SMART ACHIEVERS
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JEE Main - 2024 Session - 2

Answers & Solutions

(Physics, Chemistry and Mathematics)

08 - April - 2024 - Shift - 2

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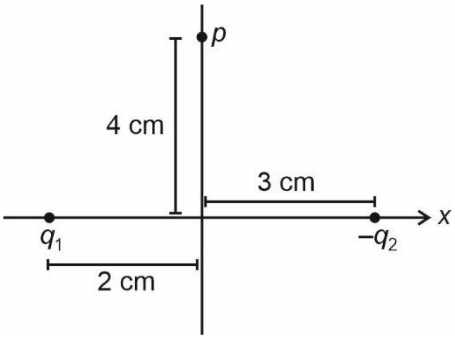
PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Figure shows two charges q_1 and $-q_2$ placed on x-axis as shown. If electric field at p is along x-direction, find $\frac{q_1}{q_2}$.



(1) $\frac{4\sqrt{5}}{25}$

(2) $\frac{8\sqrt{5}}{25}$

(3) $\frac{12}{25}$

(4) $\frac{16\sqrt{5}}{25}$

Answer (2)

Sol. $E_1 \sin\theta_1 = E_2 \sin\theta_2$

$$\frac{k_{q_1}}{(20)} \times \frac{4}{\sqrt{20}} = \frac{k_{q_2}}{(25)} \frac{4}{5}$$

$$\frac{q_1}{q_2} = \frac{8\sqrt{5}}{25}$$

2. A disk of mass M, radius R is rotating about an axis passing through its centre and perpendicular to its plane with angular speed ω. If another disk of mass $\frac{M}{2}$ and radius R is gently placed over it what will be their common angular velocity after some time?

(1) $\frac{\omega}{5}$ (2) $\frac{\omega}{2}$

(3) $\frac{2\omega}{3}$ (4) $\frac{\omega}{4}$

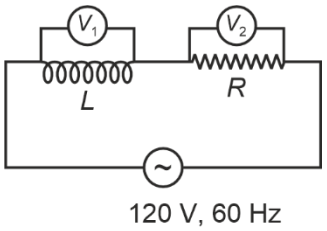
Answer (3)

Sol. $I_1\omega = (I_1 + I_2)\omega'$

$$\frac{MR^2}{2}\omega = \frac{3}{2}\left(\frac{MR^2}{2}\right)\omega'$$

$$\omega' = \frac{2\omega}{3}$$

3. In given AC circuit consisting a resistor R and an inductor L and source emf, two voltmeter V_1 & V_2 are connected as shown. If V_2 = 36 volts then inductance of inductor is (Resistance R is $\sqrt{91}\Omega$.)



(1) 0.08 H

(2) 0.8 H

(3) 8 H

(4) 80 H

Answer (1)

Sol. $i\sqrt{R^2+X_L^2}=120$ & $iR=36$

$$\Rightarrow \quad \frac{R^2+X_L^2}{R^2}=\frac{120\times120}{36\times36}=\frac{100}{9}$$

$$9R^2+9X_L^2=100R^2$$

$$9X_L^2=91R^2$$

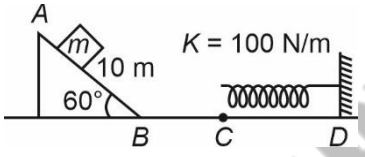
$$X_L=\frac{\sqrt{91}}{3}R$$

$$X_L=\frac{\sqrt{91}}{3}\times\sqrt{91}=\frac{91}{3}$$

$$L_\Omega=\frac{91}{3}$$

$$L=\frac{91}{3\times2\times\pi\times60}$$

4. A block of mass 5 kg is released as shown in the figure. Surface *CD* is rough with $\mu = 0.5$, rest of all the surfaces are smooth. Find the maximum compression in the spring (initially spring is in its natural length.)



(1) 1.5 m

(2) 2.0 m

(3) 3.5 m

(4) 2.5 m

Answer (2)

Sol. $|W_F| = E_i - E_f$

$$+(0.5\times50)\times x=\frac{50\times10}{2}-\frac{1}{2}\times100\times x^2$$

$x = 2.0$ m

5. A physical quantity *P* depends on electric field (*E*) and permittivity of free space (ε_0) as

$P \propto E\,\varepsilon_0{}^2$,

Find dimension of *P*

(1) $\left[M^1L^{-5}T^5I^3\right]$

(2) $\left[M^{-1}L^{-5}T^5I^3\right]$

(3) $\left[M^2L^{-5}T^5I^2\right]$

(4) $[MLTI]$

Answer (2)

Sol. $[P]=\left[MLT^{-3}I^{-1}\right]\left[M^{-1}L^{-3}T^4I^2\right]^2$

$$=\left[M^{-1}L^{-5}T^5I^3\right]$$

6. An electron and a proton has same de Broglie wavelength. If K_e and K_p are their respective kinetic energies, then

(1) $K_p > K_e$

(2) $K_e > K_p$

(3) $K_e = K_p$

(4) Nothing can be said

Answer (2)

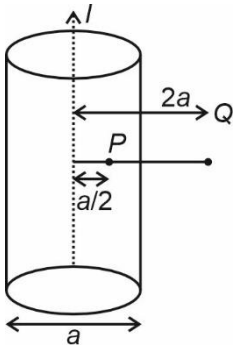
Sol. $\lambda=\frac{h}{p}$

$$K_e=\frac{p^2}{2m}$$

$$K_e\propto\frac{1}{m}$$

7. Find ratio of magnetic field at point *P* to that at point *Q*.

Point *P* is inside the solid cylinder and *Q* is outside the cylinder. Current is uniform through the cross-section of cylinder.



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

(3) 1 : 2 (4) 4 : 1

Answer (2)

Sol. For *P* :

$$B_P 2\pi\left(\frac{a}{2}\right) = \mu_0 j \pi \frac{a^2}{4}$$

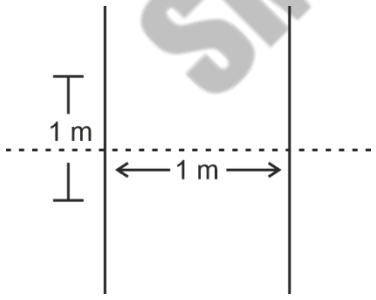
$$B_P = \frac{\mu_0 j a}{4}$$

For *Q* :

$$B_Q 2\pi(2a) = \mu_0 j \pi a^2$$

$$B_Q = \frac{\mu_0 \hat{j} a}{4}$$

8. In a YDSE shown a monochromatic light of wavelength 500 nm is incident. At point *P*, 10th maxima is formed. Now the two slits are replaced with a single slit of width *w* placed at the centre. If first diffraction minima is observed at *P*, find *w*.



