SMART ACHIEVERS
JEE I NEET I FOUNDATION

JEE Main -2024 Session - 2
Answers & Solutions
(Physics, Chemistry and Mathematics)

5-April 2024 Shift - 2

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PHYSICS

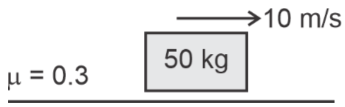
SECTION - A

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. A block of mass 50 kg is moving with speed of 10 m/s on rough horizontal surface.

(Friction coefficient of 0.3)



Find of the kinetic friction acting on the object.

(1) 500 N (2) 150 N

(3) 167 N (4) 16 N

Answer (2)

Sol. $f = \mu N = 0.3 \times 500 = 150$ N

2. A truck is moving from rest with constant power P. If the displacement of the truck is proportional to t^n, where t is time, find n.

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

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

Answer (2)

Sol. $Pt = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2Pt}{m}}$

$v = \frac{ds}{dt}$

$\therefore \quad s = \int \sqrt{\frac{2Pt}{m}}dt$

$s \propto t^{3/2}$

3. The van der Waals gas equation is expressed as $\left(P - \frac{a}{V^2}\right)(V - b) = nRT$, where symbols have their usual meaning, then dimension of $\frac{a}{b^2}$ is

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

(3) $\left[MLT^{-2}\right]$ (4) $\left[ML^3T^{-2}\right]$

Answer (1)

Sol. $[P] = \left[\frac{a}{V^2}\right]$

$ML^{-1}T^{-2} = \frac{a}{L^6}$

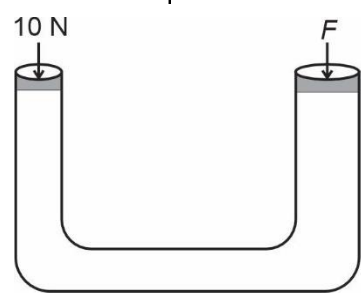
$a = ML^{+5}T^{-2}$

and $[V] = [b] = \left[L^3\right]$

$\left[\frac{a}{b^2}\right] = \frac{ML^5T^{-2}}{L^3}$

$= \left[ML^2T^{-2}\right]$

4. In a hydraulic lift force F is applied to balance 10 N load, diameter of effort arm is 14 cm and load arm is 1.4 cm. The F is equal to



(1) 500 N (2) 100 N

(3) 2000 N (4) 1000 N

Answer (4)

Sol. $P_1 = P_2$

$$\frac{10}{\frac{\pi}{4}(1.4)^2} = \frac{F}{\frac{\pi}{4}(14)^2}$$

$F = 1000$ N

5. A hollow sphere is rolling without slipping. Find ratio of rotational kinetic energy to total kinetic energy of sphere

(1) $\frac{4}{7}$ (2) $\frac{3}{7}$

(3) $\frac{2}{7}$ (4) $\frac{5}{7}$

Answer (3)

Sol. $K_{rot} = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\omega^2$

$$K_{total} = \frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\omega^2$$

$v = R\omega$

$$\therefore \quad K_{total} = \frac{1}{2}\left(\frac{7}{5}MR^2\right)\omega^2$$

$$\frac{K_{rot}}{K_{total}} = \frac{2}{7}$$

6. Shortest wavelength in Lyman series has wavelength of 915 Å. Longest wavelength of Balmer series has a value of?

(1) 5296 Å (2) 3647 Å

(3) 6588 Å (4) 7294 Å

Answer (3)

Sol. Lyman : $\frac{1}{915} = RZ^2\left(\frac{1}{1} - \frac{1}{\infty}\right)$

$$RZ^2 = \frac{1}{915}$$

Balmer : Transition from $n = 3$ to $n = 2$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\frac{1}{\lambda} = \frac{1}{915}\left(\frac{5}{36}\right)$$

$$\boxed{\lambda = 6588\,\text{Å}}$$

7. In sonometer, fundamental frequency changes from 400 Hz to 500 Hz keeping same tension. Find percentage change in length.

(1) 5% (2) 10%

(3) 20% (4) 40%

Answer (3)

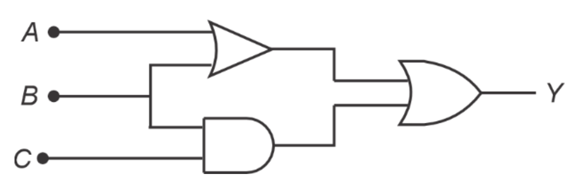
Sol. $f = \frac{v}{2l_1} = 400$

$$\frac{v}{2l_2} = 500$$

$$\frac{l_2 - l_1}{l_1} \times 100 = \frac{\frac{v}{1000} - \frac{v}{800}}{\frac{v}{800}} \times 100 = \left(\frac{8}{10} - 1\right) \times 100$$

$= -20\%$

8. For what boolean values of A, B & C the given logic gate gives output of zero?



(1) $A = 1, B = 0, C = 1$

(2) $A = 0, B = 0, C = 1$

(3) $A = 0, B = 1, C = 1$

(4) $A = 1, B = 1, C = 1$

Answer (2)

Sol. Putting values gives option (2).

9. 20R resistance wire is cut into 10 equal parts. Now each part first is connected in series and then in parallel. Find ratio of equivalent resistance in both cases (R_{series} : $R_{parallel}$)

(1) 100 : 1

(2) 50 : 1

(3) 25 : 1

(4) 5 : 1

Answer (1)

Sol. Series : $R_{eq} = 20R$

Parallel : $R'_{eq} = \frac{R}{5}$

Ratio : $R_{eq} : R'_{eq} = 20R : \frac{20R}{100} = 1 : \frac{1}{100} = 100 : 1$

10. On vehicles containing inflammable fluid, metallic chains are provided touching of the earth, then correct option is

(1) It is custom

(2) Alert for another vehicle

(3) For discharging the statics charges developed due to friction

(4) It is fashion

Answer (3)

Sol. Because of friction, metallic body gets changed.

11. 400 Ω series resistance is required to convert a galvanometer of 100 Ω to a voltameter of range 10 V. To convert same galvanometer, in ammeter of 10A, what should be the shunt resistance

(1) 4 Ω

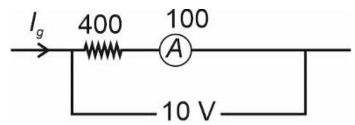
(2) 0.4 Ω

(3) 0.2 Ω

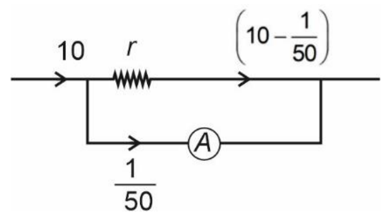
(4) 5 Ω

Answer (3)

Sol.



$$I_g = \frac{10}{500} = \frac{1}{50} \text{ A}$$



$$\Rightarrow \quad 10r = \frac{1}{50} \times 100$$

$$r = 0.2\ \Omega$$

12. A particle is moving in circular path of radius 9 m such that it completes 120 rev in 3 minutes. Find centripetal acceleration.

