## FINAL JEE-MAIN EXAMINATION - AUGUST, 2021

(Held On Tuesday 31st August, 2021)
TIME : 3:00 PM to 6:00 PM

## PHYSICS

## SECTION-A

1. Four identical hollow cylindrical columns of mild steel support a big structure of mass $50 \times 10^{3} \mathrm{~kg}$, The inner and outer radii of each column are 50 cm and 100 cm respectively. Assuming uniform local distribution, calculate the compression strain of each column. [Use $\mathrm{Y}=2.0 \times 10^{11} \mathrm{~Pa}, \mathrm{~g}=9.8 \mathrm{~m} / \mathrm{s}^{2}$ ]
(1) $3.60 \times 10^{-8}$
(2) $2.60 \times 10^{-7}$
(3) $1.87 \times 10^{-3}$
(4) $7.07 \times 10^{-4}$

Official Ans. by NTA (2)
Sol. $\quad$ Force on each column $=\frac{\mathrm{mg}}{4}$

$$
\begin{aligned}
\text { Strain } & =\frac{\mathrm{mg}}{4 \mathrm{AY}} \\
& =\frac{50 \times 10^{3} \times 9.8}{4 \times \pi(1-0.25) \times 2 \times 10^{11}} \\
& =2.6 \times 10^{-7}
\end{aligned}
$$

2. A current of 1.5 A is flowing through a triangle, of side 9 cm each. The magnetic field at the centroid of the triangle is :
(Assume that the current is flowing in the clockwise direction.)
(1) $3 \times 10^{-7} \mathrm{~T}$, outside the plane of triangle
(2) $2 \sqrt{3} \times 10^{-7} \mathrm{~T}$, outside the plane of triangle
(3) $2 \sqrt{3} \times 10^{-5} \mathrm{~T}$, inside the plane of triangle
(4) $3 \times 10^{-5} \mathrm{~T}$, inside the plane of triangle

Official Ans. by NTA (4)

Sol.


TEST PAPER WITH SOLUTION
$B=3\left[\frac{\mu_{0} \mathrm{i}}{4 \pi \mathrm{r}}\left(\sin 60^{\circ}+\sin 60^{\circ}\right)\right]$
$\tan 60^{\circ}=\frac{\ell / 2}{\mathrm{r}}$
Where $\mathrm{r}=\frac{9 \times 10^{-2}}{2 \sqrt{3}} \mathrm{M}$
$\therefore \mathrm{B}=3 \times 10^{-5} \mathrm{~T}$
Current is flowing in clockwise direction so, $\overrightarrow{\mathrm{B}}$ is inside plane of triangle by right hand rule.
3. A system consists of two identical spheres each of mass 1.5 kg and radius 50 cm at the end of light rod. The distance between the centres of the two spheres is 5 m . What will be the moment of inertia of the system about an axis perpendicular to the rod passing through its midpoint?
(1) $18.75 \mathrm{kgm}^{2}$
(2) $1.905 \times 10^{5} \mathrm{kgm}^{2}$
(3) $19.05 \mathrm{kgm}^{2}$
(4) $1.875 \times 10^{5} \mathrm{kgm}^{2}$

Official Ans. by NTA (3)

$\mathrm{M}=1.5 \mathrm{~kg}, \mathrm{r}=0.5 \mathrm{~m}, \mathrm{~d}=\frac{5}{2} \mathrm{~m}$
$\mathrm{I}=2\left(\frac{2}{5} \mathrm{Mr}^{2}+\mathrm{Md}^{2}\right)$
$=19.05 \mathrm{kgm}^{2}$
4. Statement I :

Two forces $(\overrightarrow{\mathrm{P}}+\overrightarrow{\mathrm{Q}})$ and $(\overrightarrow{\mathrm{P}}-\overrightarrow{\mathrm{Q}})$ where $\overrightarrow{\mathrm{P}} \perp \overrightarrow{\mathrm{Q}}$, when act at an angle $\theta_{1}$ to each other, the magnitude of their resultant is $\sqrt{3\left(\mathrm{P}^{2}+\mathrm{Q}^{2}\right)}$, when they act at an angle $\theta_{2}$, the magnitude of their resultant becomes $\sqrt{2\left(\mathrm{P}^{2}+\mathrm{Q}^{2}\right)}$. This is possible only when $\theta_{1}<\theta_{2}$.

## Statement II :

In the situation given above.
$\theta_{1}=60^{\circ}$ and $\theta_{2}=90^{\circ}$
In the light of the above statements, choose the most appropriate answer from the options given below :-
(1) Statement-I is false but Statement-II is true
(2) Both Statement-I and Statement-II are true
(3) Statement-I is true but Statement-II is false
(4) Both Statement-I and Statement-II are false.

Official Ans. by NTA (2)
Sol. $\overrightarrow{\mathrm{A}}=\overrightarrow{\mathrm{P}}+\overrightarrow{\mathrm{Q}}$
$\overrightarrow{\mathrm{B}}=\overrightarrow{\mathrm{P}}-\overrightarrow{\mathrm{Q}} \quad \overrightarrow{\mathrm{P}} \perp \overrightarrow{\mathrm{Q}}$
$|\overrightarrow{\mathrm{A}}|=|\overrightarrow{\mathrm{B}}|=\sqrt{\mathrm{P}^{2}+\mathrm{Q}^{2}}$
$|\overrightarrow{\mathrm{A}}+\overrightarrow{\mathrm{B}}|=\sqrt{2\left(\mathrm{P}^{2}+\mathrm{Q}^{2}\right)(1+\cos \theta)}$
For $|\overrightarrow{\mathrm{A}}+\overrightarrow{\mathrm{B}}|=\sqrt{3\left(\mathrm{P}^{2}+\mathrm{Q}^{2}\right)}$
$\theta_{1}=60^{\circ}$
For $|\overrightarrow{\mathrm{A}}+\overrightarrow{\mathrm{B}}|=\sqrt{2\left(\mathrm{P}^{2}+\mathrm{Q}^{2}\right)}$
$\theta_{2}=90^{\circ}$
5. A free electron of 2.6 eV energy collides with a $\mathrm{H}^{+}$ion. This results in the formation of a hydrogen atom in the first excited state and a photon is released. Find the frequency of the emitted photon. ( $\mathrm{h}=6.6 \times 10^{-34} \mathrm{Js}$ )
(1) $1.45 \times 10^{16} \mathrm{MHz}$
(2) $0.19 \times 10^{15} \mathrm{MHz}$
(3) $1.45 \times 10^{9} \mathrm{MHz}$
(4) $9.0 \times 10^{27} \mathrm{MHz}$

Official Ans. by NTA (3)

Sol. For every large distance P.E. $=0$
\& total energy $=2.6+0=2.6 \mathrm{eV}$
Finally in first excited state of H atom total energy $=-3.4 \mathrm{eV}$
Loss in total energy $=2.6-(-3.4)$

$$
=6 \mathrm{eV}
$$

It is emitted as photon
$\lambda=\frac{1240}{6}=206 \mathrm{~nm}$

$$
\begin{aligned}
\mathrm{f}=\frac{3 \times 10^{8}}{206 \times 10^{-9}} & =1.45 \times 10^{15} \mathrm{~Hz} \\
& =1.45 \times 10^{9} \mathrm{~Hz}
\end{aligned}
$$

6. Two thin metallic spherical shells of radii $r_{1}$ and $r_{2}$ ( $\mathrm{r}_{1}<\mathrm{r}_{2}$ ) are placed with their centres coinciding. A material of thermal conductivity K is filled in the space between the shells. The inner shell is maintained at temperature $\theta_{1}$ and the outer shell at temperature $\theta_{2}\left(\theta_{1}<\theta_{2}\right)$. The rate at which heat flows radially through the material is :-
(1) $\frac{4 \pi \mathrm{Kr}_{1} \mathrm{r}_{2}\left(\theta_{2}-\theta_{1}\right)}{\mathrm{r}_{2}-\mathrm{r}_{1}}$
(2) $\frac{\pi r_{1} r_{2}\left(\theta_{2}-\theta_{1}\right)}{\mathrm{r}_{2}-\mathrm{r}_{1}}$
(3) $\frac{K\left(\theta_{2}-\theta_{1}\right)}{r_{2}-r_{1}}$
(4) $\frac{K\left(\theta_{2}-\theta_{1}\right)\left(r_{2}-r_{1}\right)}{4 \pi r_{1}}$

Official Ans. by NTA (1)

Sol.


Thermal resistance of spherical sheet of thickness dr and radius r is
$d R=\frac{d r}{K\left(4 \pi r^{2}\right)}$
$\mathrm{R}=\int_{\mathrm{r}_{1}}^{\mathrm{r}} \frac{\mathrm{dr}}{\mathrm{K}\left(4 \pi \mathrm{r}^{2}\right)}$
$\mathrm{R}=\frac{1}{4 \pi \mathrm{~K}}\left(\frac{1}{\mathrm{r}_{1}}-\frac{1}{\mathrm{r}_{2}}\right)=\frac{1}{4 \pi \mathrm{~K}}\left(\frac{\mathrm{r}_{2}-\mathrm{r}_{1}}{\mathrm{r}_{1} \mathrm{r}_{2}}\right)$
Thermal current $(\mathrm{i})=\frac{\theta_{2}-\theta_{1}}{\mathrm{R}}$
$\mathrm{i}=\frac{4 \pi \mathrm{Kr}_{1} \mathrm{r}_{2}}{\mathrm{r}_{2}-\mathrm{r}_{1}}\left(\theta_{2}-\theta_{1}\right)$
7. If $\mathrm{V}_{\mathrm{A}}$ and $\mathrm{V}_{\mathrm{B}}$ are the input voltages (either 5 V or 0 V ) and $\mathrm{V}_{\mathrm{o}}$ is the output voltage then the two gates represented in the following circuit (A) and (B) are:-

(1) AND and OR Gate
(2) OR and NOT Gate
(3) NAND and NOR Gate
(4) AND and NOT Gate

Official Ans. by NTA (2)
Sol. $\mathrm{V}_{\mathrm{A}}=5 \mathrm{~V} \quad \Rightarrow \quad \mathrm{~A}=1$
$\mathrm{V}_{\mathrm{A}}=0 \mathrm{~V} \quad \Rightarrow \quad \mathrm{~A}=0$
$\mathrm{V}_{\mathrm{B}}=5 \mathrm{~V} \quad \Rightarrow \quad \mathrm{~B}=1$
$\mathrm{V}_{\mathrm{B}}=0 \mathrm{~V} \quad \Rightarrow \quad \mathrm{~B}=0$
If $\mathrm{A}=\mathrm{B}=0$, there is no potential anywhere here
$\mathrm{V}_{0}=0$
If $\mathrm{A}=1, \mathrm{~B}=0$, Diode $\mathrm{D}_{1}$ is forward biased, here $\mathrm{V}_{0}=5 \mathrm{~V}$
If $\mathrm{A}=0, \mathrm{~B}=1$, Diode $\mathrm{D}_{2}$ is forward biased hence $\mathrm{V}_{0}=5 \mathrm{~V}$
If $\mathrm{A}=1, \mathrm{~B}=1$, Both diodes are forward biased hence $\mathrm{V}_{0}=5 \mathrm{~V}$
Truth table for $\mathrm{I}^{\text {st }}$

| A | B | Output |
| :--- | :--- | :--- |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

$\therefore$ Given circuit is OR gate
For $\mathrm{II}^{\text {nd }}$ circuit
$\mathrm{V}_{\mathrm{B}}=5 \mathrm{~V}, \quad \mathrm{~A}=1$
$\mathrm{V}_{\mathrm{B}}=0 \mathrm{~V}, \quad \mathrm{~A}=0$
When $\mathrm{A}=0, \mathrm{E}-\mathrm{B}$ junction is unbiased there is no current through it
$\therefore \mathrm{V}_{0}=1$
When $\mathrm{A}=1, \mathrm{E}-\mathrm{B}$ junction is forward biased

$$
\mathrm{V}_{0}=0
$$

$\therefore$ Hence this circuit is not gate.
8. Consider two separate ideal gases of electrons and protons having same number of particles. The temperature of both the gases are same. The ratio of the uncertainty in determining the position of an electron to that of a proton is proportional to :-
(1) $\left(\frac{m_{p}}{m_{e}}\right)^{3 / 2}$
(2) $\sqrt{\frac{m_{e}}{m_{p}}}$
(3) $\sqrt{\frac{m_{p}}{m_{e}}}$
(4) $\frac{m_{p}}{m_{e}}$

Official Ans. by NTA (3)
Sol. $\Delta x . \Delta p \geq \frac{h}{4 \pi}$
$\Delta \mathrm{x}=\frac{\mathrm{h}}{4 \pi \mathrm{~m} \Delta \mathrm{v}} \quad \mathrm{v}=\sqrt{\frac{3 \mathrm{KT}}{\mathrm{m}}}$
$\frac{\Delta \mathrm{x}_{\mathrm{e}}}{\Delta \mathrm{x}_{\mathrm{p}}}=\sqrt{\frac{\mathrm{m}_{\mathrm{p}}}{\mathrm{m}_{\mathrm{e}}}}$
9. A bob of mass ' $m$ ' suspended by a thread of length $l$ undergoes simple harmonic oscillations with time period T. If the bob is immersed in a liquid that has density $\frac{1}{4}$ times that of the bob and the length of the thread is increased by $1 / 3^{\text {rd }}$ of the original length, then the time period of the simple harmonic oscillations will be :-
(1) T
(2) $\frac{3}{2} \mathrm{~T}$
(3) $\frac{3}{4} \mathrm{~T}$
(4) $\frac{4}{3} \mathrm{~T}$

