

FINAL JEE–MAIN EXAMINATION – APRIL, 2023

(Held On Saturday 08th April, 2023)

TIME : 9 : 00 AM to 12 : 00 NOON

MATHEMATICS

TEST PAPER WITH ANSWER

SECTION-A

1. Let $I(x) = \int \frac{(x+1)}{x(1+xe^x)^2} dx, x > 0,$

If $\lim_{x \rightarrow \infty} I(x) = 0$, then $I(1)$ is equal to

(1) $\frac{e+1}{e+2} - \log_e(e+1)$

(2) $\frac{e+1}{e+2} + \log_e(e+1)$

(3) $\frac{e+2}{e+1} + \log_e(e+1)$

(4) $\frac{e+2}{e+1} - \log_e(e+1)$

Official Ans. by NTA (4)

2. If the equation of the plane containing the line $x + 2y + 3z - 4 = 0 = 2x + y - z + 5$ and perpendicular to the plane $\vec{r} = (\hat{i} - \hat{j}) + \lambda(\hat{i} + \hat{j} + \hat{k}) + \mu(\hat{i} - 2\hat{j} + 3\hat{k})$ is $ax + by + cz = 4$, then $(a-b+c)$ is equal to

(1) 20

(2) 24

(3) 22

(4) 18

Official Ans. by NTA (3)

3. Let R be the focus of the parabola $y^2 = 20x$ and the line $y = mx + c$ intersect the parabola at two points P and Q. Let the point G(10, 10) be the centroid of the triangle PQR. If $c-m = 6$, then $(PQ)^2$ is

(1) 325

(2) 317

(3) 296

(4) 346

Official Ans. by NTA (1)

4. Let $C(\alpha, \beta)$ be the circumcenter of the triangle formed by the lines $4x + 3y = 69$, $4y - 3x = 17$ and $x + 7y = 61$

Then $(\alpha - \beta)^2 + \alpha + \beta$ is equal to

(1) 18

(2) 17

(3) 16

(4) 15

Official Ans. by NTA (2)

5. Let $P = \begin{bmatrix} \frac{\sqrt{3}}{2} & \frac{1}{2} \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix}, A = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ and

$Q = PQP^T$. If $P^T Q^{2007} P = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$, then

$2a + b - 3c - 4d$ equal to

(1) 2007

(2) 2005

(3) 2006

(4) 2004

Official Ans. by NTA (2)

6. Let α, β, γ be the three roots of the equation $x^3 + bx + c = 0$. If $\beta\gamma = 1 = -\alpha$, then $b^3 + 2c^3 - 3\alpha^3 - 6\beta^3 - 8\gamma^3$ is equal to

(1) 21

(2) $\frac{169}{8}$

(3) 19

(4) $\frac{155}{8}$

Official Ans. by NTA (3)



7. The number of ways, in which 5 girls and 7 boys can be seated at a round table so that no two girls sit together, is

- (1) $126(5!)^2$
- (2) $7(360)^2$
- (3) 720
- (4) $7(720)^2$

Official Ans. by NTA (1)

8. In a bolt factory, machines A, B and C manufacture respectively 20%, 30% and 50% of the total bolts. Of their output 3, 4 and 2 percent are respectively defective bolts. A bolt is drawn at random from the product. If the bolt drawn is found the defective, then the probability that it is manufactured by the machine C is

- (1) $\frac{2}{7}$
- (2) $\frac{9}{28}$
- (3) $\frac{5}{14}$
- (4) $\frac{3}{7}$

Official Ans. by NTA (3)

9. The number of arrangements of the letter of the word "INDEPENDENCE" in which all the vowels always occur together is

- (1) 16800
- (2) 14800
- (3) 18000
- (4) 33600

Official Ans. by NTA (1)

10. Let $f(x) = \frac{\sin x + \cos x - \sqrt{2}}{\sin x - \cos x}, x \in [0, \pi] - \left\{ \frac{\pi}{4} \right\}$.

Then $f\left(\frac{7\pi}{12}\right) f''\left(\frac{7\pi}{12}\right)$ is equal to

- (1) $-\frac{2}{3}$
- (2) $\frac{2}{9}$
- (3) $-\frac{1}{3\sqrt{3}}$
- (4) $\frac{-2}{3\sqrt{3}}$

Official Ans. by NTA (2)

11. If the points with vectors $\alpha\hat{i} + 10\hat{j} + 13\hat{k}$, $6\hat{i} + 11\hat{j} + 11\hat{k}$, $\frac{9}{2}\hat{i} + \beta\hat{j} - 8\hat{k}$ are collinear, then

$(19\alpha - 6\beta)^2$ is equal to

- (1) 36
- (2) 16
- (3) 25
- (4) 49

Official Ans. by NTA (1)

12. If the coefficients of the three consecutive terms in the expansion of $(1+x)^n$ are in the ratio 1 : 5 : 20, then the coefficient of the fourth term is

- (1) 3654
- (2) 1827
- (3) 5481
- (4) 2436

Official Ans. by NTA (1)

13. Let $S_k = \frac{1+2+\dots+K}{K}$ and

$\sum_{j=1}^n S_j^2 = \frac{n}{A}(Bn^2 + Cn + D)$, where A, B, C, D $\in \mathbb{N}$

and A has least value. Then

- (1) A + B is divisible by D
- (2) A + B = 5(D - C)
- (3) A + C + D is not divisible by B
- (4) A + B + C + D is divisible by 5

Official Ans. by NTA (1)

14. Let $A = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}$. If $|\text{adj}(\text{adj}(\text{adj}2A))| = (16)^n$,

then n is equal to

- (1) 10
- (2) 9
- (3) 12
- (4) 8

Official Ans. by NTA (1)



15. Negation of $p \Rightarrow q \Rightarrow q \Rightarrow p$ is
- (1) $(\sim p) \vee q$ (2) $(\sim q) \wedge p$
- (3) $q \wedge (\sim p)$ (4) $p \vee (\sim q)$

Official Ans. by NTA (3)

16. The shortest distance between the lines $\frac{x-4}{4} = \frac{y+2}{5} = \frac{z+3}{3}$ and $\frac{x-1}{3} = \frac{y-3}{4} = \frac{z-4}{2}$ is
- (1) $3\sqrt{6}$ (2) $6\sqrt{3}$
- (3) $6\sqrt{2}$ (4) $2\sqrt{6}$

Official Ans. by NTA (1)

17. The area of the region $\{(x, y) : x^2 \leq y \leq 8 - x^2, y \leq 7\}$ is
- (1) 21 (2) 18
- (3) 24 (4) 20

Official Ans. by NTA (4)

18. Let the number of elements in sets A and B be five and two respectively. Then the number of subsets of $A \times B$ each having at least 3 and at most 6 element is :
- (1) 792 (2) 752
- (3) 782 (4) 772

Official Ans. by NTA (1)

19. $\lim_{x \rightarrow 0} \left\{ \left(\frac{1 - \cos^2(3x)}{\cos^3(4x)} \right) \left(\frac{\sin^3(4x)}{(\log_e(2x+1))^5} \right) \right\}$ is equal to _____
- (1) 9 (2) 18
- (3) 15 (4) 24