(1) 0.5 mm

(2) 1 mm

(3) 0.1 mm

(4) 0.2 mm

Answer (3)

Sol. $10\frac{\lambda D}{d} = \frac{\lambda D}{w}$

$$w = \frac{d}{10} = 0.1\text{mm}$$

9. An object is projected such that its horizontal range and maximum height are same, then angle of projection is

(1) $\tan^{-1}(2)$

(2) $\tan^{-1}(1)$

(3) $\tan^{-1}(3)$

(4) $\tan^{-1}(4)$

Answer (4)

Sol. $R = \frac{u^2 \sin 2\theta}{g} = \frac{u^2 \sin^2 \theta}{2g}$

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

$\tan\theta = 4$

10. A wave is given by the equation

$y = A\sin\{\pi(330t - x)\}$, then frequency of the wave is

(1) 330 Hz (2) 660 Hz

(3) 165 Hz (4) $\frac{1}{330}$ Hz

Answer (3)

Sol. $y = A\sin(wt\text{-}kn)$

$\Rightarrow \quad \omega = 330\pi = 2\pi\upsilon$

$\Rightarrow \quad \upsilon = 165$ Hz

11. On two separate inclined plane (one smooth and other rough). Inclination of angle θ with horizontal. Two particles (starting from rest) travels same length in time t and nt respectively where $n > 1$. Friction coefficient for earth surface as

(1) $1-\frac{1}{n^2}$ (2) $\left(1-\frac{1}{n^2}\right)\sin\theta$

(3) $\left(1-\frac{1}{n^2}\right)\cos\theta$ (4) $\left(1-\frac{1}{n^2}\right)\tan\theta$

Answer (4)

Sol. $t=\sqrt{\frac{2l}{g\sin\theta}}$

$$nt=\sqrt{\frac{2l}{g(\sin\theta-\mu\cos\theta)}}$$

$$\frac{1}{n^2}=\frac{\sin\theta-\mu\cos\theta}{\sin\theta}$$

$$\frac{1}{n^2}=1-\mu\cot\theta$$

$$\mu=\left(1-\frac{1}{n^2}\right)\tan\theta$$

12. A vernier caliper having least count $\frac{1}{20N}$ cm and one main scale division is 1 mm, then value of one vernier scale division is

(1) $\frac{N+1}{2N}$ mm (2) $\frac{2N+1}{2N}$ mm

(3) $\frac{2N-1}{2N}$ mm (4) $\frac{2N+2}{2N}$ mm

Answer (3)

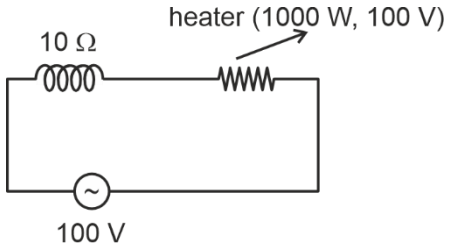
Sol. L.C. = 1 MSD – 1 VSD

$$\frac{1}{20N}\text{ cm}=1\text{ mm}-1\text{ VSD}$$

$$\text{VSD} = 1\text{ mm}-\frac{1}{2N}\text{ mm}$$

$$=\frac{2N-1}{2N}\text{ mm}$$

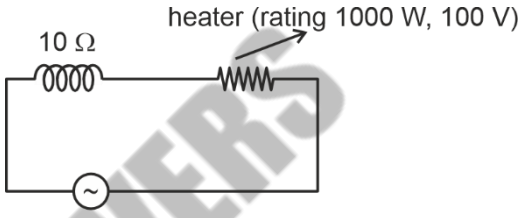
13. A heater with rating (1000 W, 100 V) is connected with AC source in series with inductor of reactance of 10 Ω as shown. Power dissipated in heater is



(1) $500\sqrt{2}$ W (2) $250\sqrt{2}$ W

(3) 500 W (4) 1000 W

Answer (3)



Sol.

$$R=\frac{100\times100}{1000}=10\ \Omega$$

$X_L = 10\ \Omega$

$$P=\frac{100\times100}{2\times10}=500\text{ W}$$

14. **Statement-I:** Mean free path is inversely proportional to the diameter of gas molecules, at constant volume, temperature.

Statement-II : Energy of n moles of gas is directly proportional to temperature.

(1) Both statements I and II are true and statement II is the correct explanation of statement I

(2) Both statements I and II are true and statement II is not the correct explanation of statement I

(3) Statement I is true but statement II is false

(4) Statement I is false but statement II is true

Answer (2)

Sol. Theoretical

$$\lambda=\frac{KT}{\sqrt{2}\pi d^2\left(\frac{N}{V}\right)}$$

15. Find binding energy of nuclei ${}^{12}_{5}X$, if its mass is m_o, m_p is mass of proton and m_n is mass of neutron.

(1) $\left(12m_p + 5m_n - m_o\right)C^2$

(2) $\left(5m_p + 12m_n - m_o\right)C^2$

(3) $\left(m_o - 5m_p - 7m_n\right)C^2$

(4) $\left(5m_p + 7m_n - m_o\right)C^2$

Answer (4)

Sol. $\Delta m = \left(5m_p + 7m_n - m_o\right)$

B.E. $= \left(5m_p + 7m_n - m_o\right)C^2$

16. A screw gauge with a pitch of 1 mm and a circular scale with 100 divisions is used to measure the thickness of aluminium sheet. Negative zero error of 0.05 mm is there.

What is the thickness of the sheet when main scale reading is 4 mm and 60th division coincides with the main scale line

(1) 10.05 mm

(2) 10.10 mm

(3) 10.15 mm

(4) 10.20 mm

Answer (1)

Sol. Reading = MSR + CSR × LC – Zero error

= 4 mm + 60 × 0.01 mm – (–0.05 mm)

= 10.05 mm

17.

18.

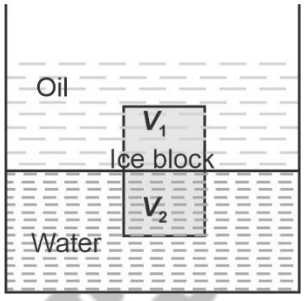
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. An ice block of density 0.9 g/cc is sub-merged as shown in figure.



Density of oil = 0.8 g/cc
Density of water = 1 g/cc
Volume inside water = V_2
Volume inside oil = V_1
Find ratio $\frac{V_1}{V_2}$.

Answer (1)

Sol. $mg = \rho_{oil}V_1g + \rho_{water}V_2g$

$\left(V_1 + V_2\right)\rho_{ice} = \left(\rho_{oil}\right)V_1 + \rho_{water}V_2$

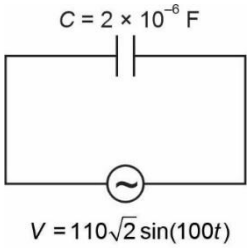
$\left(V_1 + V_2\right)\cdot 0.9 = 0.8V_1 + V_2$

$9V_1 + 9V_2 = 8V_1 + 10V_2$

$V_1 = V_2$

$\frac{V_1}{V_2} = 1$

22. A capacitive AC circuit is given. The rms value of current is k mA. Find the value of k.



Answer (22)

Sol. $i_{rms} = \dfrac{V_0}{\sqrt{2}x_C}$

$i_{rms} = \dfrac{V_0\omega_C}{\sqrt{2}} = 22$ mA

$\boxed{k = 22}$

23. At certain instant, kinetic energy and potential energy for particle executing SHM are 0.4 J and 0.5 J respectively. Find amplitude of SHM, if frequency of oscillations is $\dfrac{25}{\pi}$ Hz and mass of particle is 0.2 kg, in cm.

