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

If $\lim\limits_{x\to\infty} I(x)=0$, 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 $\vec{r}=(\hat{i}-\hat{j})+\lambda(\hat{i}+\hat{j}+\hat{k})+\mu(\hat{i}-2\hat{j}+3k)$ 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 $P^TQ^{2007}P=\begin{bmatrix}a & b\\ c & d\end{bmatrix}$, 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 $f(x)=\frac{\sin x+\cos x-\sqrt{2}}{\sin x-\cos x}, x \in [0, \pi]-\left\{\frac{\pi}{}\right\}$.

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

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

$\{(x, y) : x^2 \le y \le 8 - x^2, y \le 7\}$ 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 × 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. $\lim\limits_{x \to 0} \left(\left(\frac{1 - \cos^2(3x)}{\cos^3(4x)} \right) \left(\frac{\sin^3(4x)}{(\log_e(2x+1))^5} \right) \right)$ is equal to _____

(1) 9 (2) 18

(3) 15 (4) 24

Official Ans. by NTA (2)

20. If for $z = \alpha + i\beta, |z+2| = z + 4\ 1 + i$, 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 $\le t$. 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 $\le t$. 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 $\vec{a}.\vec{c} = -12$, $\vec{c}.(\hat{i} - 2\hat{j} + \hat{k}) = 5$, then $\vec{c}.(\hat{i} + \hat{j} + \hat{k})$ 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 $a_n = \frac{n^3}{n^4+147}, n = 1,2,3.....$, then α 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 $R = \{(x, y) \in A \times A : x - y$ 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 $\frac{x-5}{1} = \frac{y-1}{2} = \frac{z+7}{2}$ is ____

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)

SECTION-A

31. A charge particle moving in magnetic field B, has the components of velocity along B as well as perpendicular to B. The path of the charge particle will be

(1) helical path with the axis perpendicular to the direction of magnetic field B

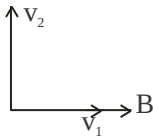
(2) straight along the direction of magnetic field B

(3) helical path with the axis along magnetic field B

(4) circular path

Official Ans. by NTA (3)

Sol.



Due to component v_1,

magnetic force $F = qv_1B\sin\theta=0$

So v_1 remains unchanged

but due to component v_2 magnetic force act towards centre i.e. moving it circular. So path is helical with the axis parallel to magnetic field B.

32. Two projectiles A and B are thrown with initial velocities of 40 m/s and 60 m/s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is (g= 10 m/s^2)

(1) $\sqrt{3}:2$ (2) $2:\sqrt{3}$

(3) 1 : 1 (4) 4 : 9

Official Ans. by NTA (4)

Sol. $R_1 = \dfrac{u_1^2 \sin 2\theta_1}{g}; R_2 = \dfrac{u_2^2 \sin 2\theta_2}{g}$

$$\frac{R_1}{R_2} = \frac{u_1^2}{u_2^2}\frac{\sin 2\theta_1}{\sin 2\theta_2} = \frac{40^2 \sin(2\times 30°)}{60^2 \sin(2\times 60°)} = \frac{4}{9}$$

33. Certain galvanometers have a fixed core made of non magnetic metallic material. The function of this metallic material is

(1) to oscillate the coil in magnetic field for longer period of time

(2) to bring the coil to rest quickly

(3) to produce large deflecting torque on the coil

(4) to make the magnetic field radial

Official Ans. by NTA (2)

Sol. Due to motion of the coil eddy current develops thus bringing the coil to rest.