Official Ans. by NTA (2)

20. If for $z = \alpha + i\beta, |z+2| = z+4$ and $1+i$, then $\alpha + \beta$ and $\alpha\beta$ are the roots of the equation
- (1) $x^2 + 7x + 12 = 0$
- (2) $x^2 + 3x - 4 = 0$
- (3) $x^2 + 2x - 3 = 0$
- (4) $x^2 + x - 12 = 0$

Official Ans. by NTA (1)

SECTION-B

21. Let $[t]$ denotes the greatest integer $\leq t$. Then $\frac{2}{\pi} \int_{\pi/6}^{5\pi/6} (8[\operatorname{cosec} x] - 5[\cot x]) dx$ is equal to

Official Ans. by NTA (14)

22. Let $[t]$ denotes the greatest integer $\leq t$. If the constant term in the expansion of $\left(3x^2 - \frac{1}{2x^5}\right)^7$ is α , then $[\alpha]$ is equal to _____

Official Ans. by NTA (1275)

23. Let $\vec{a} = 6\hat{i} + 9\hat{j} + 12\hat{k}$, $\vec{b} = \alpha\hat{i} + 11\hat{j} - 2\hat{k}$ and \vec{c} be vectors such that $\vec{a} \times \vec{c} = \vec{a} \times \vec{b}$. If $\vec{a} \cdot \vec{c} = -12$, $\vec{c} \cdot (\hat{i} - 2\hat{j} + \hat{k}) = 5$, then $\vec{c} \cdot (\hat{i} + \hat{j} + \hat{k})$ is equal to _____

Official Ans. by NTA (11)

24. The largest natural number n such that 3^n divides $66!$ is _____

Official Ans. by NTA (31)

25. If a_n is the greatest term in the sequence

$$a_n = \frac{n^3}{n^4 + 147}, n = 1, 2, 3, \dots, \text{ then } \alpha \text{ is equal to}$$

Official Ans. by NTA (5)

26. Let $A = \{0, 3, 4, 6, 7, 8, 9, 10\}$ and R be the relation defined on A such that $R = \{(x, y) \in A \times A : x - y \text{ is odd positive integer or } x - y = 2\}$. The minimum number of elements that must be added to the relation R , so that it is a symmetric relation, is equal to _____

Official Ans. by NTA (19)

27. Consider a circle $C_1 : x^2 + y^2 - 4x - 2y = \alpha - 5$.

Let its mirror image in the line $y = 2x + 1$ be another circle

$C_2 : 5x^2 + 5y^2 - 10fx - 10gy + 36 = 0$. Let r be the radius of C_2 . Then $\alpha + r$ is equal to _____

Official Ans. by NTA (2)

28. If the solution curve of the differential equation

$$(y - 2 \log_e x) dx + (x \log_e x^2) dy = 0, x > 1$$

passes through the points $\left(e, \frac{4}{3}\right)$ and (e^4, α) ,

then α is equal to _____

Official Ans. by NTA (3)

29. Let λ_1, λ_2 be the values of λ for which the points $\left(\frac{5}{2}, 1, \lambda\right)$ and $(-2, 0, 1)$ are at equal

distance from the plane $2x + 3y - 6z + 7 = 0$. if

$\lambda_1 > \lambda_2$, then the distance of the point

$(\lambda_1 - \lambda_2, \lambda_2, \lambda_1)$ from the line

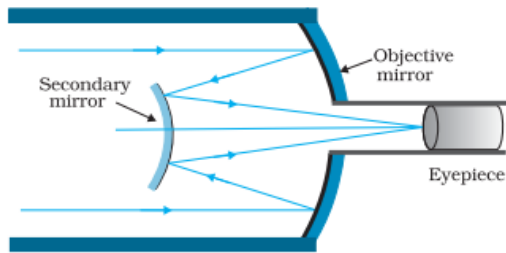
$$\frac{x-5}{1} = \frac{y-1}{2} = \frac{z+7}{2} \text{ is } \underline{\hspace{2cm}}$$

Official Ans. by NTA (9)

30. Let the mean and variance of 8 numbers $x, y, 10, 12, 6, 12, 4, 8$, be 9 and 9.25 respectively. If $x > y$, then $3x - 2y$ is equal to _____

Official Ans. by NTA (25)

Sol.



It has advantage of a large focal length in a short telescope

36. Given below are two statements:

Statement I: If heat is added to a system, its temperature must increase.

Statement II: If positive work is done by a system in a thermodynamic process, its volume must increase.

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

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

Official Ans. by NTA (4)

Sol. Statement I: $\Delta Q > 0$

According to 1st law of thermodynamics

$$\Delta Q = \Delta U + W$$

If $\Delta Q > 0$, $\Delta U < 0$ and $W > 0$ is also possible.

Hence $\Delta T < 0$, so T decreases.

Statement I is false

Statement II: $W > 0$

$$\therefore \int PdV > 0$$

Therefore volume of system must increase during positive work done by the system.

Statement II is true

37. The weight of a body on the earth is 400 N. Then weight of the body when taken to a depth half of the radius of the earth will be:

- (1) Zero
- (2) 300 N
- (3) 100 N
- (4) 200 N

Official Ans. by NTA (4)

Sol. $W = mg = 400 \text{ N}$

$$\text{At depth } d, \text{ gravity } g' = g \left(1 - \frac{d}{R} \right)$$

$$\text{For } d = \frac{R}{2} \quad g' = g \left(1 - \frac{R}{2R} \right) = \frac{g}{2}$$

$$W' = mg' = \frac{mg}{2} = 200 \text{ N}$$

38. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10} \text{ N/m}^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:

- (1) 5600
- (2) 8400
- (3) 2800
- (4) 11200

Official Ans. by NTA (1)

Sol. $Y = 7 \times 10^{10} \text{ N/m}^2$

$$\text{Strain} = \frac{0.04}{100}$$

$$\text{Energy} = \frac{1}{2} \left(\frac{YA}{l} \right) \Delta x^2$$

$$\text{Energy} = \frac{1}{2} YA \left(\frac{\Delta x}{l} \right)^2 \times l$$

$$\frac{E}{V} = \frac{1}{2} \times Y \times \text{strain}^2$$

$$= \frac{1}{2} \times 7 \times 10^{10} \times \frac{0.04 \times 0.04}{10^4} = 56 \times 10^2$$

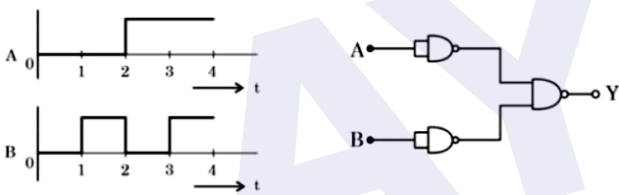
39. At any instant the velocity of a particle of mass 500 g is $(2t\hat{i} + 3t^2\hat{j})\text{ms}^{-1}$. If the force acting on the particle at $t=1\text{s}$ is $(\hat{i} + x\hat{j})\text{N}$. Then the value of x will be:


