JEE Main 2020 Paper

Date of Exam: **8th January (Shift I)**
Time: **9:30 am – 12:30 pm**
Subject: **Physics**

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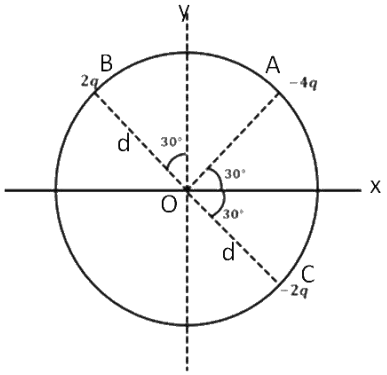
1. A particle of mass m is fixed to one end of a light spring having force constant k and ustreatch length l. The other end is fixed. The system is given an angular speed ω about the fixed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in the spring is

   a. $\frac{l m\omega^2}{k-m\omega^2}$
   b. $\frac{l m\omega^2}{k+m\omega^2}$
   c. $\frac{l m\omega^2}{k-m\omega}$
   d. $\frac{l m\omega^2}{k+m\omega}$

2. Three charged particles A, B and, C with charge -4q, +2q and -2q are present on the circumference of a circle of radius d. The charges particles A, C and centre O of the circle formed an equilateral triangle as shown in figure. Electric field at O along x- direction is:



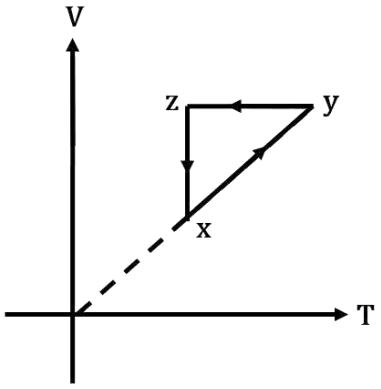
a. $\frac{\sqrt{3}q}{4\pi\varepsilon_o d^2}$

b. $\frac{2\sqrt{3}q}{\pi\varepsilon_o d^2}$

c. $\frac{\sqrt{3}q}{\pi\varepsilon_o d^2}$

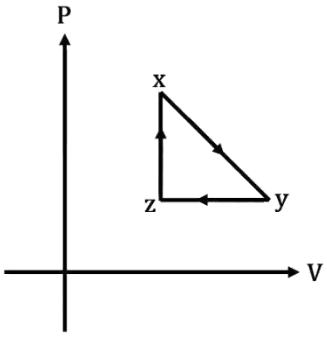
d. $\frac{3\sqrt{3}q}{4\pi\varepsilon_o d^2}$

3. A thermodynamic cycle xyzx is shown on a $V-T$ diagram .



The P-V diagram that best describes this cycle is : (Diagrams are schematic and not upto scale)

a.



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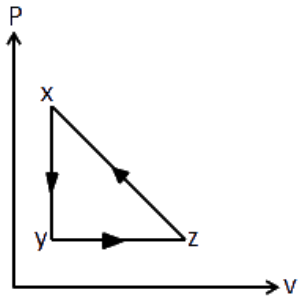

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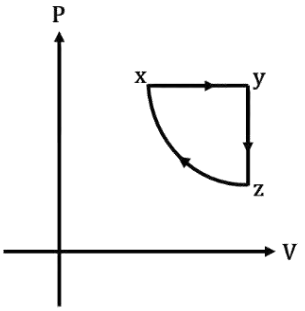
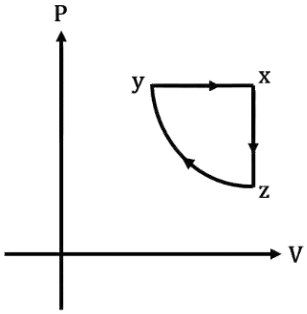
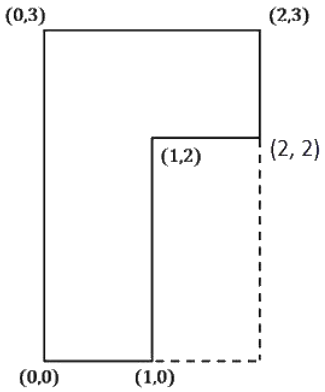


d.



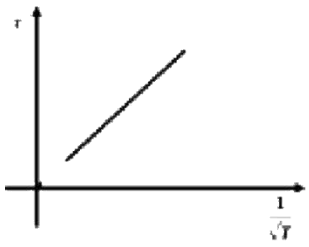
4. Find the co-ordinates of center of mass of the lamina shown in the figure below.



a. (0.75 m, 1.75 m)
b. (0.75 m, 0.75 m)
c. (1.25 m, 1.5 m)
d. (1 m, 1.75 m)

5. The plot that depicts the behavior of the mean free time τ (time between two successive collisions) fot the molecules of an ideal gas, as a function of temperatire (T), qualitatively, is: (Graph are schematic and not drawn to scale)

a.