34. A TV transmitting antenna is 98 m high and the receiving antenna is at the ground level. If the radius of the earth is 6400 km, the surface area covered by the transmitting antenna is approximately:

(1) 1240 km^2 (2) 3942 km^2

(3) 4868 km^2 (4) 1549 km^2

Official Ans. by NTA (2)

Sol. $h_T = 98\text{m}, h_R = 0, R = 6400\,\text{km}$

$$d = \sqrt{2h_T.R} + \sqrt{2h_R.R}$$

$$= \sqrt{2\times 98\times 6400\times 10^3} + 0 = \frac{112}{\sqrt{10}}\,\text{km}$$

So area = πd^2

$$= 3.14\times\frac{112^2}{10} = 3942\,\text{km}^2$$

35. In a reflecting telescope, a secondary mirror is used to:

(1) reduce the problem of mechanical support

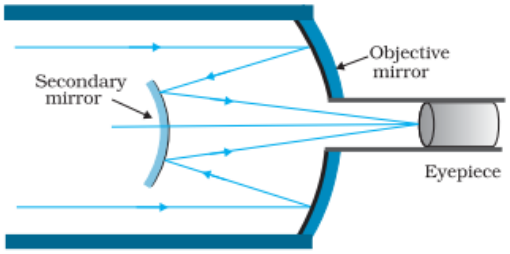
(2) remove spherical aberration

(3) make chromatic aberration zero

(4) move the eyepiece outside the telescopic tube

Official Ans. by NTA (4)

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. $W = mg = 400\ N$

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

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

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

38. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}\ N/m^2$ 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. $Y = 7 \times 10^{10}\ N/m^2$

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

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

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

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

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

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

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

Official Ans. by NTA (1)

Sol. $\vec{v}=2t\,\hat{i}+3t^2\hat{j}$

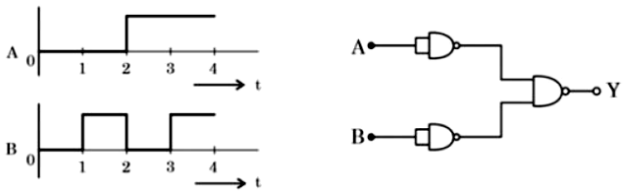
$\vec{a}=2\,\hat{i}+6t\,\hat{j}$

at $t=1, \vec{a}=2\hat{i}+6\hat{j}$

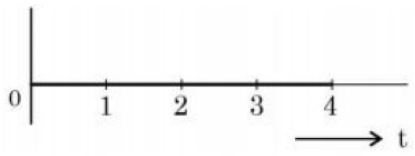
$\vec{F}=m\vec{a}=0.5\left(2\hat{i}+6\hat{j}\right)=\hat{i}+3\hat{j}$

$\vec{F}=\hat{i}+x\,\hat{j}$ Hence x = 3

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



(1)



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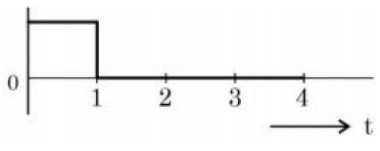

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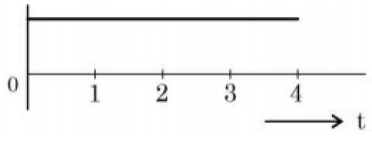

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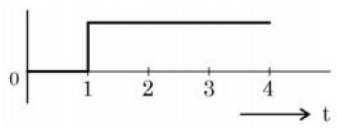
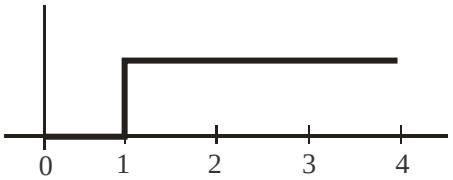


Official Ans. by NTA (4)

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 ${}^{A}_{Z}X$ having mass number A and atomic number Z

A. The surface energy per nucleon $\left(b_s\right)=a_1A^{2/3}$

B. The Coulomb contribution to the binding energy $b_c=-a_2\dfrac{Z(Z-1)}{A^{4/3}}$

C. The volume energy $b_v=a_3A$

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 $\propto\dfrac{r^2}{A}\propto\dfrac{A^{2/3}}{A}\propto\dfrac{1}{A^{1/3}}$