(1) $8\pi^2$ m/s^2

(2) $16\pi^2$ m/s^2

(3) $32\pi^2$ m/s^2

(4) 16π m/s^2

Answer (2)

Sol. $\omega = \frac{\Delta\theta}{\Delta t} = \frac{120 \times 2\pi}{3 \times 60} = \frac{4\pi}{3}$ rad/s

$a_c = \omega^2 r$

$= \left(\frac{16}{9}\pi^2\right) \times 9$

$= 16\pi^2$ m/s^2

13. The current flowing through an inductor vary with time as $i = (3t + 2)A$ and back emf induced in it is 12 V at an instant. Find inductance

(1) 1 H

(2) 2 H

(3) 4 H

(4) 5 H

Answer (3)

Sol. $\varepsilon = \left| L\frac{di}{dt} \right|$

$12 = L(3)$

$L = 4$ H

14. In thermodynamics adiabatic process, pressure is directly proportional to cube of absolute temperature. Find $\frac{C_p}{C_v}$ for the gas

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

(2) $\frac{7}{5}$

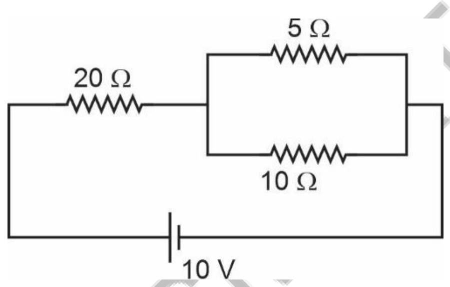
(3) $\frac{3}{2}$

(4) $\frac{8}{7}$

Answer (3)

Sol. $P \propto T^3 \Rightarrow \frac{P^3V^3}{P} \propto P^2V^3 \propto PV^{3/2} = PV^{\gamma}$

15. Find the ratio of power dissipated in 5 Ω and 10 Ω resistor.



(1) 1 : 2

(2) 1 : 4

(3) 2 : 1

(4) 4 : 1

Answer (3)

Sol. $P = i^2R = \frac{V^2}{R}$

∴ Voltage across 5 Ω and 10 Ω is same

$P \propto \frac{1}{R}$

$\frac{P_1}{P_2} = \frac{R_2}{R_1} \Rightarrow P_1 : P_2 = 10 : 5$

$\boxed{P_1 : P_2 = 2 : 1}$

16. Angular momentum of revolving electron of hydrogen atom in a given orbit is dependent on radius r as

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

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

(3) $\frac{1}{\sqrt{r}}$

(4) $\sqrt{r}$

Answer (4)

Sol. $L = \frac{nh}{2\pi}$ (i) $r = \frac{n^2}{2} r_0$ (ii)

$\Rightarrow L \propto \sqrt{r}$.

17. In a photoelectric effect, stopping potential of photoelectrons does not depend on

(1) Intensity of radiation

(2) Frequency of radiation

(3) Material or metal

(4) Kinetic energy of electrons

Answer (1)

Sol. $eV_S = h\nu - \phi_0$

$eV_S = \text{KE}$

18. If F_1 is electrostatic force, F_2 is magnetic force on a charge particle of charge q, where E is electric field, B is magnetic field and v is velocity of particle. Mark correct option.

(1) $\vec{F}_1 = q(\vec{v} \times \vec{E})$

(2) $\vec{F}_2 = q\vec{B}$

(3) $\vec{F}_1 = \vec{q}(\vec{E} \times \vec{v})$

(4) $\vec{F}_2 = q(\vec{v} \times \vec{B})$

Answer (4)

Sol. $\vec{F}_1 = q\vec{E}$

$\vec{F}_2 = q(\vec{v} \times \vec{B})$

19.

(A)	X-Ray	(P)	$\lambda > 700$ nm
(B)	UV Ray	(Q)	100 nm $< \lambda <$ 400 nm
(C)	γ-Ray	(R)	$\lambda < 0.3$ nm
(D)	Infrared	(S)	0.3 nm $< \lambda <$ 10 nm

(1) (A) → (S), (B) → (Q), (C) → (P), (D) → (R)

(2) (A) → (S), (B) → (Q), (C) → (R), (D) → (P)

(3) (A) → (P), (B) → (Q), (C) → (R), (D) → (S)

(4) (A) → (P), (B) → (R), (C) → (Q), (D) → (S)

Answer (2)

Sol. Most energetic gamma rays and less energetic are Infrared.

20. A conducting sphere is given a charge Q on it. The ratio of potential at points at a distance $\frac{R}{2}$ and $\frac{3R}{2}$ from the centre of the sphere is

(1) 1 : 3

(2) 3 : 2

(3) 3 : 1

(4) 2 : 3

Answer (2)

Sol. $V_1 = \frac{KQ}{R}$

$V_2 = \frac{2KQ}{3R}$

$\therefore \quad \frac{V_1}{V_2} = \frac{3}{2}$

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. A particle is projected with some speed and it is observed that it achieves a maximum height of 64 m. If the same particle is projected with initial speed half to the first value, then new maximum height achieved by particle will be _____ m.

Answer (16)

Sol. $H_{max} = \frac{u^2}{2g} = 64$ m

$H'_{max} = \frac{u^2}{4(2g)} = \frac{64}{4} = 16$ m

22. If a body is moving with a momentum. $\vec{P} = \sin kt\,\hat{i} - \cos kt\,\hat{j}$, then angle between $\vec{F}$ and $\vec{P}$ is ________ degrees.

Answer (90)

Sol. We know that $\vec{F} = \frac{d\vec{P}}{dt}$

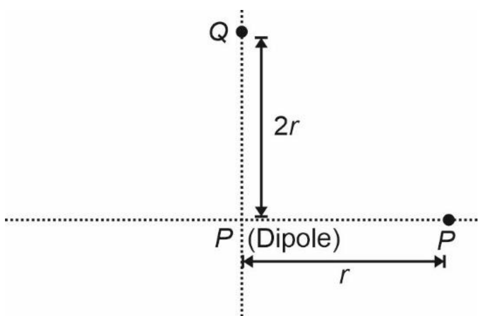
$$\vec{F} = (\cos kt \times k)\hat{i} - (-\sin kt \times k)\hat{j}$$

$$\vec{F} = (k\cos kt)\hat{i} + (k\sin kt)\hat{j}$$

$$\therefore \quad \cos\theta = \frac{\vec{F}\cdot\vec{P}}{|\vec{F}||\vec{P}|} = 0$$

$\theta = 90°$

23. Electric field due to the dipole at P is E and at point Q is $\frac{E}{K}$, find K.



Answer (16)

Sol. $E_P = \frac{2K_P}{r^3}$

$$E_Q = \frac{K_P}{(2r)^3}$$

$$\therefore \quad E_Q = \frac{1}{16}E_P$$

24. The least count of a vernier calliper is 0.1 mm and 20 vernier scale division coincides with 19 main scale division, then one main scale division is _____ mm.