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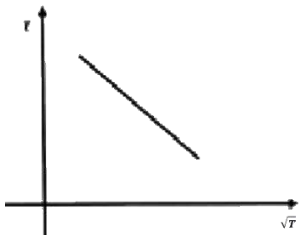
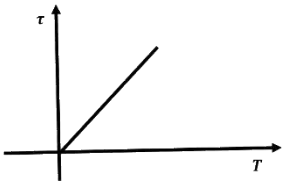
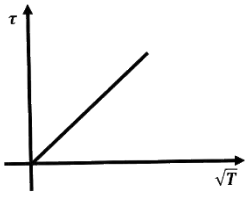


c.



d.



6. Effective capacitance of parallel combination of two capacitors C_1 and C_2 is 10 μF. When these capacitor are individually connectes to a voltage source of 1 V, the energy stored in the capacitor C_2 is 4 times of that in C_1. If these capacitors are connected in series, their effective capacitance will be:
   a. 1.6 μF
   b. 3.2 μF
   c. 4.2 μF
   d. 8.4 μF

7. Consider a uniform rod of mass $4m$ and length L pivoted about its centre. A mass m is moving with a velocity v making angle $\theta = \frac{\pi}{4}$ to the rod's long axis collides with one end of the rod rod and stick to it.. The angular speed of the rod-mass system just after collision is
   a. $\frac{3\sqrt{2}v}{7L}$
   b. $\frac{4v}{7L}$
   c. $\frac{3v}{7\sqrt{2}L}$
   d. $\frac{3v}{7L}$

8. When photons of energy 4 eV strikes the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.50 eV is
   $T_B = (T_A - 1.5)$ eV. If the de-Broglie wavelength of these photoelectrons $\lambda_B = 2\lambda_A$, then the work function of metal B is

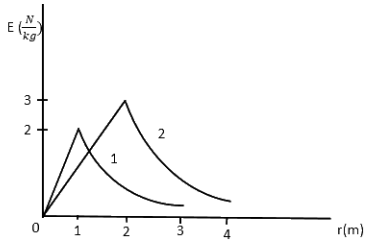
   a. 3 eV
   b. 1.5 eV
   c. 2 eV
   d. 4 eV

9. The length of a potentiometer wire of length 1200 cm and it carries a current of 60 mA. For a cell of emf 5 V and internal resistance of 20 Ω, the null point on it is found to be at 1000 cm. The resistance of whole wire is
   a. 80 Ω
   b. 100 Ω
   c. 120 Ω
   d. 60 Ω

10. The magnifying power of a telescope with tube length 60 cm is 5. What is the focal length of its eyepiece?

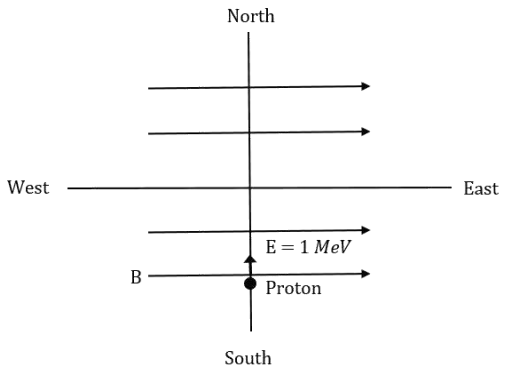
a. 10 cm
b. 20 cm
c. 30 cm
d. 40 cm

11. Consider two solid spheres of radii R_1= 1 m, R_2 = 2 m and masses M_1 & M_2, respectively. The gravitational field due to two spheres 1 and 2 are shown.The value of $\frac{M_1}{M_2}$ is



a. $\frac{1}{6}$
b. $\frac{1}{3}$
c. $\frac{1}{2}$
d. $\frac{2}{3}$

12. Proton with kinetic energy of 1 MeV moves from south to north. It gets an acceleration of 10^{12} m/s^2 by an applied magnetic field (west to east). The value of magnetic field: (Rest mass of proton is 1.6×10^{-27} kg)



a. 0.71 mT
b. 7.1 mT
c. 71 mT
d. 0.071 mT

13. If finding the electric field around a surface is given by $\left|\vec{E}\right| = \frac{q_{enclosed}}{\varepsilon_0 |A|}$ is applicable. In the formula ϵ_0 is permittivity of free space, A is area of Gaussian and q_{enc} is charge enclosed by the Gaussian surface. This equation can be used in which of the following equation?
    a. Only when the Gaussian surface is an equipotential surface.
    b. Only when $\left|\vec{E}\right|$ = constant on the surface..
    c. Equipotential surface and $\left|\vec{E}\right|$ is constant on the surface .

d. for any choice of Gaussian surfaces.

