Manipal – 2022

Solved Paper

Physics

1. The time period of a mass suspended from a spring is T. If the spring is cut into three equal parts and connected in parallel. The same mass is suspended from these parallel springs, then the new time period of the mass will be

A. T/4

B. T

C. T/3

D. 3T

2. The work done by all the forces (external and internal) on a system is equal to change in

A. total energy

B. kinetic energy

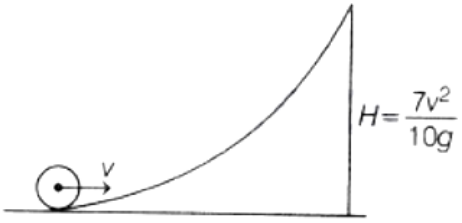
C. potential energy

D. None of these

3. A wire in the form of semi-circle of radius r rotates about its diameter with angular velocity ω in a magnetic field B. The axis of rotation is perpendicular to the field. The total resistance of the circuit is R. If the mean power generated per period of rotation is $\frac{\left(B\pi r^2(\omega)\right)^2}{xR}$, then the value of x is

Numerical

4. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches upto a maximum height of $7v^2/10g$ with respect to initial position. Then the object is



A. ring

B. solid sphere

C. hollow sphere

D. disc

5. If the radius of a planet is three times the radius of the earth. Both have same mass-densities. v_P and v_E are the escape velocities of the planet and the earth respectively, then

A. $v_P = 1.5v_E$

B. $v_P = 3v_E$

C. $v_E = 2v_P$

D. $v_P = 2v_E$

6. The stress that has to be applied to the ends of a steel wire of length 20 cm to keep its length constant, when its temperature is raised by 100°C is 2.2×10^x Pa. The value of x is

(Given $Y = 2 \times 10^{11} Nm^{-2}$,

$\alpha = 1.1 \times 10^{-5} C^{-1}$)

Numerical

7. A vessel contains oil (Density = 0.8 g/cm^3) over meŕcury (density = 13.6 g/cm^3). A homogeneous sphere floats with half of its volume immersed in mercury and the other half in oil. The density of the material of the sphere is x g/cm^3. The value of x is

Numerical

8. At which temperature, magnitude of ^{0}C and ^{0}F are equal?

A. 273

B. 40

C. -40

D. -273

9. The potential at a point at a distance r from the centre of an electric dipole is proportional to

A. $1/r$

B. $1/r^2$

C. $1/r^3$

D. r^2

10. The electric resistance of a wire is R. If the length of the wire is increased to doubled by stretching it, then the new resistance of the wire is

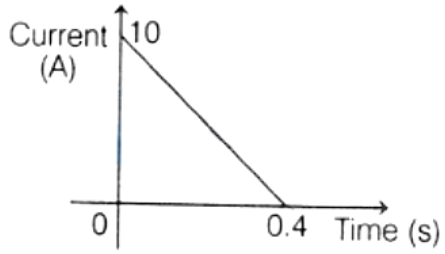
A. 2R

B. 4R

C. R

D. 16R

11. In a coil of resistance 150Ω, a current is induced by changing the magnetic flux through it as shown by figure. The magnitude of flux through the coil is Wb.



Numerical

12. A particle of charge q and mass m is moving with a velocity $-2v\hat{i}(v \neq 0)$ towards a large screen placed in Y Z-plane placed at a distance d. If there is a magnetic field $B = B_0\hat{\mathbf{k}}$, the maximum value of v for which the particle will not strike the screen is

A. $\frac{qdB_0}{m}$

B. $\frac{qdB_0}{2m}$

C. $\frac{2qqdB_0}{m}$

D. $\frac{qdB_0}{3m}$

13. The angle of a prism is A. One of its refracting surface is silvered. If light rays: falling at an angle of incidence 2A on the first suface returns back through the same path ater reflection from silvered surface. The refractive index μ of the prism is

A. 2sin A

B. 2cos A

C. 1/2cos A

D. tan A

14. An electron, helium ion (He^{++}) and proton having the same kinetic energy. The relation between their respective de-Broglie wavelengths λ_θ, λ_{He++} and λ_p is

A. $\lambda_e > \lambda_p > \lambda_{He^{++}}$

B. $\lambda_e > \lambda_{He^{++}} > \lambda_p$

C. $\lambda_e < \lambda_p < \lambda_{He^{++}}$

D. $\lambda_e < \lambda_{He^{++}} = \lambda_p$

15. The electric field of light wave is given is

$E = 10^3 \cos\left(\frac{2\pi x}{5\times10^{-7}} - 2\pi \times 6 \times 10^{14} t\right)\hat{j} N/C.$

This light falls on a metal plate of work function 1.5 eV. The stopping potential of the photoelectron is V.

(Energy of photon $= \frac{1240}{\lambda(\text{ in nm})}\text{eV}$).

Numerical

Chemistry

1. Arrange the following in increasing order of the volume (in L) occupied by them at STP

(i) 1.5 moles of CO_2

(ii) 14 g of N_2

(iii) 10^{21} molecules of oxygen

A. (iii) < (ii) < (i)

B. (i) < (ii) < (iii)

C. (ii) < (i) < (iii)

D. (i) < (iii) < (ii)

2. According to VSEPR theory, the molecular shapes of XeF_4, XeO_4, XeO_2F_2 and $XeOF_4$ respectively are

A. square planar, square planar, see-saw, square pyramidal.

B. square planar, tetrahedral, trigonal bipyramidal, octahedral.

C. square planar, tetrahedral, see-saw, square pyramidal.

D. octahedral, tetrahedral, trigonal bipyramidal, octahegral.

3. If gas absorbs 150 J of heat and expands by 450 cm^3 against a constant pressure of $2 \times 10^5 Nm^{-2}$, then change in internal energy is

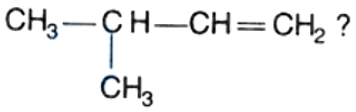
A. -60 J

B. 60 J

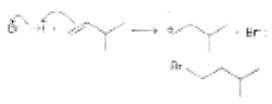
C. 240 J

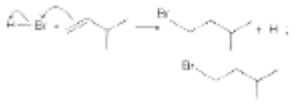
D. -240 J

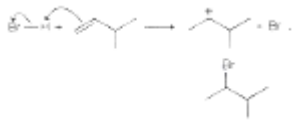
4. What is the first step and the final product formed in the reaction of H − Br with

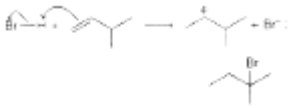


A.



B. 

C. 

D. 

5. In case of positive deviation from Raoult's law, the intermolecular attractive forces between the solute-solvent molecules as compared to those between the solute-solute and solvent-solvent molecules are

A. weaker

B. stronger

C. same

D. independent of intermolecular forces between solute-solvent molecules.

6. From the following molar conductivities at infinite dilution, Λ_m° (in $\Omega^{-1}\ cm^2\ mol^{-1}$) for NH_4OH is

Λ_m° for $Ba(OH)_2 = 446.8\Omega^{-1}\ cm^2\ mol^{-1}$
Λ_m° for $BaCl_2 = 241.6\Omega^{-1}\ cm^2\ mol^{-1}$
Λ_m° for $NH_4Cl = 130\Omega^{-1}\ cm^2\ mol^{-1}$

Numerical

7. For the reaction, $N_2O_5(g) \longrightarrow 2NO_2(g) + ½\ O_2(g)$ the value of the rate of disappearance of N_2O_5 is given as 5.15×10^{-3} mol L^{-1} s^{-1}. The rate of formation of NO_2 is.