Answer (2)

Sol. 20 VSD = 19 MSD

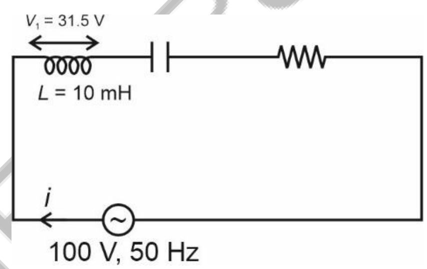
$$\text{VSD} = \frac{19}{20}\text{MSD}$$

$$\text{LC} = \text{MSD} - \frac{19}{20}\text{MSD}$$

$$0.1\text{ mm} = \frac{\text{MSD}}{20}$$

MSD = 2 mm

25. Find the current i (upto nearest integer), in the circuit.



Answer (10)

Sol. $V_L = i\,X_L$

$31.5 = (i)\times(\omega L)$

$31.5 = i \times 2\pi FL$

$$i = \frac{31.5}{2\pi\times 50\times 10^{-2}} = \frac{31.5}{3.14}$$

$\boxed{i \approx 10\text{ A}}$

26.

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. Find out E^o_{cell} of the given cell.

$M \mid M^{2+} \parallel X^{2-} \mid X$

$E^o_{M^{2+}|M} = 0.34\ V$

$E^o_{X|X^{2-}} = 0.46\ V$

(1) 0.80 V (2) 0.12 V

(3) –0.12 V (4) –0.80 V

Answer (2)

Sol.

$$M \longrightarrow M^{2+} + 2e^- \quad \text{(Anode)}$$
$$X + 2e^- \longrightarrow X^{2-} \quad \text{(Cathode)}$$
$$M + X \longrightarrow M^{2+} + X^{2-}$$

$$E^o_{cell} = (E^o_{M|M^{2+}}) + (E^o_{X|X^{2-}})$$

$= -0.34 + 0.46$

$= 0.12\ V$

2. Which of the following is true regarding coagulation of egg?

(1) 1° structure does not change

(2) 2° structure does not change

(3) 3° structure does not change

(4) Denaturation of protein does not occur

Answer (1)

Sol. Coagulation of egg white on boiling is a common example of denaturation in which primary structure only remains intact.

3. Angular momentum of an electron in an orbit of radius R of a hydrogen atom is directly proportional to _____.

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

(3) $\frac{1}{\sqrt{R}}$ (4) $\sqrt{R}$

Answer (4)

Sol. $\frac{mv^2}{R} = \frac{KZe^2}{R^2}$

$mv = \sqrt{\frac{KZe^2m}{R}}$

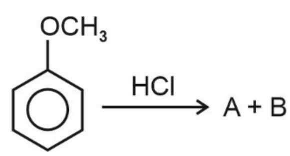
Angular momentum, L is given by

$L = mvR = R\sqrt{\frac{KZe^2m}{R}}$

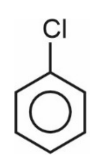
$= \sqrt{KZe^2mR}$

$\propto \sqrt{R}$

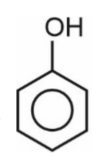
4. Consider the following sequence of reaction



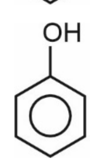
A and B products respectively are :

(1) 

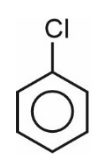
and CH_3OH

(2) 

and $CH_3–Cl$

(3) 

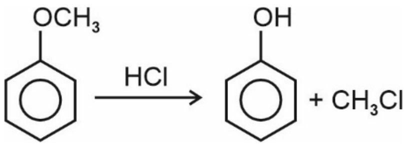
and CH_3OH

(4) 

and CH_3Cl

Answer (2)

Sol.



Due to partial double bond character between oxygen and carbon atom of phenyl ring bond can't break easily.

5. Find out the value of $\frac{C_P}{C_V}$ for an ideal gas undergoing reversible adiabatic process for which $\boxed{P \propto T^3}$ is given

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

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

Answer (2)

Sol. $PT^{-3} = \text{Constant (C)}$

$P(PV)^{-3} = C$

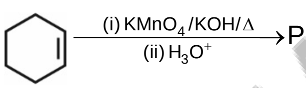
$P^1P^{-3}V^{-3} = C$

$P^{-2}V^{-3} = C$

$P^2V^3 = C$

$PV^{\frac{3}{2}} = C$

6. Consider the following reaction.



The product (P) is

(1) Adipic acid

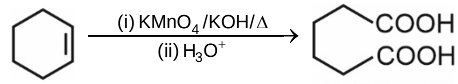
(2) Oxalic acid

(3) Succinic acid

(4) Benzoic acid

Answer (1)

Sol.



Adipic acid

7. Consider the following two statements :

S-I : NH_3 is more polar than NF_3.

S-II : N – H dipole is directed towards N while in case of NF_3 towards F as F is more electronegative.

Select the correct option.

(1) Both statements are correct and Statement-II is not correct explanation of Statement-I

(2) Both statements are correct and Statement-II is correct explanation of Statement-I

(3) Statement-I and Statement-II both are incorrect

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

Answer (2)

Sol. The direction of electric dipole is towards negative pole in case of N – H the negative pole of N while in case of N – F the negative pole is F as order of electronegativity is F > N > H.

8. From the given information, calculate enthalpy of formation of 2 moles of $C_6H_6(l)$ at 25°C.

Given:

$\Delta_C H(C_6H_6(l)) = -3264.6$ kJ/mol

$\Delta_C H(C(s)) = -393.5$ kJ/mol

$\Delta_f H(H_2O(l)) = -285.83$ kJ/mol

(1) –124.5 kJ/mol (2) –46.11 kJ/mol

(3) 46.11 kJ/mol (4) 124.5 kJ/mol

Answer (3)

Sol. Formation reaction

$6C(s) + 3H_2(g) \rightarrow C_6H_6(l)$

$\Delta_f H(C_6H_6) = 6\Delta_C H(C(s)) + 3\Delta_C H(H_2(g)) - \Delta_C H(C_6H_6(l))$

$= 6(-393.5) + 3(-285.83) - (-3264.6)$

$[\because \ \Delta_f H(H_2O(l)) = \Delta_C H(H_2(g))]$

= 3264.6 – 2361 – 857.49

= 46.11 kJ/mol

9. Choose the option with correct matching for given molecules

Column A	Column B
(A) ICl	(P) T-shape
(B) ICl_3	(Q) Pentagonal Bipyramidal
(C) ClF_5	(R) Linear
(D) IF_7	(S) Square Pyramidal

(1) A $\rightarrow$ R, B $\rightarrow$ P, C $\rightarrow$ Q, D $\rightarrow$ S

(2) A $\rightarrow$ R, B $\rightarrow$ P, C $\rightarrow$ S, D $\rightarrow$ Q

(3) A $\rightarrow$ Q, B $\rightarrow$ S, C $\rightarrow$ R, D $\rightarrow$ P

(4) A $\rightarrow$ P, B $\rightarrow$ R, C $\rightarrow$ S, D $\rightarrow$ Q

Answer (2)