Official Ans. by NTA (4)
Sol. $\mathrm{T}=2 \pi \sqrt{\ell / \mathrm{g}}$
When bob is immersed in liquid
$m g_{\text {eff }}=m g-$ Buoyant force
$\mathrm{mg}_{\text {eff }}=\mathrm{mg}-\mathrm{v} \sigma \mathrm{g} \quad(\sigma=$ density of liquid $)$

$$
=m g-v \frac{\rho}{4} g
$$

$$
=\mathrm{mg}-\frac{\mathrm{mg}}{4}=\frac{3 \mathrm{mg}}{4}
$$

$\therefore \mathrm{g}_{\text {eff }}=\frac{3 \mathrm{~g}}{4}$
$\mathrm{T}_{1}=2 \pi \sqrt{\frac{\ell_{1}}{\mathrm{~g}_{\text {eff }}}}$
$\ell_{1}=\ell+\frac{\ell}{3}=\frac{4 \ell}{3}, \quad \ell_{\text {eff }}=\frac{3 \mathrm{~g}}{4}$
By solving
$\mathrm{T}_{1}=\frac{4}{3} 2 \pi \sqrt{\ell / \mathrm{g}}$
$\mathrm{T}_{1}=\frac{4 \mathrm{~T}}{3}$
10. Statement :1

If three forces $\overrightarrow{\mathrm{F}}_{1}, \overrightarrow{\mathrm{~F}}_{2}$ and $\overrightarrow{\mathrm{F}}_{3}$ are represented by three sides of a triangle and $\overrightarrow{\mathrm{F}}_{1}+\overrightarrow{\mathrm{F}}_{2}=-\overrightarrow{\mathrm{F}}_{3}$, then these three forces are concurrent forces and satisfy the condition for equilibrium.

## Statement : II

A triangle made up of three forces $\vec{F}_{1}, \vec{F}_{2}$ and $\vec{F}_{3}$ as its sides taken in the same order, satisfy the condition for translatory equilibrium.

In the light of the above statements, choose the most appropriate answer from the options given below:
(1) Statement-I is false but Statement-II is true
(2) Statement-I is true but Statement-II is false
(3) Both Statement-I and Statement-II are false
(4) Both Statement-I and Statement-II are true.

Official Ans. by NTA (4)

Sol.


Here $\overrightarrow{\mathrm{F}}_{1}+\overrightarrow{\mathrm{F}}_{2}+\overrightarrow{\mathrm{F}}_{3}=0$

$$
\overrightarrow{\mathrm{F}}_{1}+\overrightarrow{\mathrm{F}}_{2}=-\overrightarrow{\mathrm{F}}_{3}
$$

Since $\overrightarrow{\mathrm{F}}_{\text {net }}=0$ (equilibrium)
Both statements correct
11. If velocity [V], time [T] and force [F] are chosen as the base quantities, the dimensions of the mass will be :
(1) $\left[\mathrm{FT}^{-1} \mathrm{~V}^{-1}\right]$
(2) $\left[\mathrm{FTV}^{-1}\right]$
(3) $\left[\mathrm{FT}^{2} \mathrm{~V}\right]$
(4) $\left[\mathrm{FVT}^{-1}\right]$

Official Ans. by NTA (2)
Sol. $[\mathrm{M}]=\mathrm{K}[\mathrm{F}]^{\mathrm{a}}[\mathrm{T}]^{\mathrm{b}}[\mathrm{V}]^{\mathrm{c}}$
$\left[\mathrm{M}^{1}\right]=\left[\mathrm{M}^{1} \mathrm{~L}^{1} \mathrm{~T}^{-2}\right]^{\mathrm{a}}\left[\mathrm{T}^{1}\right]^{\mathrm{b}}\left[\mathrm{L}^{1} \mathrm{~T}^{-1}\right]^{\mathrm{c}}$
$\mathrm{a}=1, \mathrm{~b}=1, \mathrm{c}=-1$
$\therefore[\mathrm{M}]=\left[\mathrm{FTV}^{-1}\right]$
12. The magnetic field vector of an electromagnetic wave is given by $B=B_{o} \frac{\hat{\mathrm{i}}+\hat{\mathrm{j}}}{\sqrt{2}} \cos (k z-\omega t)$; where $\hat{\mathrm{i}}, \hat{\mathrm{j}}$ represents unit vector along x and y -axis respectively. At $t=0 \mathrm{~s}$, two electric charges $\mathrm{q}_{1}$ of $4 \pi$ coulomb and $\mathrm{q}_{2}$ of $2 \pi$ coulomb located at $\left(0,0, \frac{\pi}{\mathrm{k}}\right)$ and $\left(0,0, \frac{3 \pi}{\mathrm{k}}\right)$, respectively, have the same velocity of $0.5 \mathrm{c} \hat{\mathrm{i}}$, (where c is the velocity of light). The ratio of the force acting on charge $\mathrm{q}_{1}$ to $\mathrm{q}_{2}$ is :-
(1) $2 \sqrt{2}: 1$
(2) $1: \sqrt{2}$
(3) $2: 1$
(4) $\sqrt{2}: 1$

Official Ans. by NTA (3)
Sol. $\vec{F}=q(\vec{V} \times \vec{B})$
$\overrightarrow{\mathrm{F}}_{1}=4 \pi\left[0.5 \mathrm{c} \hat{\mathrm{i}} \times \mathrm{B}_{0}\left(\frac{\hat{\mathrm{i}}+\hat{\mathrm{j}}}{2}\right) \cos \left(\mathrm{K} \cdot \frac{\pi}{\mathrm{K}}-0\right)\right]$
$\overrightarrow{\mathrm{F}}_{2}=2 \pi\left[0.5 \mathrm{c} \hat{\mathrm{i}} \times \mathrm{B}_{0}\left(\frac{\hat{\mathrm{i}}+\hat{\mathrm{j}}}{2}\right) \cos \left(\mathrm{K} \cdot \frac{3 \pi}{\mathrm{~K}}-0\right)\right]$
$\cos \pi=-1, \quad \cos 3 \pi=-1$
$\therefore \frac{\mathrm{F}_{1}}{\mathrm{~F}_{2}}=2$
13. The equivalent resistance of the given circuit between the terminals A and B is :

(1) $0 \Omega$
(2) $3 \Omega$
(3) $\frac{9}{2} \Omega$
(4) $1 \Omega$

Official Ans. by NTA (4)

Sol.

$\mathrm{R}_{\mathrm{eq}}=\frac{3 \times 3 / 2}{3+3 / 2}=\frac{9 / 2}{9 / 2}=1 \Omega$
14. Choose the incorrect statement :
(a) The electric lines of force entering into a Gaussian surface provide negative flux.
(b) A charge ' $q$ ' is placed at the centre of a cube. The flux through all the faces will be the same.
(c) In a uniform electric field net flux through a closed Gaussian surface containing no net charge, is zero.
(d) When electric field is parallel to a Gaussian surface, it provides a finite non-zero flux.

Choose the most appropriate answer from the options given below
(1) (c) and (d) only
(2) (b) and (d) only
(3) (d) only
(4) (a) and (c) only

Official Ans. by NTA (3)
Sol. Since $\phi=\vec{E} \cdot \vec{A}=E A \cos \theta$

$\theta=90^{\circ}$
$\therefore \phi=0$
15. A mixture of hydrogen and oxygen has volume $500 \mathrm{~cm}^{3}$, temperature 300 K , pressure 400 kPa and mass 0.76 g . The ratio of masses of oxygen to hydrogen will be :-
(1) $3: 8$
(2) $3: 16$
(3) $16: 3$
(4) $8: 3$

Official Ans. by NTA (3)
Sol. $\mathrm{PV}=\mathrm{nRT}$
$400 \times 10^{3} \times 500 \times 10^{-6}=\mathrm{n}\left(\frac{25}{3}\right)(300)$
$\mathrm{n}=\frac{2}{25}$
$\mathrm{n}=\mathrm{n}_{1}+\mathrm{n}_{2}$
$\frac{2}{25}=\frac{M_{1}}{2}+\frac{M_{2}}{32}$
Also $\mathrm{M}_{1}+\mathrm{M}_{2}=0.76 \mathrm{gm}$
$\frac{M_{2}}{M_{1}}=\frac{16}{3}$
16. A block moving horizontally on a smooth surface with a speed of $40 \mathrm{~m} / \mathrm{s}$ splits into two parts with masses in the ratio of $1: 2$. If the smaller part moves at $60 \mathrm{~m} / \mathrm{s}$ in the same direction, then the fractional change in kinetic energy is :-
(1) $\frac{1}{3}$
(2) $\frac{2}{3}$
(3) $\frac{1}{8}$
(4) $\frac{1}{4}$

Official Ans. by NTA (3)
Sol.

$$
\begin{aligned}
& \longrightarrow \mathrm{V}_{0} \longrightarrow \mathrm{~V}_{2} \longrightarrow \mathrm{~V}_{1} \\
& \begin{aligned}
3 \mathrm{M}
\end{aligned} \\
& \begin{aligned}
& 3 \mathrm{MV}_{0}=2 \mathrm{MV}_{2}+\mathrm{MV}_{1} \\
& 3 \mathrm{~V}_{0}=2 \mathrm{~V}_{2}+\mathrm{V}_{1} \\
& 120=2 \mathrm{~V}_{2}+60 \Rightarrow \mathrm{~V}_{2}=30 \mathrm{~m} / \mathrm{s} \\
& \text { K.E. }
\end{aligned} \\
& \begin{aligned}
\frac{\Delta \mathrm{K.E} .}{2} & \frac{\frac{1}{2} \mathrm{MV}_{1}^{2}+\frac{1}{2} 2 \mathrm{MV}_{2}^{2}-\frac{1}{2} 3 \mathrm{MV}_{0}^{2}}{\frac{1}{2} 3 \mathrm{MV}_{0}^{2}} \\
& =\frac{\mathrm{V}_{1}^{2}+2 \mathrm{~V}_{2}^{2}-3 \mathrm{~V}_{0}^{2}}{3 \mathrm{~V}_{0}^{2}} \\
& =\frac{3600+1800-4800}{4800} \\
& =\frac{1}{8}
\end{aligned}
\end{aligned}
$$

17. A coil is placed in a magnetic field $\vec{B}$ as shown below :


A current is induced in the coil because $\vec{B}$ is :
(1) Outward and decreasing with time
(2) Parallel to the plane of coil and decreasing with time
(3) Outward and increasing with time
(4) Parallel to the plane of coil and increasing with time

Official Ans. by NTA (1)
Sol. $\vec{B}$ must not be parallel to the plane of coil for non zero flux and according to lenz law if B is outward it should be decreasing for anticlockwise induced current.
18. For a body executing S.H.M. :
(a) Potential energy is always equal to its K.E.
(b) Average potential and kinetic energy over any given time interval are always equal.
(c) Sum of the kinetic and potential energy at any point of time is constant.
(d) Average K.E. in one time period is equal to average potential energy in one time period.

Choose the most appropriate option from the options given below :
(1) (c) and (d)
(2) only (c)
(3) (b) and (c)
(4) only (b)

Official Ans. by NTA (1)
Sol. In S.H.M. total mechanical energy remains constant and also $<$ K.E. $>=<$ P.E $>=\frac{1}{4} K^{2}$ (for 1 time period)
19. Statement-I :

To get a steady dc output from the pulsating voltage received from a full wave rectifier we can connect a capacitor across the output parallel to the load $\mathrm{R}_{\mathrm{L}}$.

