



JEE MAIN-2019

ONLINE 10-01-2019 (MORNING)

IMPORTANT INSTRUCTIONS

1. The question paper has three parts: **Mathematics, Chemistry and Physics** Each part has three sections.
2. Section 1 contains 8 questions. The answer to each question is a single digit integer ranging from 0 to 9 (both inclusive).
Marking Scheme: +4 for correct answer and 0 in all other cases.
3. Section 2 contains 10 multiple choice questions with one or more than one correct option.
Marking Scheme: +4 for correct answer, 0 if not attempted and –2 in all other cases.
4. Section 3 contains 2 “match the following” type questions and you will have to match entries in Column I with the entries in Column II.
Marking Scheme: for each entry in Column I, +2 for correct answer, 0 if not attempted and – 1 in all other cases.

PART-A-MATHEMATICS

1. In a class of 140 students numbered 1 to 140, all even numbered students opted Mathematics course, those whose number is divisible by 3 opted Physics course and those whose number is divisible by 5 opted Chemistry course. Then the number of students who did not opt for any of the three courses is
- (1) 102 (2) 42 (3) 1 (4) 38

Sol.

2. If the parabolas $y^2 = 4b(x - c)$ and $y^2 = 8ax$ have a common normal, then which one of the following is a valid choices for the ordered triad (a, b, c)?

- (1) (1, 1, 3) (2) $\left(\frac{1}{2}, 2, 0\right)$ (3) $\left(\frac{1}{2}, 2, 3\right)$ (4) (1, 1, 0)

Sol. $y = mx - 4am - 2am^2$

$$y = m(x - c) - 2bm - bm^3$$

$$-4am - 2am^2 = c + ab + bm^2$$

$$(1) 4 + 2m^2 = 3 + 2 + m^2$$

$$m^2 = 1 \text{ possible}$$

$$(2) 2 + m^2 = 0 + 4 + 2m^2 \rightarrow \text{not possible}$$

$$(3) 2 + m^2 = 3 + 4 + 2m^2 \rightarrow \text{not possible}$$

$$(4) 4 + 2m^2 = 0 + 2 + m^2 \rightarrow \text{not possible}$$

3. Let $f(x) = \begin{cases} \max\{|x|, x^2\}, & |x| \leq 2 \\ 8 - 2|x|, & 2 < |x| \leq 4 \end{cases}$

Let S be the set of points in the interval $(-4, 4)$ at which f is not differentiable. Then S

- (1) equal $\{-2, -1, 1, 2\}$ (2) equals $\{-2, 2\}$
 (3) is an empty set (4) equal $\{-2, -1, 0, 1, 2\}$

Sol.

$$f(x) = \begin{cases} x & 0 \leq x < 1 \\ x^2 & 1 \leq x \leq 2 \\ -x & -1 \leq x < 0 \\ x^2 & -2 \leq x < -1 \\ 8 - 2x & 2 < x \leq 4 \\ 8 + 2x & -4 \leq x < -2 \end{cases}$$

f(x) is not diffential at $x = -2, -1, 0, 1, 2$

4. If the line $3x + 4y - 24 = 0$ intersects the x-axis at the point A and the y-axis at the point B, then the incentre of the triangle OAB, where O is the origin, is
- (1) (2, 2) (2) (4, 4) (3) (3, 4) (4) (4, 3)
5. The sum of all two digit positive numbers which when divided by 7 yield 2 or 5 as remainder is
- (1) 1465 (2) 1256 (3) 1356 (4) 1365

Sol. $16 + 23 + 30 + \dots + 93 = 6 [16 + 93] = 6 \times 109 = 654$

and $12 + 19 + 26 + \dots + 96 = \frac{13}{2} [96 + 12] = 13 \times 54 = 702$

+ 1356

6. Let $f : \mathbb{R} \rightarrow \mathbb{R}$ be a function such that $f(x) = x^3 + x^2 f'(1) + x f''(2) + f'''(3)$, $x \in \mathbb{R}$. Then $f(2)$ equals
 (1) 30 (2) -2 (3) -4 (4) 8

7. For each $t \in \mathbb{R}$, let $[t]$ be the greatest integer less than or equal to t .

Then, $\lim_{x \rightarrow 1^+} \frac{(1 - |x| + \sin |1 - x|) \sin\left(\frac{\pi}{2}[1 - x]\right)}{|1 - x| [1 - x]}$

- (1) equal 1 (2) does not exist (3) equal 0 (4) equal -1
8. Consider the statement: " $P(n)$: $n^2 - n + 41$ is prime." The which one of the following is true?
 (1) $P(3)$ is false but $P(5)$ is true (2) $P(5)$ is false but $P(3)$ is true.
 (3) Both $P(3)$ and $P(5)$ are true (4) Both $P(3)$ and $P(5)$ are false

9. Let $\vec{a} = 2\hat{i} + \lambda_1\hat{j} + 3\hat{k}$, $\vec{b} = 4\hat{i} + (3 - \lambda_2)\hat{j} + 6\hat{k}$ and $\vec{c} = 3\hat{i} + 6\hat{j} + (\lambda_3 - 1)\hat{k}$ be three vectors such that $\vec{b} = 2\vec{a}$ and $\vec{a}$ and is perpendicular to $\vec{c}$. Then a possible value of $(\lambda_1, \lambda_2, \lambda_3)$ is:

- (1) (1, 5, 1) (2) (1, 3, 1) (3) $\left(\frac{1}{2}, 4, -2\right)$ (4) $\left(-\frac{1}{2}, 4, 0\right)$
10. If $\frac{dy}{dx} + \frac{3}{\cos^2 x} y = \frac{1}{\cos^2 x}$, $x \in \left(-\frac{\pi}{3}, \frac{\pi}{3}\right)$ and $y = \left(\frac{\pi}{4}\right) = \frac{4}{3}$, then $y\left(\frac{-\pi}{4}\right)$ equal
 (1) $\frac{1}{3} + e^3$ (2) $-\frac{4}{3}$ (3) $\frac{1}{3}$ (4) $\frac{1}{3} + e^6$