Sol. IF_7 $\quad SN = \dfrac{7+7}{2} = 7 \longrightarrow$ P.b.p

ClF_5 $\quad SN = \dfrac{7+5}{2} = 6 \longrightarrow$ 1 lone pair

Square pyramidal

ICl_3 $\quad SN = \dfrac{7+3}{2} = 5 \longrightarrow$ 2 lone pair

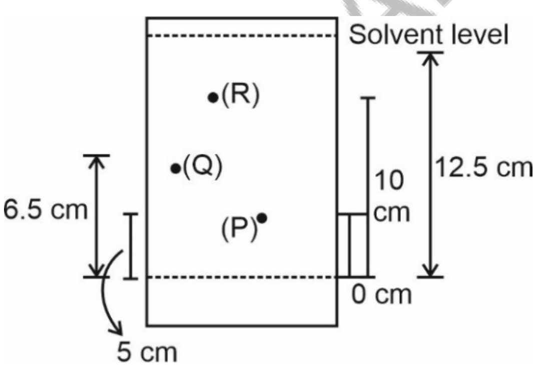
T – Shape

ICl $\quad SN = \dfrac{7+1}{2} = 4 \longrightarrow$ 3 lone pair

Linear

A $\rightarrow$ R, B $\rightarrow$ P, C $\rightarrow$ S, D $\rightarrow$ Q

10. The ratio of R_f value for P and R is



(1) 0.50 (2) 0.80

(3) 0.65 (4) 2

Answer (1)

Sol. $(R_f)_P = \dfrac{5}{12.5}$

$(R_f)_R = \dfrac{10}{12.5}$

Ratio of R_f value of P and R

$= \dfrac{5}{12.5} \times \dfrac{12.5}{10} = \dfrac{1}{2}$

11. Which of the following molecule is an acidic oxide?

(1) N_2O_3

(2) NO

(3) CO

(4) CaO

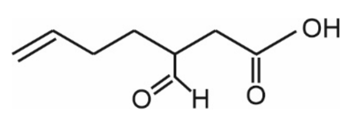
Answer (1)

Sol. $N_2O_3 \rightarrow$ Acidic oxide

NO and CO $\rightarrow$ Neutral oxide

CaO $\rightarrow$ Basic oxide

12. What is the IUPAC name of :



(1) 3-formylhept-6-enoic acid

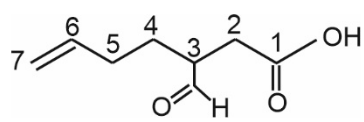
(2) 3-aldohept-7-enoic acid

(3) 3-ketohept-6-enoic acid

(4) 3-oxohept-6-enoic acid

Answer (1)

Sol.



3-formylhept-6-enoic acid

13. Which of the following metal ions can replace hydrogen ion from an acidic solution?

V^{+2}, Ti^{+2}, Cr^{+3}

(1) Only one (2) Only two

(3) All of these (4) None of these

Answer (3)

Sol. The standard reduction potential values of the given metal ions to their respective metals are negative.

$$E^{\circ}_{V^{+2}/V} = -1.18 \text{ V}$$

$$E^{\circ}_{Ti^{+2}/Ti} = -1.63 \text{ V}$$

$$E^{\circ}_{Cr^{+3}/Cr} = -0.74 \text{ V}$$

Therefore, all of these metal ions will replace hydrogen ion from an acidic solution.

14. Equanil drug is used for which disease?

(1) Infertility

(2) Hypertension and depression

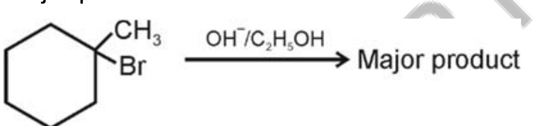
(3) Acidity

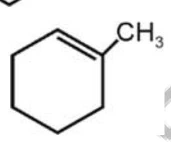
(4) Eye-itching

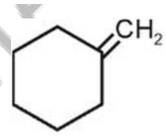
Answer (2)

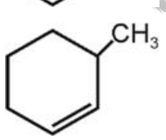
Sol. Equanil is a mild tranquilizer used to treat hypertension and depression.

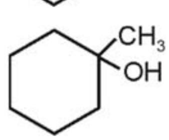
15. Consider the following reaction and identify the major product formed in it.



(1) 

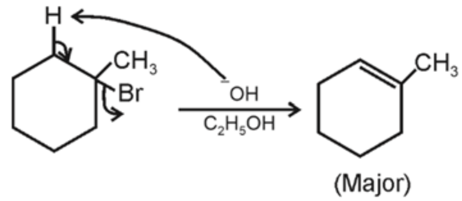
(2) 

(3) 

(4) 

Answer (1)

Sol. 1-Bromo-1-methylcyclohexane when treated with alcoholic OH^- undergoes dehydrobromination by E_2 mechanism to give 1-methylcyclohexene as the major product



16.

17.

18.

19.

20.

SECTION - B

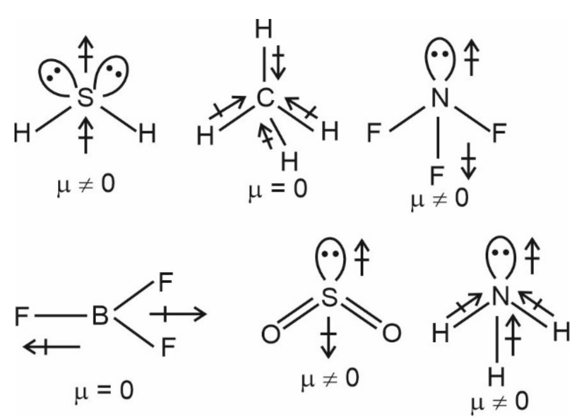
Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. How many of the following have zero dipole moment?

H_2S, CH_4, NH_3, BF_3, SO_2, NF_3

Answer (2)

Sol.

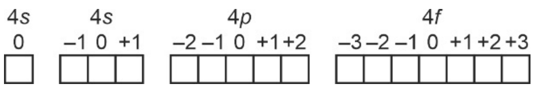


CH_4 and BF_3 have zero dipole moment

22. In an atom, how many maximum electrons that can have (i) n = 4, (ii) m_l = 1, (iii) $m_s = -\frac{1}{2}$?

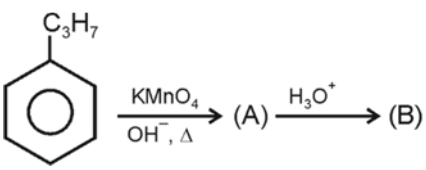
Answer (3)

Sol. In n = 4 shell,



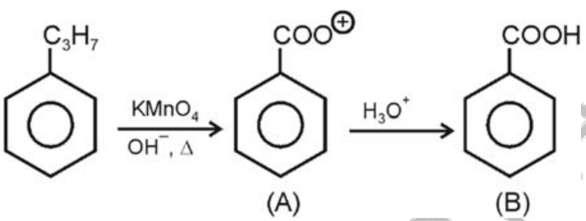
Total orbitals with m_l = 1 $\rightarrow$ 3

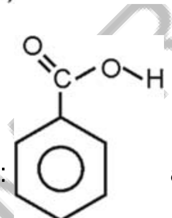
Total e^- with $m_s = -\frac{1}{2} \rightarrow 3$

23. 

Number of π bonds present in product B is:

Answer (4)

Sol. 