14. The dimension of stopping potential V_0 in photoelectric effect in units of Planck's constant (h), speed of light (c), and gravitational constant (G) and Ampere (A) is

a. $h^{2/3}c^{5/3}G^{1/3}A^{-1}$
b. $h^{2}c^{1/3}G^{3/2}A^{-1}$
c. $h^{1/3}G^{2/3}c^{1/3}A^{-1}$
d. $h^{-2/3}c^{-1/3}G^{4/3}A^{-1}$

15. A leak proof cylinder of length 1 m, made of metal which has very low coefficient of expansion is floating in water at 0^{o} C such that its height above the water surface is 20 cm. When the temperature of water is increases to 4^{o} C, the height of the cylinder above the water surface becomes 21 cm. The density of water at $T = 4^{o}$ C relative to the density at $T = 0^{o}$ C is close to

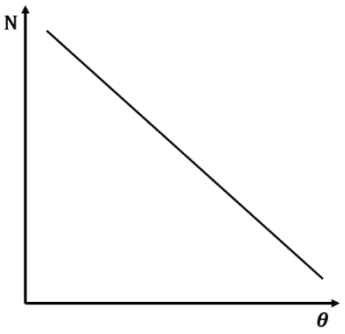
a. 1.01
b. 1.03
c. 1.26
d. 1.04

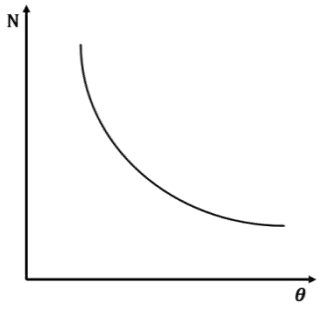
16. The graph which depicts the result of Rutherford gold foil experiement with α- particle is:

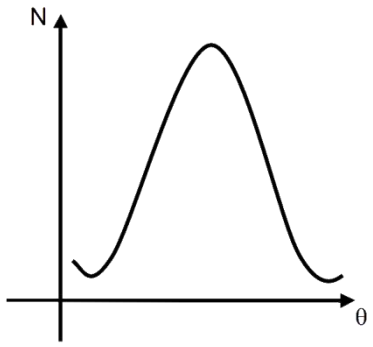
θ: Scattering angle

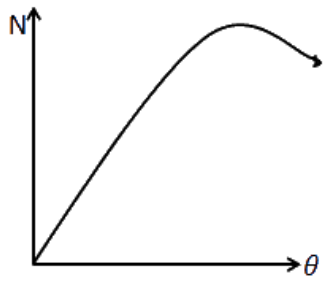
N : Number of scattered $\alpha -$ particles is detected

(Plots are schematic and not to scale)

a. 

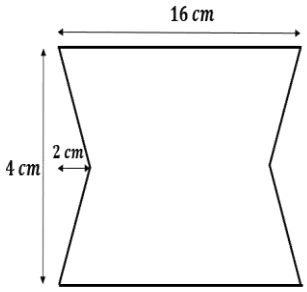
b. 

c. 

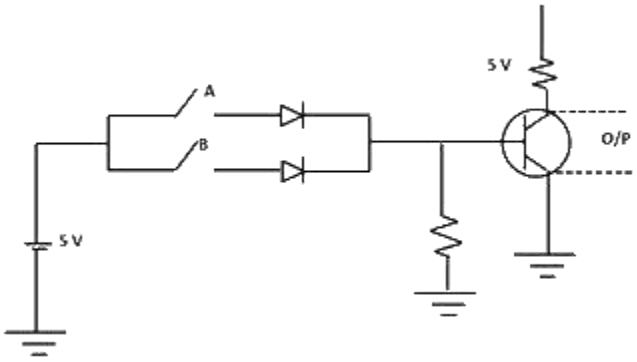
d. 