Numerical

8. Mond's process is used for refining ____ Whereas van Arkel method is used for refining
____ .

A. lead, zirconium

B. zirconium, nickel

C. nickel, lead

D. nickel, titanium

9. Out of N, P, Ar, Sb and Bi, the number of elements that form pentahalides are

Numerical

10. The number of oxygen atoms that are directly attached to one chromium in dichromate ion are ..... .

Numerical

11. Select the correct statement.

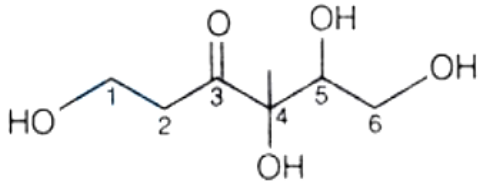
A. $[Ni(CN)_4]^{2-}$ is diamagnetic whereas $[Ni(CO)_4]$ is paramagnetic.

B. $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ both are diamagnetic.

C. $[Ni(CN)_4]^{2-}$ is sp^3 hybridised and square planar in shape
whereas $[Ni(CO)_4]$ is dsp^2 hybridised and tetrahedral in shape.

D. $[Ni(CN)_4]^{2-}$ is paramagnetic and dsp^2 hybridised whereas $[Ni(CO)_4]$ is diamagnetic and sp^3 hybridised.

12. Alcoholic group of which position in the given molecule reacts fastest with the Lucas' reagent?



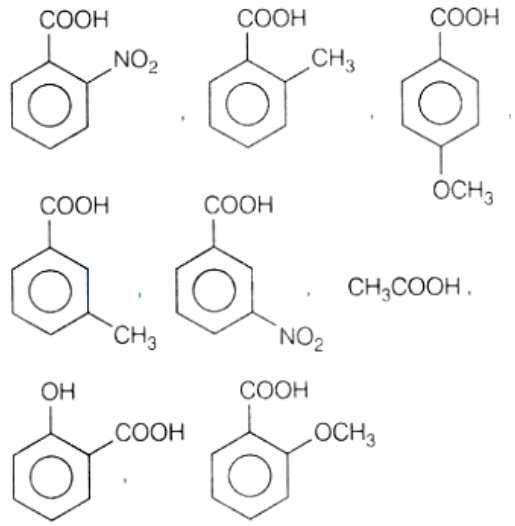
A. 1

B. 4

C. 5

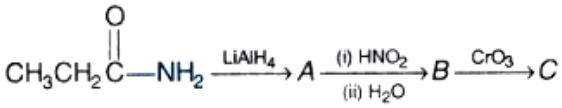
D. 6

13. Out of the given compounds, the number of compounds are weaker acids than benzoic acid are



Numerical

14. In the following sequence of reactions, the compound C formed would be



A. 2-propanol

B. propanol

C. propanoic acid

D. propanal

15. Polystyrene is a _____ polymer whereas dacron is a ____ polymer.

A. step growth, chain growth

B. chain growth, step growth

C. condensation, addition

D. thermoplastic, thermosetting

Mathematics

1. If $\left|z+\frac{2}{z}\right|=2$, then the minimum value of |z| is

A. $1+\sqrt{2}$

B. $1+2\sqrt{2}$

C. $3\sqrt{3}+1$

D. $1-\sqrt{3}$

2. The number of 4 letter word (with or without meaning) that can be formed from the eleven letters of the word 'EXAMINATION is .....

Numerical

3. If α, β and γ are in AP and $\tan^{-1}\alpha$,$\tan^{-1}\beta$ and $\tan^{-1}\gamma$ are also in AP, then

A. $\alpha-\beta-\gamma=0$

B. $\alpha=\beta=\gamma$

C. $\alpha+\beta=\gamma$

D. $2\alpha=3\beta=\gamma$

4. The coefficient of the middle term in the binomial expansion in powers of x of $(1+\alpha x)^4$ and $(1-\alpha x)^6$ is the same, if α is equal to

A. $-5/3$

B. $10/3$

C. $-3/10$

D. $3/5$

5. The differential equation of all circles passing through the origin and having their centre on the X-axis is

A. $x^2=y^2+xy\frac{dy}{dx}$

B. $x^2=y^2+3xy\frac{dy}{dx}$

C. $y^2=x^2+2xy\frac{dy}{dx}$

D. $y^2=x^2-2xy\frac{dy}{dx}$

6. The value of $\lim_{x \to 0} \frac{\int_0^{x^2} \sec^2 t dt}{x \sin x}$ is

A. 3

B. 2

C. 1

D. -1

7. $\lim_{x \to 2} \frac{x^2 + 2^{2-x} - 5}{2^{-x/2} - 2^{1-x}}$ is equal to _____

Numerical

8. If $\sum_{i=1}^{10} (x_i - 3) = 7$ and $\sum_{i=1}^{10} (x_i - 3)^2 = 27$, then the standard deviation of the 10 items

A. 2.547

B. 1.87

C. 14.86

D. 1.486

9. If A = {1,2}, B = {1,2,3,4}, C = {5,6} and D = {5,6,7,8}, then state which of the following is true?

A. (A × C) ⊂ (B × D)

B. A × B ⊂ C × D

C. (A × B) ⊂ (A × D)

D. A × C ⊂ B × D

10. If A and n × n non-singular matrix such that $AA^T = A^{-1}A$ and $B = A^{-1}A^T$, then BB′ is equal to

A. 1 + B

B. 1

C. B^{-1}

D. $(B^{-1})'$

11. Let $f(x) = \sqrt{1 + x^2}$, then

A. $f(xy) = f(x) \cdot f(y)$

B. $f(xy) \geq f(x) \cdot f(y)$

C. $f(x,y) \leq f(x) \cdot f(y)$

D. $f(xy) = f(x) - f(y)$

12. For what value of θ lying between 0 and π which satisfy inequality $\sin\theta \cos^3\theta > \sin^3\theta\cos\theta$

A. $\theta \in (\pi/4, \pi/2)$

B. $\theta \in (0, \pi/4)$

C. $\theta \in (0, \pi/2)$

D. None of these

13. If $\int f(x)dx = g(x)$, then $\int x^9 \cdot f\left(x^5\right) dx$ is equal to

A. $1/5\ (x^5 g(x^9) - 4 \int g(x)dx + C$

B. $1/5[x^9 g(x^5) - 1/5 \int x^4\, g(x^5)\, dx + C$

C. $1/5\ [g(x^9) + \int g(x^5)\, dx]$

D. $\frac{x^5}{5} g\left(x^5\right) - \int x^4 g\left(x^5\right) dx + C$

14. The area of the region bounded by the curves $y = |x - 2|$, $x = 1$, $x = 3$ and the x-axis is

A. 1 sq unit

B. 2 sq units

C. 3 sq units

D. 4 sq units

15. The area of the region described by $A = \{(x, y) : x^2 + y^2 \leq 1 \text{ and } y^2 \leq 1 - x\}$ is

A. $\pi/2 + 4/3$

B. $\pi/2 - 1/2$

C. $\pi/4 + 2/3$

D. $\pi/2 + 2/3$

16. If $\begin{vmatrix} a & a^2 & 1+a^3 \\ b & b^2 & 1+b^3 \\ c & c^2 & 1+c^3 \end{vmatrix} = 0$ and vectors $(1, a, a^2)$ $(1, b, b^2)$ and $(1, c, c^2)$ are non-coplanar, then the product abc is _____

Numerical

17. If the lines $\frac{x-2}{1} = \frac{y-3}{1} = \frac{z-4}{-k}$ and $\frac{x-1}{2k} = \frac{y-3}{2} = \frac{z-5}{1}$ are coplanar, then k can have

A. exactly one value, k = 1/2

B. exactly one value, k = 1/4

C. exactly two values, k = 1/2, −3/2

D. any value

18. If the foot of the perpendicular drawn from the point (0,2,1) on a line passing through (α,5,1) is (5/3,7/3,15/i), then α is equal to ____

Numerical

19. A multiple choice examination has 5 questions. Each question has 4 alternative answer of which exactly one is correct. The probability that a student will get 4 or more correct answer just by guessing is

A. $1/4^5$

B. $(3/4)^4$

C. $1/4^3$

D. $3/4^5$

20. If the probability that a randomly chosen 6-digit number formed by using digits 1 and 8 only is a multiple of 21 is p, then 96p is equal to .....