11. If the third term in the binomial expansion of $(1 + x^{\log_2 x})^5$ equals 2560, then a possible value of x is:
 (1) $\frac{1}{4}$ (2) $4\sqrt{2}$ (3) $\frac{1}{8}$ (4) $2\sqrt{2}$

12. If the system of equation

$$x + y + z = 5$$

$$x + 2y + 3z = 9$$

$$x + 3y + \alpha z = \beta$$

has infinitely many solutions, then $\beta - \alpha$ equals

- (1) 21 (2) 5 (3) 18 (4) 8

13. If $\sum_{i=1}^{20} \left(\frac{{}^{20}C_{i-1}}{{}^{20}C_i + {}^{20}C_{i-1}} \right)^3 = \frac{k}{21}$, then k equal
 (1) 200 (2) 400 (3) 100 (4) 50
14. Let $I = \int_a^b (x^4 - 2x^2) dx$. If I is minimum then the ordered pair (a, b) is:
 (1) $(\sqrt{2}, -\sqrt{2})$ (2) $(-\sqrt{2}, \sqrt{2})$ (3) $(-\sqrt{2}, 0)$ (4) $(0, \sqrt{2})$
15. Consider the quadratic equation $(c - 5)x^2 - 2cx + (c - 4) = 0$, $c \neq 5$. Let S be the set of all integral values of c for which one root of the equation lies in the interval (0, 2) and its other root lies in the interval (2, 3). Then the number of elements in S is
 (1) 11 (2) 10 (3) 12 (4) 18
16. If a circle C passing through the point (4, 0) touches the circle $x^2 + y^2 + 4x - 6y = 12$ externally at the point (1, -1), then the radius of C is:
 (1) $2\sqrt{5}$ (2) 4 (3) $\sqrt{57}$ (4) 5
17. A point P moves on the line $2x - 3y + 4 = 0$. If Q (1, 4) and R (3, -2) are fixed points, then the locus of the centroid of ΔPQR is a line :
 (1) with slope $\frac{2}{3}$ (2) parallel to y-axis (3) parallel to x-axis (4) with slope $\frac{3}{2}$
18. If 5, 5r, $5r^2$ are the lengths of the sides of a triangle, then r cannot be equal to
 (1) $\frac{3}{4}$ (2) $\frac{3}{2}$ (3) $\frac{5}{4}$ (4) $\frac{7}{4}$
19. Let $d \in \mathbb{R}$ and $A = \begin{bmatrix} -2 & 4+d & (\sin \theta) - 2 \\ 1 & (\sin \theta) + 2 & d \\ 5 & (2\sin \theta) - d & (-\sin \theta) + 2 + 2d \end{bmatrix}$, $\theta \in [0, 2\pi]$. If the minimum value of $\det(A)$ is 8, then a value of d is:
 (1) -7 (2) $2(\sqrt{2} + 1)$ (3) $2(\sqrt{2} + 2)$ (4) -5
20. Consider a triangular plot ABC with sides AB = 7 m, BC = 5 m and CA = 6 m. A vertical lamp-post at the mid point D of AC subtends an angle 30° at B. The height (in m) of the lamp-post is :
 (1) $7\sqrt{3}$ (2) $\frac{2}{3}\sqrt{21}$ (3) $\frac{3}{2}\sqrt{21}$ (4) $2\sqrt{21}$

21. An unbiased coin is tossed. If the outcome is a head then a pair of unbiased dice is rolled and the sum of the numbers obtained on them is noted. If the toss of the coin results in tail then a card from a well-shuffled pack of nine cards numbered 1, 2, 3, ..., 9 is randomly picked and the number on the card is noted. The probability that the noted number is either 7 or 8 is
- (1) $\frac{19}{72}$ (2) $\frac{15}{72}$ (3) $\frac{19}{36}$ (4) $\frac{13}{36}$
22. Let A be a point on the line $\vec{r} = (1-3\mu)\hat{i} + (\mu-1)\hat{j} + (2+5\mu)\hat{k}$ and B (3, 2, 6) be a point in the space. Then the value of μ for which the vector $\overrightarrow{AB}$ is parallel to the plane $x - 4y + 3z = 1$ is
- (1) $\frac{1}{8}$ (2) $\frac{-1}{4}$ (3) $\frac{1}{2}$ (4) $\frac{1}{4}$
23. The mean of five observations is 5 and their variance is 9.20. If three of the given five observations are 1, 3 and 8, then a ratio of other two observations is
- (1) 10 : 3 (2) 5 : 8 (3) 4 : 9 (4) 6 : 7
24. If the area enclosed between the curves $y = kx^2$ and $x = ky^2$, ($k > 0$), is 1 square unit. Then k is
- (1) $\frac{1}{\sqrt{3}}$ (2) $\frac{2}{\sqrt{3}}$ (3) $\sqrt{3}$ (4) $\frac{\sqrt{3}}{2}$
25. The shortest distance between the point $\left(\frac{3}{2}, 0\right)$ and the curve $y = \sqrt{x}$, ($x > 0$), is
- (1) $\frac{\sqrt{3}}{2}$ (2) $\frac{5}{4}$ (3) $\frac{\sqrt{5}}{2}$ (4) $\frac{3}{2}$
26. The plane passing through the point (4, -1, 2) and parallel to the lines $\frac{x+2}{3} = \frac{y-2}{-1} = \frac{z+1}{2}$ and $\frac{x-2}{1} = \frac{y-3}{2} = \frac{z-4}{3}$ also passes through the point
- (1) (-1, -1, -1) (2) (1, 1, -1) (3) (1, 1, 1) (4) (-1, -1, 1)
27. The sum of all values of $\theta \in \left(0, \frac{\pi}{2}\right)$ satisfying $\sin^2 2\theta + \cos^4 2\theta = \frac{3}{4}$ is
- (1) π (2) $\frac{\pi}{2}$ (3) $\frac{3\pi}{8}$ (4) $\frac{5\pi}{4}$
28. The equation of a tangent to the hyperbola $4x^2 - 5y^2 = 20$ parallel to the line $x - y = 2$ is
- (1) $x - y + 1 = 0$ (2) $x - y - 3 = 0$ (3) $x - y + 7 = 0$ (4) $x - y + 9 = 0$