## Statement-II :

To get a steady dc output from the pulsating voltage received from a full wave rectifier we can connect an inductor in series with $\mathrm{R}_{\mathrm{L}}$.
In the light of the above statements, choose the most appropriate answer from the options given below :
(1) Statement I is true but Statement II is false
(2) Statement I is false but Statement II is true
(3) Both Statement I and Statement II are false
(4) Both Statement I and Statement II are true Official Ans. by NTA (4)
Sol. To convert pulsating dc into steady dc both of mentioned method are correct.
20. If $\mathrm{R}_{\mathrm{E}}$ be the radius of Earth, then the ratio between the acceleration due to gravity at a depth 'r' below and a height ' $r$ ' above the earth surface is :
(Given : $\mathrm{r}<\mathrm{R}_{\mathrm{E}}$ )
(1) $1-\frac{r}{R_{E}}-\frac{r^{2}}{R_{E}^{2}}-\frac{r^{3}}{R_{E}^{3}}$
(2) $1+\frac{r}{R_{E}}+\frac{r^{2}}{R_{E}^{2}}+\frac{r^{3}}{R_{E}^{3}}$
(3) $1+\frac{r}{R_{E}}-\frac{r^{2}}{R_{E}^{2}}+\frac{r^{3}}{R_{E}^{3}}$
(4) $1+\frac{r}{R_{E}}-\frac{r^{2}}{R_{E}^{2}}-\frac{r^{3}}{R_{E}^{3}}$

Official Ans. by NTA (4)
Sol. $g_{u p}=\frac{g}{\left(1+\frac{\mathrm{r}}{\mathrm{R}}\right)^{2}}$
$\mathrm{g}_{\text {down }}=\mathrm{g}\left(1-\frac{\mathrm{r}}{\mathrm{R}}\right)$
$\frac{\mathrm{g}_{\text {down }}}{\mathrm{g}_{\text {up }}}=\left(1-\frac{\mathrm{r}}{\mathrm{R}}\right)\left(1+\frac{\mathrm{r}}{\mathrm{R}}\right)^{2}$
$=\left(1-\frac{\mathrm{r}}{\mathrm{R}}\right)\left(1+\frac{2 \mathrm{r}}{\mathrm{R}}+\frac{\mathrm{r}^{2}}{\mathrm{R}^{2}}\right)$
$=1+\frac{\mathrm{r}}{\mathrm{R}}-\frac{\mathrm{r}^{2}}{\mathrm{R}^{2}}-\frac{\mathrm{r}^{3}}{\mathrm{R}^{3}}$

## SECTION-B

1. A bandwidth of 6 MHz is available for A.M. transmission. If the maximum audio signal frequency used for modulating the carrier wave is not to exceed 6 kHz . The number of stations that can be broadcasted within this band simultaneously without interfering with each other will be $\qquad$ .
Official Ans. by NTA (500)
Sol. Signal bandwidth $=2 \mathrm{fm}$

$$
\begin{gathered}
=12 \mathrm{kHz} \\
\therefore \mathrm{~N}=\frac{6 \mathrm{MHZ}}{12 \mathrm{kHZ}}=\frac{6 \times 10^{6}}{12 \times 10^{3}}=500
\end{gathered}
$$

2. A parallel plate capacitor of capacitance $200 \mu \mathrm{~F}$ is connected to a battery of 200 V . A dielectric slab of dielectric constant 2 is now inserted into the space between plates of capacitor while the battery remain connected. The change in the electrostatic energy in the capacitor will be $\qquad$ J.

Official Ans. by NTA (4)
Sol. $\quad \Delta \mathrm{U}=\frac{1}{2}(\Delta \mathrm{C}) \mathrm{V}^{2}$
$\Delta \mathrm{U}=\frac{1}{2}(\mathrm{KC}-\mathrm{C}) \mathrm{V}^{2}$
$\Delta \mathrm{U}=\frac{1}{2}(2-1) \mathrm{CV}^{2}$
$\Delta \mathrm{U}=\frac{1}{2} \times 200 \times 10^{-6} \times 200 \times 200$
$\Delta \mathrm{U}=4 \mathrm{~J}$
3. A long solenoid with 1000 turns/m has a core material with relative permeability 500 and volume $10^{3} \mathrm{~cm}^{3}$. If the core material is replaced by another material having relative permeability of 750 with same volume maintaining same current of 0.75 A in the solenoid, the fractional change in the magnetic moment of the core would be approximately $\left(\frac{x}{499}\right)$. Find the value of $x$.

Official Ans. by NTA (250)

Sol. $\frac{\Delta \mathrm{M}}{\mathrm{M}}=\frac{\Delta \mu}{\mu}=\frac{250}{500}=\frac{1}{2}$
$\frac{1}{2}=\frac{x}{499} \Rightarrow x \simeq 250$
4. A particle is moving with constant acceleration ' a '.

Following graph shows $v^{2}$ versus $x($ displacement) plot. The acceleration of the particle is $\qquad$ $\mathrm{m} / \mathrm{s}^{2}$.


Official Ans. by NTA (1)
Sol. $\mathrm{y}=\mathrm{mx}+\mathrm{C}$
$\mathrm{v}^{2}=\frac{20}{10} \mathrm{x}+20$
$v^{2}=2 x+20$
$2 v \frac{d v}{d x}=2$
$\therefore a=v \frac{d v}{d x}=1$
5. In a Young's double slit experiment, the slits are separated by 0.3 mm and the screen is 1.5 m away from the plane of slits. Distance between fourth bright fringes on both sides of central bright is 2.4 cm . The frequency of light used is $\qquad$ $\times 10^{14} \mathrm{~Hz}$.

Official Ans. by NTA (5)
Sol. $8 \beta=2.4 \mathrm{~cm}$
$\frac{8 \lambda \Delta}{\mathrm{~d}}=2.4 \mathrm{~cm}$
$\frac{8 \times 1.5 \times \mathrm{c}}{0.3 \times 10^{-3} \times \mathrm{f}}=2.4 \times 10^{-2}$
$\mathrm{f}=5 \times 10^{14} \mathrm{~Hz}$
6. The diameter of a spherical bob is measured using a vernier callipers. 9 divisions of the main scale, in the vernier callipers, are equal to 10 divisions of vernier scale. One main scale division is 1 mm . The main scale reading is 10 mm and $8^{\text {th }}$ division of vernier scale was found to coincide exactly with one of the main scale division. If the given vernier callipers has positive zero error of 0.04 cm , then the radius of the bob is $\qquad$ $\times 10^{-2} \mathrm{~cm}$.

Official Ans. by NTA (52)

Sol. $9 \mathrm{MSD}=10 \mathrm{VSD}$
$9 \times 1 \mathrm{~mm}=10 \mathrm{VSD}$
$\therefore 1 \mathrm{VSD}=0.9 \mathrm{~mm}$
$\mathrm{LC}=1 \mathrm{MSD}-1 \mathrm{VSD}=0.1 \mathrm{~mm}$

Reading $=\mathrm{MSR}+\mathrm{VSR} \times \mathrm{LC}$
$10+8 \times 0.1=10.8 \mathrm{~mm}$

Actual reading $=10.8-0.4=10.4 \mathrm{~mm}$
radius $=\frac{\mathrm{d}}{2}=\frac{10.4}{2}=5.2 \mathrm{~mm}$

$$
=52 \times 10^{-2} \mathrm{~cm}
$$

7. A sample of gas with $\gamma=1.5$ is taken through an adiabatic process in which the volume is compressed from $1200 \mathrm{~cm}^{3}$ to $300 \mathrm{~cm}^{3}$. If the initial pressure is 200 kPa . The absolute value of the workdone by the gas in the process $=$ $\qquad$ J.

Official Ans. by NTA (480)

Sol. $v=1.5$
$\mathrm{p}_{1} \mathrm{~V}_{1}{ }^{\mathrm{V}}=\mathrm{p}_{2} \mathrm{~V}_{2}{ }^{\mathrm{V}}$
$(200)(1200)^{1.5}=\mathrm{P}^{2}(300)^{1.5}$
$\mathrm{P}_{2}=200[4]^{3 / 2}=1600 \mathrm{kPa}$
|W.D. $\left\lvert\,=\frac{\mathrm{p}_{2} \mathrm{v}_{2}-\mathrm{p}_{1} \mathrm{v}_{1}}{v-1}=\left(\frac{480-240}{0.5}\right)=480 \mathrm{~J}\right.$
8. At very high frequencies, the effective impendance of the given circuit will be $\qquad$ $\Omega$.


Official Ans. by NTA (2)

Sol. $X_{L}=2 \pi f L$
f is very large
$\therefore \mathrm{X}_{\mathrm{L}}$ is very large hence open circuit.
$\mathrm{X}_{\mathrm{C}}=\frac{1}{2 \pi \mathrm{fC}}$
f is very large.
$\therefore \mathrm{X}_{\mathrm{C}}$ is very small, hence short circuit.

Final circuit


$$
\mathrm{Z}_{\mathrm{eq}}=1+\frac{2 \times 2}{2+2}=2
$$

9. Cross-section view of a prism is the equilateral triangle ABC in the figure. The minimum deviation is observed using this prism when the angle of incidence is equal to the prism angle. The time taken by light to travel from P (midpoint of BC ) to A is $\qquad$ $\times 10^{-10} \mathrm{~s}$.
(Given, speed of light in vacuum $=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$ and $\left.\cos 30^{\circ}=\frac{\sqrt{3}}{2}\right)$


Official Ans. by NTA (5)
Sol. $\mathrm{i}=\mathrm{A}=60^{\circ}$
$\underline{\underline{\delta}}_{\text {min }}=2 \mathrm{i}-\mathrm{A}$
$=2 \times 60^{\circ}-60^{\circ}=60^{\circ}$
$\mu=\frac{\sin ^{-1}\left(\frac{\delta_{\text {min }}+\mathrm{A}}{2}\right)}{\sin ^{-1}\left(\frac{\mathrm{~A}}{2}\right)}$
$=\sqrt{3}$
$\mathrm{V}_{\text {prism }}=\frac{3 \times 10^{8}}{\sqrt{3}}$
$\mathrm{AP}=10 \times 10^{-2} \times \frac{\sqrt{3}}{2}$
time $=\frac{5 \times 10^{-2}}{3 \times 10^{8}} \times \sqrt{3} \times \sqrt{3}$
$=5 \times 10^{-10} \mathrm{sec}$
Ans $=5$
10. A resistor dissipates 192 J of energy in 1 s when a current of 4 A is passed through it. Now, when the current is doubled, the amount of thermal energy dissipated in 5 s in $\qquad$ J.

Official Ans. by NTA (3840)
Sol. $E=i^{2} R t$
$192=16(\mathrm{R})(1)$
$\mathrm{R}=12 \Omega$
$\mathrm{E}^{1}=(8)^{2}(12)(5)$
$=3840 \mathrm{~J}$

## FINAL JEE-MAIN EXAMINATION - AUGUST, 2021

(Held On Tuesday 31st August, 2021)
TIME : 3:00 PM to 6:00 PM

## CHEMISTRY

## SECTION-A

1. Arrange the following conformational isomers of n-butane in order of their increasing potential energy :


I


II


III


IV
(1) II $<$ III $<$ IV $<$ I
(2) I $<$ IV $<$ III $<$ II
(3) II $<$ IV $<$ III $<$ I
(4) I $<$ III $<$ IV $<$ II

Official Ans. by NTA (4)
Sol. More stable less potential energy.
Stability order : I $>$ III $>$ IV $>$ II So

Potential energy : II $>$ IV $>$ III $>$ I
2. The $\mathrm{Eu}^{2+}$ ion is a strong reducing agent in spite of its ground state electronic configuration (outermost) : [Atomic number of $\mathrm{Eu}=63$ ]
(1) $4 f^{7} 6 s^{2}$
(2) $4 f^{6}$
(3) $4 f^{7}$
(4) $4 f^{6} 6 s^{2}$

## Official Ans. by NTA (3)

Sol. $\mathrm{Eu} \rightarrow[\mathrm{Xe}] 4 \mathrm{f}^{7} 6 \mathrm{~s}^{2}$

$$
\mathrm{Eu}^{2+} \rightarrow[\mathrm{Xe}] 4 \mathrm{f}^{7}
$$

3. The structures of $\mathbf{A}$ and $\mathbf{B}$ formed in the following reaction are : $\left[\mathrm{Ph}=-\mathrm{C}_{6} \mathrm{H}_{5}\right]$

(1)
 $\mathbf{B}=$

(2) $\mathbf{A}=$


## TEST PAPER WITH SOLUTION

(3)

(4) $\mathbf{A}=$
 B $=$


Official Ans. by NTA (1)
Sol.

4. In which one of the following sets all species show disproportionation reaction?
(1) $\mathrm{ClO}_{2}^{-}, \mathrm{F}_{2}, \mathrm{MnO}_{4}^{-}$and $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2-}$
(2) $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2-}, \mathrm{MnO}_{4}^{-}, \mathrm{ClO}_{2}^{-}$and $\mathrm{Cl}_{2}$
(3) $\mathrm{MnO}_{4}^{-}, \mathrm{ClO}_{2}^{-}, \mathrm{Cl}_{2}$ and $\mathrm{Mn}^{3+}$
(4) $\mathrm{ClO}_{4}^{-}, \mathrm{MnO}_{4}^{-}, \mathrm{ClO}_{2}^{-}$and $\mathrm{F}_{2}$

Official Ans. by NTA (3)

Sol. No option contains all species that show disproportionation reaction.