Numerical

Solution

Physics

Ans 1

Correct Option. C

Solution:

As, spring constant, $(k) \propto \frac{1}{\text{length of spring } (l)}$

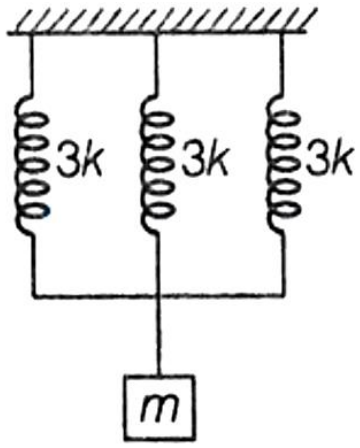
$\because$ The spring cut into three equal parts

$\therefore k' = 3k$ (For each spring)

We know that, time period of a body connected with spring.

$T = 2\pi\sqrt{\frac{m}{k}}$ ...(i)

The parallel arrangement of the spring is given as



$T' =$ Time period of springs $(k' = 3k)$ connected in parallel

$$= 2\pi\sqrt{\frac{m}{3k'}} = 2\pi\sqrt{\frac{m}{3 \times 3k}}$$

$$= \frac{1}{3}\left(2\pi\sqrt{\frac{m}{k}}\right) = \frac{T}{3} \quad \text{[From Eq. (i)]}$$

Ans 2

Correct Option. B

Solution:

According to work-energy theorem,

$$W_{\text{external}} + W_{\text{internal}} = K_f - K_i = \Delta K$$

Ans 3

Correct Option. 8

Solution:

$$(8)\ \phi = \mathbf{B} \cdot \mathbf{A} = BA\cos\theta = BA\cos\omega t, (\because \theta = \omega t)$$

$$\text{Now, emf } (e) = -\frac{d\phi}{dt} = -\frac{d}{dt}(BA\cos\omega t)$$

$$= \omega BA\sin\omega t$$

$$i = \frac{e}{R} = \frac{\omega BA\sin\omega^t}{R}$$

$$\therefore \quad P_{\text{ins}} = i^2R = \left(\frac{\omega^2B^2A^2}{R^2}\sin^2\omega t\right)\cdot R$$

$$= \frac{\omega^2B^2A^2}{R}\sin^2\omega t$$

$$\therefore \quad P_{\text{avg}} = \frac{\int_0^T P_{\text{ins}} \times dt}{\int_0^T dt}$$

$$= \frac{\omega^2B^2A^2}{R}\cdot\frac{\int_0^T \sin^2\omega t dt}{\int_0^T dt}$$

$$= \frac{1}{2}\cdot\frac{\omega^2B^2A^2}{R} \quad \left(\because <\sin^2\omega t>_{t=T} = \frac{1}{2}\right)$$

$$= \frac{\left(B\pi r^2\omega\right)^2}{8R} \quad \left(\because A = \frac{\pi r^2}{2}\right)$$

$$\therefore \quad x = 8$$

Ans 4

Correct Option. B

Solution:

By the conservation of energy,

$$E_i = E_f$$

$$\Rightarrow \quad \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgH = mg\left(\frac{7v^2}{10g}\right)$$

$$\Rightarrow \quad \frac{1}{2}mv^2 + \frac{1}{2}I \cdot \frac{v^2}{R^2} = \frac{7}{10}mv^2 \quad (\because v = \omega R)$$

$$\Rightarrow \quad \frac{1}{2}I \cdot \frac{v^2}{R^2} = \left(\frac{7}{10} - \frac{1}{2}\right)mv^2$$

$$= \frac{2}{10}mv^2 = \frac{1}{5}mv^2$$

$$\therefore \quad I = \frac{2}{5}mR^2$$

The above value of moment of inertia is equal to moment of inertia of solid sphere.

Ans 5

Correct Option. B

Solution:

The escape velocity of a planet is given by,

$$v = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G}{R} \times \frac{4}{3}\pi R^3 \cdot \rho}$$

$$\therefore \quad V \propto R\sqrt{\rho}$$

$$\therefore \quad \frac{v_P}{v_E} = \frac{R_P\sqrt{\rho_P}}{R_E\sqrt{\rho_E}} = \frac{R_P}{R_E} \quad (\because \rho_P = \rho_E)$$

$$\therefore \quad \frac{v_P}{v_E} = \frac{3R_E}{R_E} = 3 \quad (\because R_P = 3R_E)$$

$$\therefore \quad v_P = 3v_E$$

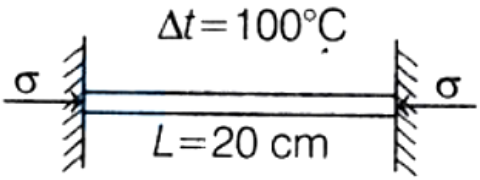
Ans 6

Correct Option. 8

Solution:

From Hook's law,

$$Y = \frac{\text{Stress}}{\text{Strain}}$$



$$\therefore \quad \text{Stress} = Y \times \text{Strain}$$

$$\text{Now,} \quad \text{Strain} = \frac{\Delta L}{L} = \frac{L\alpha\Delta T}{L} = \alpha\Delta T$$

$$\therefore \quad \text{Stress} = Y \times \alpha\Delta T$$

$$= 2 \times 10^{11} \times 1.1 \times 10^{-5} \times 100$$

$$= 2.2 \times 10^{8}\ \text{Pa}$$

According to question,

$$2.2 \times 10^{x} = 2.2 \times 10^{8}$$

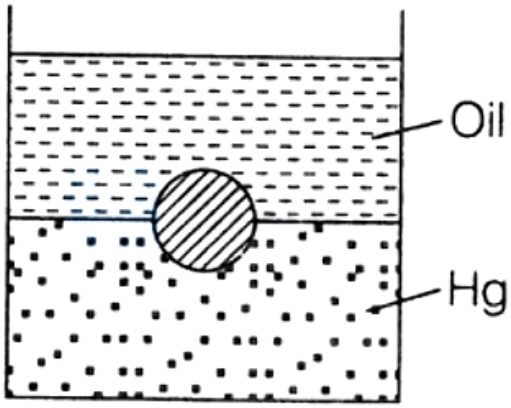
$$x = 8$$

Ans 7

Correct Option. 7.2

Solution:

For sphere to be float



$$\Rightarrow \quad V\rho g = \rho_{\text{oil}} \times \frac{V}{2} \times g + \rho_{\text{Hg}} \times \frac{V}{2} \times g$$

$$\Rightarrow \quad \rho = \frac{\rho_{\text{oil}}}{2} + \frac{\rho_{\text{Hg}}}{2} = \frac{0.8}{2} + \frac{13.6}{2}$$

$$= 0.4 + 6.8$$

$$\therefore \rho = \text{density of sphere} = 7.2\ \text{g/cm}^3$$

$$\therefore x\ \text{g/cm}^3 = 7.2\ \text{g/cm}^3$$

$$\therefore \quad x = 7.2$$

Ans 8

Correct Option. C

Solution:

As, $\frac{C}{100} = \frac{F-32}{180}$
Now, $C = F$ (given)

$$\therefore \quad \frac{C}{100} = \frac{C-32}{180}$$
$$\Rightarrow \quad 180C = 100C - 3200$$
$$\Rightarrow \quad 180C - 100C = -3200$$
$$\Rightarrow \quad 80C = -3200$$
$$\therefore \quad C = -\frac{3200}{80} = -40$$
$$\therefore \quad C = F = -40$$

Ans 9

Correct Option. B

Solution:

The electric potential due to an electric dipole at a distance r from its centre is given by

$$1\ \text{V} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p\cos\theta}{r^2}$$
[where, $p =$ electric dipole moment]

$$\therefore \quad V \propto \frac{1}{r^2}$$

Ans 10

Correct Option. B

Solution:

$$\text{As, } R = \rho \cdot \frac{L}{A} = \rho \cdot \frac{L^2}{A \cdot L} = \rho \cdot \frac{L^2}{V}; (V = \text{ Volume })$$
$$\therefore \quad R \propto L^2 \Rightarrow \frac{R_2}{R_1} = \left(\frac{L_2}{L_1}\right)^2 = \left(\frac{2L_1}{L_1}\right)^2 = 4$$
$$\therefore \quad R_2 = 4R_1 = 4R$$

Ans 11

Correct Option. 300

Solution:

By Faraday's law of electromagnetic induction,

$\varepsilon = \frac{d\phi}{dt}$, Also, $\varepsilon = iR$

$\therefore \quad \frac{d\phi}{dt} = iR \Rightarrow d\phi = iRdt$

$\Rightarrow \quad \int d\phi = R\int idt$

$\therefore \quad \phi = R\times$ Area of current versus time

$= 150 \times \frac{1}{2} \times 0.4 \times 10 = 300$ Wb

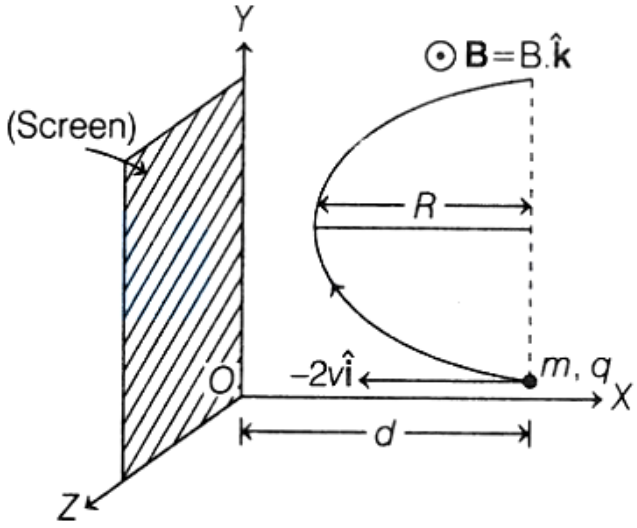
Ans 12

Correct Option. B

Solution:

The charged particle will not strike the screen, if d > R (Radius of path)

$\Rightarrow \quad d > \frac{m(2v)}{B_0 q} \Rightarrow v < \frac{qdB_0}{2m}$



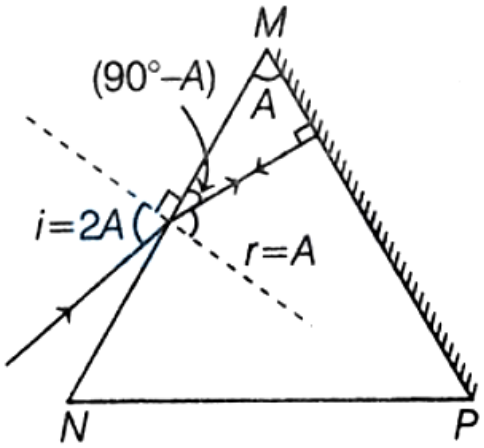
$\therefore \quad v_{max} = \frac{qdB_0}{2m}$

Ans 13

Correct Option. B

Solution:

If reflected ray from silvered surface retrace its path, then it falls normally on the silvered surface.



∴ From the geometry,

$$i = 2A, r = A$$

$$\therefore \quad \mu = \text{Refractive index} = \frac{\sin i}{\sin r} \text{ (From Snell's law)}$$

$$= \frac{\sin 2A}{\sin A} = \frac{2 \sin A \cdot \cos A}{\sin A}$$

$$= 2 \cos A$$

Ans 14

Correct Option. A

Solution:

de-Broglie wavelength is given by

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mk}}$$

$$\lambda \propto \frac{1}{\sqrt{m}} \quad (\because k_e = k_p = k_{He^{++}})$$

$$\text{As, } m_{He^{++}} > m_p > m_\theta$$

$$\therefore \lambda_{He^{++}} < \lambda_p < \lambda_\theta$$

$$\lambda_\theta > \lambda_p > \lambda_{He^{++}}$$

Ans 15

Correct Option. 0.98

Solution:

$E = E_0 \cos(kx - \omega t)$

$\therefore \quad \omega = 2\pi \times 6 \times 10^{14}$

$\therefore \quad f = \frac{\omega}{2\pi} = \frac{2\pi \times 6 \times 10^{14}}{2\pi} = 6 \times 10^{14}\ \text{Hz}$

$\phi = \text{ Energy of photon } = \frac{1240}{\lambda(\text{ in nm})}\text{eV}$

$\therefore \quad \lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^{14}} = 0.5 \times 10^{-6}\ \text{m} = 500\ \text{nm}$

$\therefore \quad \phi = \frac{1240}{500}\text{eV} = 2.48\text{eV}$

Now, by Einstein photoelectric equation,

$$\begin{aligned} \phi &= \phi_0 + \text{KE} = \phi_0 + eV_s \quad (\because \text{KE} = eV_s) \\ \Rightarrow \quad 2.48 &= 1.5 + eV_s \\ eV_s &= 2.48 - 1.5 = 0.98\text{eV} \\ V_s &= 0.98\ \text{V} \end{aligned}$$

Chemistry

Ans 1

Correct Option. A

Solution:

(i) Volume occupied by 1 mole of $\mathrm{CO_2} = 22.4\ \mathrm{L}$
Volume occupied by 1.5 moles of $\mathrm{CO_2}$

$= 1.5 \times 22.4$
$= 33.6\ \mathrm{L}$

(ii) Given, mass of nitrogen $(m) = 14\ \mathrm{g}$
Molar mass of $\mathrm{N_2}(w) = 28\ \mathrm{g}$

Number of moles of $\mathrm{N_2} = \frac{m}{w} = \frac{14}{28} = \frac{1}{2}$

$= 0.5\ \mathrm{mole}$
Volume occupied by 1 mole of $\mathrm{N_2}$ at STP

$= 22.4\ \mathrm{L}$
Volume occupied by 0.5 mole of $\mathrm{N_2}$ at STP

$= 0.5 \times 22.4$
$= 11.2\ \mathrm{L}$

(iii) Given, number of molecules of $\mathrm{O_2} = 10^{21}$
Number of molecules of $\mathrm{O_2}$ in 1 mole

$$= 6.022 \times 10^{23}\ \text{molecules}$$

$$\text{Number of moles} = \frac{10^{21}}{6.022 \times 10^{23}}$$

$$= 0.166 \times 10^{-2}\ \text{moles};$$

Volume occupied by 0.166×10^{-2} mole of

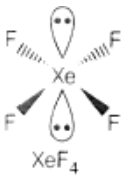
$\mathrm{O_2} = 0.166 \times 10^{-2} \times 22.4\ \mathrm{L}$
$= 3.\not{7}2 \times 10^{-2}$
$= 0.0372\ \mathrm{L}$

Therefore, correct increasing order of volume occupied by the given amount of molecules at STP is : (iii) < (ii) < (i).