Number of π bonds in B:  are : 4

24. One coulomb charge is passed through $AgNO_3$ solution during electrolysis. Find mass of silver (in mg) deposited at the electrode. (nearest integer)

Answer (1)

Sol. Equivalents of charge = $\frac{1}{96500}$

Equivalents of Ag deposited = $\frac{1}{96500}$

Mass of Ag deposited = $\frac{108}{96500}$ g

= 1.12 mg

Nearest integer = 1

25. For the reaction:

$CH_4 + O_2 \longrightarrow CO_2 + H_2O$

How many moles of methane will be required for formation of 11 g of CO_2?

Answer (0.25)

Sol. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

1 mole of CH_4 will produce 1 mole of CO_2

So, 11 g of CO_2 will be produced by $\frac{11}{44}$ moles of CH_4

i.e., $\frac{1}{4}$ moles of CH_4 = 0.25

26. In the following reaction, HCl formed is titrated with 0.2 moles of NaOH. Calculate the mass of $C_2H_5–NH_2$ taken initially.

$C_2H_5 - NH_2 + NaNO_2 \xrightarrow{HCl} A \xrightarrow{H_2O} HCl + \text{Alcohol} + N_2$

Answer (9)

Sol.

$$C_2H_5 - NH_2 + NaNO_2 \xrightarrow{HCl} \underset{(A)}{C_2H_5 - N_2^+Cl^-} \xrightarrow{H_2O} \underset{(\text{alcohol})}{C_2H_5 - OH} + HCl + N_2$$

1 mole of $C_2H_5–NH_2$ will form 1 mole of $C_2H_5 - N_2^+Cl^- (A)$ which will further reacts to form 1 mole of HCl.

$\because$ 0.2 moles of NaOH is used. So,

n_{HCl} formed = 0.2

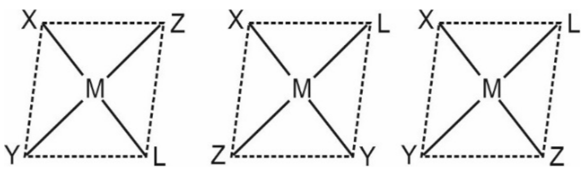
So, $n_{C_2H_5-NH_2}$ taken initial = 0.2

Mass of $C_2H_5 – NH_2$ = 0.2 × 45 = 9

27. If square planar complex [MXYZL] has all the four unidentate ligand then find out its total number of geometrical isomers.

Answer (3)

Sol. The given square planar complex has 3 geometrical isomers.



28. If λ_{max} for Lyman series of H-atom is 912 Å, then calculate λ_{min} for Balmer series of H-atom (in Å).

Answer (2736)

Sol. λ_{max} for Lyman series (E = 2 → E = 1)

$$\frac{1}{912} = R(1)^2\left(\frac{1}{1} - \frac{1}{4}\right)$$

$$\frac{1}{912} = R \times \frac{3}{4}$$

$$R = \frac{4}{912 \times 3}$$

λ_{min} for Balmer series $(E = \infty \rightarrow E = 2)$

$$\frac{1}{\lambda} = R(1)\left(\frac{1}{4}\right)$$

$$= \frac{4}{912 \times 3} \times \frac{1}{4}$$

$$= \frac{1}{912 \times 3}$$

λ = 912 × 3

= 2736 Å

29. Chromite ore + $Na_2CO_3 \xrightarrow[\text{fusion}]{\text{air}}$ A(s) + B(s) + CO_2

What is the value of sum of magnetic moment (in B.M.) of A and B? (Nearest integer)

Answer (6)

Sol. $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow$

$8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

A and B are Na_2CrO_4/CrO_4^{2-} and Fe_2O_3.

Oxidation state of Cr in CrO_4^{2-} is +6, hence it has zero electrons in its ns as well as (n – 1)d. So, the magnetic moment of chromate will be zero.

Oxidation state of Fe in Fe_2O_3 is +3, hence Fe has (n – 1)d^5 ns^0 electronic configuration, *i.e.*, five unpaired electron in each Fe. So, the magnetic moment of Fe will be 5.92 B.M.

Sum is 5.92 + 0.0 = 5.92

Nearest integer = 6

30. How many species have zero electron in t_2?

$TiCl_4, MnO_4^-, [FeO_4]^{2-}, [FeCl_4]^-, [CoCl_4]^-$

Answer (3)

Sol. $TiCl_4 \Rightarrow Ti^{4+} = 3d^o 4s^o \Rightarrow e^o t_2^o$

$MnO_4^- \Rightarrow Mn^{+7} = 3d^o 4s^o \Rightarrow e^o t_2^o$

$[FeO_4]^{2-} \Rightarrow Fe^{+6} = 3d^2 4s^o \Rightarrow e^2 t_2^0$

$[FeCl_4]^- \Rightarrow Fe^{+3} = 3d^5 4s^o \Rightarrow e^2 t_2^3$

$[CoCl_4]^- \Rightarrow Co^{+3} \Rightarrow 3d^6 4s^o \Rightarrow e^3 t_2^3$

$TiCl_4, MnO_4^-, [FeO_4]^{2-}$, have zero electron in t_2 orbital

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:

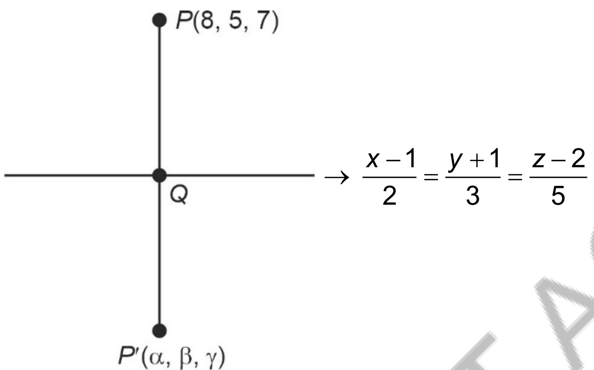
1. Let image of point (8, 5, 7) with respect to line $\frac{x-1}{2}=\frac{y+1}{2}=\frac{z-2}{5}$ is (α, β, γ). Then $\alpha + \beta + \gamma$ is equal to

(1) 10 (2) 12

(3) 9 (4) 14

Answer (4)

Sol. Given point (8, 5, 7)



Let Q be general point.