29. Let z_1 and z_2 be two non-zero complex numbers such that $3|z_1| = 4|z_2|$. If $z = \frac{3z_1}{2z_2} + \frac{2z_2}{3z_1}$ then

- (1) $\operatorname{Re}(z) = 0$ (2) $|z| = \sqrt{\frac{5}{2}}$ (3) $\operatorname{Im}(z) = 0$ (4) $|z| = \frac{1}{2}\sqrt{\frac{17}{2}}$

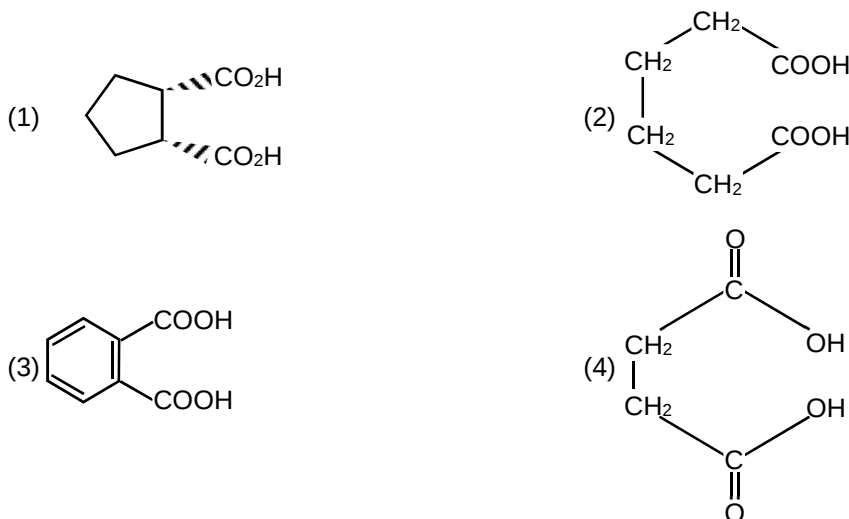
30. Let $n \geq 2$ be a natural number and $0 < \theta < \frac{\pi}{2}$. Then $\int \frac{(\sin^n \theta - \sin \theta)^{\frac{1}{n}} \cos \theta}{\sin^{n+1} \theta} d\theta$ is equal to

(where C is a constant integration)

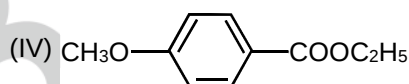
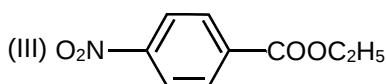
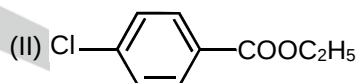
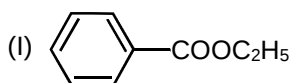
- (1) $\frac{n}{n^2+1} \left(1 - \frac{1}{\sin^{n-1} \theta}\right)^{\frac{n+1}{n}} + C$ (2) $\frac{n}{n^2-1} \left(1 - \frac{1}{\sin^{n+1} \theta}\right)^{\frac{n+1}{n}} + C$
 (3) $\frac{n}{n^2-1} \left(1 + \frac{1}{\sin^{n-1} \theta}\right)^{\frac{n+1}{n}} + C$ (4) $\frac{n}{n^2-1} \left(1 - \frac{1}{\sin^{n-1} \theta}\right)^{\frac{n+1}{n}} + C$

PART-B-CHEMISTRY

31. Which dicarboxylic acid in presence of a dehydrating agent is least reactive to give an anhydride?

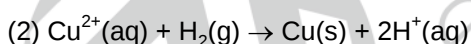
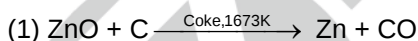


32. The decreasing order of ease of alkaline hydrolysis for the following esters is -



- (1) III > II > IV > I (2) III > II > I > IV (3) IV > II > III > I (4) II > III > I > IV

33. Hall-Heroult's process is given by:



34. A process has $\Delta H = 200 \text{ J mol}^{-1}$ and $\Delta S = 40 \text{ JK}^{-1} \text{ mol}^{-1}$. Out of the values given below, choose the minimum temperature above which the process will be spontaneous:

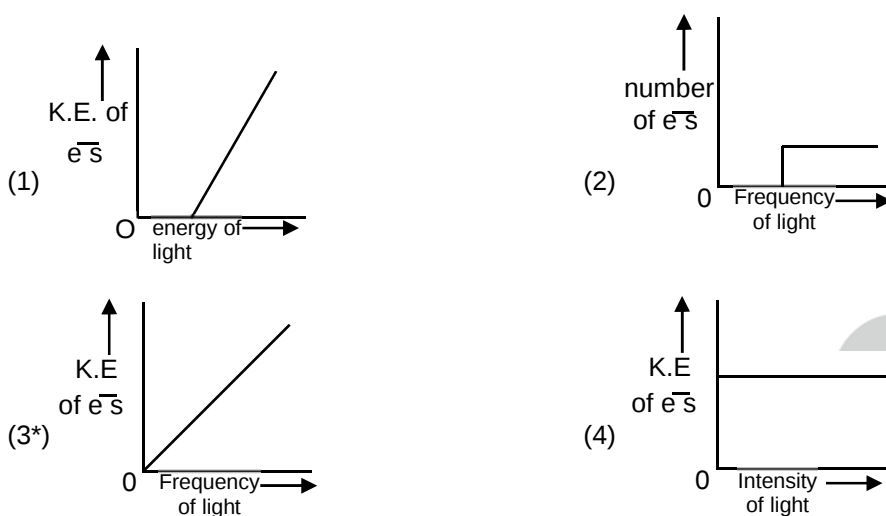
- (1*) 5 K (2) 4 K (3) 20 K (4) 12 K

- Sol. For spontaneous reaction $\Delta G < 0$

$$\Delta H - T\Delta S < 0$$

$$T > \frac{\Delta H}{\Delta S} = 5\text{K}$$

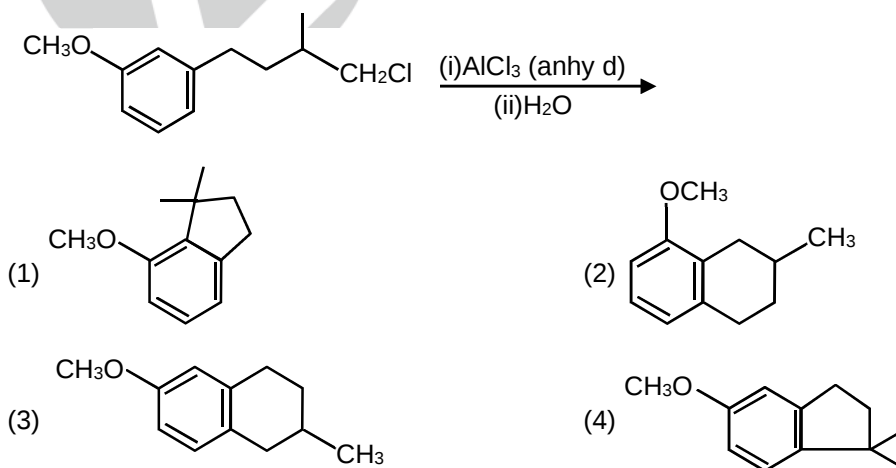
35. Which of the graphs shown below does not represent the relationship between incident light and the electron ejected from metal surface?



Sol. $\therefore (KE)_{e^-} = h\nu - \phi$

so, the graph between KE and will be a straight line having positive slope and negative intercept on y-axis.

36. The electronegativity of aluminium is similar to :
 (1*) Beryllium (2) Boron (3) Lithium (4) Carbon
37. The total number of isomers for a square planar complex $[M(F)(Cl)(SCN)(NO_2)]$ is :
 (1) 16 (2) 4 (3) 8 (4*) 12
38. The metal used for making X-ray tube window is:
 (1) Na (2*) Be (3) Ca (4) Mg
39. The major product of the following reaction is:

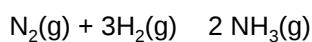
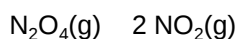
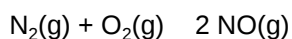


40. Two pi and half sigma bonds are present in:

- (1*) N_2^+ (2) O_2^+ (3) O_2 (4) N_2

41. The values of K_p/K_c for the following reactions at 300 K are, respectively:

[At 300 K, $RT = 24.62 \text{ dm}^3 \text{ atm mol}^{-1}$]



(1) $24.62 \text{ dm}^3 \text{ atm mol}^{-1}$, $606.0 \text{ dm}^6 \text{ atm}^2 \text{ mol}^{-2}$, $1.65 \times 10^{-3} \text{ dm}^{-6} \text{ atm}^{-2} \text{ mol}^2$

(2) 1, $4.1 \times 10^{-2} \text{ dm}^{-3} \text{ atm}^{-1} \text{ mol}$, $606 \text{ dm}^6 \text{ atm}^2 \text{ mol}^{-2}$

(3) 1, $24.62 \text{ dm}^3 \text{ atm mol}^{-1}$, $606.0 \text{ dm}^6 \text{ atm}^2 \text{ mol}^{-2}$

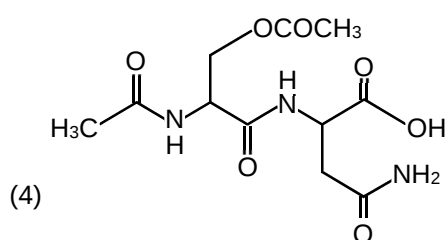
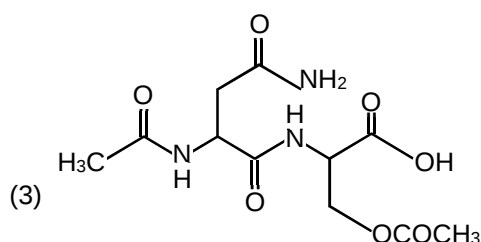
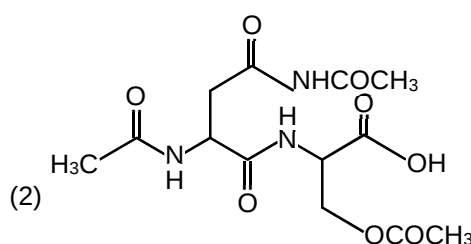
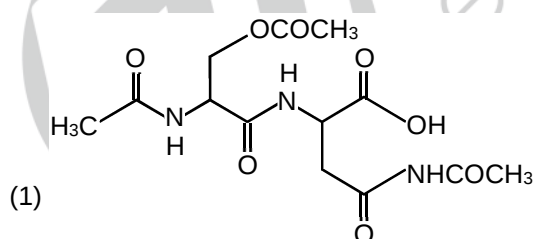
(4*) 1, $24.62 \text{ dm}^3 \text{ atm mol}^{-1}$, $1.65 \times 10^{-3} \text{ dm}^{-6} \text{ atm}^{-2} \text{ mol}^2$

Sol. $\therefore \frac{K_p}{K_c} = (RT)^{\Delta n_g}$

42. Water filled in two glasses A and B have BOD values of 10 and 20, respectively. The correct statement regarding them, is:

- (1) A is more polluted than B (2*) B is more polluted than A
(3) A is suitable for drinking, whereas B is not (4) Both A and B are suitable for drinking

