ring

4. 

Identify N **and** M**.**

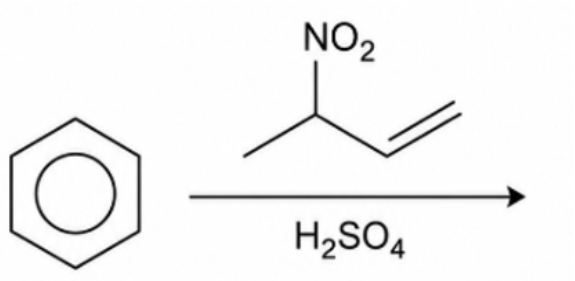
A) 6, 4

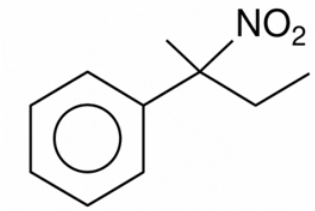
B) 6, 6

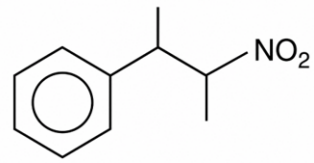
C) 4, 4

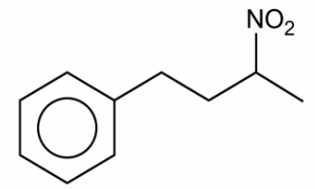
D) 3, 3

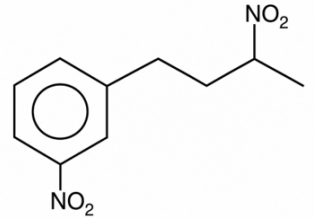
5. The major product of the following reaction is:



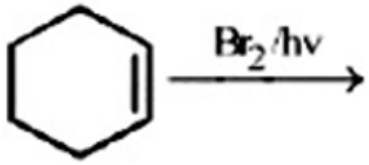
A) A) 

B) B) 

C) C) 

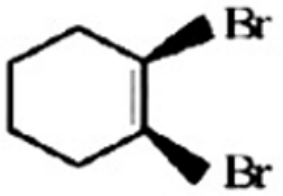
D) D) 

6. Bromination of cyclohexene under conditions of sunlight

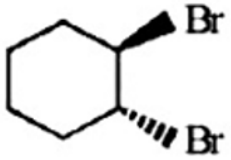


yields:

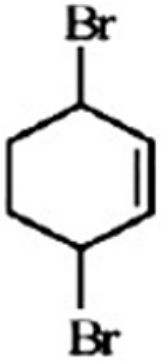
A) A)



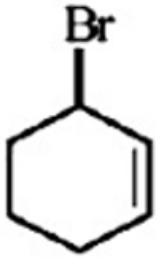
B) B)



C) C)

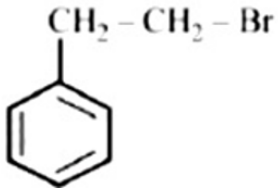


D) D)

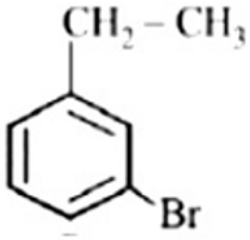


7. The product of the reaction between ethyl benzene and N-bromosuccinamide (NBS) is:

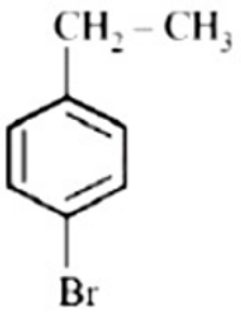
A) A)



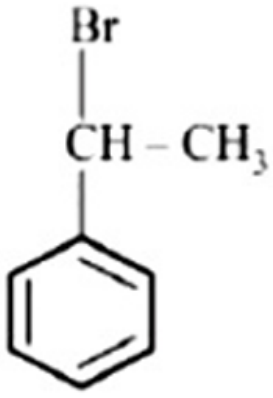
B) B)



C) C)



D) D)



8. The reaction of toluene with Cl_2 in presence of $FeCl_3$ gives predominantly:

A) m-chlorotoluene
B) benzyl chloride
C) benzoyl chloride
D) o- and p-chlorotoluene

9. The major product obtained in the photo catalysed bromination of 2 methylbutane is:

A) 1-bromo-2-methylbutane
B) 1-bromo-3-methylbutane
C) 2-bromo-3-methylbutane
D) 2-bromo-2-methylbutane

10. Of the five isomeric hexanes, the isomer which can give two monochlorinated compounds is:

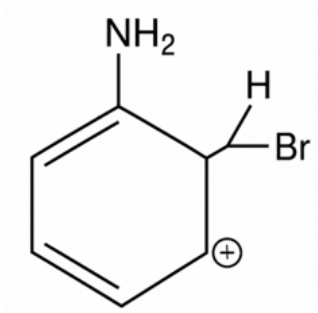
A) 2-methylpentane
B) 2,2-dimethylbutane
C) 2,3-dimethylbutane
D) n-hexane

11. On mixing a certain alkane with chlorine and irradiating it with ultraviolet light, it forms only one monochloroalkane. This alkane could be

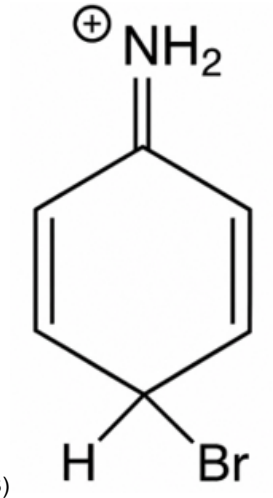
A) pentane
B) isopentane
C) neopentane
D) propane

12. The arenium ion which is not involved in the bromination of Aniline is

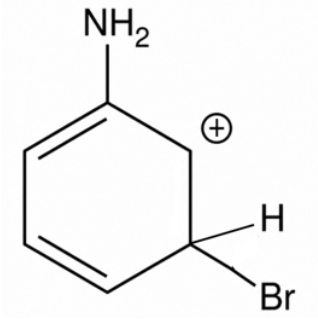
A) A)