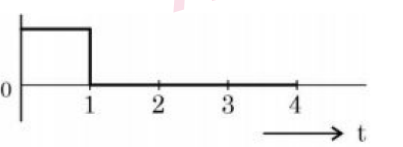
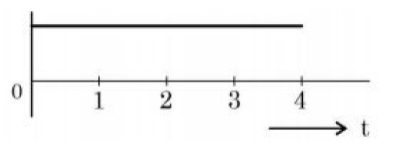
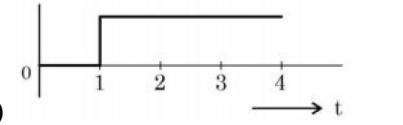
- (1) 3 (2) 4 (3) 6 (4) 2

Official Ans. by NTA (1)

Sol. $\vec{v} = 2t\hat{i} + 3t^2\hat{j}$
 $\vec{a} = 2\hat{i} + 6t\hat{j}$
 at $t=1, \vec{a} = 2\hat{i} + 6\hat{j}$
 $\vec{F} = m\vec{a} = 0.5(2\hat{i} + 6\hat{j}) = \hat{i} + 3\hat{j}$
 $\vec{F} = \hat{i} + x\hat{j}$ Hence $x = 3$

40. For the logic circuit shown, the output waveform at Y is:



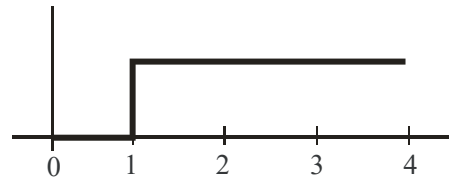
- (1) 
- (2) 
- (3) 
- (4) 

Official Ans. by NTA (4)

Sol.

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

According to truth table, resultant graph is



41. For a nucleus ${}^A_Z\text{X}$ having mass number A and atomic number Z

- A. The surface energy per nucleon $(b_s) = a_1 A^{2/3}$
 B. The Coulomb contribution to the binding energy $b_c = -a_2 \frac{Z(Z-1)}{A^{4/3}}$
 C. The volume energy $b_v = a_3 A$
 D. Decrease in the binding energy is proportional to surface area.

E. While estimating the surface energy, it is assumed that each nucleon interacts with 12 nucleons, (a_1, a_2 and a_3 are constants)

Choose the **most appropriate** answer from the options given below:

- (1) C, D only (2) B, C, E only
 (3) A, B, C, D only (4) B, C only

Official Ans. by NTA (1)

Sol. Surface energy per nucleon $\propto \frac{r^2}{A} \propto \frac{A^{2/3}}{A} \propto \frac{1}{A^{1/3}}$

(Mass number $A \propto r^3 \Rightarrow r \propto A^{1/3}$).

A is incorrect

Contribution to binding energy by columbic forces is

$$= \frac{-a_2 Z(Z-1)}{A^{1/3}}$$

B is incorrect

Volume energy $\propto A$

C is correct

For (D), if we consider only surface energy contribution then option is correct.

For (E) only 3 interactions contribute to surface energy.

42. Given below are two statements:

Statement I :

If E be the total energy of a satellite moving around the earth, then its potential energy will be $\frac{E}{2}$.

Statement II:

The kinetic energy of a satellite revolving in an orbit is equal to the half the magnitude of total energy E.

In the light of the above statements, choose the most appropriate answer from the options given below

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

Official Ans. by NTA (2)

Sol. Energy of satellite in orbit $E = \frac{-GMm}{2R}$.

PE of satellite in orbit $U = \frac{-GMm}{R}$

$$\Rightarrow U = 2E$$

KE of satellite in orbit $K = E - U$

$$K = \frac{GMm}{2R} = (-E)$$

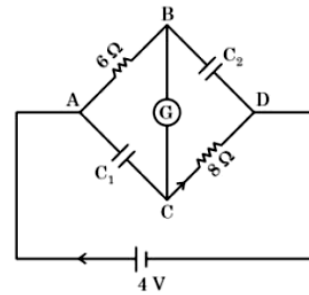
43. Dimension of $\frac{1}{\mu_0 \epsilon_0}$ should be equal to

- (1) T^2/L^2
- (2) L/T
- (3) L^2/T^2
- (4) T/L

Official Ans. by NTA (3)

Sol. $\frac{1}{\mu_0 \epsilon_0} = c^2 \Rightarrow \left[\frac{1}{\mu_0 \epsilon_0} \right] = [c^2] = [L^2 T^{-2}]$

44. In this figure the resistance of the coil of galvanometer G is 2Ω . The emf of the cell is 4 V. The ratio of potential difference across C_1 and C_2 is:



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

Official Ans. by NTA (2)

Sol. At steady state, current in the circuit is

$$i = \frac{4V}{6 + 2 + 8} = \frac{1}{4} A$$

Voltage across C_1 is

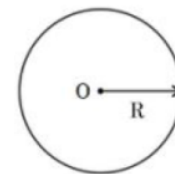
$$V_1 = V_{AC} = i(6\Omega + 2\Omega) = \frac{1}{4} \times 8 = 2V$$

Voltage across C_2 is

$$V_2 = V_{BD} = i(2\Omega + 8\Omega) = \frac{1}{4} \times 10 = 2.5V$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{2}{2.5} = \frac{4}{5}$$

45. Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the centre O is represented by:



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

Official Ans. by NTA (1)

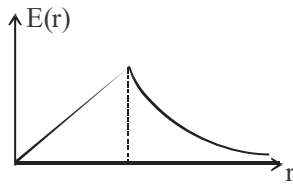
Sol. Electric field of solid sphere (uniformly charged)

$$E(r) \begin{cases} \frac{Q}{4\pi \epsilon_0 r^2} & r \geq R \\ \frac{Qr}{4\pi \epsilon_0 R^3} & r \leq R \end{cases}$$

Graphically

$$E(r) \propto r \text{ for } r \leq R$$

$$\propto \frac{1}{r^2} \text{ for } r \geq R$$

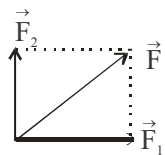


46. Two forces having magnitude A and $\frac{A}{2}$ are perpendicular to each other. The magnitude of their resultant is

- (1) $\frac{\sqrt{5}A}{4}$ (2) $\frac{5A}{2}$
 (3) $\frac{\sqrt{5}A^2}{2}$ (4) $\frac{\sqrt{5}A}{2}$

Official Ans. by NTA (4)

Sol.



$$\vec{F} = (\vec{F}_1 + \vec{F}_2)$$

$$|\vec{F}| = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos 90^\circ}$$

$$= \sqrt{A^2 + \frac{A^2}{4}} = \frac{A\sqrt{5}}{2}$$

47. The engine of a train moving with speed 10ms^{-1} towards a platform sounds a whistle at frequency 400Hz . The frequency heard by a passenger inside the train is (neglect air speed. Speed of sound in air 330ms^{-1})

- (1) 200Hz (2) 400Hz
 (3) 412Hz (4) 388Hz

Official Ans. by NTA (2)

Sol. The relative velocity of a passenger with source of sound (engine) is 0. So there will be no doppler's effect. So frequency heard is 400Hz .