Answer (6)

Sol. $\dfrac{1}{2}m4\pi^2f^2A^2 = 0.9$ J

$\dfrac{1}{2}0.2\times4\pi^2\times\dfrac{625}{\pi^2}A^2 = 0.9$

$A = \dfrac{3}{2\times25} = 6$ cm

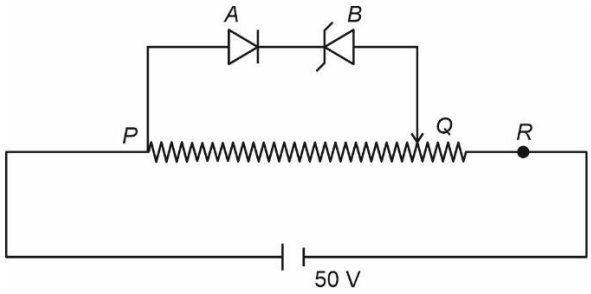
24. A planet is revolving in a circular orbit of radius R around sun with speed v. If another planet is revolving in circular orbit of radius $\dfrac{R}{4}$, its velocity is nv, find n.

Answer (2)

Sol. $v = \sqrt{\dfrac{GM}{R}}$

$v_2 = 2v$

25. A p-n junction diode (A) of potential barrier 3.8 V is connected with zener diode (B) of potential barrier 1.2 V as shown in figure. The length PR is 20 cm, then the maximum value of PQ (in cm) for which their is no current flow through diode_____ cm.



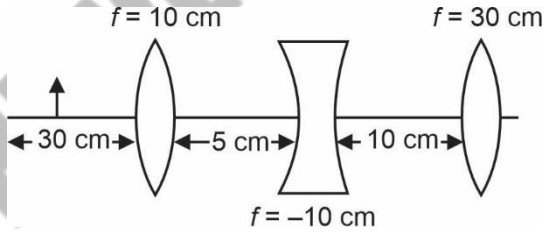
Answer (2)

Sol. $(V)_{PQ}^{max} = 5$ V

So, $PQ = \dfrac{20}{50}\times5$

= 2 cm

26. Find the distance (in cm) of image from rightmost lens.



Answer (30)

Sol. $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

$\dfrac{1}{v} - \dfrac{1}{-30} = \dfrac{1}{10}$

$\dfrac{1}{v} = \dfrac{1}{10} - \dfrac{1}{30} = \dfrac{3-1}{30}$

v = 15 cm

27.

28.

29.

30.

CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Molecular orbital σ* is represented by

   (1) $\psi_A + \psi_B$ (2) $\psi_A - \psi_B$

   (3) $\psi_A - 2\psi_B$ (4) $\psi_A + 2\psi_B$

Answer (2)

Sol. σ* is antibonding molecular orbital which is represented by $(\psi_A - \psi_B)$

2. Consider the given reaction :

   $$Cr_2O_7^{2-} \rightleftharpoons CrO_4^{2-}$$

   Above reaction shifts in forward direction in

   (1) Acidic medium

   (2) Basic medium

   (3) Neutral medium

   (4) Slightly acidic medium

Answer (2)

Sol. $H_2O + Cr_2O_7^{2-} \rightleftharpoons 2CrO_4^{2-} + 2H^+$

As per Le-Chatelier's principle, reaction will shift in forward direction in basic medium.

3. Select the correct options

   Statement 1 : Benzene sulphonyl chloride reacts with 1^0, 2^0 and 3^0 amines

   Statement 2 : All products of the reaction above are soluble in NaOH

   (1) Statement 1 is true, statement 2 is false

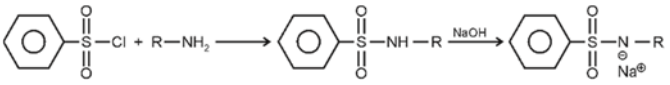
   (2) Statement 1 is false, statement 2 is true

   (3) Statement 1 and statement 2 both are true

   (4) Statement 1 and statement 2 both are false

Answer (4)

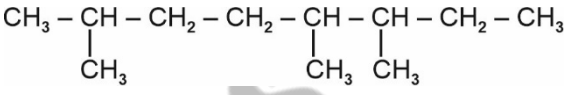
Sol.



1° and 2° amines reacts with benzene sulphonyl chloride.

Product of 1^0 amine only is soluble in NaOH

4. Consider the following compound :



What is IUPAC nomenclature of above compound?

(1) 2, 5, 6-trimethyloctane

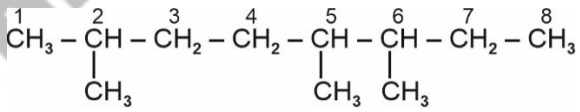
(2) 3, 4, 7-trimethyloctane

(3) 2, 4-ethyl, 3-methyloctane

(4) isopropyl hexane

Answer (1)

Sol.



2, 5, 6-trimethyloctane

5. Which of the following are aromatic compounds?

(1) Only (i) and (ii)

(2) Only (ii) and (iii)

(3) Only (i) and (iii)

(4) All are aromatic

Answer (2)

Sol. (ii) and (iii) are aromatic because they have 4n + 2 π electrons in cyclic resonance or say follow Huckel's rule while in case of (i) resonance is absent.

(ii) and (iii) both are having 6 π electrons in cyclic resonance.

6. If de-Broglie wavelength of electron is equal to de-Broglie of proton. What is the relation between their kinetic energy?

(1) $KE_e > KE_p$

(2) $KE_p > KE_e$

(3) $KE_e = KE_p$

(4) $2KE_e = KE_p$

Answer (1)

Sol. $\lambda_e = \lambda_p$

$\Rightarrow (m \cdot KE)_e = (m \cdot KE)_p$

$\Rightarrow m_e < m_p$

$(KE)_e > (KE)_p$

7. 1 mole of ethylene glycol is dissolved in 9 mol of water. Calculate the mass percentage of ethylene glycol in the resulting solution.

(1) 27.67%

(2) 38.27%

(3) 22.3%

(4) 31.2%

Answer (1)

Sol. Mass of ethylene glycol = 1 × 62 = 62 g

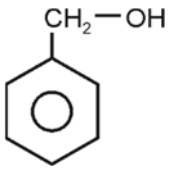
Mass of water = 9 × 18 = 162 g

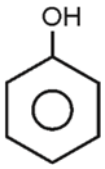
Therefore, % by mass of ethylene glycol

$$= \frac{62}{62+162} \times 100$$

= 27.67%

8. Which of the following reacts with NaOH with maximum rate?

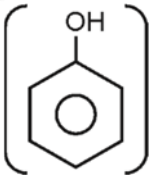
(1) 

(2) 

(3) $CH_3—CH_2—OH$

(4) $CH_3—OH$

Answer (2)

Sol. More the acidic molecule, faster will be reaction with NaOH. Phenol  is most acidic in the given options

9. Which of the following is correct?

(1) Non-metals are generally more electronegative than metals

(2) Non-metallic oxides are generally basic

(3) Metallic oxides are generally acidic or neutral

(4) Non-metallic have always lower ionisation enthalpy than metals

Answer (1)

Sol. EN order:

(Non-metals) > metals

Non-metallic oxides are generally acidic

Metallic oxides are generally basic

10. Consider the following reaction sequence involving first order reactions :

$A \xrightarrow{k_1} B \xrightarrow{k_2} C$

If net rate of formation of B is zero, what would be concentration of B in terms of concentration of A?