17. At time t = 0 magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5 s, then induced EMF in the loop is:

a. 56 μV
b. 28 μV
c. 30 μV
d. 48 μV



18. Choose the correct Boolean expression for the given circuit diagram:



a. A.B
b. $\bar{A} + \bar{B}$
c. $A + B$
d. $\bar{A}.\bar{B}$

19. Consider a solid sphere of density $\rho(r) = \rho_o \left(1 - \frac{r^2}{R^2}\right), 0 < r \leq R$. The minimum density of a liquid in which it float isjust

a. $\frac{2}{5}\rho_o$
b. $\frac{2}{3}\rho_o$
c. $\frac{\rho_0}{5}$
d. $\frac{\rho_0}{3}$

20. The critical angle of a medium for a specific wavelength, if the medium has relative permittivity 3 and relative permeability $\frac{4}{3}$ for this wavelength, will be

a. 15°
b. 30°
c. 45°
d. 60°

21. A body of mass $m = 0.10\ kg$ has an initial velocity of $3\hat{\imath}\ m/s$. It collides elastically with another body, B of the mass which has an initial velocity of $5\hat{\jmath}\ m/s$. After collision, A moves with a velocity $v = 4(\hat{\imath} + \hat{\jmath})\ m/s$. The energy of B after collision is written as $\frac{x}{10}\ J$, the value of x is

22. A point object in air is in front of the curved surface of a plano-convex lens. The radius of curvature of the curved surface is 30 cm and the refractive index of lens material is 1.5, then the focal length of the lens (in cm) is

23. A particle is moving along the x-axis with its coordinate with time t given by $x(t) = -3t^2 + 8t + 10\ m$. Another particle is moving along the y-axis with its coordinate as a function of time given by $y = 5 - 8t^3\ m$. At t = 1 s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v (m/s) is _____.

24. A one metre long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is_____Hz.

25. Four resistors of resistance 15 Ω, 12 Ω, 4 Ω and 10 Ω respectively in cyclic order to form a wheatstone's network. The resistance that is to be connected in parallel with the resistance of 10 Ω to balance the network is _____ Ω.

JEE Main 2020 Paper

Date: 8th January 2020

Time: 09:30 AM – 12:30 PM

Subject: Chemistry

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1. The number of bonds between sulphur and oxygen atoms in $S_2O_8^{2-}$ and number of bonds between sulphur and sulphur atoms in rhombic sulphur, respectively, are:
   a. 8 and 6
   b. 4 and 6
   c. 8 and 8
   d. 4 and 8

2. The predominant intermolecular forces present in ethyl acetate, a liquid, are:
   a. London dispersion, dipole-dipole and hydrogen bonding
   b. hydrogen bonding and London dispersion
   c. dipole-dipole and hydrogen bonding
   d. London dispersion and dipole-dipole

3. For the Balmer series in the spectrum of H-atom,

$$\bar{\nu} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

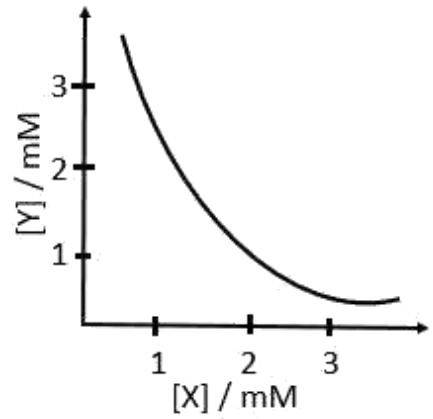
The correct statements among (A) to (D) are:

A) The integer $n_1 = 2$.
B) The ionization energy of hydrogen can be calculated from the wave number of these lines.
C) The lines of longest wavelength corresponds to $n_2 = 3$.
D) As wavelength decreases, the lines of the series converge.

a. B, C, D
b. A, B, D
c. A, C, D
d. A, B, C

4. The first ionization energy (in kJ/mol) of Na, Mg, Al and Si, respectively, are:
   a. 496, 737, 577, 786
   b. 496, 577, 737, 786
   c. 496, 577, 786, 737
   d. 786, 737, 577, 496

5. The stoichiometry and solubility product of a salt with the solubility curve given below is, respectively:

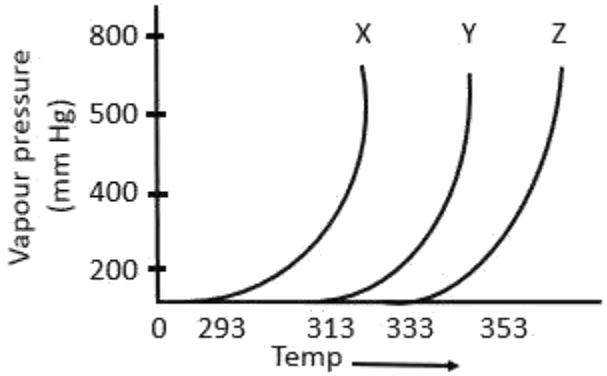


   a. X_2Y, $2 \times 10^{-9} M^3$
   b. XY_2, $1 \times 10^{-9} M^3$
   c. XY_2, $4 \times 10^{-9} M^3$
   d. XY, $2 \times 10^{-6} M^3$