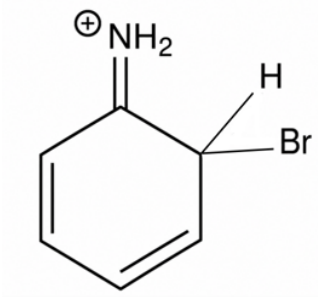
B) B)



C) C)



D) D)

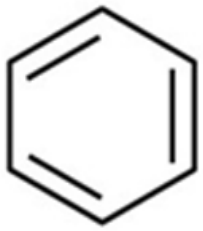


13. Given below are two statements: Statement (I) : The NH_2 group in Aniline is ortho and para directing and a powerful activating group. Statement (II) : Aniline does not undergo FriedelCraft's reaction (alkylation and acylation). In the light of the above statements, choose the most appropriate answer from the options given below :

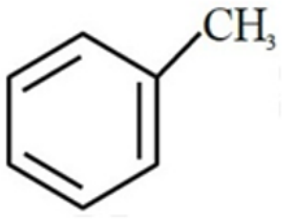
A) Both Statement I and Statement II are correct
B) Both Statement I and Statement II are incorrect
C) Statement I is incorrect but Statement II is correct
D) Statement I is correct but Statement II is incorrect

14. Which of the following compound will most easily be attacked by an electrophile?

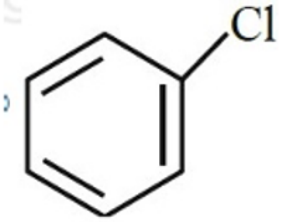
A) A)



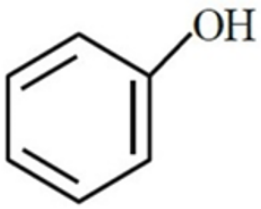
B) B)



C) C)



D) D)



15. Benzene on nitration gives nitrobenzene in presence of HNO_3 and $H_2\,SO_4$ mixture, where

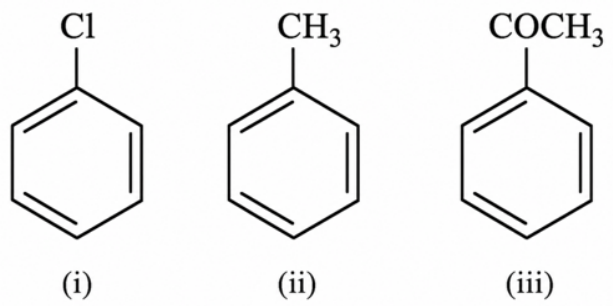
A) both $H_2\,SO_4$ and HNO_3 act as a bases

B) HNO_3 acts as an acid and $H_2\,SO_4$ acts as a base

C) both HNO_3 and HNO_3act as an acids

D) HNO_3 acts as a base and $H_2\,SO_4$ acts as an acid

16. The increasing order of the reactivity of the following compounds towards electrophilic aromatic substitution reactions is :



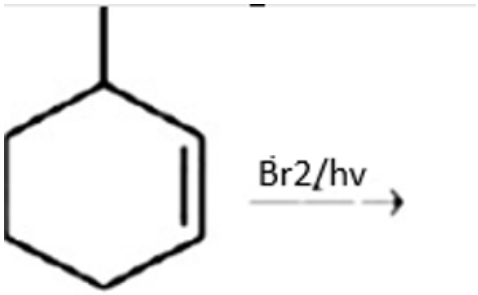
A) II < I < III

B) III < II < I

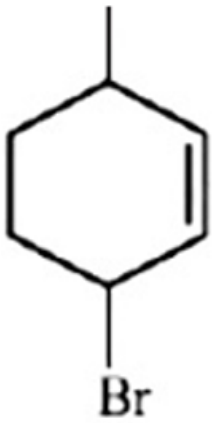
C) III < I < II

D) I < III < II

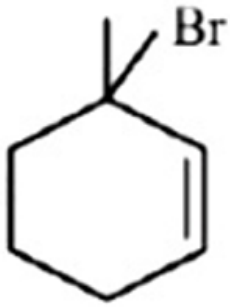
17. The major product of the following reaction is: (1-methylcyclohexene reacting with Br_2 in the presence of sunlight ($h\nu$))



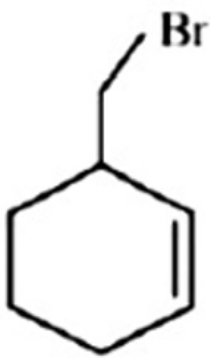
A) A)



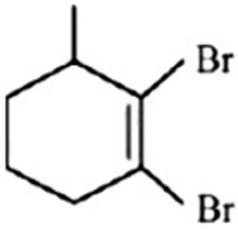
B) B)



C) C)

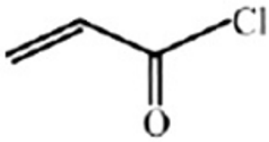


D) D)



18. Which of the following compounds will not undergo Friedel Craft's reaction with benzene?

A) A)

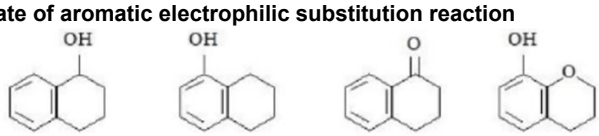


B) B)

C) C)

D) D)

19. Arrange the following compounds in increasing order of rate of aromatic electrophilic substitution reaction



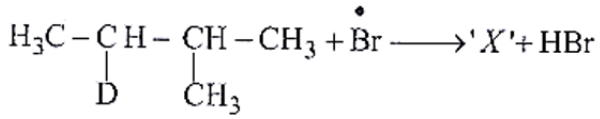
A) c, a, b, d

B) d, b, c, a

C) d, b, a, c

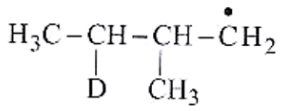
D) b, c, a, d

20. Consider the following reaction:

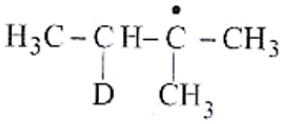


Identify the structure of the major product 'X'.