(1) $k_1k_2[A]$

(2) $\frac{k_1}{k_2}[A]$

(3) $(k_1 + k_2)[A]$

(4) $\frac{k_2}{k_1}[A]$

Answer (2)

Sol. $A \xrightarrow[r_1]{k_1} B \xrightarrow[r_2]{k_2} C$

Net rate of formation of B, $\frac{d[B]}{dt} = r_1 - r_2$

$\frac{d[B]}{dt} = k_1[A] - k_2[B] = 0$

$\Rightarrow \quad [B] = \frac{k_1[A]}{k_2}$

11. What is the correct acidic strength order of the following acids?

HCOOH, CH_3COOH, CH_3CH_2COOH, $CH_3CH_2\,CH_2COOH$

(1) HCOOH < CH_3COOH < CH_3CH_2COOH < $CH_3CH_2CH_2COOH$

(2) HCOOH > $CH_3CH_2CH_2COOH$ > CH_3COOH > CH_3CH_2COOH

(3) HCOOH > CH_3COOH > CH_3CH_2COOH > $CH_3CH_2CH_2COOH$

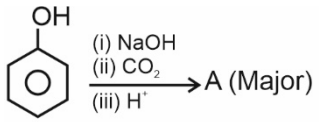
(4) CH_3COOH > HCOOH > $CH_3CH_2CH_2COOH$ > CH_3CH_2COOH

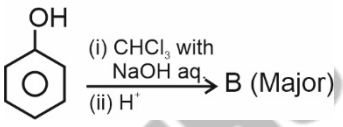
Answer (3)

Sol. Acidic strength of carboxylic acids decreases as the $_+I$ effect of the alkyl group attached to carboxylic group increases. Therefore, the correct order of acidic strength of the given acids is

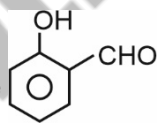
HCOOH > CH_3COOH > CH_3CH_2COOH > $CH_3CH_2CH_2COOH$

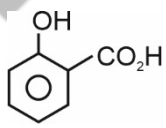
12. Consider the following two reactions

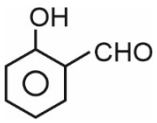


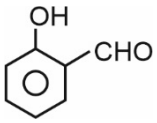


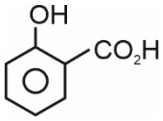
A and B are

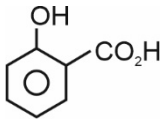
(1) Both are 

(2) A is 

B is 

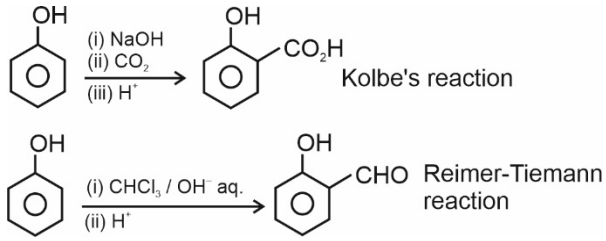
(3) A is 

B is 

(4) Both are 

Answer (2)

Sol.



13. **Assertion:** Kjeldahl method is not used for pyridine.

Reason: Nitrogen of pyridine does not change to ammonium sulphate under these conditions.

(1) Both Assertion and Reason are true and Reason is a correct explanation for assertion

(2) Both Assertion and reason are true but Reason is not a correct explanation for assertion

(3) Assertion is true but Reason is false

(4) Assertion is false but Reason is true

Answer (1)

Sol. (Reference NCERT Page 358)

Kjeldahl method is not applicable to compounds containing nitrogen in the ring (pyridine) as nitrogen of these compounds does not change to ammonium sulphate under these conditions

14. Statement-1 : S_N2 reaction is stereospecific reaction.

Statement-2 : In S_N1 reaction, racemic mixture is obtained.

(1) Statement-1 is true but Statement-2 is false

(2) Statement-1 is false but Statement-2 is true

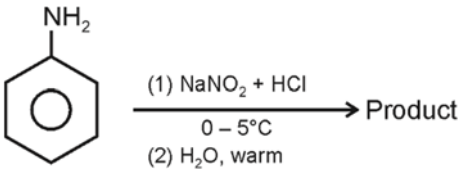
(3) Both Statement-1 and Statement-2 is true

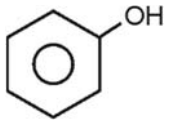
(4) Both Statement-1 and Statement-2 are false

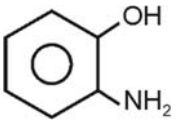
Answer (3)

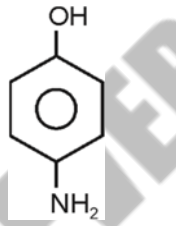
Sol. Both statements are true as in S_N2 only one product is obtained by inversion and in S_N1 due to carbocation formation, racemic mixture is obtained.

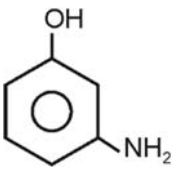
15.



(1) 

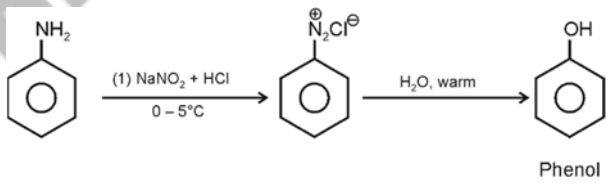
(2) 

(3) 

(4) 

Answer (1)

Sol.



16. What is the structure of a carbocation?

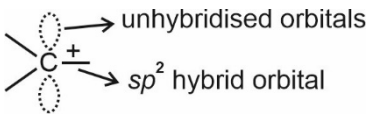
(1) Triangular planar (2) Tetrahedral

(3) Trigonal bipyramid (4) Triangular pyramid

Answer (1)

Sol. The hybridisation of carbocation is sp^2.

Therefore, its structure is triangular planar



17. **S-I:** Blood is a buffer solution, whose pH is maintained at 7.4 by an acidic buffer.

S-II: pH is maintained by $\left[HCO_3^-\right]$ and $\left[H_2CO_3\right]$

(1) S-I and S-II both are correct

(2) S-I and S-II both in correct

(3) S-I is correct and S-II are incorrect

(4) S-I is incorrect and S-II is correct

Answer (1)

Sol. H_2CO_3/HCO_3^- buffer system helps to maintain pH of blood between 7.26 to 7.42.