## $\mathrm{MnO}_{4}^{-}$

Mn is in +7 oxidation state (highest) hence cannot be simultaneously oxidized or reduced.
5. Match List-I with List-II

## List-I

(Parameter)
(a) Cell constant
(i) $\mathrm{S} \mathrm{cm}^{2} \mathrm{~mol}^{-1}$
(b) Molar conductivity
(ii) Dimensionless
(c) Conductivity
(iii) $\mathrm{m}^{-1}$
(d) Degree of dissociation
(iv) $\Omega^{-1} \mathrm{~m}^{-1}$ of electrolyte

Choose the most appropriate answer from the options given below :
(1) (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)
(2) (a)-(iii), (b)-(i), (c)-(ii), (d)-(iv)
(3) (a)-(i), (b)-(iv), (c)-(iii), (d)-(ii)
(4) (a)-(ii), (b)-(i), (c)-(iii), (d)-(iv)

Official Ans. by NTA (1)

Sol. Cell constant $=\left(\frac{\ell}{\mathrm{A}}\right) \Rightarrow$ Units $=\mathrm{m}^{-1}$
Molar conductivity $\left(\Lambda_{\mathrm{m}}\right) \Rightarrow$ Units $=\mathrm{Sm}^{2} \mathrm{~mole}^{-1}$
Conductivity $(\mathrm{K}) \Rightarrow$ Units $=\mathrm{S} \mathrm{m}^{-1}$
Degree of dissociation $(\alpha) \rightarrow$ Dimensionless
$\therefore$ (a) - (iii)
(b) - (i)
(c) - (iv)
(d) - (ii)
6. The major products A and B formed in the following reaction sequence are :

(1)

(2)

(3)



(4)



Official Ans. by NTA (2)

CAREER INSTITUTE

Sol.




(A)

7. Which of the following is NOT an example of fibrous protein?
(1) Keratin
(2) Albumin
(3) Collagen
(4) Myosin

Official Ans. by NTA (2)
Sol. Keratin, collagen and myosin are example of fibrous protein.
8. The deposition of $X$ and $Y$ on ground surfaces is referred as wet and dry depositions, respectively. X and Y are :
(1) $\mathrm{X}=$ Ammonium salts, $\mathrm{Y}=\mathrm{CO}_{2}$
(2) $\mathrm{X}=\mathrm{SO}_{2}, \mathrm{Y}=$ Ammonium salts
(3) $\mathrm{X}=$ Ammonium salts, $\mathrm{Y}=\mathrm{SO}_{2}$
(4) $\mathrm{X}=\mathrm{CO}_{2}, \mathrm{Y}=\mathrm{SO}_{2}$

Official Ans. by NTA (3)
Sol. Oxides of nitrogen and sulphur are acidic and settle down on ground as dry deposition.

Ammonium salts in rain drops result in wet deposition
9. For the reaction given below :


The compound which is not formed as a product in the reaction is a :
(1) compound with both alcohol and acid functional groups
(2) monocarboxylic acid
(3) dicarboxylic acid
(4) diol

Official Ans. by NTA (3)
Sol.



10. Spin only
magnetic moment in BM of $\left[\mathrm{Fe}(\mathrm{CO})_{4}\left(\mathrm{C}_{2} \mathrm{O}_{4}\right)\right]^{+}$is :
(1) 5.92
(2) 0
(3) 1
(4) 1.73

Official Ans. by NTA (4)
Sol. $\left[\mathrm{Fe}(\mathrm{CO})_{4}\left(\mathrm{C}_{2} \mathrm{O}_{4}\right)\right]^{+}$


One unpaired electron
Spin only magnetic moment
$=\sqrt{3}$ B.M. $=1.73 \mathrm{BM}$
11. Given below are two statements : one is labelled as

Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Lithium salts are hydrated.
Reason (R): Lithium has higher polarising power than other alkali metal group members.

In the light of the above statements, choose the most appropriate answer from the options given below :
(1) Both (A) and (R) are correct but (R) is NOT the correct explanation of (A).
(2) (A) is correct but (R) is not correct.
(3) (A) is not correct but (R) is correct.
(4) Both (A) and (R) are correct and (R) is the correct explanation of (A).

## Official Ans. by NTA (1)

Sol. Lithium salts are hydrated due to high hydration energy of $\mathrm{Li}^{+}$
$\mathrm{Li}^{+}$due to smallest size in IA group has highest polarizing power.
12. The incorrect expression among the following is:
(1) $\frac{\Delta \mathrm{G}_{\text {System }}}{\Delta \mathrm{S}_{\text {Total }}}=-\mathrm{T}($ at constant P$)$
(2) $\ln \mathrm{K}=\frac{\Delta \mathrm{H}^{\mathrm{o}}-\mathrm{T} \Delta \mathrm{S}^{\circ}}{\mathrm{RT}}$
(3) $\mathrm{K}=\mathrm{e}^{-\Delta \mathrm{G}^{\mathrm{o}} / R T}$
(4) For isothermal process $\mathrm{w}_{\text {reversible }}=-\mathrm{nRT} \ln \frac{\mathrm{V}_{f}}{\mathrm{~V}_{i}}$

Official Ans. by NTA (2)
Sol. Option (2) is incorrect

$$
\begin{aligned}
& \Delta \mathrm{G}^{\circ}=-\mathrm{RT} \ln \mathrm{~K} \\
& \Delta \mathrm{H}^{\circ}-\mathrm{T} \Delta \mathrm{~S}^{\circ}=-\mathrm{RT} \ln \mathrm{~K} \\
& \operatorname{lnK}=-\left[\frac{\Delta \mathrm{H}^{\circ}-\Delta \mathrm{S}^{\circ}}{\mathrm{RT}}\right]
\end{aligned}
$$

13. Which one of the following statements is incorrect?
(1) Atomic hydrogen is produced when $\mathrm{H}_{2}$ molecules at a high temperature are irradiated with UV radiation.
(2) At around 2000 K , the dissociation of dihydrogen into its atoms is nearly $8.1 \%$.
(3) Bond dissociation enthalpy of $\mathrm{H}_{2}$ is highest among diatomic gaseous molecules which contain a single bond .
(4) Dihydrogen is produced on reacting zinc with HCl as well as $\mathrm{NaOH}_{\text {(aq) }}$.

Official Ans. by NTA (2)
Sol. Atomic hydrogen is produced at high temperature in an electric are or under ultraviolet radiations The dissociation of dihydrogen at 2000 K is only $0.081 \%$
$\mathrm{H}-\mathrm{H}$ bond dissociation enthalpy is highest for a single bond for any diatomic molecule.

Dihydrogen can be produced on reacting Zn with dil. HCl as well as NaOH (aq.)
14. Which among the following is not a polyester?
(1) Novolac
(2) PHBV
(3) Dacron
(4) Glyptal

## Official Ans. by NTA (1)

Sol. Novalac is a linear polymer of $[\mathrm{Ph}-\mathrm{OH}+\mathrm{HCHO}]$. So ester linkage not present.
So novalac is not a polyester.
15. Which one of the following correctly represents the order of stability of oxides, $\mathrm{X}_{2} \mathrm{O} ;(\mathrm{X}=$ halogen $)$ ?
(1) $\mathrm{Br}>\mathrm{Cl}>$ I
(2) $\mathrm{Br}>$ I $>\mathrm{Cl}$
(3) $\mathrm{Cl}>$ I $>\mathrm{Br}$
(4) I $>\mathrm{Cl}>\mathrm{Br}$

Official Ans. by NTA (4)
Sol. Stability of oxides of Halogens is
$\mathrm{I}>\mathrm{Cl}>\mathrm{Br}$
16. Match List-I with List-II :

## List-I

(Metal Ion)

## List-II

(Group in Qualitative analysis)
(a) $\mathrm{Mn}^{2+}$
(i) Group - III
(b) $\mathrm{As}^{3+}$
(ii) Group - IIA
(c) $\mathrm{Cu}^{2+}$
(iii) Group - IV
(d) $\mathrm{Al}^{3+}$
(iv) Group - IIB

Choose the most appropriate answer from the options given below :
(1) (a)-(i), (b)-(ii), (c)-(iii), (d)-(iv)
(2) (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)
(3) (a)-(i), (b)-(iv), (c)-(ii), (d)-(iii)
(4) (a)-(iv), (b)-(ii), (c)-(iii), (d)-(i)

Official Ans. by NTA (2)
Sol. $\mathrm{Mn}^{2+} \rightarrow$ III group
$\mathrm{As}^{3+} \rightarrow$ II B group
$\mathrm{Cu}^{2+} \rightarrow$ II A group
$\mathrm{Al}^{3+} \rightarrow$ IV group
17. The major product of the following reaction is:

(1)

(2)

(3)

(4)


Official Ans. by NTA (4)
Sol. $\mathrm{NaOH}+\mathrm{EtOH}$ is known as alcoholic NaOH , so it give $E^{2}$ reaction with given alkyl halide.

18. For the following :

(1)

(2)

(3)

(4)


Official Ans. by NTA (2)

19. Identify correct $\mathbf{A}, \mathbf{B}$ and $\mathbf{C}$ in the reaction sequence given below :

(1) $\mathrm{A}=$

(2)

(3)

(4)


Official Ans. by NTA (1)

## Sol.


20. The number of $\mathrm{S}=\mathrm{O}$ bonds present in sulphurous acid, peroxodisulphuric acid and pyrosulphuric acid, respectively are :
(1) 2, 3 and 4
(2) 1, 4 and 3
(3) 2, 4 and 3
(4) 1, 4 and 4

Official Ans. by NTA (4)

## Sol.



Sulphurous acid


Peroxodisulphuric acid




## SECTION-B

1. $\quad \mathrm{CH}_{4}$ is adsorbed on 1 g charcoal at $0^{\circ} \mathrm{C}$ following the Freundlich adsorption isotherm. 10.0 mL of $\mathrm{CH}_{4}$ is adsorbed at 100 mm of Hg , whereas 15.0 mL is adsorbed at 200 mm of Hg . The volume of $\mathrm{CH}_{4}$ adsorbed at 300 mm of Hg is $10^{\mathrm{x}} \mathrm{mL}$. The value of $x$ is $\qquad$ $\times 10^{-2}$.
(Nearest integer)
[Use $\log _{10} 2=0.3010, \log _{10} 3=0.4771$ ]
Official Ans. by NTA (128)
Sol. We know

$$
\begin{align*}
\frac{\mathrm{x}}{\mathrm{~m}} & =\mathrm{KP}^{1 / n} ; \operatorname{using}(\mathrm{x} \propto \mathrm{~V}) \\
\Rightarrow \quad \frac{10}{1} & =\mathrm{K} \times(100)^{1 / \mathrm{n}} \quad \ldots  \tag{1}\\
\frac{15}{1} & =\mathrm{K} \times(200)^{1 / \mathrm{n}} \quad \ldots  \tag{2}\\
\frac{\mathrm{~V}}{1} & =\mathrm{K} \times(300)^{1 / \mathrm{n}} \quad \ldots \tag{3}
\end{align*}
$$

Divide
(2) / (1)

$$
\begin{aligned}
& \frac{15}{10}=2^{1 / n} \\
& \log \left(\frac{3}{2}\right)=\frac{1}{n} \log 2
\end{aligned}
$$

$$
\begin{aligned}
& \frac{1}{\mathrm{n}}=\frac{\log 3-\log 2}{\log 2}=\frac{0.4771-0.3010}{0.3010} \\
& \frac{1}{\mathrm{n}}=0.585
\end{aligned}
$$

Divide
(3) / (1)

$$
\begin{aligned}
& \frac{\mathrm{V}}{10}=3^{1 / \mathrm{n}} \\
& \log \left(\frac{\mathrm{~V}}{10}\right)=\frac{1}{\mathrm{n}} \log 3 \\
& \log \left(\frac{\mathrm{~V}}{10}\right)=0.585 \times 0.4771=0.2791 \\
& \begin{aligned}
\frac{\mathrm{V}}{10}=10^{0.279} & \Rightarrow \mathrm{~V}=10 \times 10^{0.279} \\
& \Rightarrow \mathrm{~V}=10^{1.279}=10^{\mathrm{x}} \\
& \Rightarrow \mathrm{x}=1.279 \\
& \Rightarrow \mathrm{x}=128 \times 10^{-2} \text { (Nearest integer) }
\end{aligned}
\end{aligned}
$$

2. 1.22 g of an organic acid is separately dissolved in 100 g of benzene $\left(\mathrm{K}_{\mathrm{b}}=2.6 \mathrm{~K} \mathrm{~kg} \mathrm{~mol}^{-1}\right)$ and 100 g of acetone ( $\mathrm{K}_{\mathrm{b}}=1.7 \mathrm{~K} \mathrm{~kg} \mathrm{~mol}^{-1}$ ). The acid is known to dimerize in benzene but remain as a monomer in acetone. The boiling point of the solution in acetone increases by $0.17^{\circ} \mathrm{C}$.
The increase in boiling point of solution in benzene in ${ }^{\circ} \mathrm{C}$ is $\mathrm{x} \times 10^{-2}$. The value of x is
$\qquad$ .(Nearest integer)
[Atomic mass : $\mathrm{C}=12.0, \mathrm{H}=1.0, \mathrm{O}=16.0$ ]
Official Ans. by NTA (13)
Sol. With benzene as solvent
$\Delta \mathrm{T}_{\mathrm{b}}=\mathrm{i} \mathrm{K}_{\mathrm{b}} \mathrm{m}$
$\Delta \mathrm{T}_{\mathrm{b}}=\frac{1}{2} \times 2.6 \times \frac{1.22 / \mathrm{M}_{\mathrm{w}}}{100 / 1000}$
With Acetone as solvent

$$
\begin{align*}
& \Delta \mathrm{T}_{\mathrm{b}}=\mathrm{i} \mathrm{~K}_{\mathrm{b}} \mathrm{~m} \\
& 0.17=1 \times 1.7 \times \frac{1.22 / \mathrm{M}_{\mathrm{w}}}{100 / 1000} \tag{2}
\end{align*}
$$

(1) / (2)
$\frac{\Delta \mathrm{T}_{\mathrm{b}}}{0.17}=\frac{\frac{1}{2} \times 2.6+\frac{1.22 / \mathrm{M}_{\mathrm{w}}}{100 / 1000}}{1 \times 1.7 \times \frac{1.22 / \mathrm{M}_{\mathrm{w}}}{100 / 1000}}$
$\Delta \mathrm{T}_{\mathrm{b}}=\frac{0.26}{2}$
$\Delta \mathrm{T}_{\mathrm{b}}=13 \times 10^{-2}$
$\Rightarrow \mathrm{x}=13$
3. The value of magnetic quantum number of the outermost electron of $\mathrm{Zn}^{+}$ion is $\qquad$ .