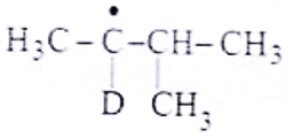
A) A)



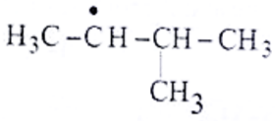
B) B)



C) C)



D) D)



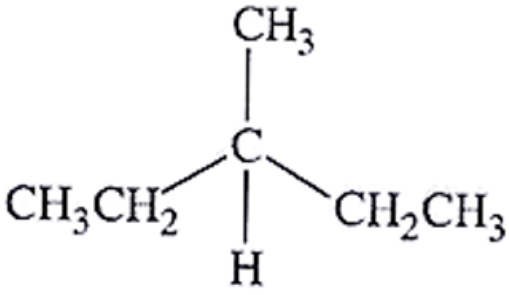
21. Among the following, the total number of meta-directing functional groups is:
$-OCH_3, -NO_2, -CN, -CH_3, -NHCOCH_3, -COR, -OH, -COOH, -Cl$

22. Number of isomeric products formed by monochlorination of 2-methylbutane in presence of sunlight is:

23. Number of bromo derivatives obtained on treating ethane with excess of Br_2, in diffused sunlight is:

24. Total number of isomers (including stereoisomers) obtained on monochlorination of methylcyclohexane is:

25. The maximum number of isomers (including stereoisomers) that are possible on monochlorination of the following compound is:



Maths

26. The number of terms in the expansion of $(a_1 + a_2 + a_3 + a_4)^3$ is

A) 64 **B)** 81
C) 30 **D)** 20

27. The 5^{th} term from the end in the expansion of $\left(\frac{x^3}{2} - \frac{2}{x^3}\right)^9$ is

A) $63x^3$ **B)** $-\frac{252}{x^3}$
C) $\frac{672}{x^{18}}$ **D)** None of these

28. The coefficient of x^4 in the expansion of $\left(\frac{x}{2} - \frac{3}{x^2}\right)^{10}$ is -

A) $\frac{405}{256}$ **B)** $\frac{504}{259}$
C) $\frac{450}{263}$ **D)** None of these

29. The coefficient of x^{11} in the expansion of $(2x^2 + x - 3)^6$ is

A) 192 **B)** 60
C) 180 **D)** 50

30. The term independent of x in the expansion of $\left(\frac{x+1}{x^{2/3}-x^{1/3}+1} - \frac{x-1}{x-x^{1/2}}\right)^{10}$

A) 210 **B)** 105
C) 70 **D)** 112

31. The coefficient of x^5 in the expansion of $(1+x)^{21} + (1+x)^{22} + \ldots + (1+x)^{30}$ is

A) ${}^{51}C_5$ **B)** ${}^{9}C_5$
C) ${}^{31}C_6 - {}^{21}C_6$ **D)** ${}^{30}C_5 + {}^{20}C_5$

32. The coefficient of x^{-26} in the expansion of $\left(x^2 - \frac{2}{x^4}\right)^{11}$ is

A) 330×2^6 **B)** -330×2^6
C) 330×2^7 **D)** -330×2^7

33. The term independent of x in $\left(2x + \frac{1}{3x}\right)^6$ is -

A) $\frac{160}{9}$ **B)** $\frac{80}{9}$
C) $\frac{160}{27}$ **D)** $\frac{80}{3}$

34. The term independent of x in the expansion of $\left(\sqrt{\frac{x}{3}} + \sqrt{\frac{3}{2x^2}}\right)^{10}$ is-

A) ${}^{10}C_1$ **B)** $\frac{5}{12}$
C) 1 **D)** None of these

35. The coefficient of x^3 in $\left(2x - \frac{3}{x^2}\right)^9$ is

A) 41472 **B)** $2^8 \cdot 3^5$
C) $2^8 \cdot 3^4$ **D)** 44172

36. The number of irrational terms in the expansion of $\left(\sqrt{3} + \sqrt[4]{5}\right)^{124}$ is

A) 125 **B)** 32
C) 93 **D)** 34

37. The sum of the rational terms in the expansion of $\left(\sqrt{2} + \sqrt[5]{3}\right)^{10}$ is :

A) 41 **B)** 42
C) 39 **D)** 45

38. If the coefficients of x^2 and x^3 in the expansion of $(3 + ax)^9$ are the same, then the value of a is

A) $-\frac{7}{9}$ **B)** $-\frac{9}{7}$
C) $\frac{7}{9}$ **D)** $\frac{9}{7}$

39. Coefficient of x^{19} in the polynomial $(x-1)(x-2)\ldots(x-20)$ is equal to

A) 210 **B)** -210
C) $20!$ **D)** None of these

40. In the expansion of $(1 + x + x^2 + x^3)^6$, then coefficient of x^{14} is

A) 130 **B)** 120
C) 128 **D)** 125

41. The coefficient of x^{10} in the expansion of $(1+x^2-x^3)^8$, is

A) 476 **B)** 496
C) 506 **D)** 528

42. The number of irrational terms in the expansion of $(5^{1/6}+2^{1/8})^{100}$ is

A) 96 **B)** 97
C) 98 **D)** 99

43. The coefficient of x^4 in the expansion of $(1+x+x^2+x^3)^{11}$, is

A) 900 **B)** 909
C) 990 **D)** 999

44. In the polynomial $(x-1)(x-2)(x-3)\ldots(x-100)$. The coefficient of x^{99} is

A) 5050 **B)** -5050
C) 100 **D)** 99

45. The term independent of x in the expansion of $(1-x)^2\left(x+\frac{1}{x}\right)^{10}$, is

A) ${}^{11}C_5$ **B)** ${}^{10}C_5$
C) ${}^{10}C_4$ **D)** None of these

46. If in the expansion of $(x^3-\frac{1}{x^2})^n,;n\in N$, sum of the coefficients of x^5 and x^{10} is zero, then $n=$

47. If in the expansion of $(3x-\frac{2}{x^2})^{15}$, the r^{th} term is independent of x, then the value of r is

48. If the coefficient of x in $\left(x^2+\frac{k}{x}\right)^5$ is 270, then the value of k is

49. In the expansion of $\left(2+\frac{x}{3}\right)^n$, the coefficients of x^7 and x^8 are equal. Then the value of n is