(Refer NCERT p-block gooup-14)

18. The EMF of the cell is 0.83 V

$$Tl\left|Tl^+\right|\left|Cu^{2+}\right|Cu$$

Then the EMF value will be increased

(1) By increasing conc. of Cu^{2+}, keeping Tl^+ constant

(2) By increasing conc. of Tl^+, keeping Cu^{2+} constant

(3) By increasing conc. of both Tl^+ and Cu^{2+}

(4) By decreasing conc. of both Cu^{2+} and Tl^+

Answer (1)

Sol.

$$\begin{array}{l}(Tl \longrightarrow Tl^+ + e^-) \times 2 \\ Cu^{2+} + 2e^- \longrightarrow Cu \\ \hline 2Tl + Cu^{2+} \longrightarrow 2Tl^+ + Cu\end{array}$$

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{2}\log\frac{[Tl^+]^2}{[Cu^{2+}]}$$

E_{cell} will increase if we

(i) Decrease Tl^+

(ii) Increase Cu^{2+}

19. For the cell reactions:

$$AgCl_{(S)} + \frac{1}{2}H_{2(g)} \rightarrow Ag_{(S)} + Cl^-_{(aq)} + H^+_{(aq)}$$

which one of the following represents the correct cell representation?

(1) $Pt|H_2|H^+||Cl^-|AgCl|Ag$

(2) $H_2|H^+||Cl^-|AgCl$

(3) $Pt|H_2|H^+||AgCl|Ag$

(4) $Pt|H^+|H_2||Ag|AgCl$

Answer (1)

Sol. At cathode :

$$AgCl_{(S)} \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

$$\begin{array}{l}Ag^+_{(aq)} + e^- \rightarrow Ag_{(S)} \\ \hline AgCl_{(S)} + e^- \rightarrow Ag_{(S)} + Cl^-_{(aq)}\end{array}$$

At anode : $\frac{1}{2}H_{2(g)} \rightarrow H^+_{(aq)} + e^-$

So, cell representation is : $Pt|H_2|H^+||Cl^-|AgCl|Ag$

20. Match the following Column-I and II.

	Column-I		Column-II
(i)	Baeyer's test	(p)	Aldehyde
(ii)	Ceric ammonium nitrate test	(q)	Alcohol
(iii)	Phenolphthalein test	(r)	Phenol
(iv)	Schiff's test	(s)	Unsaturation

(1) i → (p), ii → (q), iii → (r), iv → (s)

(2) i → (s), ii → (q), iii → (r), iv → (p)

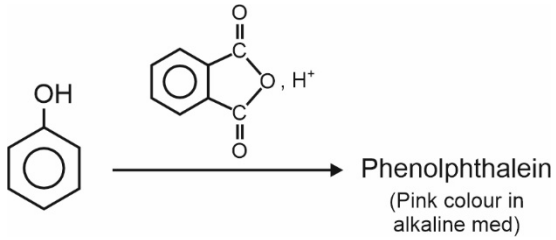
(3) i → (s), ii → (q), iii → (p), iv → (r)

(4) i → (q), ii → (s), iii → (r), iv → (p)

Answer (2)

Sol. Unsaturated compounds decolourise the Baeyer's reagent.

Alcohols give red coloured ppt with ceric ammonium nitrate.



Aldehyde gives pink colour with Schiff's reagent.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. The sum of unpaired electron present in complexes $[Co(NH_3)_6]^{3+}$ and $[NiCl_4]^{2-}$ is

Answer (2)

Sol. $[Co(NH_3)_6]^{3+}$

$Co^{3+} = 3d^6 4s^0 \Rightarrow d^2sp^3 \Rightarrow t_{2g}^6 eg^0$

No. of unpaired electron = 0

$[NiCl_4]^{2-}$

$Ni^{+2} \Rightarrow 3d^8 \Rightarrow sp^3 \Rightarrow e^4 t_2^4$

No. of unpaired electron = 2

Total no. of unpaired e^- = (2 + 0) = 2

22. The total number of compounds having bond order 2 among the following are _____.

F_2, N_2, Ne_2, O_2, Li_2, Be_2

Answer (1)

Sol.

Molecule	Bond order
F_2	1
N_2	3
Ne_2	0
O_2	2
Li_2	1
Be_2	0

23. Wave number of a radiation having 5800Å wavelength is x × 10^4 cm^{-1}. The value of x to nearest integer is :

Answer (2)

Sol. $\bar{\nu} = \frac{1}{\lambda}$

$= \frac{1}{5800 \times 10^{-8}\ cm}$

$= 1.72 \times 10^4\ cm^{-1}$

$x = 1.72 \simeq 2$

24. Molality of aqueous solution of urea is 4.44 m. Then mole fraction of urea is x × 10^{-3}, then value of x is ____

Answer (74)

Sol. $\frac{X_B}{X_A} = \frac{m \times M_A}{1000}$

Where m = molality

M_A = molar mass of solvent

$\frac{X_B}{1 - X_B} = \frac{4.44 \times 18}{1000}$

$$\frac{X_B}{1-X_B} = 0.08$$

$X_B = 0.08 - 0.08X_B$

$1.08 \times B = 0.08$

$X_B = 0.074 = 74 \times 10^{-3}$

$x = 74$

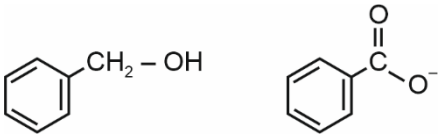
25. 2 moles of benzaldehyde is treated with aq. NaOH. The number of π-bonds present in the resulting compounds is _____ .

Answer (7)

Sol. $Ph-CHO + NaOH(aq)$
(Cannizzaro Reaction)

$\longrightarrow Ph-CH_2-OH + Ph-COO^-$

Products are:



Total number of π-bonds = 3 + 4 = 7

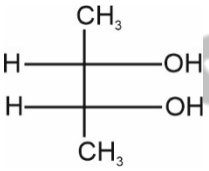
26. How many of the following are optically active?

(I) $CH_3-CH_2-CH_2-Cl$

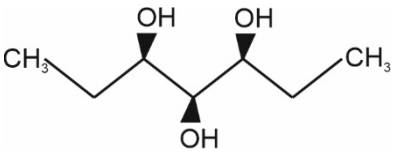
(II) $CH_3-CH_2-CH_2-OH$

(III) $CH_3-\underset{\underset{CH_3}{|}}{CH}-CH_2-CH_2-Cl$

(IV)



(V)



Answer (0)

Sol. All are optically inactive

27. Consider the following statements :

(i) N_2 is stable in divalent form

(ii) Group-15 exist in +3, –3, +5 oxidation state

(iii) Stability of +5 oxidation state increases down the group

(iv) ΔH_{eq} value for N is positive

How many of the above statement(s) is/are correct

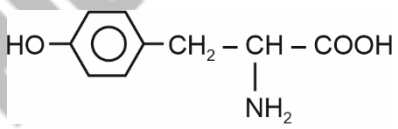
Answer (3)

Sol. Statement (iii) is incorrect

28. How many carbon atoms are there in a molecule of tyrosine?

Answer (9)

Sol. The structures of tyrosine is as given below



It has a carbon atom in its molecule.