43. The correct structure of product 'P' in the following reaction is:

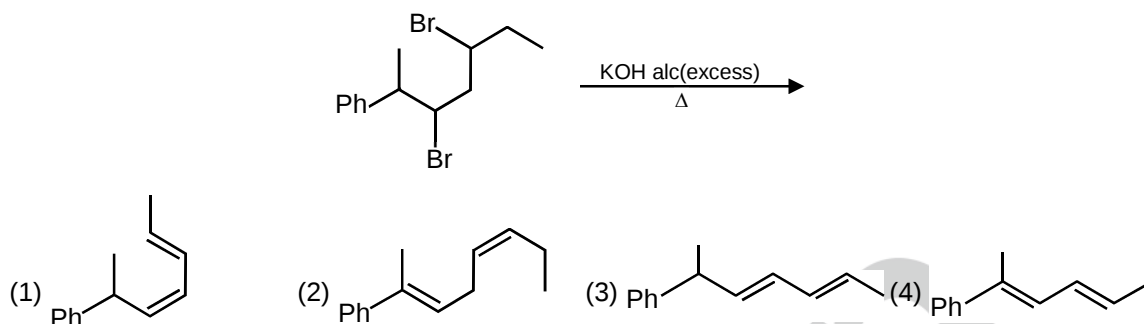


44. Which primitive unit cell has unequal edge lengths ($a \neq b \neq c$) and all axial angles different from 90° ?

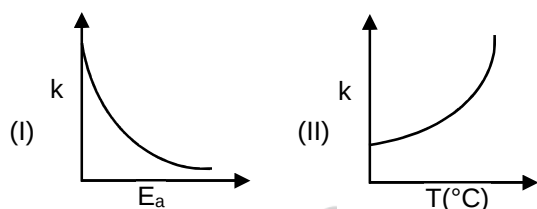
- (1*) Triclinic (2) Tetragonal (3) Monoclinic (4) Hexagonal

Sol. Theory based

45. The major product of the following reaction is:



46. Consider the given plots for a reaction obeying Arrhenius equation ($0^\circ\text{C} < T < 300^\circ\text{C}$): (k and E_a are rate constant and activation energy respectively)

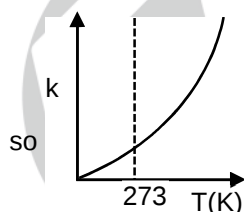


Choose the correct option:

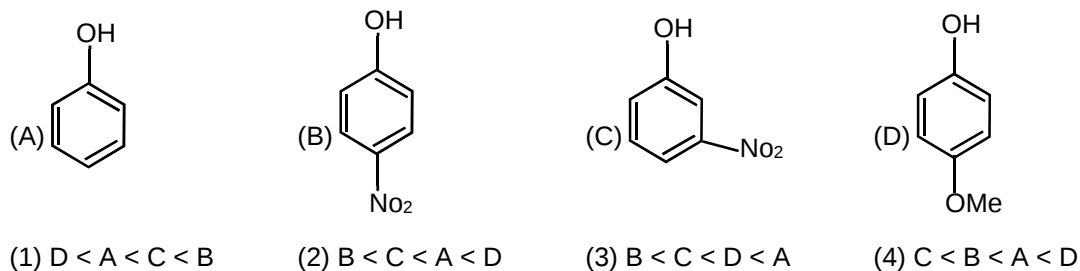
- (1) Both I and II are wrong (2) I is wrong but II is right
 (3) I is right but II is wrong (4*) Both I and II are correct

Sol. $\therefore K = A.e^{\frac{E_a}{RT}}$

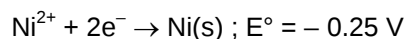
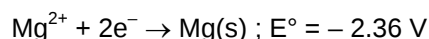
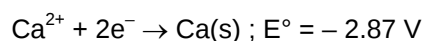
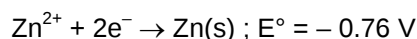
where T in Kelvin



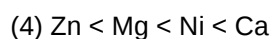
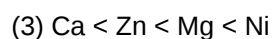
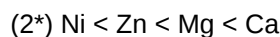
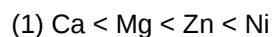
47. The increasing order of the pK_a values of the following compounds is:



48. Consider the following reduction processes:



The reducing power of the metals increases in the order:



Sol. Greater SOP $\Rightarrow$ More tendency to be oxidised
 $\Rightarrow$ More reducing power

49. Which of the following is not an example of heterogeneous catalytic reaction?

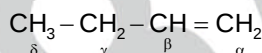
(1) Combustion of coal

(2) Haber's process

(3) Ostwald's process

(4) Hydrogenation of vegetable oils

50. Which hydrogen in compound (E) is easily replaceable during bromination reaction in presence of light?



(E)

(1) γ -hydrogen

(2) α -hydrogen

(3) β -hydrogen

(4) δ -hydrogen

51. The type of hybridisation and number of lone pair(s) of electrons of Xe in XeOF_4 respectively, are:

(1) sp^3d and 1

(2*) sp^3d^2 and 1

(3) sp^3d^2 and 2

(4) sp^3d and 2

52. If dichloromethane (DCM) and water (H_2O) are used for differential extraction, which one of the following statements is correct ?

(1) DCM and H_2O would stay as lower and upper layer respectively in the S.F.

(2) DCM and H_2O will be miscible clearly.

(3) DCM and H_2O will make turbid / colloidal mixture

(4) DCM and H_2O would stay as upper and lower layer respectively in the separating funnel (S.F.)