48. An air bubble of volume 1cm^3 rises from the bottom of a lake 40m deep to the surface at a temperature of 12°C . The atmospheric pressure is $1 \times 10^5\text{Pa}$, the density of water is 1000kg/m^3 and $g = 10\text{m/s}^2$. There is no difference of the temperature of water at the depth of 40m and on the surface. The volume of air bubble when it reaches the surface will be

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

Official Ans. by NTA (1)

Sol. $P = P_0 + \rho gh = 10^5\text{Pa} + 10^3 \times 10 \times 40 = 5 \times 10^5\text{Pa}$

At T is constant

$$PV = P_0V_0$$

$$\Rightarrow 5 \times 10^5\text{Pa} \times 1\text{cm}^3 = 10^5\text{Pa} \times V_0 \Rightarrow V_0 = 5\text{cm}^3$$

49. A cylindrical wire of mass $(0.4 \pm 0.01)\text{g}$ has length $(8 \pm 0.04)\text{cm}$ and radius $(6 \pm 0.03)\text{mm}$. The maximum error in its density will be

- (1) 1% (2) 3.5%
 (3) 4% (4) 5%

Official Ans. by NTA (3)

Sol. $\rho = \frac{m}{\pi r^2 l} \Rightarrow \left| \frac{d\rho}{\rho} \right|_{\max} = \left| \frac{dm}{m} \right| + 2 \left| \frac{dr}{r} \right| + \left| \frac{dl}{l} \right|$

$$= \frac{0.01}{0.4} + \frac{2(0.03)}{6} + \frac{0.04}{8}$$

$$\Rightarrow \% \text{ error in density} = \left(\frac{d\rho}{\rho} \right) \times 100\%$$

$$= (2.5 + 1 + 0.5)\% = 4\%$$

50. Proton (P) and electron (e) will have same de-Broglie wavelength when the ratio of their momentum is (assume, $m_p = 1849m_e$)

(1) 1 : 43 (2) 43 : 1

(3) 1 : 1849 (4) 1 : 1

Official Ans. by NTA (4)

Sol. De Broglie wavelength is $\lambda = \frac{h}{mv}$

$$\lambda_p = \lambda_e \Rightarrow m_p v_p = m_e v_e \Rightarrow p_p = p_e$$

SECTION-B

51. An electric dipole of dipole moment is $6.0 \times 10^{-6} \text{ Cm}$ placed in a uniform electric field of $1.5 \times 10^3 \text{ NC}^{-1}$ in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be _____ mJ

Official Ans. by NTA (18)

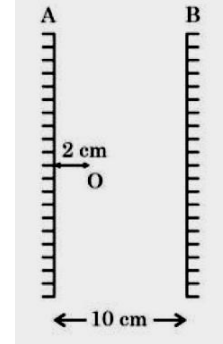
Sol. The work done in rotating the electric dipole = $\Delta U = U_f - U_i$

$$= (-pE \cos(180^\circ)) - (-pE \cos(0^\circ))$$

$$= pE + pE = 2pE$$

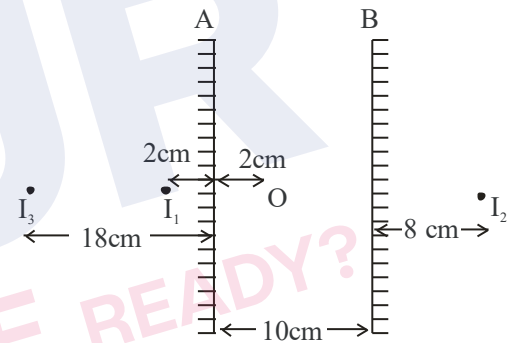
$$= 2 \times 6 \times 10^{-6} \times 1.5 \times 10^3 = 18 \text{ mJ}$$

52. Two vertical parallel mirrors A and B are separated by 10 cm. A point object O is placed at a distance of 2 cm from mirror A. The distance of the second nearest image behind mirror A from the mirror A is _____ cm



Official Ans. by NTA (18)

Sol.



The desired image is 18 cm from A.

53. The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is _____%

Official Ans. by NTA (125)

Sol. Kinetic energy of body = $\frac{p^2}{2m}$

Initial kinetic energy = $\frac{p_i^2}{2m}$

Final kinetic energy = $\frac{p_f^2}{2m} = \frac{(1.5p_i)^2}{2m}$

$$= \frac{2.25 p_i^2}{2m}$$

$$\% \text{ increase in KE} = \frac{2.25 \frac{p_i^2}{2m} - \frac{p_i^2}{2m}}{\frac{p_i^2}{2m}} \times 100 = 125\%$$



54. The moment of inertia of semicircular ring about an axis, passing through the center and perpendicular to the plane of ring, is $\frac{1}{x}MR^2$, where R is the radius and M is the mass of semicircular ring. The value of x will be

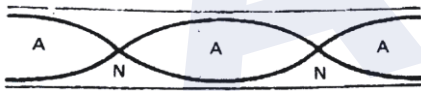
Official Ans. by NTA (1)

- Sol.** The moment of inertia of semicircular ring about axis passing through centre of ring and perpendicular to plane of ring is $= MR^2$
 so $x = 1$

55. An organ pipe 40cm long is open at both ends. The speed of sound in air is 360ms^{-1} . The frequency of the second harmonic is ___ Hz.

Official Ans. by NTA (900)

Sol.



For second harmonic of open organ pipe

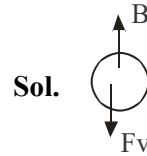
$$L = \lambda$$

So frequency of vibration is $f = \frac{v}{\lambda}$

$$f = \frac{v}{\lambda} = \frac{v}{L} = \frac{360}{\frac{40}{100}} = 900\text{Hz}$$

56. An air bubble of diameter 6 mm rises steadily through a solution of density 1750kg/m^3 at the rate of 0.35 cm/s. The co-efficient of viscosity of the solution (neglect density of air) is ___ Pas (given, $g = 10\text{ms}^{-2}$)

Official Ans. by NTA (10)



Since the bubble is moving at constant speed the force acting on it is zero.

$$B = F_v$$

$$\frac{4}{3}\pi R^3 \rho g = 6\pi\eta Rv$$

$$\eta = \frac{2R^2 \rho g}{9v} = \frac{2 \times (3 \times 10^{-3})^2 \times 1750 \times 10}{9 \times 0.35 \times 10^{-2}} = 10\text{Pas}$$

57. An oscillating LC circuit consists of a 75 mH inductor and a $1.2\mu\text{F}$ capacitor. If the maximum charge to the capacitor is $2.7\mu\text{C}$. The maximum current in the circuit will be ___ mA.