$(x, y, z) = (2\lambda + 1, 3\lambda - 1, 5\lambda + 2)$

$\therefore$ Now D.R. of $P.Q$

$PQ \Rightarrow (2\lambda + 1 - 8, 3\lambda - 1 - 5, 5\lambda + 2 - 7)$

$= (2\lambda - 7, 3\lambda - 6, 5\lambda - 5)$ ...(1)

$\therefore$ D.R. of line <2, 3, 5> ....(2)

From (1) and (2)

$2(2\lambda - 7) + 3(3\lambda - 6) + 5(5\lambda - 5) = 0$

$4\lambda - 14 + 9\lambda - 18 + 25\lambda - 25 = 0$

$38\lambda - 57 = 0$

$\lambda = \frac{57}{38} \Rightarrow \boxed{\lambda = \frac{3}{2}}$

$Q \equiv \left(2\left(\frac{3}{2}\right)+1,\ 3\left(\frac{3}{2}\right)-1,\ 5\left(\frac{3}{2}\right)+2\right)$

$Q \equiv \left(4,\ \frac{7}{2},\ \frac{19}{2}\right)$

$\therefore \frac{8+\alpha}{2} = 4, \frac{5+\beta}{2} = \frac{7}{2}, \frac{7+\gamma}{2} = \frac{19}{2}$

$\Rightarrow \alpha = 0, \beta = 2, \gamma = 12$

$\therefore (\alpha, \beta, \gamma) \equiv (0, 2, 12)$

$\therefore \alpha + \beta + \gamma = 0 + 2 + 12 = 14$

2. The 50^{th} word in the dictionary using the letters B, B, H, J, O is

(1) OBBJH (2) OBBHJ

(3) JHBBO (4) BBHOJ

Answer (1)

Sol. Number of words staring with 'B' = 4!

= 24

Number of words staring with 'H' = $\frac{4!}{2!}$

= 12

Number of words staring with 'J' = 12

49^{th} word = OBBHJ

50^{th} word = OBBJH

3. $\left(\frac{3^{\frac{1}{5}}}{x}+\frac{2x}{5^{\frac{1}{3}}}\right)^{12}$. Find which term is constant.

(1) 4^{th} (2) 5^{th}

(3) 6^{th} (4) 7^{th}

Answer (4)

Sol. $\left(\dfrac{3^{\frac{1}{5}}}{x}+\dfrac{2x}{5^{\frac{1}{3}}}\right)^{12}$

$T_{r+1} = {}^nC_r\left(\dfrac{3^{\frac{1}{5}}}{x}\right)^{n-r}\left(\dfrac{2x}{5^{\frac{1}{3}}}\right)^{r}$

$\left(3^{\frac{1}{5}}\right)^{n-r} x^{r-n}\dfrac{2^r . x^r}{5^{\frac{r}{3}}}$

For constant term

$r - n + r = 0$

$\Rightarrow \; 2r - n = 0$

We have $n = 12$

$\Rightarrow \; 2r - 12 = 0$

$r = 6$

So 7th term is constant.

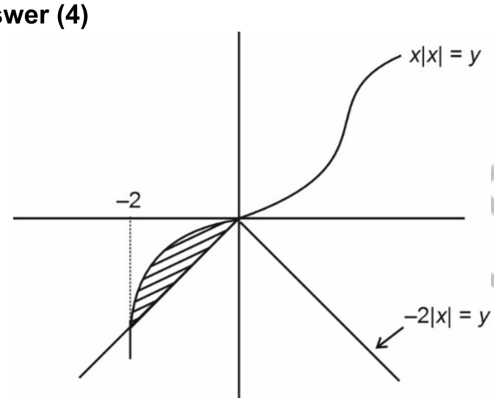
4. Area bounded by $y = -2|x|$ and $y = x|x|$ is

(1) $\dfrac{2}{3}$ (2) $\dfrac{1}{3}$

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

Answer (4)

Sol.



Area = $\left|\int_{-2}^{0}(-x^2-(2x))dx\right|$

$= \left|\left[\dfrac{-x^3}{3}-x^2\right]_{-2}^{0}\right|$

$= \left|\dfrac{8}{3}-4\right| = \dfrac{4}{3}$ sq. unit

5. $A=\begin{bmatrix}\alpha & \alpha & \alpha\\ \beta & \alpha & -\beta\\ -\alpha & \alpha & \alpha\end{bmatrix}$

B is formed by co-factor of A matrix, then find out determinant of AB.

(1) $4\alpha^3(2\alpha + \beta)^5$

(2) $12\alpha^4(\alpha + \beta)^2$

(3) $8\alpha^6(\alpha + \beta)^3$

(4) $18\alpha^8(\alpha + \beta)^3$

Answer (3)

Sol. $A=\begin{bmatrix}\alpha & \alpha & \alpha\\ \beta & \alpha & -\beta\\ -\alpha & \alpha & \alpha\end{bmatrix}$

$|A|=\begin{bmatrix}2\alpha & 0 & 0\\ \beta & \alpha & -\beta\\ -\alpha & \alpha & \alpha\end{bmatrix}$

$= 2\alpha\,(\alpha^2 + \alpha\beta)$

$= 2\alpha^2\,(\alpha + \beta)$

Now, $\beta = (\text{adj}A)^T$

Determinant of $A{\cdot}B = |A{\cdot}B|$

$= |A{\cdot}(\text{adj}A)^T|$

$= |A|{\cdot}|A|^2$

$= |A|^3$

$|A|^3 = 8\alpha^6(\alpha + \beta)^3$

6. Consider a equation $P(x) = ax^2 + bx + c = 0$. If $a, b, c \in A$, were $A = \{1, 2, 3, 4, 5, 6\}$. Then the probability that $P(x)$ has real and distinct roots?

(1) $\dfrac{1}{4}$ (2) $\dfrac{1}{16}$

(3) $\dfrac{25}{108}$ (4) $\dfrac{19}{108}$

Answer (4)

Sol. $b^2 - 4ac > 0$

$\Rightarrow b < 2$ not possible

$\Rightarrow b = 3 \Rightarrow ac < \frac{9}{4}$

$(a, c) \in \{(1, 1), (1, 2), (2, 1)\} \Rightarrow 3$ cases

$\Rightarrow b = 4 \Rightarrow ac < 4 \Rightarrow ac = \{1, 2, 3\}$

$(a, c) \in \{(1, 1), (1, 2), (2, 1), (3, 1), (1, 3)\} = 5$ ways

$\Rightarrow b = 5 \Rightarrow ac < \frac{25}{4} \Rightarrow ac = \{1, 2, 3, 4, 5, 6\}$

$(a, c) \in \{(1, 1), (1, 2), (2, 1), (3, 1), (1, 3), (2, 2), (4, 1), (1, 4), (3, 2), (2, 3), (5, 1), (1, 5), (1, 6), (6, 1)\} \Rightarrow 14$ ways

$\Rightarrow b = 6 \Rightarrow ac < 9 \Rightarrow ac \in \{1, 2, 3, 4, 5, 6, 7, 8\}$

$(a, c) \in \{(1, 1), (1, 2), (2, 1), (3, 1), (1, 3), (2, 2), (4, 1), (1, 4), (3, 2), (2, 3), (5, 1), (1, 5), (1, 6), (6, 1), (2, 4), (4, 2)\} \Rightarrow 16$ ways

$\Rightarrow 3 + 5 + 14 + 16 = 38$ cases

$\Rightarrow$ Probability $= \frac{38}{6^3} = \frac{19}{108}$

7. If $f : R \to R$ and $g: R \to R$ defined such that

$f(x) = |x| - 1$

$$g(x) = \begin{cases} e^x & ; x > 0 \\ x - 1 & ; x \le 0 \end{cases}$$

Then,

(1) Both f and g is one-one

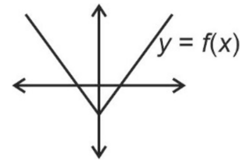
(2) f is one-one and g is many one

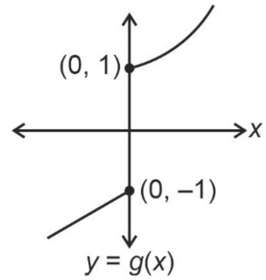
(3) f is many one and g is one-one

(4) f and g both are many one

Answer (3)

Sol.