53. Wilkinson catalyst is :

(1) $[(\text{Et}_3\text{P})_3\text{RhCl}]$

(2*) $[(\text{Ph}_3\text{P})_3\text{RhCl}]$ ($\text{Et} = \text{C}_2\text{H}_5$)

(3) $[(\text{Ph}_3\text{P})_3\text{IrCl}]$

(4) $[(\text{Et}_3\text{P})_3\text{IrCl}]$

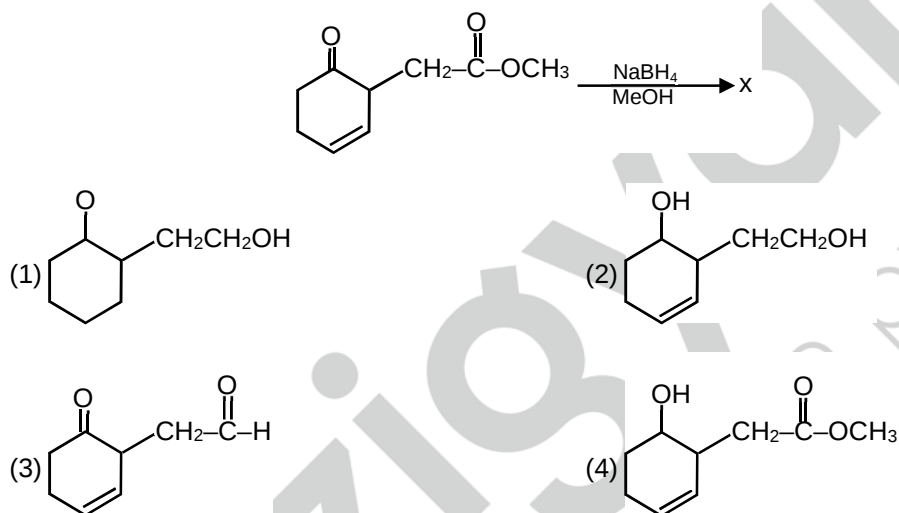
54. The total number of isotopes of hydrogen and number of radioactive isotopes among them, respectively, are:

- (1) 2 and 0 (2) 3 and 2 (3*) 3 and 1 (4) 2 and 1

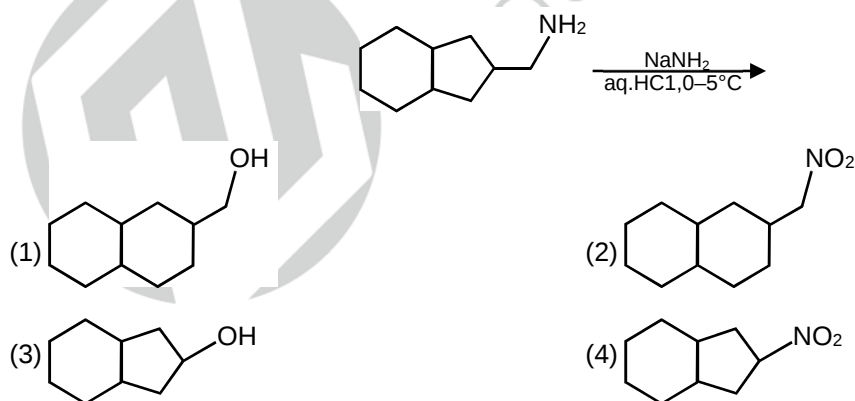
55. The chemical nature of hydrogen peroxide is:

- (1) Reducing agent in basic medium, but not in acidic medium
 (2*) Oxidising and reducing agent in both acidic and basic medium
 (3) Oxidising agent in acidic medium, but not in basic medium
 (4) Oxidising and reducing agent in acidic medium, but not in basic medium

56. The major product 'X' formed in the following reaction is :



57. The major product formed in the reaction given below will be:



58. Liquids A and B form an ideal solution in the entire composition range. At 350 K, the vapour pressures of pure A and pure B are 7×10^3 Pa and 12×10^3 Pa, respectively. The composition of the vapour in equilibrium with a solution containing 40 mole percent of A at this temperature is:

- (1) $x_A = 0.4$; $x_B = 0.6$ (2) $x_A = 0.76$; $x_B = 0.24$
 (3) $x_A = 0.37$; $x_B = 0.63$ (4*) $x_A = 0.28$; $x_B = 0.72$

Sol. $P_{\text{solution}} = 7 \times 10^3 (0.4) + 12 \times 10^3 (0.6)$
 $= 10^4 \text{ Pa}$

In vapour phase,

$$x_A = \frac{7 \times 10^3 \times 0.4}{10^4} = 0.28$$

$$x_B = 1 - x_A = 0.72$$

- 59.** A mixture of 100 m mol of Ca(OH)_2 and 2 g of sodium sulphate was dissolved in water and the volume was made up to 100 mL. The mass of calcium sulphate formed and the concentration of OH^- in resulting solution, respectively, are :

(Molar mass of Ca(OH)_2 , Na_2SO_4 and CaSO_4 are 74, 143 and 136 g mol^{-1} , respectively; K_{sp} of Ca(OH)_2 is 5.5×10^{-6})

(1) 13.6 g, 0.14 mol L^{-1}

(2) 1.9 g, 0.14 mol L^{-1}

(3) 13.6 g, 0.28 mol L^{-1}

(4*) 1.9 g, 0.28 mol L^{-1}



0.1 mole $\frac{2}{143}$ mole



Mass of $\text{CaSO}_4 = \frac{2}{143} \times 136 = 1.9 \text{ gram}$

$$[\text{OH}^-] = \frac{2\left(\frac{2}{143}\right)}{100/1000} = 0.28 \text{ Mol / L}$$

- 60.** The effect of lanthanoid contraction in the lanthanoid series of elements by and large means:

(1) increase in both atomic and ionic radii

(2) increase in atomic radii and decrease in ionic radii

(3) decrease in atomic radii and increase in ionic radii

(4*) decrease in both atomic and ionic radii

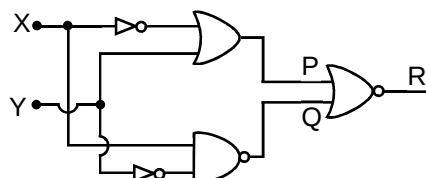
PART-C-PHYSICS

61. If the magnetic field of a plane electromagnetic wave is given by (The speed of light = 3×10^8 m/s).

$$B = 100 \times 10^{-6} \sin \left[2\pi \times 2 \times 10^{15} \left(t - \frac{x}{c} \right) \right] \text{ then the maximum electric field associated with it is:}$$