6. The complex that can show fac- and mer-isomers is:

a. $[Co(NO_2)_3(NH_3)_3]$
b. $[PtCl_2(NH_3)_2]$
c. $[Co(NH_3)_4Cl_2]^+$
d. $[CoCl_2(en)_2]$

7. A graph of vapour pressure and temperature for three different liquids X, Y and Z is shown below:



The following inferences are made:

A) X has higher intermolecular interactions compared to Y
B) X has lower intermolecular interactions compared to Y
C) Z has lower intermolecular interactions compared to Y

The correct inference(s) is/are:

a. C
b. A
c. B
d. A and C

8. As per Hardy-Schulze formulation, the flocculation values of the following for ferric hydroxide sol are in the order:
   a. $AlCl_3 > K_3[Fe(CN)_6] > K_2CrO_4 > KBr = KNO_3$
   b. $K_3[Fe(CN)_6] < K_2CrO_4 < AlCl_3 < KBr < KNO_3$
   c. $K_3[Fe(CN)_6] < K_2CrO_4 < KBr = KNO_3 = AlCl_3$
   d. $K_3[Fe(CN)_6] > AlCl_3 > K_2CrO_4 > KBr > KNO_3$

9. The rate of a certain biochemical reaction at physiological temperature (T) occurs 10^6 times faster with enzyme than without. The change in activation energy upon adding enzyme is:
   a. $-6RT$
   b. $-6 \times 2.303\ RT$
   c. $+6RT$
   d. $+6 \times 2.303\ RT$

10. When gypsum is heated to 393K, it forms:

a. $CaSO_4.\frac{1}{2}\ H_2O$
b. Dead burnt plaster
c. $CaSO_4 \cdot 5H_2O$
d. Anhydrous $CaSO_4$

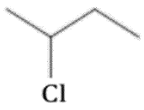
11. The third ionization enthalpy is minimum for:
a. Mn
b. Co
c. Ni
d. Fe

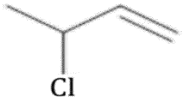
12. The strength of an aqueous NaOH solution is most accurately determined by titrating:
(Note: consider that an appropriate indicator is used)
   a. Aq. NaOH in a pipette and aqueous oxalic acid in a burette
   b. Aq. NaOH in a volumetric flask and concentrated H_2SO_4 in a conical flask
   c. Aq. NaOH in a burette and concentrated H_2SO_4 in a conical flask
   d. Aq. NaOH in a burette and aqueous oxalic acid in a conical flask

13. The decreasing order of reactivity towards dehydrohalogenation (E_1) reaction of the following compounds is:

A. 

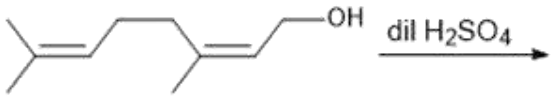
B. 

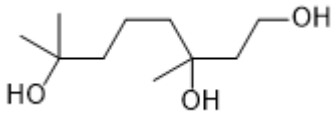
C. 

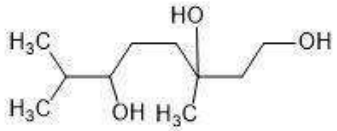
D. 

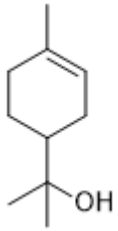
   a. B > A > D > C
   b. B > D > C > A
   c. B > D > A > C
   d. D > B > C > A

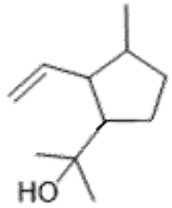
14. Major product in the following reaction is:



a. 

b. 

c. 

d. 

15. Arrange the following compounds in increasing order of C—OH bond length:
methanol, phenol, p-ethoxyphenol

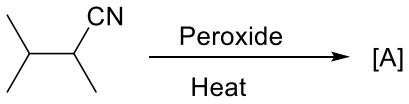
a. Phenol < methanol < p-ethoxyphenol
b. methanol < p-ethoxyphenol < phenol
c. Phenol < p-ethoxyphenol < methanol
d. methanol < phenol < p-ethoxyphenol

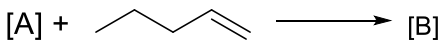
16. Among the gases (i) – (v), the gases that cause greenhouse effect are:

i. CO_2
ii. H_2O
iii. CFC
iv. O_2
v. O_3

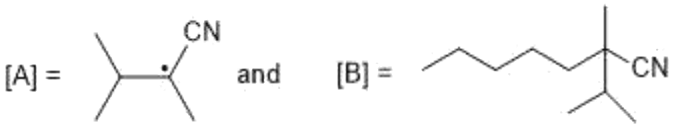
a. i, ii iii and iv
b. i, iii, iv and v
c. i and iv
d. i, ii, iii and v

17. The major products A and B in the following reactions are:

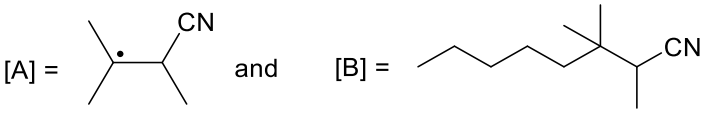




a.



b.