Official Ans. by NTA (0)
Sol. $\quad \mathrm{Zn}^{+} \rightarrow 1 \mathrm{~s}^{2} 2 \mathrm{~s}^{2} 2 \mathrm{p}^{6} 3 \mathrm{~s}^{2} 3 \mathrm{p}^{6} 3 \mathrm{~d}^{10} 4 \mathrm{~s}^{1}$
Outermost electron is in 4 s subshell $\mathrm{m}=0$
4. The empirical formula for a compound with a cubic close packed arrangement of anions and with cations occupying all the octahedral sites in $A_{x} B$. The value of $x$ is $\qquad$
(Integer answer)
Official Ans. by NTA (1)
Sol. Anions froms CCP or $\operatorname{FCC}\left(\mathrm{A}^{-}\right)=4 \mathrm{~A}^{-}$per unit cell
Cations occupy all octahedral voids $\left(\mathrm{B}^{+}\right)=4 \mathrm{~B}^{+}$per unit cell
cell formula $\rightarrow \mathrm{A}_{4} \mathrm{~B}_{4}$
Empirical formula $\rightarrow \mathrm{AB}$

$$
\rightarrow(\mathrm{x}=1)
$$

5. In the electrolytic refining of blister copper, the total number of main impurities, from the following, removed as anode mud is $\qquad$

$$
\mathrm{Pb}, \mathrm{Sb}, \mathrm{Se}, \mathrm{Te}, \mathrm{Ru}, \mathrm{Ag}, \mathrm{Au} \text { and } \mathrm{Pt}
$$

## Official Ans. by NTA (6)

Sol. Anode mud contains $\mathrm{Sb}, \mathrm{Se}, \mathrm{Te}, \mathrm{Ag}, \mathrm{Au}$ and Pt
6. The pH of a solution obtained by mixing 50 mL of 1 M HCl and 30 mL of 1 M NaOH is $\mathrm{x} \times 10^{-4}$. The value of $x$ is $\qquad$ . (Nearest integer)
$[\log 2.5=0.3979]$
Official Ans. by NTA (6021)
Sol. $\quad \mathrm{HCl}$ (aq.) +NaOH (aq.) $\rightarrow \mathrm{NaCl}($ aq. $)+\mathrm{H}_{2} \mathrm{O}(\ell)$
$50 \mathrm{ml}, 1 \mathrm{M} \quad 30 \mathrm{ml}, 1 \mathrm{M}$
$\mathrm{t}=0 \quad 50 \mathrm{~mm} \quad 30 \mathrm{~mm}$
$\mathrm{t}=\infty 20 \mathrm{~mm}$
$[\mathrm{HCl}]=\frac{20}{80}=\frac{1}{4} \mathrm{M}=2.5 \times 10^{-1} \mathrm{M}$
$\mathrm{pH}=-\log 2.15 \times 10^{-1}=1-0.3979=0.6021$
$\mathrm{pH}=6021 \times 10^{-4}$
7. For the reaction $\mathrm{A} \rightarrow \mathrm{B}$, the rate constant $\mathrm{k}\left(\mathrm{in} \mathrm{s}^{-1}\right)$ is given by

$$
\log _{10} \mathrm{k}=20.35-\frac{\left(2.47 \times 10^{3}\right)}{\mathrm{T}}
$$

The energy of activation in $\mathrm{kJ} \mathrm{mol}^{-1}$ is $\qquad$ .
(Nearest integer)
[Given : $\mathrm{R}=8.314 \mathrm{~J} \mathrm{~K}^{-1} \mathrm{~mol}^{-1}$ ]
Official Ans. by NTA (47)
Sol. Given $\quad \log \mathrm{K}=20.35-\frac{2.47 \times 10^{3}}{\mathrm{~T}}$
We know $\quad \log \mathrm{K}=\log \mathrm{A}-\frac{\mathrm{E}_{\mathrm{a}}}{2.303 \mathrm{RT}}$

$$
\begin{gathered}
\Rightarrow \frac{\mathrm{E}_{\mathrm{a}}}{2.303 \mathrm{RT}}=2.47 \times 10^{3} \\
\mathrm{E}_{\mathrm{a}}=2.47 \times 10^{3} \times 2.303 \times \frac{8.314}{1000} \mathrm{KJ} / \text { mole } \\
=47.29=47(\text { Nearest integer })
\end{gathered}
$$

8. Sodium oxide reacts with water to produce sodium hydroxide. 20.0 g of sodium oxide is dissolved in 500 mL of water. Neglecting the change in volume, the concentration of the resulting NaOH solution is $\qquad$ $\times 10^{-1} \mathrm{M}$. (Nearest integer)
[Atomic mass : $\mathrm{Na}=23.0, \mathrm{O}=16.0, \mathrm{H}=1.0$ ]
Official Ans. by NTA (13)
Sol. $\mathrm{Na}_{2} \mathrm{O}+\mathrm{H}_{2} \mathrm{O} \rightarrow 2 \mathrm{NaOH}$
$\frac{20}{62}$ moles
Moles of NaOH formed $=\frac{20}{62} \times 2$
$[\mathrm{NaOH}]=\frac{\frac{40}{62}}{\frac{500}{1000}}=1.29 \mathrm{M}=13 \times 10^{-1} \mathrm{M}$
(Nearest integer)
9. According to molecular orbital theory, the number of unpaired electron(s) in $\mathrm{O}_{2}^{2-}$ is :

Official Ans. by NTA (0)
Sol. Molecular orbital configuration of $\mathrm{O}_{2}^{2-}$ is

$$
\sigma_{1 \mathrm{~s}}^{2} \sigma_{1 \mathrm{~s}}^{* 2} \sigma_{2 \mathrm{~s}}^{2} \sigma_{2 \mathrm{~s}}^{* 2}\left(\pi 2 \mathrm{p}_{\mathrm{x}}^{2}=\pi 2 \mathrm{p}_{\mathrm{y}}^{2}\right)\left(\pi_{2 \mathrm{px}}^{* 2}=\pi_{2 \mathrm{py}}^{* 2}\right)
$$

Zero unpaired electron
10. The transformation occurring in Duma's method is given below :
$\mathrm{C}_{2} \mathrm{H}_{7} \mathrm{~N}+\left(2 \mathrm{x}+\frac{\mathrm{y}}{2}\right) \mathrm{CuO} \rightarrow \mathrm{xCO}_{2}+\frac{y}{2} \mathrm{H}_{2} \mathrm{O}+\frac{\mathrm{z}}{2} \mathrm{~N}_{2}+\left(2 \mathrm{x}+\frac{\mathrm{y}}{2}\right) \mathrm{Cu}$
The value of $y$ is $\qquad$ . (Integer answer)

## Official Ans. by NTA (7)

## Sol.

$\mathrm{C}_{2} \mathrm{H}_{7} \mathrm{~N}+\left(2 \mathrm{x}+\frac{\mathrm{y}}{2}\right) \mathrm{CuO} \rightarrow \mathrm{xCO}_{2}+\frac{\mathrm{y}}{2} \mathrm{H}_{2} \mathrm{O}+\frac{\mathrm{z}}{2} \mathrm{~N}_{2}+\left(2 \mathrm{x}+\frac{\mathrm{y}}{2}\right) \mathrm{Cu}$

On balancing
$\mathrm{C}_{2} \mathrm{H}_{7} \mathrm{~N}+\frac{15}{2} \mathrm{CuO} \rightarrow 2 \mathrm{CO}_{2}+\frac{7}{2} \mathrm{H}_{2} \mathrm{O}+\frac{1}{2} \mathrm{~N}_{2}+\frac{15}{2} \mathrm{Cu}$
On comparing
$y=7$

## MATHEMATICS

## SECTION-A

1. If $\alpha+\beta+\gamma=2 \pi$, then the system of equations
$x+(\cos \gamma) y+(\cos \beta) z=0$
$(\cos \gamma) \mathrm{x}+\mathrm{y}+(\cos \alpha) \mathrm{z}=0$
$(\cos \beta) \mathrm{x}+(\cos \alpha) \mathrm{y}+\mathrm{z}=0$
has :
(1) no solution
(2) infinitely many solution
(3) exactly two solutions
(4) a unique solution

Official Ans. by NTA (2)
Sol. $\alpha+\beta+\gamma=2 \pi$
$\left|\begin{array}{ccc}1 & \cos \gamma & \cos \beta \\ \cos \gamma & 1 & \cos \alpha \\ \cos \beta & \cos \alpha & 1\end{array}\right|$
$=1+2 \cos \alpha \cdot \cos \beta \cdot \cos \gamma-\cos ^{2} \alpha-\cos ^{2} \beta-\cos ^{2} \gamma$
$=\sin ^{2} \gamma-\cos ^{2} \alpha-\cos ^{2} \beta+(\cos (\alpha+\beta)+\cos (\alpha-$
$\beta$ ) $\cos \gamma$
$=\sin ^{2} \gamma-\cos ^{2} \alpha-\cos ^{2} \beta+\cos ^{2} \gamma+\cos (\alpha-\beta) \cos \gamma$
$=\sin ^{2} \alpha-\cos ^{2} \beta+\cos (\alpha-\beta) \cos (\alpha+\beta)$
$=\sin ^{2} \alpha-\cos ^{2} \beta+\cos ^{2} \alpha-\sin ^{2} \beta=0$
2. Let $\vec{a}, \vec{b}, \vec{c}$ be three vectors mutually perpendicular to each other and have same magnitude. If a vector $\overrightarrow{\mathrm{r}}$ satisfies.
$\vec{a} \times\{(\vec{r}-\vec{b}) \times \vec{a}\}+\vec{b} \times\{(\vec{r}-\vec{c}) \times \vec{b}\}+\vec{c} \times\{(\vec{r}-\vec{a}) \times \vec{c}\}=\overrightarrow{0}$, then $\overrightarrow{\mathrm{r}}$ is equal to :
(1) $\frac{1}{3}(\vec{a}+\vec{b}+\vec{c})$
(2) $\frac{1}{3}(2 \vec{a}+\vec{b}-\vec{c})$
(3) $\frac{1}{2}(\vec{a}+\vec{b}+\vec{c})$
(4) $\frac{1}{2}(\vec{a}+\vec{b}+2 \vec{c})$

Official Ans. by NTA (3)

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Sol. Suppose $\overrightarrow{\mathrm{r}}=x \vec{a}+y \vec{b}+2 \overrightarrow{\mathrm{c}}$
and $|\vec{a}|=|\vec{b}|=|\vec{c}|=k$
$\overrightarrow{\mathrm{a}} \times\{(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{b}}) \times \overrightarrow{\mathrm{a}}\}+\overrightarrow{\mathrm{b}} \times\{(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{c}}) \times \overrightarrow{\mathrm{b}}\}+\overrightarrow{\mathrm{c}} \times\{(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{a}}) \times \overrightarrow{\mathrm{c}}\}=\overrightarrow{0}$
$\Rightarrow \mathrm{k}^{2}(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{b}})-\mathrm{k}^{2} \mathrm{x} \overrightarrow{\mathrm{a}}+\mathrm{k}^{2}(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{c}})-\mathrm{k}^{2} \mathrm{y} \overrightarrow{\mathrm{b}}+$

$$
\mathrm{k}^{2}(\overrightarrow{\mathrm{r}}-\overrightarrow{\mathrm{a}})-\mathrm{k}^{2} \mathrm{z} \overrightarrow{\mathrm{c}}=\overrightarrow{0}
$$

$\Rightarrow 3 \vec{r}-(\vec{a}+\vec{b}+\vec{c})-\vec{r}=\overrightarrow{0}$
$\Rightarrow \overrightarrow{\mathrm{r}}=\frac{\overrightarrow{\mathrm{a}}+\overrightarrow{\mathrm{b}}+\overrightarrow{\mathrm{c}}}{2}$
3. The domain of the function
$f(x)=\sin ^{-1}\left(\frac{3 x^{2}+x-1}{(x-1)^{2}}\right)+\cos ^{-1}\left(\frac{x-1}{x+1}\right)$ is :
(1) $\left[0, \frac{1}{4}\right]$
(2) $[-2,0] \cup\left[\frac{1}{4}, \frac{1}{2}\right]$
(3) $\left[\frac{1}{4}, \frac{1}{2}\right] \cup\{0\}$
(4) $\left[0, \frac{1}{2}\right]$

Official Ans. by NTA (3)
Sol. $f(\mathrm{x})=\sin ^{-1}\left(\frac{3 \mathrm{x}^{2}+\mathrm{x}-1}{(\mathrm{x}-1)^{2}}\right)+\cos ^{-1}\left(\frac{\mathrm{x}-1}{\mathrm{x}+1}\right)$ $-1 \leq \frac{\mathrm{x}-1}{\mathrm{x}+1} \leq 1 \Rightarrow 0 \leq \mathrm{x}<\infty$
$-1 \leq \frac{3 x^{2}+x-1}{(x-1)^{2}} \leq 1 \Rightarrow x \in\left[\frac{-1}{4}, \frac{1}{2}\right] \cup\{0\}$
(1) \& (2)
$\Rightarrow$ Domain $=\left[\frac{1}{4}, \frac{1}{2}\right] \cup\{0\}$
4. Let $S=\{1,2,3,4,5,6\}$. Then the probability that a randomly chosen onto function $g$ from $S$ to $S$ satisfies $\mathrm{g}(3)=2 \mathrm{~g}(1)$ is :
(1) $\frac{1}{10}$
(2) $\frac{1}{15}$
(3) $\frac{1}{5}$
(4) $\frac{1}{30}$

Official Ans. by NTA (1)

Sol. $g(3)=2 g(1)$ can be defined in 3 ways number of onto functions in this condition $=3 \times 4$ !