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

A is incorrect

Contribution to binding energy by columbic forces is

$=\dfrac{-a_2Z(Z-1)}{A^{1/3}}$

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 $K = E - U$

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

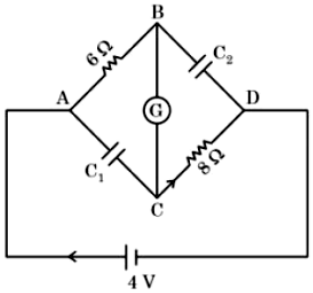
43. Dimension of $\frac{1}{\mu_0 \in_0}$ should be equal to

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

Official Ans. by NTA (3)

Sol. $$\frac{1}{\mu_0 \in_0} = c^2 \Rightarrow \left[\frac{1}{\mu_0 \in_0}\right] = \left[c^2\right] = \left[L^2T^{-2}\right]$$

44. In this figure the resistance of the coil of galvanometer G is 2 Ω. 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

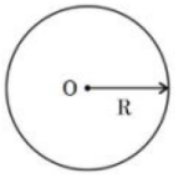
$$V_1 = V_{AC} = i(6\Omega + 2\Omega) = \frac{1}{4} \times 8 = 2V$$

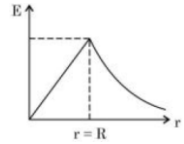
Voltage across C_2 is

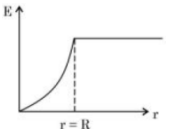
$$V_2 = V_{BD} = i(2\Omega + 8\Omega) = \frac{1}{4} \times 10 = 2.5V$$

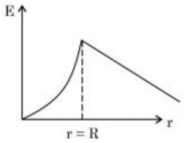
$$\Rightarrow \frac{V_1}{V_2} = \frac{2}{2.5} = \frac{4}{5}$$

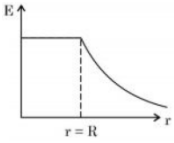
45. Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the centre O is represented by:



(1) 

(2) 

(3) 

(4) 

Official Ans. by NTA (1)

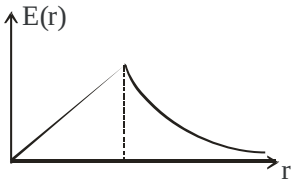
Sol. Electric field of solid sphere (uniformly charged)

$$E(r)\begin{cases}\dfrac{Q}{4\pi\in_0 r^2} & r\geq R\\ \dfrac{Qr}{4\pi\in_0 R^3} & r\leq R\end{cases}$$

Graphically

$E(r)\propto r$ for $r\leq R$

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



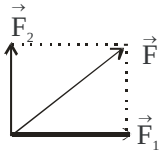
46. Two forces having magnitude A and $\dfrac{A}{2}$ are perpendicular to each other. The magnitude of their resultant is

(1) $\dfrac{\sqrt{5}A}{4}$ (2) $\dfrac{5A}{2}$

(3) $\dfrac{\sqrt{5}A^2}{2}$ (4) $\dfrac{\sqrt{5}A}{2}$

Official Ans. by NTA (4)

Sol.



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

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

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

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) 412 Hz (4) 388 Hz

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 400 Hz.

48. An air bubble of volume $1cm^3$ rises from the bottom of a lake 40m deep to the surface at a temperature of 12ºC. The atmospheric pressure is 1×10^5 Pa, the density of water is 1000 kg/m^3 and g =10m/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. $P=P_0+\rho gh=10^5Pa+10^3\times10\times40=5\times10^5Pa$

At T is constant

$PV=P_0V_0$

$\Rightarrow\ 5\times10^5Pa\times1cm^3=10^5Pa\times V_0\Rightarrow V_0=5cm^3$

49. A cylindrical wire of mass $(0.4\pm0.01)g$ has length $(8\pm0.04)cm$ and radius $(6\pm0.03)mm$. The maximum error in its density will be