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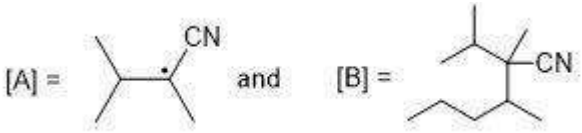

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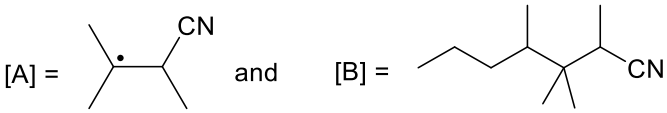
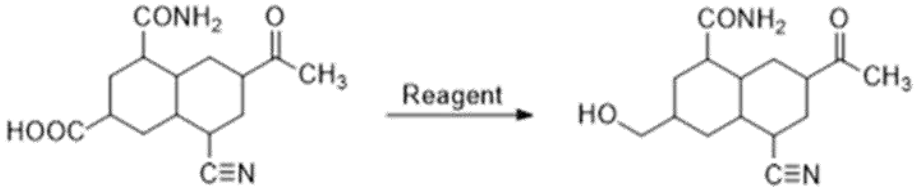


18. A flask contains a mixture of isohexane and 3-methylpentane. One of the liquids boils at 63 °C while the other boils at 60 °C. What is the best way to separate the two liquids and which one will be distilled out first?
    a. Fractional distillation, isohexane
    b. Simple distillation, 3-methylpentane
    c. Fractional distillation, 3-methylpentane
    d. Simple distillation, isohexane

19. Which of the given statement is not true for glucose?
    a. The pentacetate glucose does not react with hydroxylamine to give oxime.
    b. Glucose reacts with hydroxylamine to form oxime.
    c. Glucose gives Schiff's test for aldehyde.
    d. Glucose exists in two crystalline forms α and β.

20. The reagent used for the given conversion is:



a. B_2H_6
b. $LiAlH_4$
c. $NaBH_4$
d. H_2, Pd

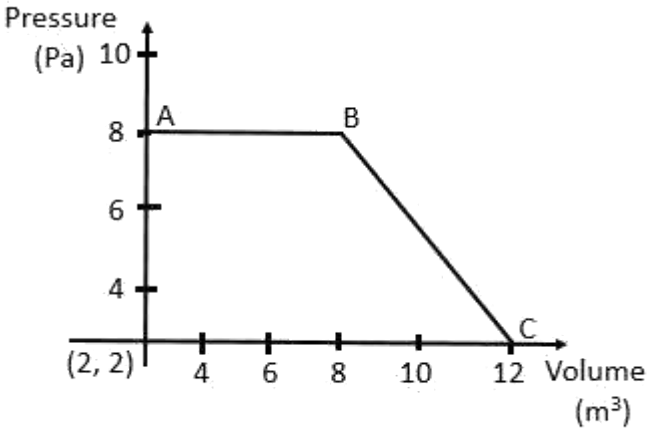
21. The volume (in mL) of 0.125 M $AgNO_3$ required to quantitatively precipitate chloride ions in 0.3 g of $[Co(NH_3)_6]Cl_3$ is ____.
$M_{[Co(NH_3)_6]Cl_3}$ = 267.46 g/mol
M_{AgNO_3} = 169.87 g/mpl

22. What will be the electrode potential for the given half cell reaction at pH= 5?
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-; \quad E° = -1.23\,V$

(R=8.314 $Jmol^{-1}K^{-1}$; temp.=298 K; oxygen under std. atm. Pressure of 1bar.)

23. Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is _____.
Atomic weight: Fe=55.85; S=32.00; O=16.00)

24. The magnitude of work done by gas that undergoes a reversible expansion along the path ABC shown in figure is _____.



25. The number of chiral centres in Penicillin is ___.

JEE Main 2020 Paper

Date of Exam: **8th January 2020 (Shift 1)**
Time: **9:30 A.M. to 12:30 P.M.**
Subject: **Mathematics**

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1. For which of the following ordered pairs (μ, δ), the system of linear equations
   $x + 2y + 3z = 1$
   $3x + 4y + 5z = \mu$
   $4x + 4y + 4z = \delta$
   is inconsistent?
   a. $(4,\ 6)$
   b. $(3,\ 4)$
   c. $(1,\ 0)$
   d. $(4,\ 3)$

2. Let $y = y(x)$ be a solution of the differential equation, $\sqrt{1-x^2}\ \frac{dy}{dx} + \sqrt{1-y^2} = 0, |x| < 1$. If $y\left(\frac{1}{2}\right) = \frac{\sqrt{3}}{2}$, then $y\left(\frac{-1}{\sqrt{2}}\right)$ is equal to :
   a. $-\frac{1}{\sqrt{2}}$
   b. $-\frac{\sqrt{3}}{2}$
   c. $\frac{1}{\sqrt{2}}$
   d. $\frac{\sqrt{3}}{2}$

3. If a, b and c are the greatest values of ${}^{19}C_p$, ${}^{20}C_q$, ${}^{21}C_r$ respectively, then :

a. $\frac{a}{11} = \frac{b}{22} = \frac{c}{42}$

b. $\frac{a}{10} = \frac{b}{11} = \frac{c}{42}$

c. $\frac{a}{11} = \frac{b}{22} = \frac{c}{21}$

d. $\frac{a}{10} = \frac{b}{11} = \frac{c}{21}$

4. Which of the following is a tautology?

a. $(P \wedge (P \longrightarrow Q)) \longrightarrow Q$
b. $P \wedge (P \vee Q)$
c. $(Q \rightarrow (P \wedge (P \rightarrow Q))$
d. $P \vee (P \wedge Q$

5. Let $f: \mathbf{R} \rightarrow \mathbf{R}$ be such that for all $x \in \mathbf{R}$, $(2^{1+x} + 2^{1-x}), f(x)$ and $(3^x + 3^{-x})$ are in A.P., then the minimum value of $f(x)$ is :

a. 0
b. 4
c. 3
d. 2

6. The locus of a point which divides the line segment joining the point $(0, -1)$ and a point on the parabola, $x^2 = 4y$, internally in the ratio 1: 2, is :

   a. $9x^2 - 12y = 8$
   b. $4x^2 - 3y = 2$
   c. $x^2 - 3y = 2$
   d. $9x^2 - 3y = 2$

7. For $a > 0$, let the curves $C_1: y^2 = ax$ and $C_2 : x^2 = ay$ intersect at origin O and a point P. Let the line $x = b$ $(0 < b < a)$ intersect the chord OP and the x-axis at points Q and R, respectively. If the line $x = b$ bisects the area bounded by the curves, C_1 and C_2, and the area of $\Delta OQR = \frac{1}{2}$, then $'a'$ satisfies the equation :

   a. $x^6 - 12x^3 + 4 = 0$
   b. $x^6 - 12x^3 - 4 = 0$
   c. $x^6 + 6x^3 - 4 = 0$
   d. $x^6 - 6x^3 + 4 = 0$

8. The inverse function of $f(x) = \frac{8^{2x}-8^{-2x}}{8^{2x}+8^{-2x}}$, $x \in (-1,1)$, is

a. $\frac{1}{4}(\log_8 e)\log_e\left(\frac{1-x}{1+x}\right)$

b. $\frac{1}{4}(\log_8 e)\log_e\left(\frac{1+x}{1-x}\right)$

c. $\frac{1}{4}\log_e\left(\frac{1+x}{1-x}\right)$

d. $\frac{1}{4}\log_e\left(\frac{1-x}{1+x}\right)$

10. Let $f(x) = (\sin(\tan^{-1} x) + \sin(\cot^{-1} x))^2 - 1$, where $|x| > 1$.
If $\frac{dy}{dx} = \frac{1}{2}\frac{d}{dx}(\sin^{-1}(f(x)))$ and $y(\sqrt{3}) = \frac{\pi}{6}$, then $y(-\sqrt{3})$ is equal to :

a. $\frac{\pi}{3}$

b. $\frac{2\pi}{3}$

c. $-\frac{\pi}{6}$

d. $\frac{5\pi}{6}$

11. If the equation, $x^2 + bx + 45 = 0$ ($b \in \boldsymbol{R}$) has conjugate complex roots and they satisfy $|z + 1| = 2\sqrt{10}$, then :

a. $b^2 + b = 12$

b. $b^2 - b = 42$

c. $b^2 - b = 30$

d. $b^2 + b = 72$

12. The mean and standard deviation (s.d.) of 10 observations are 20 and 2 respectively. Each of these 10 observations is multiplied by p and then reduced by q, where $p \neq 0$ and $q \neq 0$. If the new mean and standard deviation become half of their original values, then q is equal to:

a. -20 b. -5

c. 10 d. -10

13. If $\int \frac{\cos x}{\sin^3 x(1+\sin^6 x)^{\frac{2}{3}}}\, dx = f(x)(1+\sin^6 x)^{\frac{1}{\lambda}} + c$, where c is a constant of integration, then $\lambda f\left(\frac{\pi}{3}\right)$ is equal to :

a. $-\frac{9}{8}$ b. $\frac{9}{8}$

c. 2 d. -2

14. Let A and B be two independent events such that $P(A) = \frac{1}{3}$ and $P(B) = \frac{1}{6}$. Then, which of the following is TRUE ?