Total number of onto functions $=6$ !
Required probability $=\frac{3 \times 4!}{6!}=\frac{1}{10}$
5. Let $\mathrm{f}: \mathbf{N} \rightarrow \mathbf{N}$ be a function such that
$\mathrm{f}(\mathrm{m}+\mathrm{n})=\mathrm{f}(\mathrm{m})+\mathrm{f}(\mathrm{n})$ for every $\mathrm{m}, \mathrm{n} \in \mathbf{N}$. If $\mathrm{f}(6)=18$, then $f(2) \cdot f(3)$ is equal to :
(1) 6
(2) 54
(3) 18
(4) 36

Official Ans. by NTA (2)
Sol. $\quad f(\mathrm{~m}+\mathrm{n})=f(\mathrm{~m})+f(\mathrm{n})$
Put $\mathrm{m}=1, \mathrm{n}=1$
$f(2)=2 f(1)$
Put $\mathrm{m}=2, \mathrm{n}=1$
$f(3)=f(2)+f(1)=3 f(1)$
Put $m=3, n=3$
$f(6)=2 f(3) \Rightarrow f(3)=9$
$\Rightarrow f(1)=3, f(2)=6$
$f(2) . f(3)=6 \times 9=54$
6. The distance of the point $(-1,2,-2)$ from the line of intersection of the planes $2 x+3 y+2 z=0$ and $x-2 y+z=0$ is :
(1) $\frac{1}{\sqrt{2}}$
(2) $\frac{5}{2}$
(3) $\frac{\sqrt{42}}{2}$
(4) $\frac{\sqrt{34}}{2}$

Official Ans. by NTA (4)
Sol. $\quad P_{1}: 2 x+3 y+2 z=0$
$\Rightarrow \overrightarrow{\mathrm{n}}_{1}=2 \hat{\mathrm{i}}+3 \hat{\mathrm{j}}+2 \hat{\mathrm{k}}$
$P_{2}: x-2 y+z=0$
$\Rightarrow \overrightarrow{\mathrm{n}}_{2}=\hat{\mathrm{i}}-2 \hat{\mathrm{j}}+\mathrm{k}$
Direction vector of line $L$ which is line of intersection of $\mathrm{P}_{1} \& \mathrm{P}_{2}$
$\overrightarrow{\mathrm{r}}=\overrightarrow{\mathrm{n}}_{1} \times \overrightarrow{\mathrm{n}}_{2}=7 \hat{\mathrm{i}}-7 \hat{\mathrm{k}}$
DR's of $L$ are $(1,0,-1)$
$\Rightarrow$ Equation of $\mathrm{L}: \frac{\mathrm{x}}{1}=\frac{\mathrm{y}}{0}=\frac{\mathrm{z}}{-1}=\lambda$


DR's of $\overrightarrow{\mathrm{PQ}}=(\lambda+1,-2,2-\lambda)$
$\because \overrightarrow{\mathrm{PQ}} \perp \overrightarrow{\mathrm{r}}$
$\Rightarrow(\lambda+1)(1)+(-2)(0)+(2-\lambda)(-1)=0$
$\Rightarrow \lambda=\frac{1}{2} \Rightarrow \mathrm{Q}\left(\frac{1}{2}, 0, \frac{-1}{2}\right)$
$\Rightarrow \mathrm{PQ}=\frac{\sqrt{34}}{2}$
7. Negation of the statement $(\mathrm{p} \vee \mathrm{r}) \Rightarrow(\mathrm{q} \vee \mathrm{r})$ is :
(1) $\mathrm{p} \wedge \sim \mathrm{q} \wedge \sim \mathrm{r}$
(2) $\sim \mathrm{p} \wedge \mathrm{q} \wedge \sim \mathrm{r}$
(3) $\sim p \wedge q \wedge r$
(4) $\mathrm{p} \wedge \mathrm{q} \wedge \mathrm{r}$

Official Ans. by NTA (1)
Sol. $\because \sim(A \Rightarrow B)=A \wedge \sim B$
$\therefore \sim((p \vee r) \Rightarrow(q \vee r))$
$=(p \vee r) \wedge(\sim q \wedge \sim r)$
$=((\mathrm{p} \vee \mathrm{r}) \wedge(\sim \mathrm{r})) \wedge(\sim \mathrm{q})$
$=\mathrm{p} \wedge(\sim \mathrm{r}) \wedge(\sim \mathrm{q})$
8. If $\alpha=\lim _{x \rightarrow \pi / 4} \frac{\tan ^{3} x-\tan x}{\cos \left(x+\frac{\pi}{4}\right)}$ and $\beta=\lim _{x \rightarrow 0}(\cos x)^{\cot x}$ are the roots of the equation, $\mathrm{ax}^{2}+\mathrm{bx}-4=0$, then the ordered pair $(a, b)$ is :
(1) $(1,-3)$
(2) $(-1,3)$
(3) $(-1,-3)$
(4) $(1,3)$

## Official Ans. by NTA (4)

Sol. $\alpha=\lim _{x \rightarrow \frac{\pi}{4}} \frac{\tan ^{3} x-\tan x}{\cos \left(x+\frac{\pi}{4}\right)} ; \frac{0}{0}$ form
Using L Hopital rule
$\alpha=\lim _{x \rightarrow \frac{\pi}{4}} \frac{3 \tan ^{2} x \sec ^{2} x-\sec ^{2} x}{-\sin \left(x+\frac{\pi}{4}\right)}$
$\Rightarrow \alpha=-4$
$\beta=\lim _{x \rightarrow 0}(\cos x)^{\cot x}=e^{\lim _{x \rightarrow 0} \frac{(\cos x-1)}{\tan x}}$
$\beta=e^{\lim _{x \rightarrow 0} \frac{-(1-\cos x)}{x^{2}} \cdot \frac{x^{2}}{\left(\frac{\tan x}{x}\right)^{x}}}$
$\beta=e^{\lim _{x \rightarrow 0}\left(\frac{-1}{2}\right) \cdot \frac{x}{1}}=e^{0} \Rightarrow \beta=1$
$\alpha=-4 ; \beta=1$
If $a x^{2}+b x-4=0$ are the roots then
$16 \mathrm{a}-4 \mathrm{~b}-4=0 \& \mathrm{a}+\mathrm{b}-4=0$
$\Rightarrow \mathrm{a}=1 \& \mathrm{~b}=3$
9. The locus of mid-points of the line segments joining ( $-3,-5$ ) and the points on the ellipse $\frac{x^{2}}{4}+\frac{y^{2}}{9}=1$ is :
(1) $9 x^{2}+4 y^{2}+18 x+8 y+145=0$
(2) $36 x^{2}+16 y^{2}+90 x+56 y+145=0$
(3) $36 x^{2}+16 y^{2}+108 x+80 y+145=0$
(4) $36 x^{2}+16 y^{2}+72 x+32 y+145=0$

Official Ans. by NTA (3)
Sol. General point on $\frac{x^{2}}{4}+\frac{y^{2}}{9}=1$ is $\mathrm{A}(2 \cos \theta, 3 \sin \theta)$ given $B(-3,-5)$
midpoint $\mathrm{C}\left(\frac{2 \cos \theta-3}{2}, \frac{3 \sin \theta-5}{2}\right)$
$\mathrm{h}=\frac{2 \cos \theta-3}{2} ; \mathrm{k}=\frac{3 \sin \theta-5}{2}$
$\Rightarrow\left(\frac{2 \mathrm{~h}+3}{2}\right)^{2}+\left(\frac{2 \mathrm{k}+5}{3}\right)^{2}=1$
$\Rightarrow 36 x^{2}+16 y^{2}+108 x+80 y+145=0$
10. If $\frac{d y}{d x}=\frac{2^{x} y+2^{y} \cdot 2^{x}}{2^{x}+2^{x+y} \log _{e} 2}, y(0)=0$, then for $y=1$, the value of $x$ lies in the interval:
(1) $(1,2)$
(2) $\left(\frac{1}{2}, 1\right]$
(3) $(2,3)$
(4) $\left(0, \frac{1}{2}\right]$

Sol. $\frac{d y}{d x}=\frac{2^{x}\left(y+2^{y}\right)}{2^{x}\left(1+2^{y} \ln 2\right)}$
$\Rightarrow \int \frac{\left(1+2^{y}\right) \ln 2}{\left(y+2^{y}\right)} d y=\int d x$
$\Rightarrow \ell \mathrm{nly}+2^{y} \mid=\mathrm{x}+\mathrm{c}$
$x=0 ; y=0 \Rightarrow c=0$
$\Rightarrow \mathrm{x}=$ थnly $+2^{x} \mid$
$\Rightarrow$ at $y=1, x=\ln 3$
$\because 3 \in\left(\mathrm{e}, \mathrm{e}^{2}\right) \Rightarrow \mathrm{x} \in(1,2)$
11. An angle of intersection of the curves, $\frac{x^{2}}{a^{2}}+\frac{y^{2}}{b^{2}}=1$ and $x^{2}+y^{2}=a b, a>b$, is :
(1) $\tan ^{-1}\left(\frac{a+b}{\sqrt{a b}}\right)$
(2) $\tan ^{-1}\left(\frac{a-b}{2 \sqrt{a b}}\right)$
(3) $\tan ^{-1}\left(\frac{a-b}{\sqrt{a b}}\right)$
(4) $\tan ^{-1}(2 \sqrt{\mathrm{ab}})$

Official Ans. by NTA (3)
Sol. $\frac{\mathrm{x}^{2}}{\mathrm{a}^{2}}+\frac{\mathrm{y}^{2}}{\mathrm{~b}^{2}}=1, \mathrm{x}^{2}+\mathrm{y}^{2}=\mathrm{ab}$
$\frac{2 x_{1}}{a^{2}}+\frac{2 y_{1} y^{\prime}}{b^{2}}=0$
$\Rightarrow \mathrm{y}_{1}{ }^{\prime}=\frac{-\mathrm{x}_{1}}{\mathrm{a}^{2}} \frac{\mathrm{~b}^{2}}{\mathrm{y}_{1}}$
$\therefore 2 \mathrm{x}_{1}+2 \mathrm{y}_{1} \mathrm{y}^{\prime}=0$
$\Rightarrow \mathrm{y}_{2}{ }^{\prime}=\frac{-\mathrm{x}_{1}}{\mathrm{y}_{1}}$
Here $\left(x_{1} y_{1}\right)$ is point of intersection of both curves
$\therefore \mathrm{x}_{1}^{2}=\frac{\mathrm{a}^{2} \mathrm{~b}}{\mathrm{a}+\mathrm{b}}, \mathrm{y}_{1}^{2}=\frac{\mathrm{ab}^{2}}{\mathrm{a}+\mathrm{b}}$
$\therefore \tan \theta=\left|\frac{y_{1}{ }^{\prime}-y_{2}{ }^{\prime}}{1+y_{1}{ }^{\prime} y_{2}{ }^{\prime}}\right|=\left|\frac{\frac{-x_{1} b^{2}}{a^{2} y_{1}}+\frac{x_{1}}{y_{1}}}{1+\frac{x_{1}^{2} b^{2}}{a^{2} y_{1}^{2}}}\right|$
$\tan \theta=\left|\frac{-b^{2} x_{1} y_{1}+a^{2} x_{1} y_{1}}{a^{2} y_{1}^{2}+b^{2} x_{1}^{2}}\right|$
$\tan \theta=\left|\frac{\mathrm{a}-\mathrm{b}}{\sqrt{\mathrm{ab}}}\right|$
12. If $y \frac{d y}{d x}=x\left[\frac{y^{2}}{x^{2}}+\frac{\phi\left(\frac{y^{2}}{x^{2}}\right)}{\phi^{\prime}\left(\frac{y^{2}}{x^{2}}\right)}\right], x>0, \phi>0$, and $y(1)=-1$, then $\phi\left(\frac{y^{2}}{4}\right)$ is equal to :
(1) $4 \phi(2)$
(2) $4 \phi(1)$
(3) $2 \phi(1)$
(4) $\phi(1)$