(1) 1% (2) 3.5 %

(3) 4% (4) 5%

Official Ans. by NTA (3)

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

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

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

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

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

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

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

Official Ans. by NTA (4)

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

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

SECTION-B

51. An electric dipole of dipole moment is 6.0×10^{-6} Cm placed in a uniform electric field of 1.5×10^3 NC^{-1} in such a way that dipole moment is along electric field. The work done in rotating dipole by 180º in this field will be _____mJ

Official Ans. by NTA (18)

Sol. The work done in rotating the electric dipole = ΔU

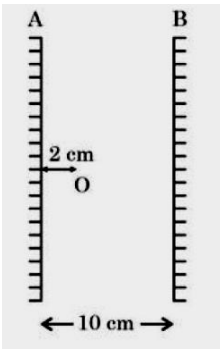
$= U_f - U_i$

$= (-pE\cos(180°)) - (-pE\cos(0°))$

$= pE + pE = 2pE$

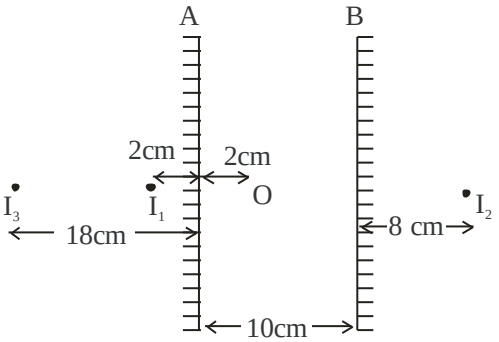
$= 2 \times 6 \times 10^{-6} \times 1.5 \times 10^3 = 18$mJ

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 $= \dfrac{p^2}{2m}$

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

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

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

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

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)

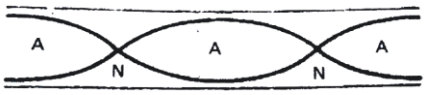
Sol. The moment of inertia of semicircular ring about axis passing through centre of ring and perpendicular to plane of ring is = MR^2

so x = 1

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

Official Ans. by NTA (900)

Sol.



For second harmonic of open organ pipe

$L = \lambda$

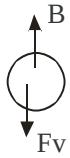
So frequency of vibration is $f = \frac{V}{\lambda}$

$$f = \frac{V}{\lambda} = \frac{V}{L} = \frac{360}{\frac{40}{100}} = 900\,Hz$$

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

Official Ans. by NTA (10)

Sol.



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

$B = F_V$

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

$$\eta = \frac{2R^2\rho g}{9v} = \frac{2\times\left(3\times10^{-3}\right)^2\times1750\times10}{9\times0.35\times10^{-2}} = 10\,Pas$$

57. An oscillating LC circuit consists of a 75 mH inductor and a $1.2\mu F$ capacitor. If the maximum charge to the capacitor is $2.7\mu C$. 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.

$$\frac{1}{2}Li_{max}^2 = \frac{1}{2}\frac{Q_{max}^2}{C}$$

$$i_{max} = \sqrt{\frac{1}{LC}}Q_{max}$$

$$= \frac{2.7\times10^{-6}}{\sqrt{75\times10^{-3}\times1.2\times10^{-6}}} = 9\,mA$$

58. The magnetic intensity at the centre of a long current carrying solenoid is found to be $1.6\times10^3\,Am^{-1}$. If the number of turns is 8 per cm, then the current flowing through the solenoid is_____A.