Ans 2

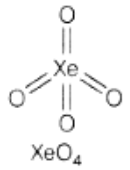
Correct Option. C

Solution:



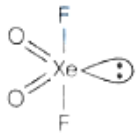
XeF_4

Shape : Square planar
Geometry : Octahedral



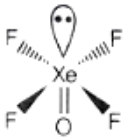
XeO_4

Shape : Tetrahedral
Geometry : Tetrahedral



XeO_2F_2

Shape : See-saw
Geometry : Trigonal and bipyamidal



$XeOF_4$

Shape : Square pyramidal
Geometry : Octahedral

Ans 3

Correct Option. B

Solution:

Given, $q = 150\ \text{J}$
We know,

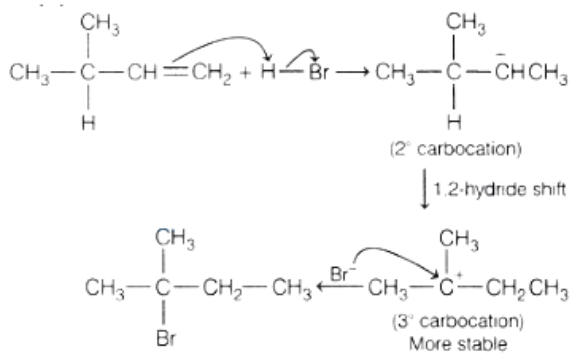
$$w = p\Delta V = 2 \times 10^5 \text{Nm}^{-2} \times 450 \times 10^{-6}\ \text{m}^3$$
$$= 90\text{Nm} = 90\ \text{J}$$
$$\Delta U = q - w = 150 - 90 = 60\ \text{J}$$

Also,

Ans 4

Correct Option. D

Solution:



Ans 5

Correct Option. A

Solution:

In case of positive deviation from Raoult's law, the intermolecular attractive forces between the solute-solvent molecules are weaker than those

between the solute-solute and solvent-solvent molecules. Therefore, it becomes easy for the solute/solvent molecules to escape from the solution than in pure state. This will increase the vapour pressure and results in positive deviation.

Ans 6

Correct Answer. 232.6

Solution:

$$\begin{aligned}
&\Lambda^{\circ}_{m(NHH_4OH)=} = \Lambda^{\circ}_{NH_4^+} + \\
&= \Lambda^{\circ}_{OH^-} \\
&= \left(\Lambda^{\circ}_{NH_4^+} + \Lambda^{\circ}_{Cl^-}\right) + \frac{1}{2}\left(\Lambda^{\circ}_{Ba^{2+}} + 2\Lambda^{\circ}_{OH^-}\right) \\
&- \frac{1}{2}\left(\Lambda^{\circ}_{Ba^{2+}} + 2\Lambda^{\circ}_{Cl^-}\right) \\
&= \Lambda^{\circ}_{m(NH_4Cl)} + \frac{1}{2}\Lambda^{\circ}_{m[Ba(OH)_2]} - \frac{1}{2}\Lambda^{\circ}_{m(BaCl_2)} \\
&= 130 + \frac{1}{2} + 446.8 - \frac{1}{2} \times 241.6 \\
&= 232.6\Omega^{-1}\ \mathrm{cm}^2\ \mathrm{mol}^{-1}.
\end{aligned}$$

Ans 7

Correct Answer. 0.0103

Solution:

$\left(1.03 \times 10^{-2}\right)$ For the given reaction,

$$\begin{aligned}
&N_2O_5(g) \longrightarrow 2NO_2(g) + \frac{1}{2}O_2(g) \\
&-\frac{d[N_2O_5]}{dt} = \frac{1}{2}\frac{d[NO_2]}{dt} = \frac{2d[O_2]}{dt} \\
&\therefore \quad \frac{d[NO_2]}{dt} = -2\frac{d[N_2O_5]}{dt} = 2 \times 5.15 \times 10^{-3} \\
&\qquad = 1.03 \times 10^{-2}\ \mathrm{mol\ L^{-1}\ s^{-1}}.
\end{aligned}$$

Ans 8

Correct Option. D

Solution:

Mond's process is used for refining nickel. Whereas, van Arkel method is used for refining zirconium and titanium.

Ans 9

Correct Answer. 4

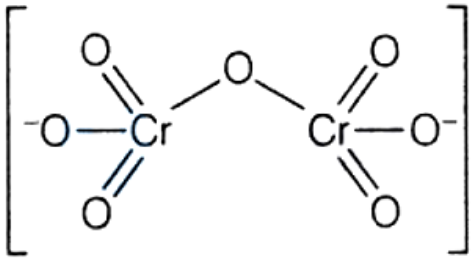
Solution:

Nitrogen does not form pentahalide due to non-availability of the d-orbitals in its valence shell.

Ans 10

Correct Answer. 4

Solution:



Dichromate ion

4 oxygen atoms are directly attached to one chromium ion.

Ans 11

Correct Option. B

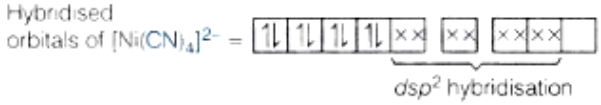
Solution:

Both $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ are diamagnetic.

$[Ni(CN)_4]^{2-}$

Electronic configuration of $Ni^{2+} = [Ar]3d^8$.

CN^- being strong field ligand cause pairing of electrons.



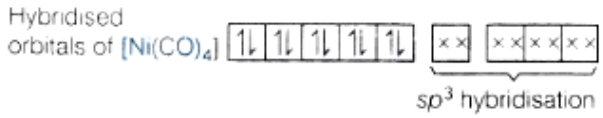
There are no unpaired electrons. Therefore, it is diamagnetic.

Shape : square planar

$[Ni(CO)_4]$

Electronic configuration of $Ni = [Ar]3d^8 4s^2$

CO being strong field ligand cause pairing of electrons.



No unpaired electrons are there. Therefore, it is diamagnetic in nature.

Shape : Tetrahedral.

Ans 12

Correct Option. B

Solution:

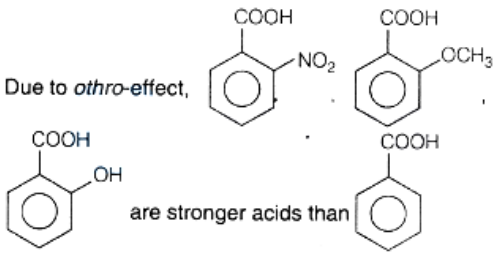
Alcohols are soluble in Lucas' reagent (conc. HCl and $ZnCl_2$) while their halides are immiscible and produce turbidity in solution. Tertiary alcohols react the fastest and form halides easily. Primary alcohols do not produce turbidity at room temperature. Therefore, alcoholic group at the 4th position is tertiary, therefore it reacts the fastest.