Official Ans. by NTA (2)
Sol. Let, $\mathrm{y}=\mathrm{tx}$
$\frac{d y}{d x}=t+x \frac{d t}{d x}$
$\therefore \mathrm{tx}\left(\mathrm{t}+\mathrm{x} \frac{\mathrm{dt}}{\mathrm{dx}}\right)=\mathrm{x}\left(\mathrm{t}^{2}+\frac{\varphi\left(\mathrm{t}^{2}\right)}{\varphi^{\prime}\left(\mathrm{t}^{2}\right)}\right)$
$\mathrm{t}^{2}+\mathrm{xt} \frac{\mathrm{dt}}{\mathrm{dx}}=\mathrm{t}^{2}+\frac{\varphi\left(\mathrm{t}^{2}\right)}{\varphi^{\prime}\left(\mathrm{t}^{2}\right)}$
$\int \frac{t \varphi^{\prime}\left(\mathrm{t}^{2}\right)}{\varphi\left(\mathrm{t}^{2}\right)} \mathrm{dt}=\int \frac{\mathrm{dx}}{\mathrm{x}}$
Let $\varphi\left(\mathrm{t}^{2}\right)=\mathrm{p}$
$\therefore \varphi^{\prime}\left(\mathrm{t}^{2}\right) 2 \mathrm{tdt}=\mathrm{dp}$
$\Rightarrow \int \frac{d y}{2 p}=\int \frac{d x}{x}$
$\frac{1}{2} \ell \mathrm{n} \varphi\left(\mathrm{t}^{2}\right)=\ell \mathrm{nx}+\ell \mathrm{nc}$
$\varphi\left(\mathrm{t}^{2}\right)=\mathrm{x}^{2} \mathrm{k}$
$\varphi\left(\frac{\mathrm{y}^{2}}{\mathrm{x}^{2}}\right)=\mathrm{kx}^{2}, \varphi(1)=\mathrm{k}$
$\varphi\left(\frac{\mathrm{y}^{2}}{4}\right)=4 \varphi(1)$
13. The sum of the roots of the equation $x+1-2 \log _{2}\left(3+2^{x}\right)+2 \log _{4}\left(10-2^{-x}\right)=0$, is :
(1) $\log _{2} 14$
(2) $\log _{2} 11$
(3) $\log _{2} 12$
(4) $\log _{2} 13$

Sol. $x+1-2 \log _{2}\left(3+2^{x}\right)+2 \log _{4}\left(10-2^{-x}\right)=0$
$\log _{2}\left(2^{x+1}\right)-\log _{2}\left(3+2^{x}\right)^{2}+\log _{2}\left(10-2^{-x}\right)=0$
$\log _{2}\left(\frac{2^{x+1} \cdot\left(10-2^{-x}\right)}{\left(3+2^{x}\right)^{2}}\right)=0$
$\frac{2\left(10.2^{x}-1\right)}{\left(3+2^{x}\right)^{2}}=1$
$\Rightarrow 20.2^{x}-2=9+2^{2 x}+6.2^{x}$
$\therefore\left(2^{x}\right)^{2}-14\left(2^{x}\right)+11=0$
Roots are $2^{x_{1}} \& 2^{x_{2}}$
$\therefore 2^{\mathrm{x}_{1}} \cdot 2^{\mathrm{x}_{2}}=11$
$\mathrm{X}_{1}+\mathrm{x}_{2}=\log _{2}(11)$
14. If $z$ is a complex number such that $\frac{z-i}{z-1}$ is purely imaginary, then the minimum value of $|z-(3+3 i)|$ is :
(1) $2 \sqrt{2}-1$
(2) $3 \sqrt{2}$
(3) $6 \sqrt{2}$
(4) $2 \sqrt{2}$

## Official Ans. by NTA (4)

Sol. $\frac{\mathrm{z}-\mathrm{i}}{\mathrm{z}-1}$ is purely Imaginary number
Let $\mathrm{z}=\mathrm{x}+\mathrm{iy}$
$\therefore \frac{x+i(y-1)}{(x-1)+i(y)} \times \frac{(x-1)-i y}{(x-1)-i y}$
$\Rightarrow \frac{\mathrm{x}(\mathrm{x}-1)+\mathrm{y}(\mathrm{y}-1)+\mathrm{i}(-\mathrm{y}-\mathrm{x}+1)}{(\mathrm{x}-1)^{2}+\mathrm{y}^{2}}$ is purely
Imaginary number
$\Rightarrow \mathrm{x}(\mathrm{x}-1)+\mathrm{y}(\mathrm{y}-1)=0$
$\Rightarrow\left(\mathrm{x}-\frac{1}{2}\right)^{2}+\left(\mathrm{y}-\frac{1}{2}\right)^{2}=\frac{1}{2}$


Official Ans. by NTA (2)
$\therefore|\mathrm{z}-(3+3 \mathrm{i})|_{\min }=|\mathrm{PC}|-\frac{1}{\sqrt{2}}$

$$
=\frac{5}{\sqrt{2}}-\frac{1}{\sqrt{2}}=2 \sqrt{2}
$$

15. Let $a_{1}, a_{2}, a_{3}, \ldots$ be an A.P. If
$\frac{a_{1}+a_{2}+\ldots+a_{10}}{a_{1}+a_{2}+\ldots+a_{p}}=\frac{100}{p^{2}}, p \neq 10$, then $\frac{a_{11}}{a_{10}}$ is equal to :
(1) $\frac{19}{21}$
(2) $\frac{100}{121}$
(3) $\frac{21}{19}$
(4) $\frac{121}{100}$

## Official Ans. by NTA (3)

Sol. $\frac{\frac{10}{2}\left(2 a_{1}+9 d\right)}{\frac{p}{2}\left(2 a_{1}+(p-1) d\right)}=\frac{100}{p^{2}}$
$\left(2 a_{1}+9 d\right) p=10\left(2 a_{1}+(p-1) d\right)$
$9 \mathrm{dp}=20 \mathrm{a}_{1}-2 \mathrm{pa}_{1}+10 \mathrm{~d}(\mathrm{p}-1)$
$9 \mathrm{p}=(20-2 \mathrm{p}) \frac{\mathrm{a}_{1}}{\mathrm{~d}}+10(\mathrm{p}-1)$
$\frac{\mathrm{a}_{1}}{\mathrm{~d}}=\frac{(10-\mathrm{p})}{2(10-\mathrm{p})}=\frac{1}{2}$
$\therefore \frac{\mathrm{a}_{11}}{\mathrm{a}_{10}}=\frac{\mathrm{a}_{1}+10 \mathrm{~d}}{\mathrm{a}_{1}+9 \mathrm{~d}}=\frac{\frac{1}{2}+10}{\frac{1}{2}+9}=\frac{21}{19}$
16. Let $A$ be the set of all points $(\alpha, \beta)$ such that the area of triangle formed by the points $(5,6),(3,2)$ and $(\alpha, \beta)$ is 12 square units. Then the least possible length of a line segment joining the origin to a point in A , is :
(1) $\frac{4}{\sqrt{5}}$
(2) $\frac{16}{\sqrt{5}}$
(3) $\frac{8}{\sqrt{5}}$
(4) $\frac{12}{\sqrt{5}}$

Official Ans. by NTA (3)

## Sol.


$\left|\frac{1}{2}\right| \begin{array}{lll}5 & 6 & 1 \\ 3 & 2 & 1 \\ \alpha & \beta & 1\end{array}|\mid=12$
$4 \alpha-2 \beta= \pm 24+8$
$\Rightarrow 4 \alpha-2 \beta=+24+8 \Rightarrow 2 \alpha-\beta=16$
$2 \mathrm{x}-\mathrm{y}-16=0$
$\Rightarrow 4 \alpha-2 \beta=-24+8 \Rightarrow 2 \alpha-\beta=-8$
$2 \mathrm{x}-\mathrm{y}+8=0$
perpendicular distance of $(1)$ from $(0,0)$
$\left|\frac{0-0-16}{\sqrt{5}}\right|=\frac{16}{\sqrt{5}}$
perpendicular distance of $(2)$ from $(0,0)$ is $\left|\frac{0-0+8}{\sqrt{5}}\right|=\frac{8}{\sqrt{5}}$
17. The number of solutions of the equation $32^{\tan ^{2} x}+32^{\sec ^{2} x}=81,0 \leq x \leq \frac{\pi}{4}$ is :
(1) 3
(2) 1
(3) 0
(4) 2

Official Ans. by NTA (2)
Sol. $(32)^{\tan ^{2} x}+(32)^{\sec ^{2} x}=81$
$\Rightarrow(32)^{\tan ^{2} x}+(32)^{1+\tan ^{2} x}=81$
$\Rightarrow(32)^{\tan ^{2} x}=\frac{81}{33}$
In interval $\left[0, \frac{\pi}{4}\right]$ only one solution
18. Let f be any continuous function on $[0,2]$ and twice differentiable on $(0,2)$. If $f(0)=0, f(1)=1$ and $f(2)=2$, then
(1) $\mathrm{f}^{\prime \prime}(\mathrm{x})=0$ for all $\mathrm{x} \in(0,2)$
(2) $f^{\prime \prime}(x)=0$ for some $x \in(0,2)$
(3) $f^{\prime}(x)=0$ for some $x \in[0,2]$
(4) $\mathrm{f}^{\prime \prime}(\mathrm{x})>0$ for all $\mathrm{x} \in(0,2)$

Official Ans. by NTA (2)
Sol. $f(0)=0 \quad f(1)=1$ and $f(2)=2$
Let $\mathrm{h}(\mathrm{x})=f(\mathrm{x})-\mathrm{x}$ has three roots

By Rolle's theorem $\mathrm{h}^{\prime}(\mathrm{x})=f^{\prime}(\mathrm{x})-1$ has at least two roots
$h^{\prime \prime}(\mathrm{x})=f^{\prime \prime}(\mathrm{x})=0$ has at least one roots
19. If $[x]$ is the greatest integer $\leq x$, then
$\pi^{2} \int_{0}^{2}\left(\sin \frac{\pi x}{2}\right)(x-[x])^{[x]} d x$ is equal to :
(1) $2(\pi-1)$
(2) $4(\pi-1)$
(3) $4(\pi+1)$
(4) $2(\pi+1)$

Official Ans. by NTA (2)
Sol. $\quad \pi^{2}\left[\int_{0}^{1} \sin \frac{\pi \mathrm{x}}{2} \mathrm{dx}+\int_{1}^{2} \sin \frac{\pi \mathrm{x}}{2}(\mathrm{x}-1) \mathrm{dx}\right]$
$=\pi^{2}\left[-\frac{2}{\pi}\left(\cos \frac{\pi \mathrm{x}}{2}\right)+\left((\mathrm{x}-1)\left(-\frac{2}{\pi} \cos \frac{\pi \mathrm{x}}{2}\right)\right)_{1}^{2}-\int_{1}^{2}-\frac{2}{\pi} \cos \frac{\pi \mathrm{x}}{2} \mathrm{dx}\right]$
$=\pi^{2}\left[0+\frac{2}{\pi}+\frac{2}{\pi}+\frac{2}{\pi} \cdot \frac{2}{\pi}\left(\sin \frac{\pi \mathrm{x}}{2}\right)_{1}^{2}\right]$
$=4 \pi-4=4(\pi-1)$
20. The mean and variance of 7 observations are 8 and 16 respectively. If two observations are 6 and 8 , then the variance of the remaining 5 observations is :
(1) $\frac{92}{5}$
(2) $\frac{134}{5}$
(3) $\frac{536}{25}$
(4) $\frac{112}{5}$

Official Ans. by NTA (3)
Sol. Let 8, 16, $x_{1}, x_{2}, x_{3}, x_{4}, x_{5}$ be the observations.
Now $\frac{x_{1}+x_{2}+\ldots+x_{5}+14}{7}=8$
$\Rightarrow \sum_{\mathrm{i}=1}^{5} \mathrm{x}_{\mathrm{i}}=42$
Also $\frac{x_{1}^{2}+x_{2}^{2}+\ldots x_{5}^{2}+8^{2}+6^{2}}{7}-64=16$
$\Rightarrow \sum_{\mathrm{i}=1}^{5} \mathrm{x}_{\mathrm{i}}^{2}=560-100=460$
So variance of $\mathrm{x}_{1}, \mathrm{x}_{2}, \ldots, \mathrm{x}_{5}$

$$
=\frac{460}{5}-\left(\frac{42}{5}\right)^{2}=\frac{2300-1764}{25}=\frac{536}{25}
$$

## SECTION-B

1. If the coefficient of $a^{7} b^{8}$ in the expansion of $(a+2 b+4 a b)^{10}$ is $K .2^{16}$, then $K$ is equal to $\qquad$ .