Official Ans. by NTA (2)

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

$$i = \frac{H}{n} = \frac{1.6\times10^3}{\left(\frac{8}{10^{-2}}\right)} = 2A$$

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 $\_\_\_\_\_\times10^{-6}ms^{-1}$ (given, charge on electron $=1.6\times10^{-19}C$)

Official Ans. by NTA (25)

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

$=\frac{2}{2\times10^{28}\times1.6\times10^{-19}\times25\times10^{-6}}$

$=25\times10^{-6}ms^{-1}$

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 ____MeV

Official Ans. by NTA (121)

Sol. Initial binding energy = 242 × 7.6 MeV

Final binding energy

= 121 × 8.1 MeV + 121 × 8.1 MeV

= 242×8.1 MeV

Total gain in binding energy

= 242 (8.1 – 7.6) = 121 MeV

SECTION-A

61. $2IO_3^- + xI^- + 12H^+ \rightarrow 6I_2 + 6H_2O$

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

$2 + x = 6 \times 2$

$X = 10$

$2IO_3^- + 10I^- + 12H^+ \rightarrow 6I_2 + 6H_2O$

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

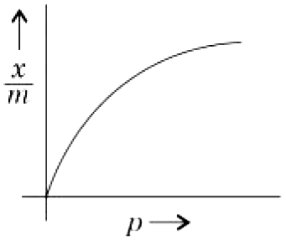
(B) Aspartame IV. Unstable at cooking temperature

(C) Alitame I. High potency sweetener

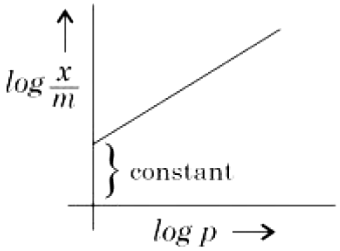
(D) Sucralose III. Stable at cooking temperature

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

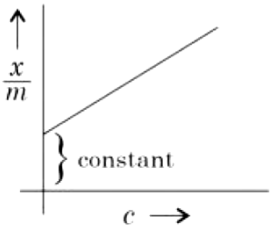
(A)



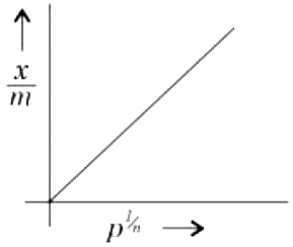
(B)



(C)



(D)



Choose the correct answer from the options given below:

(1) B, C, D only (2) A, B, D only

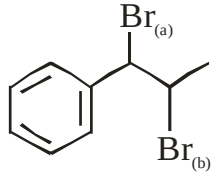
(3) A, B only (4) A, C, D only

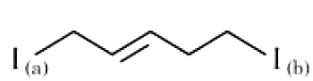
Official Ans. by NTA (2)

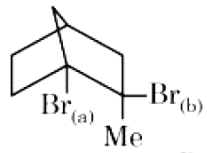
Sol. $\frac{x}{m} = k\ p^{1/n}$

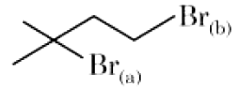
and $\log\frac{x}{m} = \log k + \frac{1}{n}\log P$

65. Choose the halogen which is most reactive towards SN1 reaction in the given compounds (A, B, C & D)

A. 

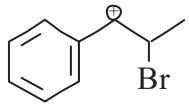
B. 

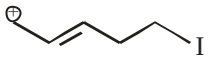
C. 

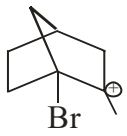
D. 

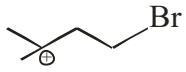
(1) A-$Br_{(b)}$; B-$I_{(b)}$; C-$Br_{(b)}$; D-$Br_{(b)}$
(2) A-$Br_{(a)}$; B-$I_{(a)}$; C-$Br_{(b)}$; D-$Br_{(a)}$
(3) A-$Br_{(b)}$; B-$I_{(a)}$; C-$Br_{(a)}$; D-$Br_{(a)}$
(4) A-$Br_{(b)}$; B-$I_{(a)}$; C-$Br_{(a)}$; D-$Br_{(a)}$
Official Ans. by NTA (2)

Sol. Stable is the carbocation, faster will be rate of SN1 reaction

(A)  (Benzylic carbocation)

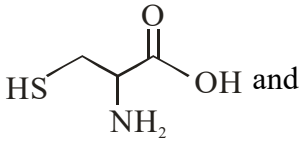
(B)  (Allylic carbocation)