By horizontal line test $f(x)$ is many one and $g(x)$ is one-one.

Option (3) is correct.

8. A line L is perpendicular to $y = 2x + 10$ such that it touches the parabola $y^2 = 4(x - g)$. Then the distance between point of contact and origin is equal to

(1) $\sqrt{165}$ (2) $\sqrt{175}$

(3) $\sqrt{185}$ (4) $\sqrt{190}$

Answer (3)

Sol. L: $2y + x = c$

$y^2 = 4(x - 9)$

Now

$$\left(\frac{c - x}{2}\right)^2 = 4(x - 9)$$

$x^2 - 2(c + 8)x + c^2 + 144 = 0$

$D = 0$

$\Rightarrow c = 5$

$\therefore L: 2y + x = 5$

Parabola and L meets at $(13, -4)$

Now, distance $= \sqrt{185}$

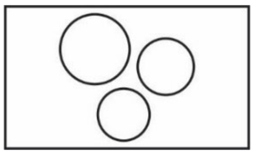
9. If $S = \{2, 4, 8, 16, \ldots, 512\}$. If S is broken in 3 equal subsets A, B and C such that $A \cap B = B \cap C = C \cap A = \phi$ and $A \cup B \cup C = S$ then maximum number of ways to break is

(1) ${}^9C_3$ (2) $\dfrac{9!}{(3!)3}$

(3) $\dfrac{9!}{(3!)4}$ (4) $\dfrac{9!}{(3!)^2}$

Answer (2)

Sol. $S = \{2^1, 2^2, 2^3, \ldots, 2^9\}$



$A \cap B = B \cap C = A \cap C = \phi$

and $= A \cup B \cup C = S$

$\Rightarrow$ A, B, C are disjoint mutually exhaustive and exclusive

$$\Rightarrow {}^9C_3 \cdot {}^6C_3 \cdot {}^3C_3 = \frac{9!}{6!3!} \times \frac{6!}{3!3!} \times (1)$$

$$= \frac{9!}{3!3!3!} = 1680$$

10. If $y = \dfrac{2\cos 2\theta + \cos\theta}{\cos 3\theta + \cos^2\theta + \cos\theta}$

Then value of $y'' + y' + y$ is

(1) $\sec\theta(1 - \tan^3\theta)$

(2) $\tan\theta(\sec^3\theta + 2\tan^2\theta)$

(3) $\sec\theta(2\sec^2\theta + \tan\theta)$

(4) $\cot\theta(\sec^3\theta + 2\tan\theta)$

Answer (3)

Sol. $y = \dfrac{2\cos 2\theta + \cos\theta}{\cos 3\theta + \cos^2\theta + \cos\theta}$

$$y = \frac{2\cos 2\theta + \cos\theta}{2\cos 2\theta \cdot \cos\theta + \cos^2\theta}$$

$$y = \frac{2\cos 2\theta + \cos\theta}{\cos\theta(2\cos 2\theta + \cos\theta)}$$

$$y = \frac{1}{\cos\theta}$$

$y = \sec\theta$

$y' = \sec\theta\tan\theta$

$y'' = \sec^3\theta + \tan\theta\cdot(\sec\theta\tan\theta)$

$= \sec^3\theta + \sec\tan^2\theta$

$y'' + y' + y = \sec^3\theta + \sec\theta\tan^2\theta + \sec\theta\tan\theta + \sec\theta$

$= \sec\theta(\sec^2\theta + 1) + \sec\theta\tan\theta(\tan\theta + 1)$

$= \sec\theta(\sec^2\theta + 1 + \tan^2\theta + \tan\theta)$

$= \sec\theta(2\sec^2\theta + \tan\theta)$

11. If $2x^2 - x + 2 = 0$ and one root is a then $\displaystyle\lim_{x \to \frac{1}{a}} \frac{16(1 - \cos(2x^2 - x + 2))}{(ax - 1)^2}$ equals

(1) $\dfrac{32(1 - a^2)^2}{a^4}$ (2) $\dfrac{8(1 - a^2)^2}{a^3}$

(3) $\dfrac{16(1 - a^2)^2}{a^4}$ (4) $\dfrac{20(1 - a^2)^2}{a^3}$

Answer (1)

Sol. $2x^2 - x + 2 = 0$ has roots a and $\dfrac{1}{a}$

$$\lim_{x \to \frac{1}{a}} \frac{16[1 - \cos(2x^2 - x + 2)]}{a^2\left(x - \frac{1}{a}\right)^2}$$

$$= \lim_{x \to \frac{1}{a}} \frac{16\left[1 - \cos\left[2(x - a)\left(x - \frac{1}{a}\right)\right]\right]}{a^2 4\left(x - \frac{1}{a}\right)^2 (x - a)^2}(x - a)^2.4$$

$$= \frac{32}{a^2}\left(\frac{1}{a} - a\right)^2$$

$$= \frac{32(1 - a^2)^2}{a^4}$$

12. If $\frac{dy}{dx}+\frac{y\cdot 2x}{(1+x^2)^2}=xe^{\frac{1}{1+x^2}}$ and $y(0) = 0$. Given $f(x)=y(x)e^{\frac{-1}{1+x^2}}$, then the area bounded between these two curves equals to _____

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

(3) $\frac{7}{6}$ (4) 2

Answer (1)

Sol. $\frac{dy}{dx}+\frac{y\cdot 2x}{(1+x^2)^2}=x\cdot e^{\frac{1}{1+x^2}}$

I.F. = $e^{\int\frac{2x}{1+x^2}dx}$

Put $x^2 = t$

$2xdx = dt$

$= e^{\int\frac{dt}{(1+t)^2}}$

$= e^{-\frac{1}{1+t}}$

$= e^{-\frac{1}{1+x^2}}$

$y\cdot e^{-\frac{1}{1+x^2}}=\int x\cdot e^{-\frac{1}{1+x^2}}e^{\frac{1}{1+x^2}}dx$

$y\cdot e^{-\frac{1}{1+x^2}}=\int x\cdot dx$

$y\cdot e^{-\frac{1}{1+x^2}}=\frac{x^2}{2}+c$

$y=\frac{x^2}{2}e^{\frac{1}{1+x^2}}+c\cdot e^{\frac{1}{1+x^2}}$

$y(0) = 0$

$c = 0$

$\therefore\ f(x) = \left(e^{\frac{1}{1+x^2}}\cdot\frac{x^2}{2}\right)e^{-\frac{1}{1+x^2}}$

$f(x)=\frac{x^2}{2}$ ...(1)

Given $y = x$ ...(2)

$\therefore$ Area bounded between (1) and (2)

$\therefore\ A=\int_0^2\left(x-\frac{x^2}{2}\right)dx$

$=\left(\frac{x^2}{2}-\frac{x^3}{6}\right)_0^2$

$=\left(\frac{4}{2}-\frac{8}{6}\right)$

$=2-\frac{4}{3}$

$\Rightarrow\ \frac{2}{3}$

Option (1) is correct.