Official Ans. by NTA (315)
Sol. $\frac{10!}{\alpha!\beta!\gamma!} a^{\alpha}(2 b)^{\beta} .(4 a b)^{\gamma}$
$\frac{10!}{\alpha!\beta!\gamma!} \mathrm{a}^{\alpha+\gamma} \cdot b^{\beta+\gamma} \cdot 2^{\beta} \cdot 4^{\gamma}$
$\alpha+\beta+\gamma=10$
$\alpha+\gamma=7$
$\beta+\gamma=8$
(2) $+(3)-(1) \Rightarrow \gamma=5$
$\alpha=2$
$\beta=3$
so coefficients $=\frac{10!}{2!3!5!} 2^{3} \cdot 2^{10}$
$=\frac{10 \times 9 \times 8 \times 7 \times 6 \times 5}{2 \times 3 \times 2 \times 5!} \times 2^{13}$
$=315 \times 2^{16} \Rightarrow \mathrm{k}=315$
2. Suppose the line $\frac{x-2}{\alpha}=\frac{y-2}{-5}=\frac{z+2}{2}$ lies on the plane $x+3 y-2 z+\beta=0$. Then $(\alpha+\beta)$ is equal to
$\qquad$ .

Official Ans. by NTA (7)
Sol. Point $(2,2,-2)$ also lies on given plane
So $2+3 \times 2-2(-2)+\beta=0$
$\Rightarrow 2+6+4+\beta=0 \Rightarrow \beta=-12$
Also $\alpha \times 1-5 \times 3+2 \times-2=0$
$\Rightarrow \alpha-15-4=0 \Rightarrow \alpha=19$
$\therefore \alpha+\beta=19-12=7$
3. The number of 4-digit numbers which are neither multiple of 7 nor multiple of 3 is $\qquad$ .

Official Ans. by NTA (5143)
Sol. A $=4$ - digit numbers divisible by 3
$\mathrm{A}=1002,1005, \ldots, 9999$.
$9999=1002+(n-1) 3$
$\Rightarrow(\mathrm{n}-1) 3=8997 \Rightarrow \mathrm{n}=3000$
$\mathrm{B}=4-$ digit numbers divisible by 7
$B=1001,1008, \ldots, 9996$
$\Rightarrow 9996=1001+(\mathrm{n}-1) 7$
$\Rightarrow \mathrm{n}=1286$
$\mathrm{A} \cap \mathrm{B}=1008,1029, \ldots, 9996$
$9996=1008+(n-1) 21$
$\Rightarrow \mathrm{n}=429$
So, no divisible by either 3 or 7
$=3000+1286-429=3857$
total 4-digits numbers $=9000$
required numbers $=9000-3857=5143$
4. If $\int \frac{\sin x}{\sin ^{3} x+\cos ^{3} x} d x=$ $\alpha \log _{e}|1+\tan x|+\beta \log _{e}\left|1-\tan x+\tan ^{2} x\right|+\gamma \tan ^{-1}\left(\frac{2 \tan x-1}{\sqrt{3}}\right)+C$,
when C is constant of integration, then the value of $18\left(\alpha+\beta+\gamma^{2}\right)$ is $\qquad$ .

Official Ans. by NTA (3)
Sol. $=\int \frac{\frac{\sin x}{\cos ^{3} x}}{1+\tan ^{3} x} d x=\int \frac{\tan x \cdot \sec ^{2} x}{(\tan x+1)\left(1+\tan ^{2} x-\tan x\right)} d x$
Let $\tan \mathrm{x}=\mathrm{t} \Rightarrow \sec ^{2} \mathrm{x} . \mathrm{dx}=\mathrm{dt}$
$=\int \frac{t}{(t+1)\left(t^{2}-t+1\right)} d t$
$=\int\left(\frac{A}{t+1}+\frac{B(2 t-1)}{t^{2}-t+1}+\frac{C}{t^{2}-t+1}\right) d x$
$\Rightarrow \mathrm{A}\left(\mathrm{t}^{2}-\mathrm{t}+1\right)+\mathrm{B}(2 \mathrm{t}-1)\left(\mathrm{t}^{2}-\mathrm{t}+1\right)+\mathrm{C}(\mathrm{t}+1)=\mathrm{t}$
$\Rightarrow \mathrm{t}^{2}(\mathrm{~A}+2 \mathrm{~B})+\mathrm{t}(-\mathrm{A}+\mathrm{B}+\mathrm{C})+\mathrm{A}-\mathrm{B}+\mathrm{C}=1$
$\therefore \mathrm{A}+2 \mathrm{~B}=0$
$-\mathrm{A}+\mathrm{B}+\mathrm{C}=1$
$\mathrm{A}-\mathrm{B}+\mathrm{C}=0$
$\Rightarrow \mathrm{C}=\frac{1}{2} \Rightarrow \mathrm{~A}-\mathrm{B}=-\frac{1}{2}$
$A+2 B=0$
$\mathrm{A}-\mathrm{B}=-\frac{1}{2}$
$\Rightarrow 3 \mathrm{~B}=\frac{1}{2} \Rightarrow \mathrm{~B}=\frac{1}{6}$
$A=-\frac{1}{3}$
$\mathrm{I}=-\frac{1}{3} \int \frac{\mathrm{dt}}{1+\mathrm{t}}+\frac{1}{6} \int \frac{2 \mathrm{t}-1}{\mathrm{t}^{2}-\mathrm{t}+1} \mathrm{dt}+\frac{1}{2} \int \frac{\mathrm{dt}}{\mathrm{t}^{2}-\mathrm{t}+1}$
$=-\frac{1}{3} \ell \operatorname{n}|(1+\tan x)|+\frac{1}{6} \ell \operatorname{n}\left|\tan ^{2} x-\tan x+1\right|$

$$
+\frac{1}{2} \cdot \frac{2}{\sqrt{3}} \tan ^{-1}\left(\frac{\left(\tan x-\frac{1}{2}\right)}{\frac{\sqrt{3}}{2}}\right)
$$

$=-\frac{1}{3} \ln |(1+\tan x)|+\frac{1}{6} \ln \left|\tan ^{2} x-\tan x+1\right|$

$$
+\frac{1}{\sqrt{3}} \tan ^{-1}\left(\frac{2 \tan x-1}{\sqrt{3}}\right)+\mathrm{C}
$$

$\alpha=-\frac{1}{3}, \beta=\frac{1}{6}, \gamma=\frac{1}{\sqrt{3}}$
$18\left(\alpha+\beta+\gamma^{2}\right)=18\left(-\frac{1}{3}+\frac{1}{6}+\frac{1}{3}\right)=3$
5. A tangent line $L$ is drawn at the point $(2,-4)$ on the parabola $y^{2}=8 x$. If the line $L$ is also tangent to the circle $x^{2}+y^{2}=a$, then ' $a$ ' is equal to $\qquad$ -

Official Ans. by NTA (2)

Sol. tangent of $y^{2}=8 x$ is $y=m x+\frac{2}{m}$
$\mathrm{P}(2,-4) \Rightarrow-4=2 \mathrm{~m}+\frac{2}{\mathrm{~m}}$
$\Rightarrow \mathrm{m}+\frac{1}{\mathrm{~m}}=-2 \Rightarrow \mathrm{~m}=-1$
$\therefore$ tangent is $\mathrm{y}=-\mathrm{x}-2$
$\Rightarrow x+y+2=0$
(1) is also tangent to $x^{2}+y^{2}=a$

So $\frac{2}{\sqrt{2}}=\sqrt{\mathrm{a}} \Rightarrow \sqrt{\mathrm{a}}=\sqrt{2}$
$\Rightarrow \mathrm{a}=2$
6. If $\mathrm{S}=\frac{7}{5}+\frac{9}{5^{2}}+\frac{13}{5^{3}}+\frac{19}{5^{4}}+\ldots$, then 160 S is equal to $\qquad$ .

Official Ans. by NTA (305)
Sol.

$$
\begin{aligned}
S & =\frac{7}{5}+\frac{9}{5^{2}}+\frac{13}{5^{3}}+\frac{19}{5^{4}}+\ldots \\
\frac{1}{5} S & =\frac{7}{5^{2}}+\frac{9}{5^{3}}+\frac{13}{5^{4}}+\ldots
\end{aligned}
$$

On subtracting
$\frac{4}{5} S=\frac{7}{5}+\frac{2}{5^{2}}+\frac{4}{5^{3}}+\frac{6}{5^{4}}+\ldots$
$S=\frac{7}{4}+\frac{1}{10}\left(1+\frac{2}{5}+\frac{3}{5^{2}}+\ldots\right)$
$S=\frac{7}{4}+\frac{1}{10}\left(1-\frac{1}{5}\right)^{-2}$
$=\frac{7}{4}+\frac{1}{10} \times \frac{25}{16}=\frac{61}{32}$
$\Rightarrow 160 \mathrm{~S}=5 \times 61=305$
7. The number of elements in the set

$$
\left\{\mathrm{A}=\left(\begin{array}{ll}
\mathrm{a} & \mathrm{~b} \\
0 & \mathrm{~d}
\end{array}\right): \mathrm{a}, \mathrm{~b}, \mathrm{~d} \in\{-1,0,1\} \operatorname{and}(\mathrm{I}-\mathrm{A})^{3}=\mathrm{I}-\mathrm{A}^{3}\right\},
$$

where I is $2 \times 2$ identity matrix, is:
Official Ans. by NTA (8)
Sol. $(I-A)^{3}=I^{3}-A^{3}-3 A(I-A)=I-A^{3}$
$\Rightarrow 3 \mathrm{~A}(\mathrm{I}-\mathrm{A})=0$ or $\mathrm{A}^{2}=\mathrm{A}$
$\Rightarrow\left[\begin{array}{cc}a^{2} & a b+b d \\ 0 & d^{2}\end{array}\right]=\left[\begin{array}{cc}a & b \\ 0 & d\end{array}\right]$
$\Rightarrow a^{2}=a, b(a+d-1)=0, d^{2}=d$
If $b \neq 0, a+d=1 \Rightarrow 4$ ways

If $\mathrm{b}=0, \mathrm{a}=0,1 \& \mathrm{~d}=0,1 \Rightarrow 4$ ways
$\Rightarrow$ Total 8 matrices
8. If the line $y=m x$ bisects the area enclosed by the lines $\mathrm{x}=0, \mathrm{y}=0, \mathrm{x}=\frac{3}{2}$ and the curve $y=1+4 x-x^{2}$, then $12 m$ is equal to $\qquad$ .

Official Ans. by NTA (26)
Sol.


Total area $=\int_{0}^{3 / 2}\left(1+4 x-x^{2}\right) d x$
$=x+2 x^{2}-\left.\frac{x^{3}}{3}\right|_{0} ^{3 / 2}=\frac{39}{8}$
$\& \frac{39}{16}=\frac{1}{2} \cdot \frac{3}{2} \cdot \frac{3}{2} \mathrm{~m}$
$\Rightarrow 3 \mathrm{~m}=\frac{13}{2} \Rightarrow 12 \mathrm{~m}=26$
9. Let B be the centre of the circle $\mathrm{x}^{2}+y^{2}-2 x+4 y+1=0$. Let the tangents at two points P and Q on the circle intersect at the point $\mathrm{A}(3,1)$. Then 8. $\left(\frac{\text { area } \triangle \mathrm{APQ}}{\operatorname{area} \triangle \mathrm{BPQ}}\right)$ is equal to $\qquad$ -.
Official Ans. by NTA (18)
Sol.

$\tan \theta=\frac{3}{2}$
$\frac{\text { Area } \triangle \mathrm{APQ}}{\text { Area } \triangle \mathrm{BPQ}}=\frac{\mathrm{AR}}{\mathrm{RB}}=\frac{3 \sin \theta}{2 \cos \theta}=\frac{9}{4}$
$8\left(\frac{\text { Area } \triangle \mathrm{APQ}}{\text { Area } \triangle \mathrm{BPQ}}\right)=18$
10. Let $\mathrm{f}(\mathrm{x})$ be a cubic polynomial with $\mathrm{f}(1)=-10$, $\mathrm{f}(-1)=6$, and has a local minima at $\mathrm{x}=1$, and $f^{\prime}(x)$ has a local minima at $x=-1$. Then $f(3)$ is equal to $\qquad$ .

Official Ans. by NTA (22)
Sol. $\quad F^{\prime}(x)=a(x-1)(x+3)$
$F^{\prime \prime}(\mathrm{x})=6 \mathrm{a}(\mathrm{x}+1)$
$\mathrm{F}^{\prime}(\mathrm{x})=3 \mathrm{a}(\mathrm{x}+1)^{2}+\mathrm{b}$
$\mathrm{F}^{\prime}(1)=0 \Rightarrow \mathrm{~b}=-12 \mathrm{a}$
$\mathrm{F}(\mathrm{x})=\mathrm{a}(\mathrm{x}+1)^{3}-12 \mathrm{ax}+\mathrm{c}$
$=(\mathrm{x}+1)^{3}-12 \mathrm{x}-6$
$F(3)=64-36-6=22$