Ans 13

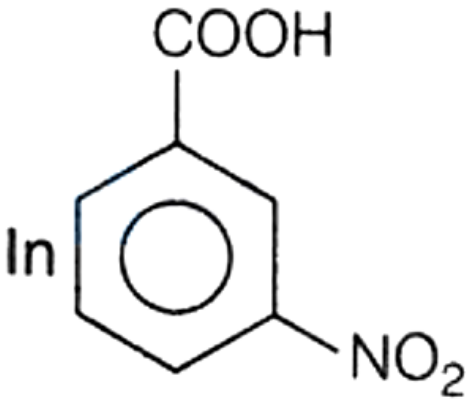
Correct Answer. 3

Solution:

Attached electron withdrawing groups increase the acidity of benzoic acid by $-/$ and $-$M-effect (whenever applicable) whereas electron releasing groups decrease the acidity of benzoic acid.



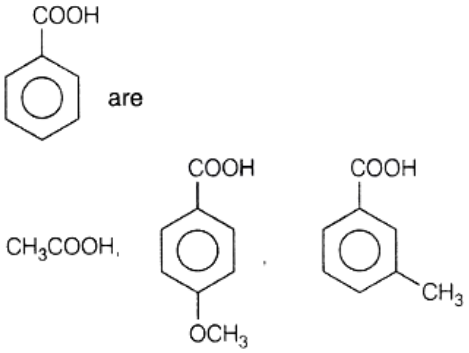
even though they have electron releasing groups (i.e. OCH_3) attached.



one electron withdrawing group is attached, due to this reason it is more acidic than benzoic acid.

Moreover, aliphatic carboxylic acid is a weaker acid than aromatic carboxylic acid because benzene itself is electron withdrawing in nature that makes the release of proton from - COOH easy.

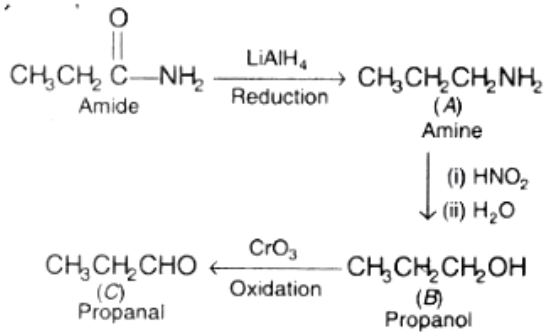
Therefore, acids which are weaker than



Ans 14

Correct Option. D

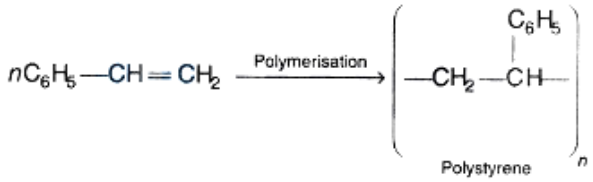
Solution:



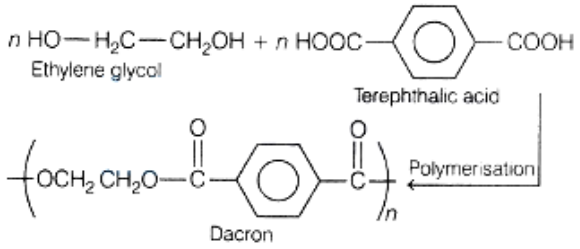
Ans 15

Correct Option. B

Solution:



Polystyrene is an addition and chain growth polymer. It is thermoplastic. Addition polymers have unsaturated monomers.



Dacron is a condensation and step-growth polymer. It is a fibre.

Condensation polymerisation involves a repetitive condensation reaction between two bi-functional or tri-functional monomeric units.

Mathematics

Ans 1

Correct Option. D

Solution:

We can write

$$|z| = \left|z + \frac{2}{|z|} - \frac{2}{|z|}\right| \le \left|z + \frac{2}{z}\right| + \left|\frac{2}{|z|}\right|$$
$$= 2 + \frac{2}{|z|}$$
$$\therefore \quad |z|^2 - 2|z| - 2 \le 0$$

Here, $|z|$ lies between $\frac{2 \pm \sqrt{12}}{2} = 1 \pm \sqrt{3}$

$\therefore$ Minimum value of $|z| = 1 - \sqrt{3}$

Ans 2

Correct Option. 2454

Solution:

Given word is 'EXAMINATION' having letters (AA), (II), (NN), EXMOT, we have to form 4 letter words, then following cases are possible,

(I) 2 same, 2 same and number of words are ${}^3C_2 \times \frac{4!}{2!2!} = 18$

(II) 2 same, 2 different and number of words are

$${}^3C_1 \times {}^7C_2 \times \frac{4!}{2!} = 3 \times \frac{7 \times 6}{2} \times \frac{4 \times 3 \times 2}{2}$$
$$= 21 \times 36 = 756$$

(III) All are different and number of words are

${}^8C_4 \times 4! = \frac{8 \times 7 \times 6 \times 5}{4!} 4! = 1680$

So, total number of 4 letter words

$18 + 756 + 1680 = 2454$

Ans 3

Correct Option. B

Solution:

Since, α, β and γ are in AP.

$\therefore \quad 2\beta = \alpha + \gamma$ ...(i)

Also, $\tan^{-1}\alpha, \tan^{-1}\beta$ and $\tan^{-1}\gamma$ are also in AP.

$$\begin{aligned}
\therefore \quad 2\tan^{-1}\beta &= \tan^{-1}\alpha + \tan^{-1}\gamma \\
\Rightarrow \quad \tan^{-1}\left(\frac{2\beta}{1-\beta^2}\right) &= \tan^{-1}\left(\frac{\alpha+\gamma}{1-\alpha\gamma}\right) \\
\Rightarrow \quad \frac{2\beta}{1-\beta^2} &= \frac{\alpha+\gamma}{1-\alpha\gamma} \\
\Rightarrow \quad \frac{\alpha+\gamma}{1-\beta^2} &= \frac{\alpha+\gamma}{1-\alpha\gamma} \quad \text{by using} \\
\Rightarrow \quad \beta^2 &= \alpha\gamma
\end{aligned}$$

[by using Eq. (i)]
Since, α, β and γ are in AP as well as in GP.

$\therefore \quad \alpha = \beta = \gamma$

Ans 4

Correct Option. C

Solution:

The coefficient of the middle term in power of

$x(1+\alpha x)^4 = {}^4C_2\alpha^2$
The coefficient of the middle term in power of

$x(1-\alpha x)^6 = {}^6C_3(-\alpha)^3$
According to given condition,

$$\begin{aligned}
{}^4C_2\alpha^2 &= {}^6C_3(-\alpha)^3 \\
\Rightarrow \quad \frac{4!}{2!2!}\alpha^2 &= -\frac{6!}{3!3!}\alpha^3 \\
\Rightarrow \quad 6\alpha^2 &= -20\alpha^3 \\
\Rightarrow \quad \alpha &= -\frac{6}{20} \\
\therefore \quad \alpha &= -\frac{3}{10}
\end{aligned}$$

Ans 5

Correct Option. C

Solution:

General equation of all such circles which passing through the origin whose centre lie on X-axis is

$x^2 + y^2 + 2gx = 0$ ...(i)

On differentiating w.r.t. ' x ', we get

$2x + 2y\frac{dy}{dx} + 2g = 0$

$\Rightarrow \quad 2g = -\left(2x + 2y\frac{dy}{dx}\right)$

On putting the value of $2g$ in Eq. (i),

$$x^2 + y^2 + \left(-2x - 2y\frac{dy}{dx}\right)x = 0$$

$$\Rightarrow \quad x^2 + y^2 - 2x^2 - 2xy\frac{dy}{dx} = 0$$

$$\Rightarrow \quad y^2 = x^2 + 2xy\frac{dy}{dx}$$

which is the required equation.