(C)  (Non bridgehead tertiary carbocation)

(D)  (Tertiary carbocation)

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

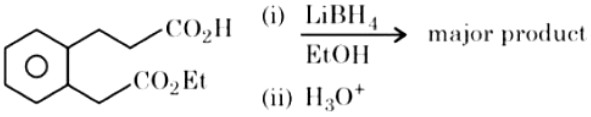
(b) cysteine  and

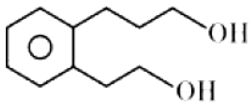
(d) methionine $CH_3–S–CH_2–CH_2–\underset{\underset{NH_2}{|}}{CH}–\overset{\overset{O}{||}}{C}–OH$.

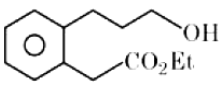
67. The water gas on reacting with cobalt as a catalyst forms
(1) Ethanol (2) Methanoic acid
(3) Methanal (4) Methanol
Official Ans. by NTA (4)

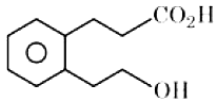
Sol. $CO + 2H_2 \xrightarrow{Co} CH_3OH$

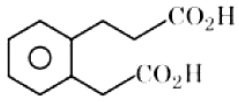
68. The major product formed in the following reaction is:



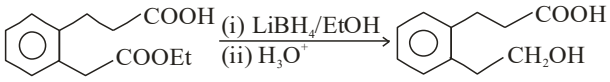
(1) 

(2) 

(3) 

(4) 

Official Ans. by NTA (3)

Sol. 

$LiBH_4$ 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)

Sol. $Co^{+3} = t_2g^6\ eg^0$
CN^- -strong field ligand
All d-electrons should be paired ($\mu_s = 0$)
Hence diamagnetic.

70. The reaction

$$\frac{1}{2}H_2(g) + AgCl(s) \rightleftharpoons H^+(aq) + Cl^-(aq) + Ag(s)$$

occurs in which of the given galvanic cell.

(1) $Pt\left|H_2(g)\right|KCl(sol^n)\left|AgCl(s)\right|Ag$

(2) $Pt\left|H_2(g)\right|HCl(sol^n)\left|AgCl(s)\right|Ag$

(3) $Ag\left|AgCl(s)\right|KCl(sol^n)\left|AgCl(s)\right|Ag$

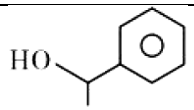
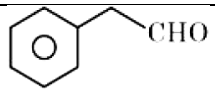
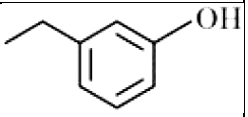
(4) $Pt\left|H_2(g)\right|HCl(sol^n)\left|AgNO_3(sol^n)\right|Ag$

Official Ans. by NTA (2)

Sol. $\text{Anode}: \frac{1}{2}H_2(g) \rightleftharpoons H^+(aq) + e^-$

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

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

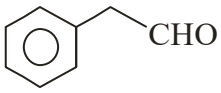
(2) A-IV, B-I, C-II, D-III

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

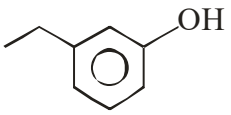
(4) A-III, B-IV, C-II, D-I

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.

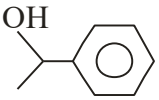


B. Neutral $FeCl_3$ solution is used to test phenolic compound (IV) i.e.



C. Alkaline chloroform solution is used to test primary amines (II) i.e.

D. $2KI + NaOCl + H_2O \rightarrow NaCl + I_2 + 2KOH$

Potassium iodide and sodium hypochlorite gives (I_2 + KOH) which is used to test those compounds which have $CH_3-\overset{\overset{O}{\|}}{C}-$ or $CH_3-\overset{\overset{OH}{|}}{CH}-$ group (iodoform test). Hence the compound is (I)  .