29. In the test for phosphorus using ammonium molybdate, yellow precipitate of compound (X) is obtained. What is the oxidation state of molybdenum in (X)?

Answer (6)

Sol. NCERT Page – 355 : Test for Phosphorus

$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \longrightarrow$

$\underset{\text{Yellow ppt.}}{(NH_4)_3PO_4 \cdot 12MoO_3} + 21NH_4NO_3 + 12H_2O$

Oxidation state of Mo = +6

30.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Given $\left(\sqrt{a}x^2+\frac{1}{2x^3}\right)^{10}$ if the coefficient of independent term is 105 then a^3 equals to

(1) 2 (2) 8

(3) 9 (4) 6

Answer (2)

Sol. General term = $^{10}C_r\left(\sqrt{a}x^2\right)^{10-r}\left(\frac{1}{2x^3}\right)^r$

$= {}^{10}C_r\left(\sqrt{a}\right)^{10-r}x^{20-2r}\left(\frac{1}{2}\right)^r x^{-3r}$

$= {}^{10}C_r\left(\sqrt{a}\right)^{10-r}x^{20-5r}2^{-r}$

Now, $20 - 5r = 0$

$20 = 5r$

$r = 4$

$\therefore \quad {}^{10}C_4\left(\sqrt{a}\right)^6 2^{-4} = 105$

$\frac{10\cdot9\cdot8\cdot7}{4\cdot3\cdot2}\frac{a^3}{16}=105$

$\Rightarrow \quad a^3 = 8$

Option (2) is correct.

2. Number of 5 letters words made from the word "MATHEMATICS" is equal to

(1) 13540 (2) 13560

(3) 14210 (4) 17310

Answer (2)

Sol. 2M

2A

2T

H, E, I, C, S

Case-I

2 Alike 2 Alike 1 Diff

$^3C_2\cdot{}^6C_1\cdot\frac{5!}{2!2!}=18\times30=540$

Case-II

2 Alike + 3 Diff

$^3C_1\cdot{}^7C_3\times\frac{5!}{2!}=105\times60=6300$

Case-III

All different

$^8C_5\cdot5!=6720$

Total words = 13560

3. If the shortest distance between the lines $\frac{x-\lambda}{2}=\frac{y-4}{4}=\frac{z-7}{8}, \frac{x-2}{1}=\frac{y-3}{2}=\frac{z-4}{4}$ is $\frac{13}{\sqrt{21}}$ then sum of values of λ is

(1) $\frac{23}{4}$ (2) $\frac{23}{5}$

(3) $\frac{21}{4}$ (4) $\frac{25}{2}$

Answer (2)

Sol. S.D = $\frac{\left|\left(\hat{i}+2\hat{j}+4\hat{k}\right)\times\left((\lambda-2)\hat{i}+\hat{j}+3\hat{k}\right)\right|}{\left|\hat{i}+2\hat{j}+4\hat{k}\right|}=\frac{13}{\sqrt{21}}$

$$\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 2 & 4\\ \lambda-2 & 1 & 3\end{vmatrix}=2\hat{i}+\hat{j}(4\lambda-9)+\hat{k}(1-2\lambda+4)$$

$$=\left|2\hat{i}+\hat{j}(4\lambda-9)+(5-2\lambda)\hat{k}\right|$$

$\Rightarrow \quad \frac{\sqrt{4+(4\lambda-9)^2+(5-2\lambda)^2}}{\sqrt{21}} = \frac{13}{\sqrt{21}}$

$\Rightarrow \quad 20\lambda^2 + 110 - 92\lambda = 169$

$\Rightarrow \quad 20\lambda^2 - 92\lambda - 59 = 0$

4.

2

5 8

11 14 17

Then the sum of elements of 10th row.

(1) 1505 (2) 1438

(3) 1981 (4) 1745

Answer (1)

Sol. The given sequence is

2, (5, 8), (11, 14, 17), (20, 21, 24, 27) …

Before 10th term total number of numbers would be

1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 = 9 × 5 = 45

It is an A.P. with $a = 2$ and $d = 3$

$T_{46} = 2 + 45 \times 3$

$= 137$

Sum of 10th terms = $\frac{10}{2}(2 \times 137 + (10-1)3)$

$= 1505$

5. If $y(x)$ be the solution of differential equation $\sec y \frac{dy}{dx} + 2x \sin y = x^3 \cos y$ and $y(1) = 0$ then $y(\sqrt{3})$ is equal to

(1) $\frac{\pi}{4}$ (2) $\frac{\pi}{12}$

(3) $\frac{\pi}{6}$ (4) $\frac{\pi}{3}$

Answer (1)

Sol. $\sec^2 y \frac{dy}{dx} + 2x \tan y = x^3$

$\Rightarrow$ Let $z = \tan y$

$\frac{dz}{dx} = \sec^2 y \frac{dy}{dx}$

$\Rightarrow \quad \frac{dz}{dx} + 2xz = x^3$

$\Rightarrow$ I.F. $= e^{\int 2x\,dx} = e^{x^2}$

$\Rightarrow \quad z.e^{x^2} = \int e^{x^2}.x^3 dx + C$

$\Rightarrow \quad \tan y.e^{x^2} = \frac{1}{2}\left(x^2e^{x^2} - e^{x^2}\right) + C$

$\tan(0).e' = \frac{1}{2}(1.e' - e') + C$

$\Rightarrow \quad C = 0$

$\Rightarrow \quad \tan y = \left(\frac{x^2-1}{2}\right)$

$f(x) = \tan^{-1}\left(\frac{x^2-1}{2}\right)$

$f(\sqrt{3}) = \tan^{-1}\left(\frac{3-1}{2}\right) = \frac{\pi}{4}$

6. Two points (5, 2) and (2, a). Line passes through these points makes an angle of $\frac{\pi}{4}$ at origin. The product of all values of a is equal to

(1) 8 (2) –4

(3) –2 (4) 1

Answer (2)

Sol. $m_1 = \frac{2}{5}, \; m_2 = \frac{a}{2}$

$1 = \left[\frac{\frac{2}{5} - \frac{a}{2}}{1 + \frac{2}{5}.\frac{a}{2}}\right] \qquad \left(\tan\theta = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|\right)$

$\pm 1 = \frac{4 - 5a}{10 + 2a}$

$\oplus$ $10 + 2a = 4 - 5a$

$\Rightarrow 7a = -6$

$\Rightarrow a = \frac{-6}{7}$

$\ominus$ $-10 - 2a = 4 - 5a$

$\Rightarrow 3a = 14$

$\Rightarrow a = \frac{14}{3}$

$$a_1 \cdot a_2 = -\frac{6}{7} \times \frac{14}{3} = -4$$

7. A circle $x^2 + y^2 = 8$ and a parabola $y^2 = 2x$ are given. Find area bounded by these two curves in first quadrant which lie inside the circle and outside the parabola.