Official Ans. by NTA (9)

- Sol.** Maximum energy stored in capacitor is same as maximum energy stored in inductor.

$$\begin{aligned} \frac{1}{2} Li_{\text{max}}^2 &= \frac{1}{2} \frac{Q_{\text{max}}^2}{C} \\ i_{\text{max}} &= \sqrt{\frac{1}{LC}} Q_{\text{max}} \\ &= \frac{2.7 \times 10^{-6}}{\sqrt{75 \times 10^{-3} \times 1.2 \times 10^{-6}}} = 9\text{mA} \end{aligned}$$

58. The magnetic intensity at the centre of a long current carrying solenoid is found to be $1.6 \times 10^3 \text{Am}^{-1}$. If the number of turns is 8 per cm, then the current flowing through the solenoid is ___ A.

Official Ans. by NTA (2)

Sol. $H = \frac{B}{\mu_0} = \frac{\mu_0 ni}{\mu_0} = ni$

$$i = \frac{H}{n} = \frac{1.6 \times 10^3}{\left(\frac{8}{10^{-2}}\right)} = 2\text{A}$$

59. A current of 2 A flows through a wire of cross-sectional area 25.0 mm^2 . The number of free electrons in a cubic meter are 2.0×10^{28} . The drift velocity of the electrons is $\text{_____} \times 10^{-6} \text{ ms}^{-1}$ (given, charge on electron = $1.6 \times 10^{-19} \text{ C}$)

Official Ans. by NTA (25)

Sol. Drift velocity $v_d = \frac{I}{neA}$

$$= \frac{2}{2 \times 10^{28} \times 1.6 \times 10^{-19} \times 25 \times 10^{-6}}$$

$$= 25 \times 10^{-6} \text{ ms}^{-1}$$

60. A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into fragment each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is $\text{_____} \text{ MeV}$

Official Ans. by NTA (121)

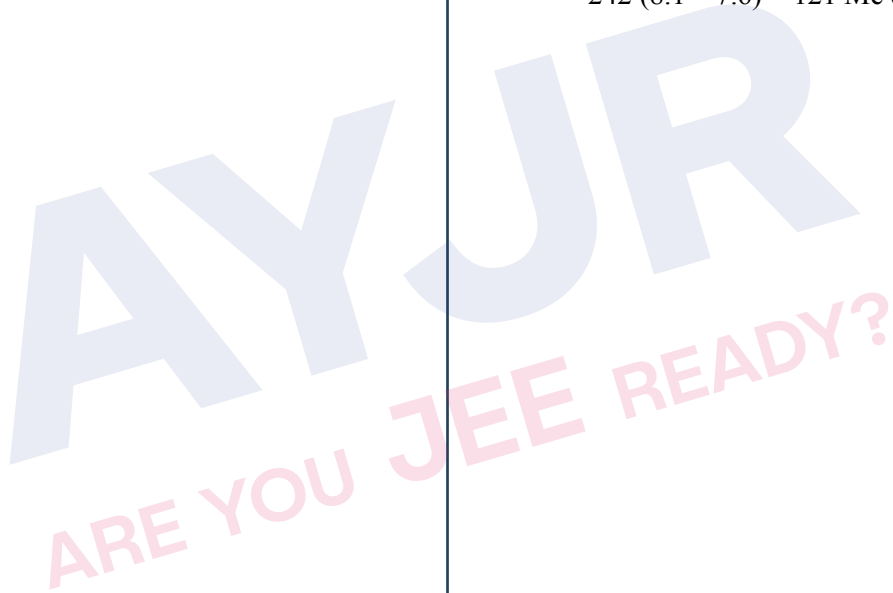
Sol. Initial binding energy = $242 \times 7.6 \text{ MeV}$
 Final binding energy

$$= 121 \times 8.1 \text{ MeV} + 121 \times 8.1 \text{ MeV}$$

$$= 242 \times 8.1 \text{ MeV}$$

Total gain in binding energy

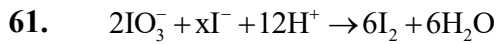
$$= 242 (8.1 - 7.6) = 121 \text{ MeV}$$



CHEMISTRY

TEST PAPER WITH SOLUTION

SECTION-A



What is the value of x?

- (1) 12 (2) 2
 (3) 6 (4) 10

Official Ans. by NTA (4)

Sol. Number of atoms of iodine on reactant side = number of atoms of Iodine on product side

$$2 + x = 6 \times 2$$

$$x = 10$$



62. Which of the following metals can be extracted through alkali leaching technique?

- (1) Cu (2) Sn
 (3) Pb (4) Au

Official Ans. by NTA (2)

Sol. Reference : NCERT

63. Match List I with List II

A.	Saccharin	I.	High potency sweetener
B.	Aspartame	II.	First artificial sweetening agent
C.	Alitame	III.	Stable at cooking temperature
D.	Sucralose	IV.	Unstable at cooking temperature

Choose the correct answer from the options given below:

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

Official Ans. by NTA (4)

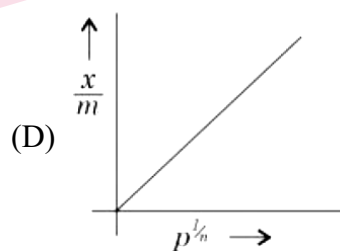
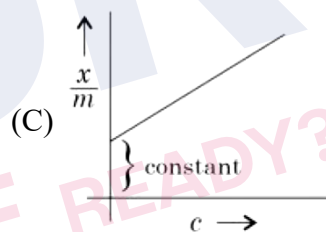
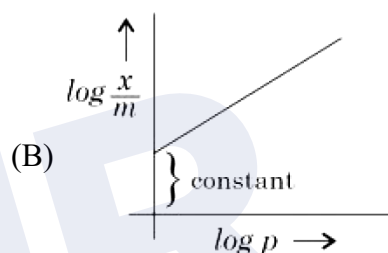
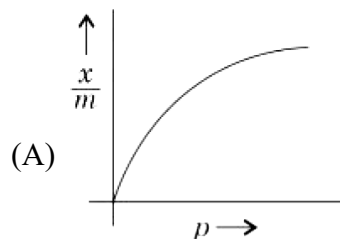
Sol. (A) Saccharin II. First artificial sweetener

(B) Aspartame IV. Unstable at cooking temperature

(C) Alitame I. High potency sweetener

(D) Sucralose III. Stable at cooking temperature

64. Which of the following represent the Freundlich adsorption isotherms?



Choose the correct answer from the options given below:

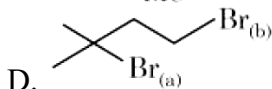
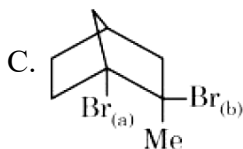
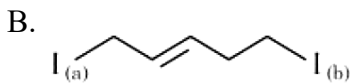
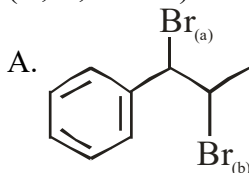
- (1) B, C, D only (2) A, B, D only
 (3) A, B only (4) A, C, D only

Official Ans. by NTA (2)