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 ($CH_3CH_2CH_2CH_2OH$) can undergo hydrogen bonding. Ethoxyethane ($CH_3CH_2-O-CH_2CH_3$) 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

Cr (VI) = $[Ar]^{18}\ 3d^0$

Mn(VII) = $[Ar]^{18}\ 3d^0$

Fe(III) = $[Ar]^{18}\ 3d^5$

Ti(III) = $[Ar]^{18}\ 3d^1$

V(IV) = $[Ar]^{18}\ 3d^1$

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) $[Fe(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-} < [Mn(CN)_6]^{3-}$

(2) $[Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-}$

(3) $[MnBr_4]^{2-} < [CoF_6]^{3-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$

(4) $[CoF_6]^{3-} < [MnBr_4]^{2-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$

Official Ans. by NTA (2)

			Unpaired e^-
Sol.	$[Fe(CN)_6]^{3-}$	$Fe^{+3} \Rightarrow t_2g^5\ eg^0$,	1
	$[Mn(CN)_6]^{3-}$	$Mn^{+3} \Rightarrow t_2g^4\ eg^0$,	2
	$[CoF_6]^{3-}$	$Co^{+3} \Rightarrow t_2g^4\ eg^2$,	4
	$[MnBr_4]^{2-}$	$Mn^{+2} \Rightarrow e^2\ t_2^3$,	5

Spin magnetic moment $\mu = \sqrt{n(n+2)}$ B.M

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

$$2Cu^{2+} + 4X^- \rightarrow Cu_2X_2(s) + X_2$$

(1) Only Iodine (2) Only Bromine

(3) All halogens (4) Only Chlorine

Official Ans. by NTA (1)

Sol. $2Cu^{2+} + 4I^- \rightarrow Cu_2I_2(s) + I_2$

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) C > P > At > Br

(2) Br > P > At > C

(3) P > Br > C > At

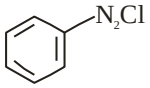
(4) Br > C > At > P

Official Ans. by NTA (4)

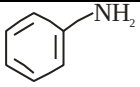
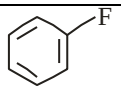
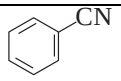
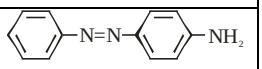
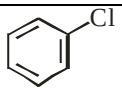
Sol.

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.	HBF_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

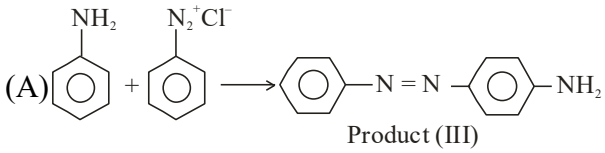
(2) A-I, B-III, C-IV, D-II

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

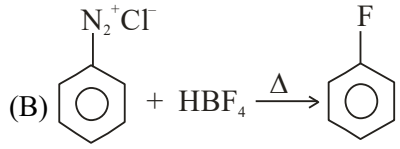
(4) A-III, B-I, C-IV, D-II

Official Ans. by NTA (4)

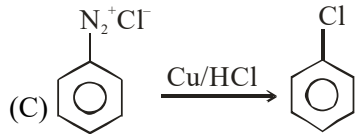
Sol.



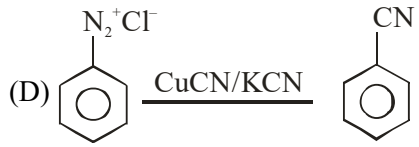
Product (III)



Product (I)



Product (IV)



Product (II)

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 Mg^{2+}

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)

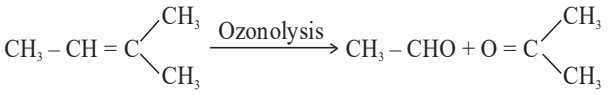
Sol. Li & Mg form oxide and order of size $Li^+ > Mg^{2+}$

SECTION-B

81. Molar mass of the hydrocarbon (X) which on ozonolysis consumes one mole of O_3 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_____JK^{-1} (Nearest integer)

Official Ans. by NTA (1200)

Sol. Power of heater = 60 W

= 60 J/sec

Total energy emitted

= 60 × 100 = 6000 J

Heat capacity × temp difference = 6000

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

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.