50. If in the expansion of $(1+x)^{21}$, the coefficients of x^r and x^{r+1} are equal, then r is equal to

Physics

51. Four point charges are placed at the corners of a square of side length a as shown: $+q$ at $(0,a)$, $+q$ at (a,a), $-q$ at $(a,0)$, and $-q$ at $(0,0)$. The net electric potential V and the magnitude of the electric field E at the center of the square are:

A) $V=0, E=0$ **B)** $V=0, E\neq 0$
C) $V\neq 0, E=0$ **D)** $V\neq 0, E\neq 0$

52. The electrostatic potential V in a 1D region along the x-axis varies as $V=\beta x^4+c$, where β and c are constants. If the total charge enclosed within a region between $x=0$ and $x=L$ (with a cross-sectional area A perpendicular to the x-axis) is given by $Q=-\delta\cdot A\epsilon_0\beta L^3$, find the value of δ.

A) 6 **B)** 4
C) 8 **D)** 12

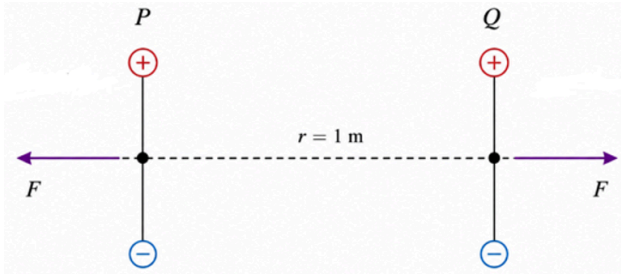
53. Three concentric conducting spherical shells A, B, and C have radii a, $2a$, and $3a$ respectively. They are charged with charges q, $2q$, and $3q$ respectively. The ratio of the potential at the surface of the innermost shell (V_A) to the potential at the surface of the outermost shell (V_C) is:

A) $1:1$ **B)** $6:1$
C) $3:2$ **D)** $11:2$

54. Three point charges $q_1=+q$, $q_2=-2q$, and $q_3=+q$ are placed at coordinates $(a,0)$, $(0,0)$, and $(-a,0)$ respectively in the xy-plane. The resultant electric dipole moment $\vec{P}$ of the system with respect to the origin is:

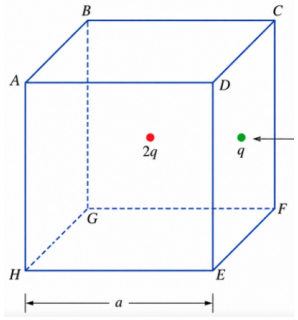
A) 0 **B)** $2qa\hat{i}$
C) $-2qa\hat{i}$ **D)** $4qa\hat{i}$

55. Two short electric dipoles P and Q are placed along the same axis with their centers separated by a distance $r=1\text{ m}$. Dipole P has a dipole moment $p_1=4\times10^{-9}\text{ C}\cdot\text{m}$ and dipole Q has a dipole moment $p_2=2\times10^{-9}\text{ C}\cdot\text{m}$. If the dipoles are oriented such that they are parallel to each other and perpendicular to the line joining their centers, the magnitude of the force F between them is given by $F=\frac{k}{4\pi\epsilon_0 r^4}$, where k is a constant. Find the value of k.



A) 12×10^{-18} **B)** 18×10^{-18}
C) 24×10^{-18} **D)** 36×10^{-18}

56. A charge q is placed at the center of one of the faces of a cube of side length a. Additionally, a point charge $2q$ is placed at the center of the same cube. What is the total electric flux passing through the entire cube?



A) $\frac{q}{\epsilon_0}$ **B)** $\frac{2q}{\epsilon_0}$
C) $\frac{2.5q}{\epsilon_0}$ **D)** $\frac{3q}{\epsilon_0}$

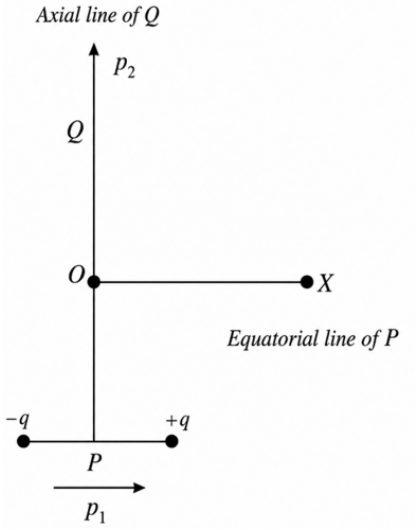
57. Two identical small spheres of mass m and charge q are released from rest at a distance d apart on a frictionless horizontal surface. If the spheres are allowed to move freely under their mutual electrostatic repulsion, find the maximum speed v attained by each sphere. (Assume $k=\frac{1}{4\pi\epsilon_0}$)

A) $v=\sqrt{\frac{kq^2}{md}}$ **B)** $v=\sqrt{\frac{kq^2}{2md}}$
C) $v=\sqrt{\frac{2kq^2}{md}}$ **D)** $v=\sqrt{\frac{kq^2}{4md}}$

58. Two conducting spheres of radii $R_1 = 5\ \text{cm}$ and $R_2 = 10\ \text{cm}$ are given the same amount of charge Q. They are then brought into contact and separated. If the final surface charge densities on the spheres are σ_1 and σ_2 respectively, the ratio σ_1/σ_2 is:

A) $1:2$ **B)** $2:1$
C) $4:1$ **D)** $1:4$

59. Two short electric dipoles P and Q are placed with their axes mutually perpendicular, as shown in the figure. The dipole moments are p_1 and p_2 respectively. Point x lies on the equatorial line of dipole P and on the axial line of dipole Q. If the resultant electric field at point x makes an angle of 45° with the line joining the centers of the dipoles (the equatorial line of P), find the ratio p_1/p_2.