13. Find the differential equation of circle whose centre lies on $y = x$ and passes through (0, 1).

(1) $-x^2+y^2-2xy+2x-1+\frac{dy}{dx}(x^2+y^2-2+2y)=0$

(2) $-x^2-y^2-2xy+2x-1+\frac{dy}{dx}(x^2+y^2)=0$

(3) $-x^2-y^2-2xy+2x-1+\frac{dy}{dx}(x^2-y^2)=0$

(4) $x^2+y^2-2xy+2x-1+\frac{dy}{dx}(x^2+y^2-2)=0$

Answer (1)

Sol. The centre lies on $y = x$

$\therefore$ Centre of circle is of form (a, a)

$\therefore$ It passes through (0, 1)

$\therefore$ The equation of circle will be

$(x-a)^2 + (y-a)^2 = a^2 + (a-1)^2$

$\Rightarrow\ x^2 + y^2 - 2ax - 2ay = -2a + 1$ ...(1)

Differentiating w.r.t. x & eliminating 'a',

$$a = \frac{x + y\frac{dy}{dx}}{1 + \frac{dy}{dx}}$$

Putting value of 'a' in equation (1), we get

$$-x^2 + y^2 - 2xy + 2x - 1 + \frac{dy}{dx}(x^2 + y^2 - 2 + 2y) = 0$$

14. $\beta(m, n) = \int_0^1 x^m (1 - x^m)^{n-1} dx$

$$a \times \beta(-b, c) = \int_0^1 (1 - x^{10})^{20} dx$$

Then $(a + b + c)$ is equal to

(1) 210

(2) 230

(3) 250

(4) 270

Answer (1)

Sol. $I = \int_0^1 (1 - x^{10})^{20} dx$

Applying integration by parts

$$I = \left[x(1 - x^{10})^{20}\right]_0^1 + 200\int_0^1 x^{10}(1 - x^{10})^{19} dx$$

$$I = 200\int_0^1 x^{10}(1 - x^{10})^{19} dx = a \times \beta(-b, c)$$

$\Rightarrow$ $a = 200$

$b = -10$

$c = 20$

$(200 - 10 + 20) = 210$

15. If $|\vec{a}| = 2$, $|\vec{b}| = 3$ and $\vec{a} = \vec{b} \times \vec{c}$ then minimum value of $|\vec{c} - \vec{a}|^2$ is

(1) 13

(2) 5

(3) $\frac{40}{9}$

(4) $\frac{20}{9}$

Answer (3)

Sol. $|\vec{a}| = 2$, $|\vec{b}| = 3$

Also, $\vec{a} = \vec{b} \times \vec{c}$

$\Rightarrow$ $\vec{a} \cdot \vec{b} = 0$ and $\vec{a} \cdot \vec{c} = 0$

$|\vec{a} - \vec{c}|^2 = |\vec{a}|^2 + |\vec{c}|^2 - 2\vec{a} \cdot \vec{c}$

$= 4 + |\vec{c}|^2$

$|\vec{a}| = |\vec{b} \times \vec{c}| = |\vec{b}|\sin\theta|\vec{c}|$

$\Rightarrow$ $(\sin\theta)|\vec{c}| = \frac{2}{3}$

$\Rightarrow$ $\sin^2\theta = \frac{4}{9|\vec{c}|^2}$

$\Rightarrow$ $|\vec{c}|^2 = \frac{4}{9\sin^2\theta}$

$|\vec{a} - \vec{c}|^2 = 4 + \frac{4}{9\sin^2\theta}$

For $|\vec{a} - \vec{c}|^2$ to be minimum

$\Rightarrow$ $\sin\theta = 1$

$\Rightarrow$ $4 + \frac{4}{9} = \left(\frac{40}{9}\right)$

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. Let $4^{1+x}+4^{1-x}, \frac{K}{2}, 16^{x}+16^{-x}$ are in AP then least value of K is

Answer (10)

Sol. $4^{1+x}+4^{1-x}, \frac{K}{2}, 16^{x}+16^{-x}$

$$2\times\frac{K}{2}=4^{1+x}+4^{1-x}+16^{x}+16^{-x}$$

$$K=\underbrace{4.4^{x}+\frac{4}{4^{x}}}_{\geq 8}+\underbrace{4^{2x}+4^{-2x}}_{\geq 2}$$

$\Rightarrow K \geq 10 \Rightarrow K = 10$

22. The number of real solution $x|x+5|+2|x+7|-2=0$ is

Answer (03.00)

Sol. $x|x+5|+2|x+7|-2=0$

−7 −5

(i) $d\, x\geq -5 \Rightarrow x(x+5)+2(x+7)-2=0$

$x^{2}+7x+12=0 \Rightarrow x=-3,-4$

(ii) $x\in(-7,-5)$

$x(-x-5)+2(x+7)-2=0$

$-x^{2}-3x+12=0$

$\Rightarrow x^{2}+3x-12=0$

$\Rightarrow x=\frac{-3-\sqrt{57}}{2}$ satisfy

(iii) $x\leq -7$

$\Rightarrow x(-x-5)+2(-x-7)-2=0$

$-x^{2}-7x-16=0 \Rightarrow x^{2}+7x+16=0$

No solution

23. If $f(t)=\int_{0}^{\pi}\frac{2x}{1-\cos^{2}t\sin^{2}x}dx$, then the value of $\int_{0}^{\pi}\frac{\pi^{2}}{f(t)}dt$ is equal to

Answer (2)

Sol. $f(t)=\int_{0}^{\pi}\frac{2x}{1-\cos^{2}t\sin^{2}x}dx$

$$f(t)=2\int_{0}^{\pi}\frac{(\pi-x)}{1-\cos^{2}t\sin^{2}x}dx$$

$$2f(t)=2\int_{0}^{\pi}\frac{\pi}{1-\cos^{2}t\sin^{2}x}dx$$

$$f(t)=\pi\int_{0}^{\pi}\frac{\sec^{2}x}{\sec^{2}x-\cos^{2}t\tan^{2}x}dx$$

$\tan x = k$

$\sec^{2}x\, dx = dk$

$$f(t)=\pi\int\frac{dk}{1+\sin^{2}t\, k^{2}}$$

$$f(t)=\pi\times\frac{1}{\sin t}\left[\tan^{-1}(\sin t\times\tan x)\right]_{0}^{\pi/2}+\left[\tan^{-1}(\sin t\tan x)\right]_{\frac{\pi}{2}}^{\pi}$$

$$=\frac{\pi}{\sin t}(\pi)=\frac{\pi^{2}}{\sin t}$$

$$\Rightarrow \int_{0}^{\pi}\frac{\pi^{2}}{\frac{\pi^{2}}{\sin t}}dt=\int_{0}^{\pi}\sin t\, dt=2$$

24.

25.

26.

27.

28.

29.

30.