(1) $\pi - \frac{2}{3}$

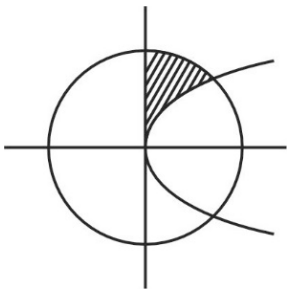
(2) $\pi - \frac{1}{3}$

(3) $\pi + \frac{1}{3}$

(4) $\pi - \frac{4}{3}$

Answer (1)

Sol.



$$\text{Area} = \int_0^2 \left(\sqrt{8 - x^2} - \sqrt{2x}\right) dx$$

$$= \left[\frac{x}{2}\sqrt{8 - x^2} + \frac{8}{2}\sin^{-1}\left(\frac{x}{2\sqrt{2}}\right)\right]_0^2 - \sqrt{2} \times \frac{2}{3}[x^{3/2}]_0^2$$

$$= 2 + 4\sin^{-1}\left(\frac{1}{\sqrt{2}}\right) - \frac{2\sqrt{2}}{3}(2\sqrt{2})$$

$$= \left(\pi - \frac{2}{3}\right) \text{ sq. units.}$$

8. If $\alpha \neq a$, $\beta \neq b$, $\gamma \neq c$ and

$$\begin{vmatrix} \alpha & b & c \\ a & \beta & c \\ a & b & \gamma \end{vmatrix} = 0, \text{ then}$$

$\frac{a}{\alpha - a} + \frac{b}{\beta - b} + \frac{\gamma}{\gamma - c}$ is equal to

(1) 3 (2) 2

(3) 0 (4) 1

Answer (3)

Sol. $\begin{vmatrix} \alpha & b & c \\ a & \beta & c \\ a & b & \gamma \end{vmatrix} = 0$

$R_1 \to R_1 - R_2$

$R_2 \to R_2 - R_3$

$$\begin{vmatrix} \alpha - a & b - \beta & 0 \\ 0 & \beta - b & c - \gamma \\ a & b & \gamma \end{vmatrix} = 0$$

Take $(\alpha - a)$, $(\beta - b)$ and $(\gamma - c)$ common from column 1, column 2 and column 3 respectively.

$$\begin{vmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ \frac{a}{\alpha - a} & \frac{b}{\beta - b} & \frac{\gamma}{\gamma - c} \end{vmatrix} = 0$$

$$\Rightarrow \frac{b}{\beta - b} + \frac{\gamma}{\gamma - c} + \frac{a}{\alpha - a} = 0$$

9. Bag X contains five one-rupee coins, four five-rupee coins. Bag Y contains 4 one rupee and 5 five rupees. Bag Z contains 3 one-rupee coin and 6 five-rupee coins. If 1 rupee coin is selected at random, what is the probability it is drown from bag *Y*?

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

(3) $\frac{1}{5}$ (4) $\frac{1}{6}$

Answer (1)

Sol. By Baye's theorem

Probability (coin drawn from bag *Y*)

$$= \frac{\frac{1}{3}\cdot\frac{4}{9}}{\frac{1}{3}\cdot\frac{5}{9}+\frac{1}{3}\cdot\frac{4}{9}+\frac{1}{3}\cdot\frac{3}{9}} = \frac{4}{12} = \frac{1}{3}$$

10. If $\frac{3\cos 36° - 2\sin 18°}{2\cos 36° - 3\sin 18°} = \frac{a\sqrt{5}+b}{c}$, where *a* and *c* are co-primes. The value of *a* + *b* + *c* is equal to

(1) 6 (2) 7

(3) 2 (4) 5

Answer (1)

Sol. $\cos 36° = \frac{\sqrt{5}+1}{4}$

$\sin 18° = \frac{\sqrt{5}-1}{4}$

$\frac{3\cos 36° - 2\sin 18°}{2\cos 36° - 3\sin 18°} = \frac{\sqrt{5}+3}{2}$

$\therefore$ *b* = 3, *a* = 1, *c* = 2

11. $\lim\limits_{x\to 0^+} \frac{e^{\sqrt{\tan x}} - e^{\sqrt{x}}}{\sqrt{\tan x} - \sqrt{x}}$ is equal to

(1) 1 (2) $\frac{1}{2}$

(3) 2 (4) $\frac{3}{2}$

Answer (1)

Sol. $\lim\limits_{x\to 0^+} \frac{e^{\sqrt{x}}\left(e^{\sqrt{\tan x}-\sqrt{x}} - 1\right)}{\sqrt{\tan x} - \sqrt{x}} = 1$

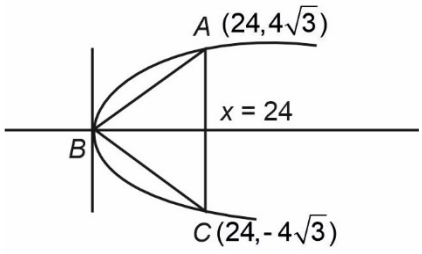
12. A triangle is drawn inside bounded region of $y^2 = 2x$ and $x = 24$. Then maximum area of triangle is

(1) $64\sqrt{3}$ (2) $108\sqrt{3}$

(3) $96\sqrt{3}$ (4) $120\sqrt{3}$

Answer (3)

Sol.



Base is constant i.e., $AC = 8\sqrt{3}$

Area of ΔABC will be maximum when height is maximum

$\therefore$ *B* is (0, 0)

$\therefore$ $(\text{Area})_{max} = = \frac{1}{2}\times 24 \times 8\sqrt{3} = 96\sqrt{3}$

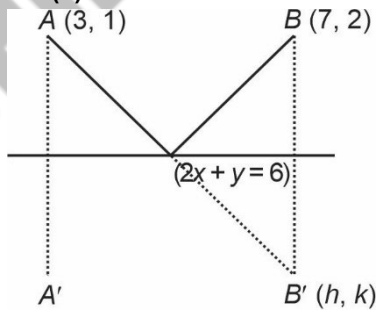
13. A ray of light coming from (3, 1) incident on $2x + y = 6$ and deflected ray passing through (7, 2). If equation of incident ray is $ax + by + 1 = 0$, then $a^2 + b^2 + 3ab$ =

(1) $\frac{11}{25}$ (2) $-\frac{11}{25}$

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

Answer (2)

Sol.