A) $1:2$ **B)** $2:1$
C) $1:1$ **D)** $1:4$

60. An irregularly shaped metallic conductor is given a positive charge Q. Let σ_A and σ_B be the surface charge densities at two points A and B on the surface of the conductor. If the radius of curvature at point A is $R_A = 2\ \text{cm}$ and at point B is $R_B = 8\ \text{cm}$, which of the following relations is correct?

A) $\sigma_A = \sigma_B$ **B)** $\sigma_A = 4\sigma_B$
C) $\sigma_B = 4\sigma_A$ **D)** $\sigma_A = 16\sigma_B$

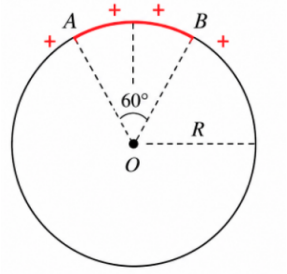
61. An infinitely long wire with uniform linear charge density $\lambda = 1\ \text{nC/m}$ passes through the center of a Gaussian cylinder of radius $r = 2\ \text{cm}$ and length $L = 10\ \text{cm}$. What is the net electric flux Φ passing through the entire surface of the cylinder? (Use $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ \text{Nm}^2\text{C}^{-2}$)

A) $1.8\pi\ \text{Nm}^2\text{C}^{-1}$ **B)** $3.6\pi\ \text{Nm}^2\text{C}^{-1}$
C) $0.9\pi\ \text{Nm}^2\text{C}^{-1}$ **D)** $7.2\pi\ \text{Nm}^2\text{C}^{-1}$

62. An electric dipole consisting of two charges $\pm 4, \mu\text{C}$ separated by a distance of $0.2, \mu\text{m}$ is placed in a uniform electric field of $5 \times 10^3, \text{V/m}$. If the dipole is initially oriented at 60° to the direction of the field, what is the magnitude of the torque acting on the dipole?

A) $2 \times 10^{-9}, \text{Nm}$ **B)** $4 \times 10^{-9}, \text{Nm}$
C) $3.46 \times 10^{-9}, \text{Nm}$ **D)** $1.73 \times 10^{-9}, \text{Nm}$

63. A thin non-conducting ring of radius R is uniformly charged with a linear charge density λ. A small arc of the ring subtends an angle of 60° at the center O of the ring. If the magnitude of the electric field produced by this arc at the center O is E, what is the magnitude of the electric field at O due to a semi-circular arc of the same ring?

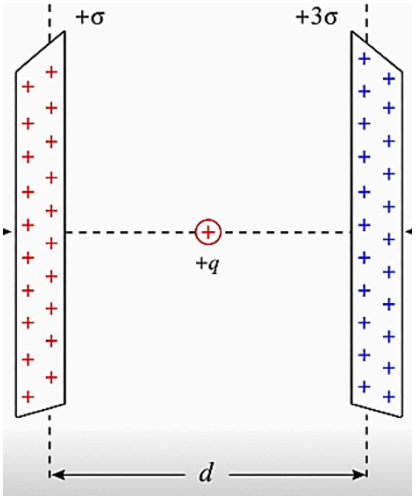


A) $\sqrt{2}E$ **B)** $\sqrt{3}E$
C) $2E$ **D)** $3E$

64. A short electric dipole of dipole moment magnitude p_0 is placed in the electric field of an infinite non-conducting sheet having uniform surface charge density σ. The dipole axis makes an angle of 60° with the electric field generated by the sheet. The magnitude of the torque experienced by the dipole is:

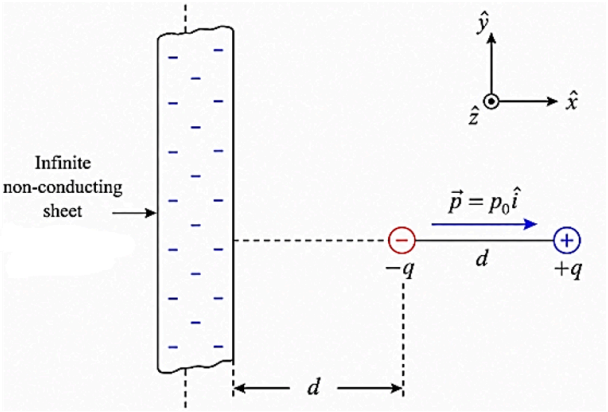
A) $\frac{p_0\sigma\sqrt{3}}{4\epsilon_0}$ **B)** $\frac{p_0\sigma\sqrt{3}}{2\epsilon_0}$
C) $\frac{p_0\sigma}{4\epsilon_0}$ **D)** $\frac{p_0\sigma}{2\epsilon_0}$

65. Two infinitely large parallel non-conducting plates are placed at a distance d apart. The plates carry uniform surface charge densities $+\sigma$ and $+3\sigma$, respectively. A point charge $+q$ is placed in the region between the two plates. The force experienced by the point charge $+q$ is:



A) $\frac{\sigma q}{\epsilon_0}$ towards the plate with charge density $+\sigma$ **B)** $\frac{\sigma q}{\epsilon_0}$ towards the plate with charge density $+3\sigma$
C) $\frac{2\sigma q}{\epsilon_0}$ towards the plate with charge density $+\sigma$ **D)** $\frac{2\sigma q}{\epsilon_0}$ towards the plate with charge density $+3\sigma$

66. An electric dipole of dipole moment $\vec{p} = p_0\hat{i}$ is placed at a distance d from an infinite non-conducting sheet carrying a uniform surface charge density $-\sigma$ (where $\sigma > 0$). The dipole moment vector points away from the sheet. Which of the following is true regarding the torque and potential energy of the dipole?