- (1) 4×10^4 N/C (2) 4.5×10^4 N/C (3*) 3×10^4 N/C (4) 6×10^4 N/C

62. To get output '1' at R, for the given logic gate circuit the input values must be:

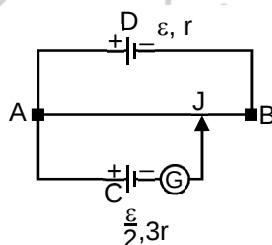


- (1*) $X = 1, Y = 0$ (2) $X = 0, Y = 1$ (3) $X = 0, Y = 0$ (4) $X = 1, Y = 1$

63. Water flows into a large tank with flat bottom at the rate of $10^{-4} \text{ m}^3 \text{ s}^{-1}$. Water is also leaking out of a hole of area 1 cm^2 at its bottom. If the height of the water in the tank remains steady, then this height is:

- (1) 2.9 cm (2) 1.7 cm (3*) 5.1 cm (4) 4 cm

64. A potentiometer wire AB having length L and resistance $12r$ is joined to a cell D of emf ε and internal resistance r . A cell C having emf $\varepsilon/2$ and internal resistance $3r$ is connected. The length AJ at which the galvanometer as shown in figure shows no deflection is:



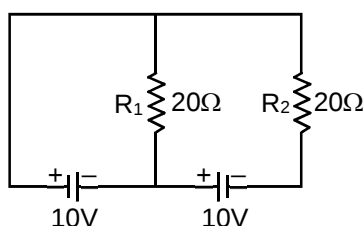
- (1) $\frac{11}{12}L$ (2) $\frac{5}{12}L$ (3) $\frac{11}{24}L$ (4*) $\frac{13}{24}L$

65. To mop-clean a floor, a cleaning machine presses a circular mop of radius R vertically down with a total force F and rotates it with a constant angular speed about its axis. If the force F is distributed uniformly over the mop and if coefficient of friction between the mop and the floor is μ , the torque, applied by the machine on the mop is :

- (1) $\mu FR / 2$ (2*) $\frac{2}{3}\mu FR$ (3) $\mu FR / 6$ (4) $\mu FR / 3$

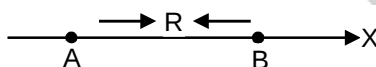
66. A heat source at $T = 10^3$ K is connected to another heat reservoir at $T = 10^2$ K by a copper slab which is 1m thick. Given that the thermal conductivity of copper is $0.1 \text{ WK}^{-1} \text{ m}^{-1}$, the energy flux through it in the steady state is :
- (1) 120 Wm^{-2} (2) 200 Wm^{-2} (3*) 90 Wm^{-2} (4) 65 Wm^{-2}
67. An insulating thin rod of length l has a linear charge density $\rho(x) = \rho_0 \frac{x}{l}$ on it. The rod is rotated about an axis passing through the origin ($x = 0$) and perpendicular to the rod. If the rod makes n rotations per second, then the time averaged magnetic moment of the rod is:
- (1) $n\rho l^3$ (2) $\frac{\pi}{3}n\rho l^3$ (3) $\pi n\rho l^3$ (4*) $\frac{\pi}{4}n\rho l^3$
68. In an electron microscope, the resolution that can be achieved is of the order of the wavelength of electrons used. To resolve a width of $7.5 \times 10^{-12} \text{ m}$, the minimum electron energy required is close to :
- (1) 500 keV (2) 100 keV (3) 1 keV (4*) 25 keV
69. A uniform metallic wire has a resistance of 18Ω and is bent into an equilateral triangle. Then, the resistance between any two vertices of the triangle is :
- (1*) 4Ω (2) 2Ω (3) 8Ω (4) 12Ω
70. A satellite is moving with a constant speed v in circular orbit around the earth. An object of mass ' m ' is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of ejection, the kinetic energy of the object is :
- (1*) mv^2 (2) $\frac{3}{2}mv^2$ (3) $2mv^2$ (4) $\frac{1}{2}mv^2$
71. A charge Q is distributed over three concentric spherical shells of radii a, b, c ($a < b < c$) such that their surface charge densities are equal to one another. The total potential at a point at distance r from their common centre, where $r < a$, would be:
- (1) $\frac{Q}{12\pi\epsilon_0} \frac{ab+bc+ca}{abc}$ (2) $\frac{Q(a^2+b^2+c^2)}{4\pi\epsilon_0 (a^3+b^3+c^3)}$ (3) $\frac{Q}{4\pi\epsilon_0 (a+b+c)}$ (4*) $\frac{Q(a+b+c)}{4\pi\epsilon_0 (a^2+b^2+c^2)}$
72. The density of a material in SI units is 128 kg m^{-3} . In certain units in which the unit of length is 25 cm and the unit of mass is 50 g, the numerical value of density of the material is :
- (1) 16 (2*) 40 (3) 410 (4) 640

73. In the given circuit the cells have zero internal resistance. The currents (in Amperes) passing through resistance R_1 and R_2 respectively, are :



- (1*) 0.5, 0 (2) 1, 2 (3) 2, 2 (4) 0, 1

74. Two electric dipoles, A, B with respective dipole moments and are placed on the x-axis with a separation R , as shown in the figure. The distance from A at which both of them produce the same potential is :



- (1) $\frac{R}{\sqrt{2}+1}$ (2) $\frac{R}{\sqrt{2}-1}$ (3) $\frac{\sqrt{2}R}{\sqrt{2}+1}$ (4*) $\frac{\sqrt{2}R}{\sqrt{2}-1}$

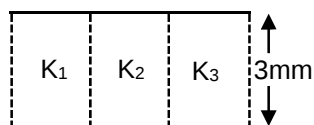
75. Using a nuclear counter the count rate of emitted particles from a radioactive source is measured. At $t = 0$ it was 1600 counts per second and $t = 8$ seconds it was 100 counts per second. The count rate observed, as counts per second, at $t = 6$ seconds is close to :

- (1) 360 (2) 150 (3*) 200 (4) 400

76. A TV transmission tower has a height of 140 m and the height of the receiving antenna is 40 m. What is the maximum distance upto which signals can be broadcasted from this tower in LOS (Line of Sight) mode? (Given : radius of earth = 6.4×10^6 m).