$\frac{h-7}{2} = \frac{k-2}{1} = -2\frac{(14+2-6)}{5} = -4$

$\therefore$ $h = -1, k = -2$

$\therefore$ $B'(-1, -2)$

$\therefore$ $AB' \equiv \frac{4}{5}y - \frac{3}{5}x + 1 = 0$

$a = \frac{4}{5}, b = \frac{-3}{5}$

$a^2 + b^2 + 3ab = \frac{16}{25} + \frac{9}{25} - \frac{36}{25} = \frac{-11}{25}$

14.
15.
16.
17.
18.
19.
20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. If $|x+1||x+3|-4|x+2|+5=0$, then sum of squares of solutions is

Answer (16.00)

Sol. Let $t = x + 2$

$\Rightarrow |t^2-1|-4|t|+5=0$

(1) $t \in [1, \infty)$

$t^2 - 4t + 4 = 0 \Rightarrow t = 2$

(2) $t \in [0, 1]$

$\Rightarrow (t+2)^2 = 10 \Rightarrow t = \sqrt{10}-2$ or $t = -\sqrt{10}-2$

No solution

(3) $t \in [-1, 0]$

$\Rightarrow (t+2)^2 = 10 \Rightarrow$ Again no solution

(4) $t \in (-\infty, -1)$, $(t+2)^2 = 0$, $t = -2$

$\Rightarrow x + 2 = 2 \Rightarrow x = 0$

$x + 2 = -2 \Rightarrow x = -4$

$\Rightarrow$ Sum of squares $= 0^2 + (-4)^2 = 16$

22. For a given GP if sum of $T_2 + T_6 = \frac{70}{3}$ and product $(T_3 \times T_5) = 49$ and common ratio $r > 1$ then find the sum of $(T_4 + T_6 + T_8)$

Answer (91)

Sol. $T_2 + T_6 = \frac{70}{3}$

$ar + ar^5 = \frac{70}{3} \Rightarrow ar(1+r^4) = \frac{70}{3}$ ...(1)

$ar^2 \times ar^4 = 49$

$\Rightarrow a^2r^6 = 49$

$\Rightarrow (ar^3)^2 = 49$

$\Rightarrow ar^3 = \pm 7$ ...(2)

Multiply equation (1) by r^2

$ar^3(1+r^4) = \frac{70}{3} r^2$

$(1+r^4) = \frac{10}{3} r^2$

$r^4 - \frac{10}{3}r^2 + 1 = 0$

$3r^4 - 10r^2 + 3 = 0$

$3r^4 - 9r^2 - r^2 + 3 = 0$

$3r^2(r^2-3) - 1(r^2-3) = 0$

$r^2 = 3, \ r^2 = \frac{1}{3}$

Now, $T_4 + T_6 + T_8$

$= ar^3(1 + r^2 + r^4)$

$= 7\ (1 + 3 + 9) = 91$

23. If $\int \frac{dx}{\sqrt[5]{(x-1)^4(x+3)^6}} = A\left(\frac{ax-1}{bx-3}\right)^B$ then $a + b$ $20AB$ is equal to

Answer (12)

Sol. Let $\left(\frac{x+3}{x-1}\right) = t \Rightarrow x = \left(\frac{3+t}{t-1}\right)$

$\Rightarrow dx = \frac{(t-1)(1)-1(3+t)}{(t-1)^2} = \frac{-4}{(t-1)^2}dt$

$(x-1)^4\ (x+3)^6 = \left((x-1)(x+3)\right)^5\left(\frac{x+3}{x-1}\right)$

$\Rightarrow I = \int \frac{\frac{-4}{(t-1)^2}dt}{t^{\frac{1}{5}}\left(\frac{3+t}{t-1}-1\right)\left(\frac{3+t}{t-1}+3\right)}$

$I = \int \frac{-4\ dt}{t^{\frac{1}{5}}[t+3-(t-1)]\ [3+t+3t-3]}$

$$I = \int \frac{-4\,dt}{2t^{\frac{1}{5}}(4t)}$$

$$= \frac{(-4)}{8}\int \frac{dt}{t^{\frac{6}{5}}} = \frac{(-4)}{8}\frac{\left(\frac{x+3}{x-1}\right)^{\frac{-1}{5}}}{\frac{-1}{5}}$$

$$\Rightarrow \quad I = \frac{5}{2}\left(\frac{x-1}{x+3}\right)^{\frac{1}{5}}$$

Comparing, $A = \frac{5}{2}, B = \frac{1}{5}$, $a = 1$, $b = 1$

$$\Rightarrow \quad a + b + 20AB = 1+1+20\times\frac{1}{2} = 12$$

24. Given $f(x) = \begin{cases} \frac{\tan((a+1)x) + \tan x \cdot b}{x} & x < 0 \\ 3 & x = 0 \\ \frac{\sqrt{ax + b^2x^2} - \sqrt{ax}}{\sqrt{a}\ bx\sqrt{x}} & x > 0 \end{cases}$

It is continuous function at $x = 0$, then find $\frac{b}{a}$.

Answer (6)

Sol. $\lim\limits_{x\to 0^-} f(x) = f(0) = \lim\limits_{x\to 0^+} f(x)$

$$\Rightarrow \quad a + 1 + b = 3$$

$$\lim_{x\to 0^+} \frac{\sqrt{ax + b^2x^2} - \sqrt{ax}}{\sqrt{a}bx\sqrt{x}}$$

$$= \lim_{x\to 0^+} \frac{\sqrt{a + b^2x} - \sqrt{a}}{\sqrt{a}bx}$$

Rationalising

$$= \lim_{x\to 0} \frac{b^2x}{\sqrt{a}bx\left(\sqrt{a + b^2x} + \sqrt{a}\right)}$$

$$3 = \frac{b}{2a}$$

$$\Rightarrow \quad \frac{b}{a} = 6$$

25. If complex number $\frac{1+2i\cos\theta}{1-3i\cos\theta}$ is purely imaginary, then find the number of values of θ in the interval $[-2\pi, 2\pi]$.

Answer (08.00)

Sol. $\because \quad \frac{1+2i\cos\theta}{1-3i\cos\theta} = \frac{(1+2i\cos\theta)(1+3i\cos\theta)}{1+9\cos^2\theta} =$ purely imaginary

$\therefore \quad 1 - 6\cos^2\theta = 0$

$$\Rightarrow \quad \cos^2\theta = \frac{1}{6}$$

$$\therefore \quad \cos\theta = \pm\frac{1}{\sqrt{6}}$$

$\therefore$ Total 8 solutions

26. If solution of differential equation $xdy - ydx = xy(xdy - ydx)$ and $y(1) = 1$ is $\alpha|y| = |x|e^{(xy-\beta)}$ then $(\alpha + \beta)$ is equal to

Answer (02.00)

Sol. $(xdy - ydx) = xy(xdy + ydx)$

$$\Rightarrow \quad \frac{dy}{y} - \frac{dx}{x} = xdy + ydx = d(xy)$$

$$\Rightarrow \quad \ln|y| - \ln|x| = xy + c$$

$$\Rightarrow \quad \ln\left(\left|\frac{y}{x}\right|\right) = (xy + c) \quad \Rightarrow \quad \left|\frac{y}{x}\right| = Ae^{xy},\ A > 0$$

$$y(1) = 1$$

$$\Rightarrow \quad 1 = Ae^1 \quad \Rightarrow \quad A = \frac{1}{e}$$

$$\Rightarrow \quad \left|\frac{y}{x}\right| = e^{(xy-1)}$$

$$\Rightarrow \quad |y| = |x|e^{(xy-1)}$$

27.

28.

29.

30.