A) Torque on the dipole is zero and the potential energy is minimum.

B) Torque on the dipole is zero and the potential energy is maximum.

C) Torque on the dipole is non-zero and the potential energy is minimum.

D) Torque on the dipole is non-zero and the potential energy is maximum.

67. A small electric dipole of total mass m, charge q, and dipole length d is free to rotate about its center in a uniform electric field $\vec{E} = E_0\hat{j}$. When the dipole is slightly displaced from its equilibrium position (where the dipole moment is parallel to the field) and released, the angular frequency (ω) of its small oscillations is:

A) $\sqrt{\frac{qE_0 d}{m}}$

B) $\sqrt{\frac{4qE_0}{md}}$

C) $\sqrt{\frac{2qE_0}{md}}$

D) $\sqrt{\frac{qE_0}{md}}$

68. A short electric dipole with dipole moment $\vec{P} = p_0\hat{i}$ is placed at the origin. Let V_P and E_P be the electric potential and electric field magnitude at a point $P(r, 0, 0)$ on the axial line. If point $Q(0, r/2, 0)$ is a point on the equatorial line, what are the values of the electric potential V_Q and electric field magnitude E_Q at point Q?

A) $V_Q = 0, ; E_Q = 2E_P$

B) $V_Q = 0, ; E_Q = 4E_P$

C) $V_Q = 0, ; E_Q = 8E_P$

D) $V_Q = 4V_P, ; E_Q = 4E_P$

69. A line charge of length $l = \frac{a}{3}$ is placed along the center of an edge of a cube of edge length a. If the linear charge density of the line charge is λ, the total electric flux passing through the cube is:

A) $\frac{\lambda a}{3\epsilon_0}$

B) $\frac{\lambda a}{12\epsilon_0}$

C) $\frac{\lambda a}{9\epsilon_0}$

D) $\frac{\lambda a}{6\epsilon_0}$

70. An electric dipole of dipole moment $P = 6 \times 10^{-6}\ \mathrm{Cm}$ is placed in a uniform electric field of magnitude $E = 2 \times 10^5\ \mathrm{N/C}$. Initially, the dipole moment is aligned antiparallel to the electric field. The work done by an external agent to rotate the dipole until its dipole moment is perpendicular to the electric field is $\alpha \times 10^{-1}$ J. The value of α is:

A) A)10

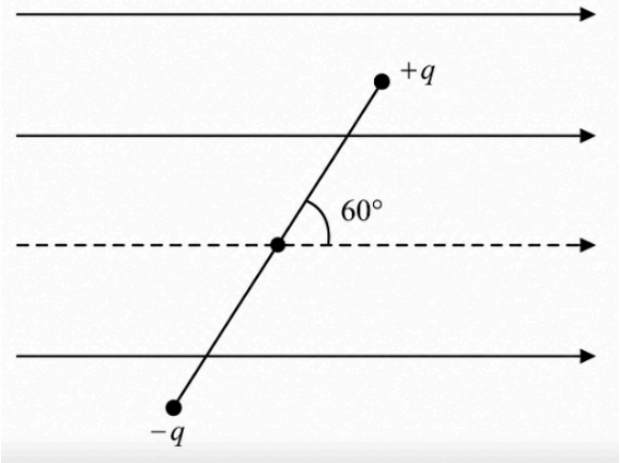
B) B)12

C) C)15

D) D)14

71. The electric field in a region is given by $\vec{E} = (4\hat{i} + 2\hat{j} + 3\hat{k}) \times 10^3\ \mathrm{N/C}$. The flux of this field through a rectangular surface of area $0.2\ \mathrm{m}^2$ parallel to the $x - z$ plane is $\Phi\ \mathrm{Nm^2C^{-1}}$. The value of Φ is:

72. An electric dipole of dipole moment $P = 5 \times 10^{-6}\ \mathrm{Cm}$ is placed in a uniform electric field of magnitude $E = 4 \times 10^5\ \mathrm{N/C}$. Initially, the dipole moment is at an angle of 60° with the electric field. The work done by an external agent to rotate the dipole until it is at an angle of 90° with the electric field is $\beta \times 10^{-1}$ J. The value of β is:



73. A square loop of sides $a = 2\ \mathrm{m}$ is held normally in front of a point charge $q = 1\ \mathrm{C}$ at a distance $a/2$. The flux of the electric field through the square loop is $\Phi = \frac{1}{n\epsilon_0}\ \mathrm{Nm^2C^{-1}}$. The value of n is:

74. An electric field $\vec{E} = (3x^2\hat{i})\ \mathrm{NC^{-1}}$ exists in a region of space. A cube of side $L = 3\ \mathrm{m}$ is placed in this space with one vertex at the origin and its edges along the $x, y,$ and z axes. The total electric flux through the cube is $\Phi\ \mathrm{Nm^2C^{-1}}$. The value of Φ is:

75. An electric dipole of dipole moment $P = 4 \times 10^{-6}\ \mathrm{Cm}$ is placed in a uniform electric field of magnitude $E = 10^5\ \mathrm{N/C}$. Initially, the dipole moment is aligned parallel to the electric field. The work done by an external agent to rotate the dipole until its dipole moment is perpendicular to the electric field is $\alpha \times 10^{-1}$ J. The value of α is:

ANSWER KEY

Chemistry

1.	**1**	8.	**4**	15.	**4**	22.	**6**
2.	**1**	9.	**4**	16.	**3**	23.	**9**
3.	**4**	10.	**3**	17.	**2**	24.	**12**
4.	**1**	11.	**3**	18.	**2**	25.	**8**
5.	**2**	12.	**2**	19.	**1**		
6.	**4**	13.	**1**	20.	**2**		
7.	**4**	14.	**4**	21.	**4**		

Maths

26.	**4**	33.	**3**	40.	**2**	47.	**6**
27.	**2**	34.	**4**	41.	**1**	48.	**3**
28.	**1**	35.	**1**	42.	**2**	49.	**55**
29.	**1**	36.	**3**	43.	**3**	50.	**10**
30.	**1**	37.	**1**	44.	**2**		
31.	**3**	38.	**4**	45.	**1**		
32.	**3**	39.	**2**	46.	**15**		

Physics

51.	**2**	58.	**2**	65.	**1**	72.	**10**
52.	**2**	59.	**2**	66.	**2**	73.	**6**
53.	**3**	60.	**2**	67.	**2**	74.	**243**
54.	**1**	61.	**2**	68.	**2**	75.	**4**
55.	**3**	62.	**3**	69.	**2**		
56.	**3**	63.	**3**	70.	**2**		
57.	**1**	64.	**1**	71.	**400**		

SOLUTIONS

Q1.

Answer: A

Explanation:
The reaction begins with the protonation of the methylene double bond by HF to form the most stable carbocation intermediate, which is the 3° 1-methylcyclohexyl cation. This cation then acts as an electrophile in an Electrophilic Aromatic Substitution (EAS) reaction with benzene.

Q2.

Answer: A

Explanation:
Free-radical substitution occurs when energy (heat or light) causes homolytic cleavage of a bond to form radicals. The reaction of toluene with chlorine while boiling involves the formation of a stable benzyl free radical intermediate.

Q3.

Answer: D

Explanation:
Aniline does not undergo Friedel-Crafts reactions effectively. The $-NH_2$ group is a strong Lewis base and reacts with the Lewis acid catalyst ($AlCl_3$) used in the reaction to form a salt/complex. This places a positive charge on the nitrogen, making it a highly deactivating group that prevents further substitution.

Q4.

Answer: A

Explanation:
This problem involves the free-radical monochlorination of 2-methylbutane (isopentane). The value N represents the total number of stereoisomers produced, including enantiomers. The value M represents the number of distinct fractions obtained through fractional distillation. Since enantiomers possess identical boiling points, they cannot be separated by fractional distillation and will come off as a single fraction together.

Q5.

Answer: B

Explanation:
In the presence of H_2SO_4, the alkene (3-nitrobut-1-ene) is protonated to form a carbocation. The 2° carbocation formed at C2 is more stable than the 1° carbocation and undergoes electrophilic aromatic substitution on benzene to form the major product.

Q6.

Answer: D

Explanation:
In the presence of sunlight ($h\nu$), bromine reacts with alkenes via a free-radical substitution mechanism rather than addition. The reaction occurs at the allylic position because the intermediate allylic radical is resonance-stabilized.

Q7.

Answer: D

Explanation:
NBS is a specific reagent used for benzylic or allylic bromination. In ethylbenzene, the benzylic position (the carbon attached directly to the ring) is the most reactive toward radical substitution because the resulting radical is resonance-stabilized by the benzene ring.

Q8.

Answer: D

Explanation:
In the presence of the Lewis acid catalyst $FeCl_3$, the reaction is an electrophilic aromatic substitution. The methyl group in toluene is an activating and ortho/para-directing group, leading to a mixture of o-chlorotoluene and p-chlorotoluene as major products.

Q9.

Answer: D

Explanation:
Bromination of alkanes follows a free-radical substitution mechanism. The stability of the intermediate free radical determines the major product, following the order:
$tertiary\ (3^{\circ}) > secondary\ (2^{\circ}) > primary\ (1^{\circ})$. Bromine is highly selective and preferentially replaces the hydrogen on the most stable carbon atom, which in 2-methylbutane is the tertiary carbon.

Q10.

Answer: C

Explanation:
The number of monochlorinated derivatives formed depends on the number of sets of equivalent hydrogen atoms in the molecule. For an isomer to yield only two products, it must have high symmetry such that it only possesses two distinct types of hydrogens. Among the hexanes, 2,3-dimethylbutane meets this criteria.

Q11.

Answer: C

Explanation:
An alkane produces only one monochlorinated derivative if all the hydrogen atoms in the molecule are chemically equivalent. In neopentane, all twelve hydrogen atoms are primary and attached to methyl groups that are symmetrically bonded to a single central carbon atom.

Q12.

Answer: B

Q13.

Answer: A

Q14.

Answer: D

Q15.

Answer: D

Q16.

Answer: C

Q17.

Answer: B

Explanation:
Reaction with bromine in the presence of light ($h\nu$) follows a free-radical substitution mechanism rather than addition. The reaction occurs at the allylic position because the intermediate radical is resonance-stabilized. The secondary allylic radical at $C_3$is the most stable intermediate, leading to the major product.

Q18.

Answer: B

Q19.

Answer: A

Q20.

Answer: B

Explanation:
Bromination of alkanes proceeds through a free-radical substitution mechanism. The bromine radical ($Br^{\bullet}$) is highly selective and preferentially abstracts a hydrogen atom that leads to the formation of the most stable radical intermediate. In 2-deutero-3-methylbutane, the tertiary (3°) carbon atom (the one bonded to the methyl group) provides the most stable radical site. Therefore, the bromine atom substitutes the tertiary hydrogen to form the major product.

Q21.

Answer: 4

Explanation:
Meta-directing groups are typically electron-withdrawing groups that deactivate the benzene ring toward electrophilic aromatic substitution. These groups usually have a pi-bond or a positive charge on the atom directly attached to the ring. In the provided list, the meta-directing groups are $-NO_2$, $-CN$, $-COR$, and $-COOH$.