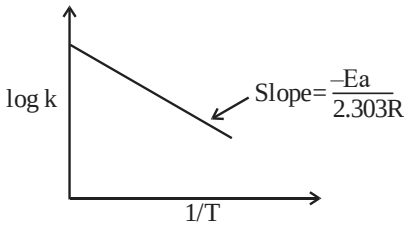
(C) The stronger the temperature dependence of the rate constant, the smaller is the activation energy.

(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. $k = A.e^{-Ea/RT}$

$$\underset{y}{\log k} = \underset{C}{\log A} - \underbrace{\frac{Ea}{2.303R}}_{m}.\underset{x}{\frac{1}{T}}$$

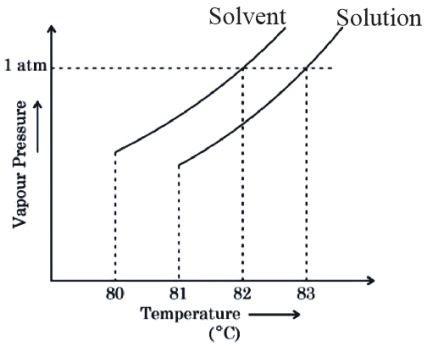


Higher is Ea, stronger is the temperature dependence of k (i.e. steeper the slope)

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

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

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 82ºC

Boiling point of solution is 83ºC

86. XeF_4 reacts with SbF_5 to form

$[XeF_m]^{n+}[SbF_y]^{z-}$

m + n + y + z = _____

Official Ans. by NTA (11)

Sol. $XeF_4 + SbF_5 \rightarrow [XeF_3]^+[SbF_6]^-$

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

$$= \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{\text{mass of compound taken}} \times 100$$

$$60 = \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{0.5} \times 100$$

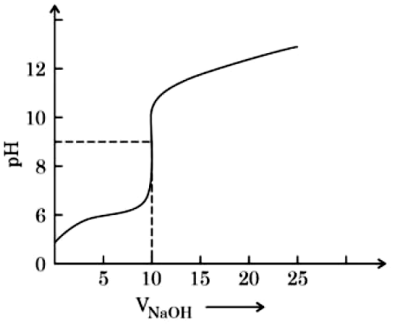
$$\text{Mass of } CO_2 \text{ formed} = \frac{60 \times 44 \times 0.5}{12 \times 100} g$$

= 1.1 gram

= 11 × 10^{-1} gram

88. The titration curve of weak acid vs. strong base with phenolphthalein as indictor) is shown below. The $K_{phenolphthalein} = 4 \times 10^{-10}$.

Given: log2 = 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 pH = 8.4

C. It is a weak organic base

D. It is colourless in acidic medium

Official Ans. by NTA (2)

Sol. (B) $pk_{In} = -\log(4 \times 10^{-10}) = 9.4$

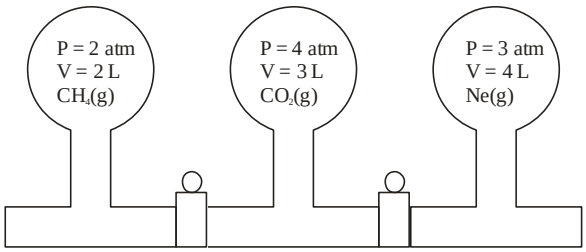
Indicator range

$\Rightarrow pk_{In} \pm 1$

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. $P_TV_T = n_TRT$

For CH_4

$2 \times 2 = n_1RT$

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

For CO_2

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

For Ne

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

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

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

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

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.