Ans 6

Correct Option. C

Solution:

Let $I' = \lim_{x\to 0} \frac{\int_0^{x^2} \sec^2 t dt}{x \sin x}$ $\left[\frac{0}{0} \text{ form }\right]$

Using L'Hospital's rule,

$= \lim_{x\to 0} \frac{\sec^2 x^2 \cdot 2x}{x\cos x + \sin x}$ $\left[\frac{0}{0} \text{ form}\right]$

Again using L'Hospital's rule,

$$\lim_{x\to 0} \frac{2x \cdot 2\sec^2 x^2 \cdot \tan x^2 \cdot 2x + 2\sec^2 x^2}{-x\sin x + \cos x + \cos x}$$

$$= \frac{0 + 2\sec^2 0}{0 + 2\cos 0} = 1$$

Ans 7

Correct Option. 12

Solution:

We have,

$\lim_{x\to 2} \frac{2^x+2^{2-x}-5}{2^{-x/2}-2^{1-x}} \quad \left[\frac{0}{0} \text{ form}\right]$

So, apply L' Hospital's rule

$$= \lim_{x\to 2} \frac{\frac{d}{dx}\left(2^x+2^{2-x}-5\right)}{\frac{d}{dx}\left(2^{-x/2}-2^{1-x}\right)}$$

$$= \lim_{x\to 2} \frac{2^x \ln 2 - 2^{2-x}\ln 2}{2^{1-x}\ln 2 - \frac{2^{-\frac{x}{2}}\ln 2}{2}}$$

$$= \lim_{x\to 2} \frac{2^{x+1} - 2^{3-x}}{2^{2-x} - 2^{-\frac{x}{2}}}$$

$$= \frac{2^3-2^1}{2^0-2^{-1}} = \frac{8-2}{2-\frac{1}{2}} = \frac{12}{2-1} = 12$$

Ans 8

Correct Option. D

Solution:

We have,

$\sum_{i=1}^{10}(x_i-3)=7$ and $\sum_{i=1}^{10}(x_i-3)^2=27$

∴ Standard deviation is remain unchanged, if observation are added or subtracted by a fixed number.

∴ Standard deviation

$$= \sqrt{\frac{\sum_{i=1}^{10}(xi-3)^2}{10} - \left(\frac{\sum_{i=1}^{10}(xi-3)}{10}\right)^2}$$

$$= \sqrt{\frac{27}{10} - \left(\frac{7}{10}\right)^2}$$

$$= \sqrt{\frac{270}{100} - \frac{49}{100}} = \frac{\sqrt{221}}{10} = \frac{14.86}{10} = 1.486$$

Ans 9

Correct Option. A

Solution:

Here,

$$
\begin{aligned}
A \times C &= \{1,2\} \times \{5,6\} \\
&= \{(1,5),(1,6),(2,5),(2,6)\} \\
\text{and } B \times D &= \{1,2,3,4\} \times \{5,6,7,8\} \\
&= \{(1,5),(1,6),(1,7),(1,8),(2,5),(2,6), \\
&\quad (2,7),(2,8),(3,5),(3,6),(3,7),(3,8), \\
&\quad (4,5),(4,6),(4,7),(4,8)\} \\
\therefore \quad (A \times C) &\subset (B \times D)
\end{aligned}
$$

Ans 10

Correct Option. B

Solution:

If A is non-singular matrix, then $|A| \neq 0$

$$
\begin{aligned}
& AA^T = A^{-1}A \text{ and } B = A^{-1}A^T \\
\Rightarrow \quad & BB' = \left(A^{-1}A^T\right)\left(A^{-1}A^T\right)^T \\
& = A^{-1}A^T \cdot A\left(A^{-1}\right)^T \quad \left[\because (AI)' = A\right] \\
& = A^{-1}AA^T\left(A^{-1}\right)^T \\
& = IA^T\left(A^{-1}\right)^T \\
& = A^T\left(A^{-1}\right)^T \\
& = \left(A^{-1}A\right)^T \quad \left[\because (AB)^T = B^TA^T\right] \\
& = I^T = 1
\end{aligned}
$$

Ans 11

Correct Option. C

Solution:

Given that, $f(x) = \sqrt{1+x^2}$

$$
\begin{aligned}
\therefore \quad & f(y) = \sqrt{1+y^2} \\
\text{and} \quad & f(xy) = \sqrt{1+x^2y^2} \\
\text{Now,} \quad & \| f(xy) = f(x)f(y)
\end{aligned}
$$

$$
\begin{aligned}
\Rightarrow \quad \sqrt{1+x^2y^2} &= \sqrt{1+x^2}\sqrt{1+y^2} \\
&= \sqrt{\left(1+x^2\right)\left(1+y^2\right)}
\end{aligned}
$$

On squaring both sides, we get

$$
\begin{aligned}
& 1+x^2y^2 = \left(1+x^2\right)\left(1+y^2\right) \\
\Rightarrow \quad & 1+x^2y^2 = 1+y^2+x^2+x^2y^2 \\
\therefore \quad & 1+x^2y^2 \leq 1+x^2+y^2+x^2y^2 \\
\text{Hence,} \quad & f(xy) \leq f(x) \cdot f(y)
\end{aligned}
$$

Ans 12

Correct Option. B

Solution:

We have, $\sin\theta\cos^3\theta > \sin^3\theta\cos\theta$

$$\Rightarrow \quad \sin\theta\cos^3\theta - \sin^3\theta\cos\theta > 0$$
$$\Rightarrow \quad \sin\theta\cos\theta\left(\cos^2\theta - \sin^2\theta\right) > 0$$
$$\Rightarrow \quad \sin 2\theta \cdot \cos 2\theta > 0$$
$$\Rightarrow \quad \sin 4\theta > 0$$
$$\Rightarrow \quad \theta \in \left(0, \tfrac{\pi}{4}\right) \quad [\because 4\theta \in (0, \pi)]$$

Ans 13

Correct Option. D

Solution:

Given that, $\int f(x)dx = g(x)$
Let $I = \int x^9 \int \left(x^5\right) dx$

Put $x^5 = t \Rightarrow 5x^4dx = dt$

$$= \frac{1}{5}\int tf(t)dt$$
$$= \frac{1}{5}\left[t\int f(t)dt - \int [f(t)dt]\right.$$

[integrating by part]

$$= \frac{1}{5}\left[tg(t) - \int g(t)dt\right]$$
$$= \frac{1}{5}\left[x^2 g\left(x^5\right) - 5\int g\left(x^5\right)x^4dx\right] + C$$
$$= \frac{x^5}{5}g\left(x^5\right) - \int x^4 g\left(x^5\right)dx + C$$

Ans 14

Correct Option. A

Solution:

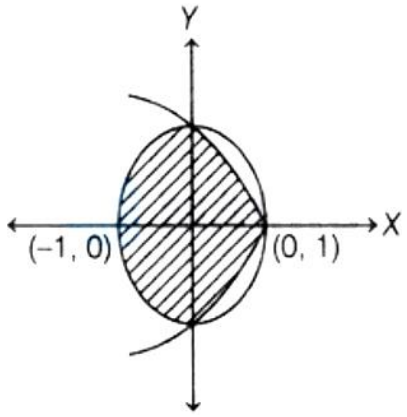
$$
\begin{aligned}
\because \text{ Required area } &= \int_1^3 y dx \\
&= \int_1^3 |x-2| dx \\
&= \int_1^2 -(x-2)dx + \int_2^3 (x-2)dx \\
&= \int_1^2 (2-x)dx + \int_2^3 (x-2)dx \\
&= \left[2x - \frac{x^2}{2}\right]_1^2 + \left[\frac{x^2}{2} - 2x\right]_2^3 \\
&= \left[4 - 2 - \left(2 - \frac{1}{2}\right)\right] + \left[\frac{9}{2} - 6 - (2-4)\right] \\
&= 2 - \frac{3}{2} - \frac{3}{2} + 2 \\
&= 1 \text{ sq unit}
\end{aligned}
$$