Sol. $\frac{x}{m} = k p^{1/n}$

and $\log \frac{x}{m} = \log k + \frac{1}{n} \log P$

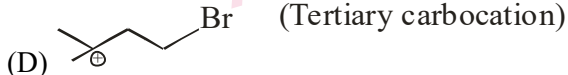
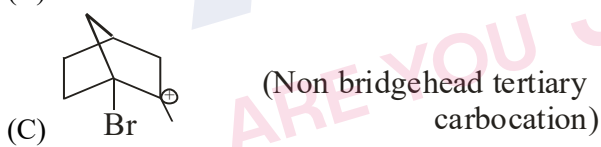
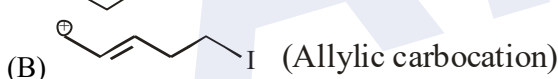
65. Choose the halogen which is most reactive towards S_N1 reaction in the given compounds (A, B, C & D)



- (1) A-Br(b) ; B-I(b) ; C-Br(b) ; D-Br(b)
 (2) A-Br(a) ; B-I(a) ; C-Br(b) ; D-Br(a)
 (3) A-Br(b) ; B-I(a) ; C-Br(a) ; D-Br(a)
 (4) A-Br(b) ; B-I(a) ; C-Br(a) ; D-Br(a)

Official Ans. by NTA (2)

Sol. Stable is the carbocation, faster will be rate of S_N1 reaction



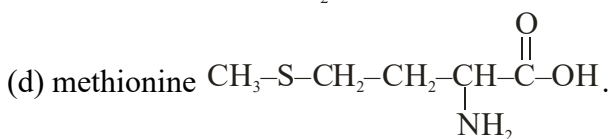
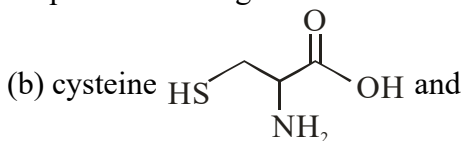
66. Sulphur (S) containing amino acids from the following are:

- (a) isoleucine (b) cysteine (c) lysine
 (d) methionine (e) glutamic acid

- (1) a, d (2) b, d
 (3) b, c, e (4) a, b, c

Official Ans. by NTA (2)

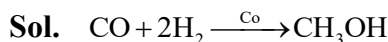
Sol. Sulphur containing amino acids



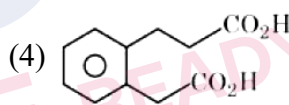
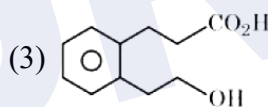
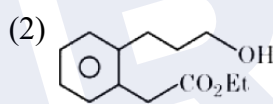
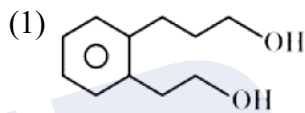
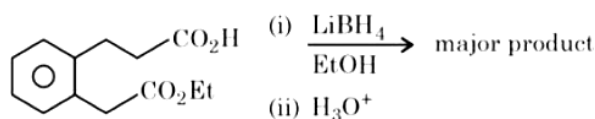
67. The water gas on reacting with cobalt as a catalyst forms

- (1) Ethanol (2) Methanoic acid
 (3) Methanal (4) Methanol

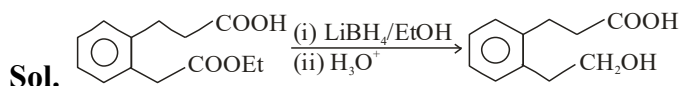
Official Ans. by NTA (4)



68. The major product formed in the following reaction is:



Official Ans. by NTA (3)



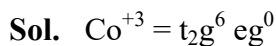
$LiBH_4$ can reduce ester selectively but not carboxylic acids.

Hence correct answer is option (3).

69. Which of the following complex is octahedral, diamagnetic and the most stable?

- (1) $Na_3[CoCl_6]$ (2) $[Ni(NH_3)_6]Cl_2$
 (3) $K_3[Co(CN)_6]$ (4) $[Co(H_2O)_6]Cl_2$

Official Ans. by NTA (3)

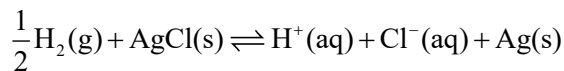


CN^- -strong field ligand

All d-electrons should be paired ($\mu_s = 0$)

Hence diamagnetic.

70. The reaction



occurs in which of the given galvanic cell.

- (1) $\text{Pt}|\text{H}_2(\text{g})|\text{KCl}(\text{sol}^n)|\text{AgCl}(\text{s})|\text{Ag}$
- (2) $\text{Pt}|\text{H}_2(\text{g})|\text{HCl}(\text{sol}^n)|\text{AgCl}(\text{s})|\text{Ag}$
- (3) $\text{Ag}|\text{AgCl}(\text{s})|\text{KCl}(\text{sol}^n)|\text{AgCl}(\text{s})|\text{Ag}$
- (4) $\text{Pt}|\text{H}_2(\text{g})|\text{HCl}(\text{sol}^n)|\text{AgNO}_3(\text{sol}^n)|\text{Ag}$

Official Ans. by NTA (2)

Sol. Anode: $\frac{1}{2}\text{H}_2(\text{g}) \rightleftharpoons \text{H}^+(\text{aq}) + \text{e}^-$

Cathode: $\text{AgCl}(\text{s}) + \text{e}^- \rightarrow \text{Ag}(\text{s}) + \text{Cl}^-(\text{aq})$

71. Match List-I with List-II :

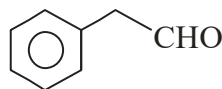
	List-I (Reagents used)		List-II (Compound with functional group detected)
A.	Alkaline solution of copper sulphate and sodium citrate	I.	
B.	Neutral FeCl ₃ solution	II.	
C.	Alkaline chloroform solution	III.	
D.	Potassium iodide and sodium hypochlorite	IV.	

Choose the correct answer from the options given below:

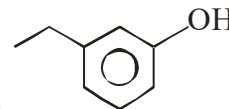
- (1) A-II, B-IV, C-III, D-I
- (2) A-IV, B-I, C-II, D-III
- (3) A-III, B-IV, C-I, D-II
- (4) A-III, B-IV, C-II, D-I

Official Ans. by NTA (4)

Sol. A. Alkaline solution of copper sulphate and sodium citrate is known as Benedict's solution and it is used to test aliphatic aldehydes. Hence it can be used to test compound (III) i.e.



B. Neutral FeCl₃ solution is used to test



phenolic compound (IV) i.e.

C. Alkaline chloroform solution is used to test

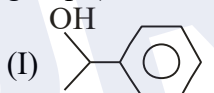


primary amines (II) i.e.

D. $2\text{KI} + \text{NaOCl} + \text{H}_2\text{O} \rightarrow \text{NaCl} + \text{I}_2 + 2\text{KOH}$

Potassium iodide and sodium hypochlorite gives (I₂ + KOH) which is used to test those

compounds which have $\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-$ or $\text{CH}_3-\overset{\text{OH}}{\text{C}}-$ group (iodoform test). Hence the compound is



72. Given below are two statements: One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A: Butan-1-ol has higher boiling point than ethoxyethane.

Reason R: Extensive hydrogen bonding leads to stronger association of molecules.