- (1) 80 km (2*) 65 km (3) 48 km (4) 40 km

77. A parallel plate capacitor is of area 6 cm^2 and a separation 3mm. The gap is filled with three dielectric materials of equal thickness (see figure) with dielectric constants $K_1 = 10$, $K_2 = 12$ and $K_3 = 14$. The dielectric constant of a material which when fully inserted in above capacitor, gives same capacitance would be :

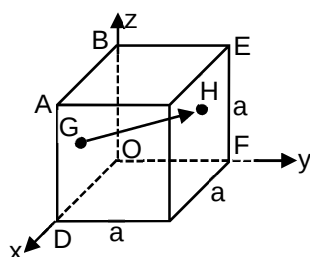


- (1) 36 (2) 14 (3*) 12 (4) 4

78. A homogeneous solid cylindrical roller of radius R and mass M is pulled on a cricket pitch by a horizontal force. Assuming rolling without slipping, angular acceleration of the cylinder is :

- (1) $\frac{3F}{2mR}$ (2) $\frac{F}{3mR}$ (3*) $\frac{2F}{3mR}$ (4) $\frac{F}{2mR}$

79. In the cube of side 'a' shown in the figure, the vector from the central point of the face ABOD to the central point of the face BEFO will be :



- (1) $\frac{1}{2}a(\hat{k} - \hat{i})$ (2) $\frac{1}{2}a(\hat{i} - \hat{k})$ (3) $\frac{1}{2}a(\hat{j} - \hat{k})$ (4*) $\frac{1}{2}a(\hat{j} - \hat{i})$

80. A block of mass m is kept on a platform which starts from rest with constant acceleration $g/2$ upward, as shown in figure. Work done by normal reaction on block in time t is :



- (1*) $\frac{3mg^2t^2}{8}$ (2) $\frac{mg^2t^2}{8}$ (3) 0 (4) $-\frac{mg^2t^2}{8}$

81. A solid metal cube of edge length 2cm is moving in a positive y -direction at a constant speed of 6 m/s. There is a uniform magnetic field of 0.1 T in the positive z -direction. The potential difference between the two faces of the cube perpendicular to the x -axis, is :

- (1) 2mV (2*) 12mV (3) 1 mV (4) 6 mV

82. In a Young's double slit experiment with slit separation 0.1 mm, one observes a bright fringe at angle $\frac{1}{40}$ rad by using light of wavelength λ_1 . When the light of wavelength λ_2 is used a bright fringe is seen at the same angle in the same set up. Given that λ_1 and λ_2 are in visible range (380 nm to 740 nm), their values are :

- (1) 400 nm, 500 nm (2) 380 nm, 500 nm (3*) 625 nm, 500 nm (4) 380 nm, 525 nm

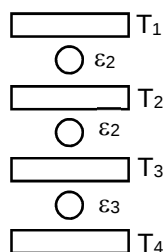
83. Three Carnot engines operate in series between a heat source at a temperature T_1 and a heat sink at temperature T_4 (see figure). There are two other reservoirs at temperature T_2 and T_3 , as shown, with $T_1 > T_2 > T_3 > T_4$. The three engines are equally efficient if :

(1*) $T_2 = (T_1 T_4)^{1/3}$; $T_3 = (T_1 T_4)^{1/3}$

(2) $T_2 = (T_1 T_4)^{1/2}$; $T_3 = (T_1 T_4)^{1/3}$

(3) $T_2 = (T_1 T_4)^{1/4}$; $T_3 = (T_1 T_4)^{1/4}$

(4) $T_2 = (T_1 T_4)^{1/3}$; $T_3 = (T_1 T_4)^{1/3}$



84. A 2W carbon resistor is color coded with green, black, red and brown respectively. The maximum current which can be passed through this resistor is :
(1*) 20 mA (2) 63 mA (3) 0.4 mA (4) 100 mA
85. Two guns A and B can fire bullets at speeds 1 km/s and 2 km/s respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is :
(1) 1 : 4 (2) 1 : 2 (3) 1 : 8 (4*) 1 : 16
86. A plano convex lens of refractive index μ_1 and focal length f_1 is kept in contact with another plano concave lens of refractive index μ_2 and focal length f_2 . If the radius of curvature of their spherical faces is R each and $f_1 = 2f_2$, then μ_1 and μ_2 are related as :
(1) $3\mu_2 - 2\mu_1 = 1$ (2) $2\mu_2 - \mu_1 = 1$ (3) $\mu_1 + \mu_2 = 3$ (4*) $2\mu_1 - \mu_2 = 1$
87. A piece of wood of mass 0.03 kg is dropped from the top of a 100 m height building. At the same time, a bullet of mass 0.02 kg is fired vertically upward, with a velocity 100 ms^{-1} , from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is : ($g = 10 \text{ ms}^{-2}$)
(1) 20 m (2) 30 m (3) 10 m (4*) 40 m
88. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1 . If the speed of the train is reduced to 17 m/s, the frequency registered is f_2 . If speed of sound is 340 m/s, then the ratio f_1/f_2 is:
(1) 18/17 (2) 20/19 (3) 21/20 (4*) 19/18
89. A magnet of total magnetic moment $10^{-2} \hat{i} \text{ A-m}^2$ is placed in a time varying magnetic field, $B\hat{i}(\cos \omega t)$ where $B = 1 \text{ Tesla}$ and $\omega = 0.125 \text{ rad/s}$. The work done for reversing the direction of the magnetic moment at $t = 1 \text{ second}$, is:
(1) 0.007 J (2) 0.01 J (3) 0.014 J (4) 0.028 J
90. A string of length 1m and mass 5g is fixed at both ends. The tension in the string is 8.0 N. The string is set into vibration using an external vibrator of frequency 100 Hz. The separation between successive nodes on the string is close to:
(1) 16.6 cm (2*) 20.0 cm (3) 33.3 cm (4) 10.0 cm