Q22.

Answer: 6

Explanation:
Monochlorination of 2-methylbutane $(CH_3)_2CHCH_2CH_3$ occurs at four distinct carbon positions. Considering the chirality introduced at certain positions, the total number of stereoisomers produced is six.

Q23.

Answer: 9

Explanation:
Under excess bromine and sunlight, ethane undergoes exhaustive free-radical substitution. The total number of derivatives (including positional isomers) across all levels of substitution (mono- to hexa-) is nine.

Q24.

Answer: 12

Explanation:
Monochlorination can occur at five constitutionally distinct sites: the methyl group, C_1, C_2, C_3, and C_4. When considering the stereochemistry (chirality) of the resulting molecules, the total number of isomers is twelve.

Q25.

Answer: 8

Explanation:
To find the total number of monochlorinated isomers for 3-methylpentane, we identify all unique substitution sites and account for any chirality introduced during the reaction: C_1/C_5 substitution: Produces 1-chloro-3-methylpentane. This creates a chiral center at C_3, resulting in 2 enantiomers. C_2/C_4 substitution: Produces 2-chloro-3-methylpentane. This creates two chiral centers (C_2 and C_3), resulting in 4 stereoisomers. C_3 substitution: Produces 3-chloro-3-methylpentane. This molecule is achiral, giving 1 isomer. Methyl group substitution: Produces 1-chloro-2-ethylbutane. This molecule is also achiral, giving 1 isomer. The total is $2 + 4 + 1 + 1 = 8$.

Q26.

Answer: D

Q27.

Answer: B

Q28.

Answer: A

Q29.

Answer: A

Q30.

Answer: A

Q31.

Answer: C

Q32.

Answer: C

Q33.

Answer: C

Q34.

Answer: D

Q35.

Answer: A

Q36.

Answer: C

Q37.

Answer: A

Q38.

Answer: D

Q39.

Answer: B

Q40.

Answer: B

Q41.

Answer: A

Q42.

Answer: B

Q43.

Answer: C

Q44.

Answer: B

Q45.

Answer: A

Q46.

Answer: 15

Q47.

Answer: 6

Q48.

Answer: 3

Q49.

Answer: 55

Q50.

Answer: 10

Q51.

Answer: B

Explanation:
The center of the square is at $(\frac{a}{2}, \frac{a}{2})$. Each corner is at an equal distance $r = \frac{a}{\sqrt{2}}$ from the center.

Q52.

Answer: B

Explanation:
We use the relationship between electric potential and electric field, and then apply Gauss's Law in 1D to relate the field to the enclosed charge.

Q53.

Answer: C

Explanation:
The potential at any point is the superposition of potentials due to each individual shell. For a shell of radius R and charge Q, the potential is $V = \frac{kQ}{R}$ at its surface and inside, and $V = \frac{kQ}{r}$ outside.

Q54.

Answer: A

Explanation:
The electric dipole moment $\vec{P}$ for a system of point charges is the vector sum $\vec{P} = \sum q_i \vec{r}_i$, where q_i is the charge and $\vec{r}_i$ is the position vector of the charge relative to the origin.

Q55.

Answer: C

Explanation:

For two dipoles of moments p_1 and p_2 oriented parallel to each other and perpendicular to the line joining their centers (equatorial configuration), the force F is given by the formula $F = \frac{3}{4\pi\epsilon_0} \frac{p_1 p_2}{r^4}$.

Q56.

Answer: C

Explanation:

According to Gauss's Law, the total electric flux Φ through a closed surface is $\frac{Q_{enclosed}}{\epsilon_0}$. We must account for the fraction of each charge that is actually enclosed within the volume of the cube.

Q57.

Answer: A

Explanation:
The electrostatic force is conservative, so the initial electrostatic potential energy is completely converted into the kinetic energy of the two spheres as they move infinitely far apart. Since the spheres are identical, they attain equal speeds.

Q58.

Answer: B

Q59.

Answer: B

Explanation:

The electric field at point x due to dipole P (equatorial position) is $E_P = \frac{1}{4\pi\epsilon_0} \frac{p_1}{r^3}$ (directed anti-parallel to p_1). The electric field at point x due to dipole Q (axial position) is $E_Q = \frac{1}{4\pi\epsilon_0} \frac{2p_2}{r^3}$ (directed parallel to p_2). Since the resultant field makes a 45° angle with the equatorial line of P, the components E_P and E_Q must be equal in magnitude.

Q60.

Answer: B

Explanation:
For a charged conductor in electrostatic equilibrium, the surface charge density σ is inversely proportional to the local radius of curvature R of the surface at that point ($\sigma \propto \frac{1}{R}$).

Q61.

Answer: B

Explanation:
According to Gauss's Law, the net electric flux Φ through any closed surface is equal to the enclosed charge divided by the permittivity of free space ϵ_0. For a line charge passing along the axis of a cylinder, the enclosed charge is the charge contained in the length of wire inside the cylinder.

Q62.

Answer: C

Explanation:
The torque on an electric dipole in a uniform electric field is given by $\tau = pE\sin\theta$, where p is the dipole moment, E is the electric field strength, and θ is the angle between the dipole moment and the electric field. The dipole moment is given by $p = qd$, where d is the separation between the charges.

Q63.

Answer: C

Explanation:

The magnitude of the electric field at the center due to a uniformly charged arc subtending an angle α is given by $E_{\text{arc}} = \frac{2k\lambda}{R}\sin\left(\frac{\alpha}{2}\right)$ Using this formula for both the 60° arc and the semicircular arc gives the required ratio.

Q64.

Answer: A

Q65.

Answer: A

Q66.

Answer: B

Q67.

Answer: B

Q68.

Answer: B

Q69.

Answer: B

Q70.

Answer: B

Q71.

Answer: 400

Q72.

Answer: 10

Q73.

Answer: 6

Q74.

Answer: 243

Q75.

Answer: 4