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

- (1) Both A and R are true and R is the correct explanation of A
- (2) A is true but R is false
- (3) Both A and R are true but R is not the correct explanation of A
- (4) A is false but R is true

Official Ans. by NTA (1)

Sol. Butan-1-ol (CH₃CH₂CH₂CH₂OH) can undergo hydrogen bonding. Ethoxyethane (CH₃CH₂-O-CH₂CH₃) has no hydrogen (attached with F, O, N) which can undergo hydrogen bonding. More is the extent of intermolecular H-bonding, more will be association of molecules. Thus leading to higher boiling point.

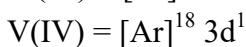
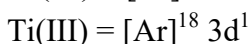
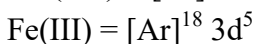
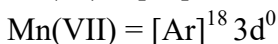
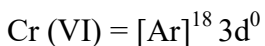
Hence both Assertion (A) and Reason(R) are true and (R) is the correct explanation of (A).

73. In chromyl chloride, the number of d-electrons present on chromium is same as in (Given at no. of Ti : 22, V : 23, Cr : 24, Mn : 25, Fe : 26)

- (1) Ti (III) (2) Fe (III)
(3) V (IV) (4) Mn (VII)

Official Ans. by NTA (4)

Sol. In CrO_2Cl_2 oxidation state of Cr is +6



Hence Cr (VI) and Mn (VII) have same d^0 configuration.

74. What is the purpose of adding gypsum to cement?

- (1) To facilitate the hydration of cement
(2) To speed up the process of setting
(3) To slow down the process of setting
(4) To give a hard mass

Official Ans. by NTA (3)

Sol. Factual

75. The correct order of spin only magnetic moments for the following complex ions is

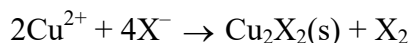
- (1) $[\text{Fe}(\text{CN})_6]^{3-} < [\text{CoF}_6]^{3-} < [\text{MnBr}_4]^{2-} < [\text{Mn}(\text{CN})_6]^{3-}$
(2) $[\text{Fe}(\text{CN})_6]^{3-} < [\text{Mn}(\text{CN})_6]^{3-} < [\text{CoF}_6]^{3-} < [\text{MnBr}_4]^{2-}$
(3) $[\text{MnBr}_4]^{2-} < [\text{CoF}_6]^{3-} < [\text{Fe}(\text{CN})_6]^{3-} < [\text{Mn}(\text{CN})_6]^{3-}$
(4) $[\text{CoF}_6]^{3-} < [\text{MnBr}_4]^{2-} < [\text{Fe}(\text{CN})_6]^{3-} < [\text{Mn}(\text{CN})_6]^{3-}$

Official Ans. by NTA (2)

Unpaired e^-

- Sol.** $[\text{Fe}(\text{CN})_6]^{3-}$ $\text{Fe}^{+3} \Rightarrow t_2g^5 eg^0$, 1
 $[\text{Mn}(\text{CN})_6]^{3-}$ $\text{Mn}^{+3} \Rightarrow t_2g^4 eg^0$, 2
 $[\text{CoF}_6]^{3-}$ $\text{Co}^{+3} \Rightarrow t_2g^4 eg^2$, 4
 $[\text{MnBr}_4]^{2-}$ $\text{Mn}^{+2} \Rightarrow e^2 t_2^3, 5$
Spin magnetic moment $\mu = \sqrt{n(n+2)}$ B.M

76. Which halogen is known to cause the reaction given below:



- (1) Only Iodine (2) Only Bromine
(3) All halogens (4) Only Chlorine

Official Ans. by NTA (1)

Sol. $2\text{Cu}^{2+} + 4\text{I}^- \rightarrow \text{Cu}_2\text{I}_2(\text{s}) + \text{I}_2$

77. Match List-I with List-II :

	List-I (Species)		List-II (Maximum allowed concentration in ppm in drinking water)
A.	F^-	I.	< 50 ppm
B.	SO_4^{2-}	II.	< 5 ppm
C.	NO_3^-	III.	< 2 ppm
D.	Zn	IV.	< 500 ppm

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

Official Ans. by NTA (4)

Sol. Correct answer

A-III, B-IV, C-I, D-II

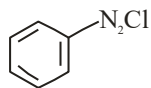
78. The correct order of electronegativity for given elements is:

- (1) $\text{C} > \text{P} > \text{At} > \text{Br}$
(2) $\text{Br} > \text{P} > \text{At} > \text{C}$
(3) $\text{P} > \text{Br} > \text{C} > \text{At}$
(4) $\text{Br} > \text{C} > \text{At} > \text{P}$

Official Ans. by NTA (4)

- Sol.** **Atom** **E.N.**
Br 3.0
C 2.5
At 2.2
P 2.1

79. Match List I with List II:



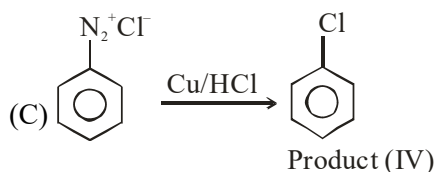
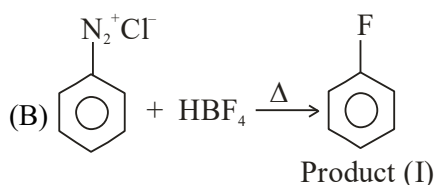
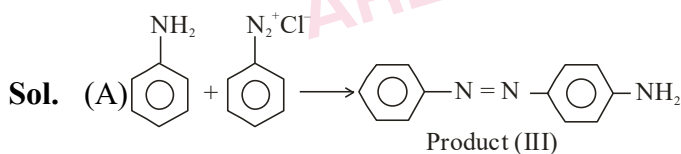
is reacted with reagents in List I to form products in List II.

	List-I (Reagent)		List-II (Product)
A.		I.	
B.	HF ₄ , Δ	II.	
C.	Cu, HCl	III.	
D.	CuCN/KCN	IV.	

Choose the correct answer from the options given below:

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

Official Ans. by NTA (4)



80. Given below are two statements:

Statement I: Lithium and Magnesium do not form superoxide

Statement II: The ionic radius of Li⁺ is larger than ionic radius of Mg²⁺

In the light of the above statements, choose the most appropriate answer from the options given below:

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

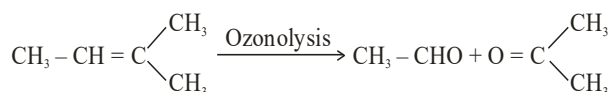
Official Ans. by NTA (3)

Sol. Li & Mg form oxide and order of size Li⁺ > Mg²⁺

SECTION-B

81. Molar mass of the hydrocarbon (X) which on ozonolysis consumes one mole of O₃ per mole of (X) and gives one mole each of ethanal and propanone is _____ g mol⁻¹ (Molar mass of C : 12 g mol⁻¹, H : 1 g mol⁻¹)

Official Ans. by NTA (70)



Sol. Hydrocarbon (X)

Hence molar mass of hydrocarbon (X) is 70.