a. $P(A/(A \cup B)) = \frac{1}{4}$

b. $P(A/B') = \frac{1}{3}$

c. $P(A/B) = \frac{2}{3}$

d. $P(A'/B') = \frac{1}{3}$

15. If volume of parallelopiped whose coterminous edges are given by $\vec{u} = \hat{\imath} + \hat{\jmath} + \lambda\,\hat{k}$,

$\vec{v} == \hat{\imath} + \hat{\jmath} + 3\hat{k}$ and $\vec{w} = 2\hat{\imath} + \hat{\jmath} + \hat{k}$ be 1 cu. unit. If θ be the angle between the edges $\vec{u}$ and $\vec{w}$, then, $\cos\theta$ can be :

a. $\frac{7}{6\sqrt{6}}$

b. $\frac{5}{7}$

c. $\frac{7}{6\sqrt{3}}$

d. $\frac{5}{3\sqrt{3}}$

16. Let two points be $A(1, -1)$ and $B(0, 2)$. If a point $P(x', y')$ be such that the area of $\Delta PAB = 5$ sq. units and it lies on the line, $3x + y - 4\lambda = 0$, then the value of λ is :

a. 4
b. 1
c. -3
d. 3

17. The shortest distance between the lines

$\frac{x-3}{3} = \frac{y-8}{-1} = \frac{z-3}{1}$ and
$\frac{x+3}{-3} = \frac{y+7}{2} = \frac{z-6}{4}$ is :

a. $2\sqrt{30}$
b. $\frac{7}{2}\sqrt{30}$
c. 3
d. $3\sqrt{30}$

18. Let the line $y = mx$ and the ellipse $2x^2 + y^2 = 1$ intersect a point P in the first quadrant. If the normal to this ellipse at P meets the co-ordinate axes at $\left(-\frac{1}{3\sqrt{2}}, 0\right)$ and $(0, \beta)$, then β is equal to :

a. $\frac{2}{\sqrt{3}}$

b. $\frac{2}{3}$

c. $\frac{2\sqrt{2}}{3}$

d. $\frac{\sqrt{2}}{3}$

19. If c is a point at which Rolle's theorem holds for the function, $f(x) = \log_e\left(\frac{x^2+\alpha}{7x}\right)$ in the interval $[3, 4]$, where $\alpha \in \mathbf{R}$, then $f''(c)$ is equal to :

a. $-\frac{1}{24}$

b. $\frac{-1}{12}$

c. $\frac{\sqrt{3}}{7}$

d. $\frac{1}{12}$

20. Let $f(x) = x\cos^{-1}(\sin(-|x|))\,, x \in \left(-\frac{\pi}{2},\ \frac{\pi}{2}\right)$, then which of the following is true ?
    a. $f'(0) = -\frac{\pi}{2}$
    b. f' is decreasing in $\left(-\frac{\pi}{2},\ 0\right)$ and increasing in $\left(0,\ \frac{\pi}{2}\right)$
    c. f is not differentiable at $x = 0$
    d. f' is increasing in $\left(-\frac{\pi}{2},\ 0\right)$ and decreasing in $\left(0,\ \frac{\pi}{2}\right)$

21. An urn contains 5 red marbles, 4 black marbles and 3 white marbles. Then the number of ways in which 4 marbles can be drawn so that at most three of them are red is _____.

22. Let the normal at a P on the curve $y^2 - 3x^2 + y + 10 = 0$ intersect the y-axis at $\left(0, \frac{3}{2}\right)$. If m is the slope of the tangent at P to the curve, then $|m|$ is equal to_____.

23. The least positive value of $'a'$ for which the equation, $2x^2 + (a - 10)x + \frac{33}{2} = 2a$ has real roots is _____.

24. The sum $\sum_{k=1}^{20}(1+2+3+\ldots.+k)$ is _____.

25. The number of all 3×3 matrices A, with entries from the set $\{-1, 0, 1\}$ such that the sum of the diagonal elements of (AA^T) is 3, is _____.