Ans 15

Correct Option. A

Solution:

Given, $A = \{(x, y) : x^2 + y^2 \leq 1 \text{ and } y^2 \leq 1 - x\}$



$$
\begin{aligned}
\because \text{ Required area } &= \frac{1}{2}\pi r^2 + 2\int_0^1 (1-y^2)\, dy \\
&= \frac{1}{2}\pi(1)^2 + 2\left[y - \frac{y^3}{3}\right]_0^1 \\
&= \frac{\pi}{2} + \frac{4}{3}
\end{aligned}
$$

Ans 16

Correct Option. -1

Solution:

We can rewrite,

$$\begin{vmatrix} a & a^2 & 1+a^3 \\ b & b^2 & 1+b^3 \\ c & c^2 & 1+c^3 \end{vmatrix} = \begin{vmatrix} a & a^2 & 1 \\ b & b^2 & 1 \\ c & c^2 & 1 \end{vmatrix} + \begin{vmatrix} a & a^2 & a^3 \\ b & b^2 & b^3 \\ c & c^2 & c^3 \end{vmatrix} = 0$$

$$= \begin{vmatrix} a & a^2 & 1 \\ b & b^2 & 1 \\ c & c^2 & 1 \end{vmatrix} + abc \begin{vmatrix} a & a^2 & 1 \\ b & b^2 & 1 \\ c & c^2 & 1 \end{vmatrix} = 0$$

$$= (1+abc) \begin{vmatrix} a & a^2 & 1 \\ b & b^2 & 1 \\ c & c^2 & 1 \end{vmatrix} = 0$$

$$= (1+abc) = 0 \quad \left[\because \begin{vmatrix} a & a^2 & 1 \\ b & b^2 & 1 \\ c & c^2 & 1 \end{vmatrix} \neq 0 \right]$$

$$\Rightarrow \quad abc = -1$$

Ans 17

Correct Option. B

Solution:

The given lines are

$\frac{x-2}{1} = \frac{y-3}{1} = \frac{z-4}{-k}$ ...(i)

and

$\frac{x-1}{2k} = \frac{y-3}{2} = \frac{z-5}{1}$ ...(ii)

Condition for two lines are coplanar

$$\begin{vmatrix} x_1 - x_2 & y_1 - y_2 & z_1 - z_2 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$

where (x_1, y_1, z_1) and (x_2, y_2, z_2) are points on lines (i) and (ii) and (l_1, m_1, n_4) and (l_2, m_2, n_2) are direction cosines of lines (i) and (ii), respectively.

$$\therefore \quad \begin{vmatrix} 2-1 & 3-3 & 4-5 \\ 1 & 1 & -k \\ 2k & 2 & 1 \end{vmatrix} = 0$$

$$\Rightarrow \quad \begin{vmatrix} 1 & 0 & -1 \\ 1 & 1 & -k \\ 2k & 2 & 1 \end{vmatrix} = 0$$

$$\Rightarrow \quad 1(1+2k) - 0 - 1(2-2k) = 0$$

$$\Rightarrow \quad 1 + 2k - 2 + 2k = 0$$

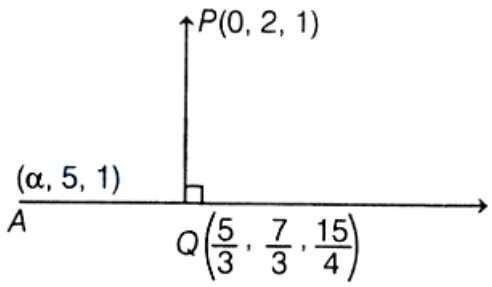
$$\Rightarrow \quad 114k - 1 = 0 \Rightarrow k = \frac{1}{4}$$

Ans 18

Correct Option. 10.893

Solution:

It is given that point $Q\left(\frac{5}{3}, \frac{7}{3}, \frac{15}{4}\right)$ is foot of perpendicular of point $P(0,2,1)$ to a line passes through point $A(\alpha, 5, 1)$. So, $PQ \perp AQ$.



$\because$ Direction ratios of line segments PQ is $\left(\frac{5}{3}, \frac{1}{3}, \frac{11}{4}\right)$ and direction ratios of line AQ is $\left(\alpha - \frac{5}{3}, \frac{8}{3}, -\frac{11}{4}\right)$.

$$\therefore \quad \frac{5}{3}\left(\alpha - \frac{5}{3}\right) + \frac{1}{3} \times \frac{8}{3} + \frac{11}{4} \times \left(-\frac{11}{4}\right) = 0$$

$$\Rightarrow \quad 15\alpha - 25 + 8 + \frac{99(-11)}{16} = 0$$

$$\Rightarrow \quad 15\alpha - 17 = \frac{99 \times 11}{16}$$

$$\Rightarrow \quad 5\alpha = \frac{1089 - 817}{16}$$

$$\Rightarrow \quad 5\alpha = 54.466 \Rightarrow \alpha = 10.893$$

Ans 19

Correct Option. C

Solution:

Probability of guessing a correct answer, $p = \frac{1}{4}$ and probability of guessing a wrong answer $q = \frac{3}{4}$

So, the probability of guessing 4 or more correct answer

$$P(X \geq 4) = {}^5C_4\left(\frac{1}{4}\right)^4 \cdot \left(\frac{3}{4}\right) + {}^5C_5\left(\frac{1}{4}\right)^5$$

$$= 5 \cdot \frac{1}{4^4} \cdot \frac{3}{4} + \frac{1}{4^5}$$

$$= \frac{15}{4^5} + \frac{1}{4^5} = \frac{16}{4^5} = \frac{4^2}{4^5} = \frac{1}{4^3}$$

Ans 20

Correct Option. 33

Solution:

Total possibilities to make a 6-digit number using only 1 and 8

$\overline{2}\ \overline{2}\ \overline{2}\ \overline{2}\ \overline{2}\ \overline{2}$

Every position has 2 possibility either 1 or 8 $\therefore 2^6$

Number divisible by 21 :

1. for divisibility by 3

A (sum of digits must be divisible by 3)

(a) Number of 1 's = Number of 8

(b) Every digit is 1

(c) Every digit is 8.

2. for divisiblity by 7.

|2 (last digit) - remaining número |=7k

K ∈ Z

(a) all are 1 s ⇒ 1 no

(b) all are 8s ⇒ 1 no

(c) 31 's and 38 s $\Rightarrow \frac{6!}{3!3!}$

Total number divisible by 21 = number divisible by 3 and 7

$$= \frac{6!}{3!3!} + 2 = \left(\frac{6 \times 5 \times 4 \times 3!}{3! \times 3 \times 2}\right) + 2 = 22$$

$$\therefore \text{ Probability } = \frac{22}{2^6} = p$$

$$96p = 96 \times \frac{22}{2^6} = 96 \times \frac{22}{2 \times 2 \times 2 \times 2 \times 2 \times 2} = 33$$