82. The number of following factors which affect the percent covalent character of the ionic bond is _____

- (a) Polarising power of cation
- (b) Extent of distortion of anion
- (c) Polarisability of the anion
- (d) Polarising power of anion

Official Ans. by NTA (3)

Sol. (a), (b) and (c) are factors which affect the percent covalent character of the ionic bond according to Fajan's rule

83. When a 60 W electric heater is immersed in a gas for 100s in a constant volume container with adiabatic walls, the temperature of the gas rises by 5°C. The heat capacity of the given gas is _____ J K⁻¹ (Nearest integer)

Official Ans. by NTA (1200)

Sol. Power of heater = 60 W
= 60 J/sec

Total energy emitted

$$= 60 \times 100 = 6000 \text{ J}$$

Heat capacity \times temp difference = 6000

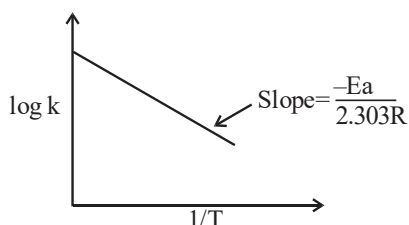
$$\text{Heat capacity} = \frac{6000}{5} = 1200 \text{ JK}^{-1}$$

84. The number of given statement/s which is/are correct is _____
- (A) The stronger the temperature dependence of the rate constant, the higher is the activation energy.
- (B) If a reaction has zero activation energy, its rate is independent of temperature.
- (C) The stronger the temperature dependence of the rate constant, the smaller is the activation energy.
- (D) If there is no correlation between the temperature and the rate constant then it means that the reaction has negative activation energy.

Official Ans. by NTA (2)

Sol. $k = A \cdot e^{-E_a/RT}$

$$\log k = \log A - \underbrace{\frac{E_a}{2.303R}}_m \cdot \frac{1}{T}_x$$

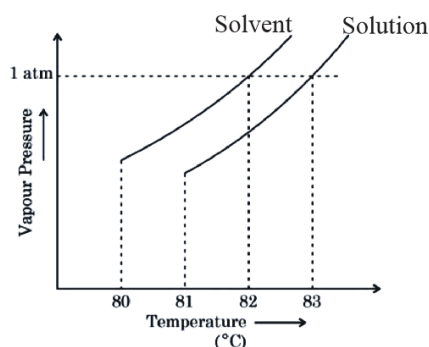


Higher is E_a , stronger is the temperature dependence of k (i.e. steeper the slope)

$$(B) \Rightarrow \frac{1}{k} \frac{dk}{dT} = \frac{E_a}{R} \cdot \frac{1}{T^2}$$

$$\Rightarrow \frac{dk}{dT} = A \times e^{-\frac{E_a}{R}} \cdot \frac{E_a}{RT^2}$$

85. The vapour pressure vs. temperature curve for a solution solvent system is shown below.



The boiling point of the solvent is _____ °C

Official Ans. by NTA (82)

- Sol.** Boiling point of solvent is 82°C
Boiling point of solution is 83°C

86. XeF_4 reacts with SbF_5 to form $[\text{XeF}_m]^{n+} [\text{SbF}_y]^{z-}$
 $m + n + y + z =$ _____

Official Ans. by NTA (11)

Sol. $\text{XeF}_4 + \text{SbF}_5 \rightarrow [\text{XeF}_3]^+ [\text{SbF}_6]^-$

$$m = 3$$

$$n = 1$$

$$y = 6$$

$$z = 1$$

$$m + n + y + z = 11$$

87. 0.5 g of an organic compound (X) with 60% carbon will produce _____ $\times 10^{-1}$ g of CO_2 on complete combustion.

Official Ans. by NTA (11)

Sol. Percentage of Carbon

$$= \frac{12}{44} \times \frac{\text{mass of } \text{CO}_2 \text{ formed}}{\text{mass of compound taken}} \times 100$$

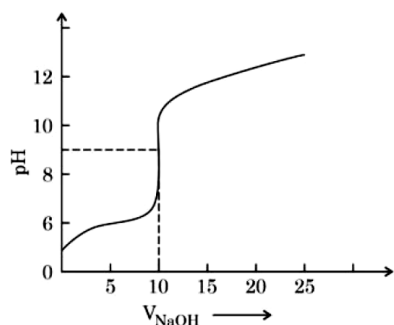
$$60 = \frac{12}{44} \times \frac{\text{mass of } \text{CO}_2 \text{ formed}}{0.5} \times 100$$

$$\text{Mass of } \text{CO}_2 \text{ formed} = \frac{60 \times 44 \times 0.5}{12 \times 100} \text{ g}$$

$$= 1.1 \text{ gram}$$

$$= 11 \times 10^{-1} \text{ gram}$$

88. The titration curve of weak acid vs. strong base with phenolphthalein as indicator) is shown below. The $K_{\text{phenolphthalein}} = 4 \times 10^{-10}$. Given: $\log 2 = 0.3$

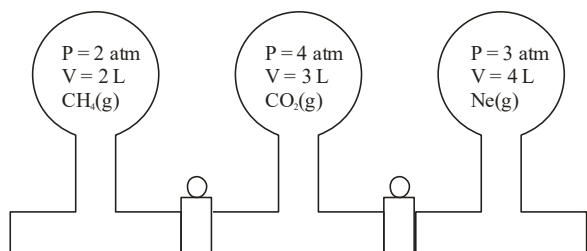


The number of following statements which is/are correct about phenolphthalein is _____

- A. It can be used as an indicator for the titration of weak acid with weak base.
- B. It begins to change colour at $\text{pH} = 8.4$
- C. It is a weak organic base
- D. It is colourless in acidic medium

Official Ans. by NTA (2)

- Sol.** (B) $\text{pk}_{\text{In}} = -\log(4 \times 10^{-10}) = 9.4$
Indicator range
 $\Rightarrow \text{pk}_{\text{In}} \pm 1$
i.e. 8.4 to 10.4
(D) In acidic medium, phenolphthalein is in unionized form and is colourless.



89. Three bulbs are filled with CH_4 , CO_2 and Ne as shown in the picture. The bulbs are connected through pipes of zero volume. When the stopcocks are opened and the temperature is kept constant throughout, the pressure of the system is found to be _____ atm. (Nearest integer)

Official Ans. by NTA (3)

Sol. $P_T V_T = n_T RT$

For CH_4

$$2 \times 2 = n_1 RT$$

$$\Rightarrow n_1 = \frac{4}{RT}$$

For CO_2

$$\Rightarrow n_2 = \frac{12}{RT}$$

For Ne

$$\Rightarrow n_3 = \frac{12}{RT}$$

$$\Rightarrow n_T = \frac{1}{RT} [4 + 12 + 12] = \frac{28}{RT}$$

$$P_T = \frac{28 RT}{RT V_T}$$

$$P_T = \frac{28}{V_T} = 3.11$$

90. The number of following statement/s which is/are incorrect is _____

- (A) Line emission spectra are used to study the electronic structure
- (B) The emission spectra of atoms in the gas phase show a continuous spread of wavelength from red to violet
- (C) An absorption spectrum is like the photographic negative of an emission spectrum
- (D) The element helium was discovered in the sun by spectroscopic method

Official Ans. by NTA (1)

- Sol.** Statement (B) is incorrect.