28/06/2022
Morning

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Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2022 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

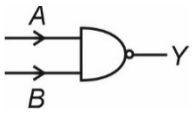
PHYSICS

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:

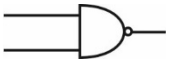
1. For the following gate the output y is given by



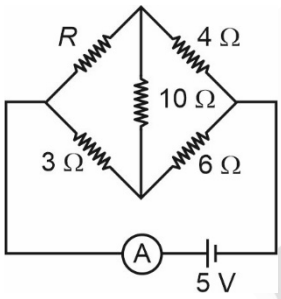
(1) $A + B$ (2) $\overline{A+B}$

(3) AB (4) $\overline{AB}$

Answer (4)

Sol.  is a NAND gate

2. For what value of R current in 10 Ω resistance should be 0?

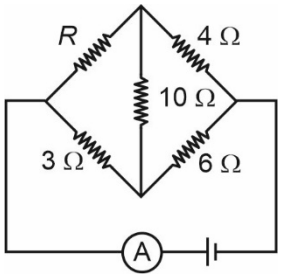


(1) 1 Ω (2) 2 Ω

(3) 3 Ω (4) 4 Ω

Answer (2)

Sol.



For no current through 10 Ω resistor, the bridge is balanced wheatstone.

$$\therefore \quad \frac{R}{3}=\frac{4}{6} \Rightarrow R = 2\ \Omega$$

3. Resolving power of a telescope for the aperture 24.4 cm for the wavelength λ = 2440 Å

(1) 2.5×10^{-5} (2) 4.5×10^{5}

(3) 5.0×10^{-4} (4) 7.5×10^{6}

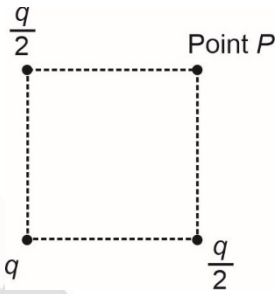
Answer (2)

Sol. $\frac{1}{R.P.}=\frac{1.22\lambda}{a}$

$$\Rightarrow \quad R.P=\frac{24.4\times10^{-2}}{2.22\times2440\times10^{-10}}$$

$= 4.5 \times 10^5$

4. Three point charges are arranged at the three corners of a square as shown:



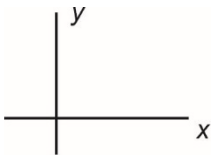
If the side of the square is unity, find the electric field at P.

(1) $\frac{kq(1+\sqrt{2})}{2}$ (2) $\frac{kq(1+\sqrt{2})}{\sqrt{2}}$

(3) $\frac{kq(\sqrt{2}-1)}{2\sqrt{2}}$ (4) $\frac{kq(3+\sqrt{2})}{2\sqrt{2}}$

Answer (1)

Sol.



$$\vec{E}_p=\vec{E}_1+\vec{E}_2+\vec{E}_3$$

$$=\frac{k\left(\frac{q}{2}\right)}{(1)^2}\{\hat{i}+\hat{j}\}+\frac{k(q)}{(\sqrt{2})^2}\left\{\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right\}$$

$$=kq(\hat{i}+\hat{j})\left[\frac{1}{2}+\frac{1}{2\sqrt{2}}\right]$$

$$=\frac{kq}{2\sqrt{2}}(\sqrt{2}+1)(\hat{i}+\hat{j})$$

$$\Rightarrow \quad |\vec{E}_p|=\frac{kq}{2}(\sqrt{2}+1)$$

5. A water drop of diameter 2 cm is divided into 64 small drops. If surface tension is 0.0075 N/m then gain in surface energy is

(1) 8.1×10^{-4} J

(2) 3.6×10^{-5} J

(3) 2.8×10^{-5} J

(4) 4.2×10^{-4} J

Answer (3)

Sol. $\because \quad \frac{4}{3}\pi R^3 = 64 \times \frac{4}{3}\pi r^3$

$\Rightarrow R^3 = (4r)^3$

$\Rightarrow R = 4r$

$\therefore \quad \Delta U_{gain} = U_f - U_i$

$= 64 \times 4\pi r^2 \times T - 4\pi R^2 \times T$

$= 4\pi T\left[64 \times \frac{R^2}{16} - R^2\right]$

$= 4\pi T \times 3R^2$

$= 4 \times 3.142 \times 0.0075 \times 3 \times 10^{-6}$

$= 2.8 \times 10^{-5}$ J

6. **Statement I:** *npn* transistor conducts more current then *pnp*.

Statement II: Electrons have more mobility than holes.

(1) Both statements are true

(2) Statement I is true and statement II is false

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

(4) Both statements are false

Answer (1)

Sol. Both the statements are true based upon transistor theory.

7. If a positive charge is moved against an electric field then its

(1) Energy will increase

(2) Energy will decrease

(3) Energy will remain same

(4) Behaviour of energy is unpredictable

Answer (1)

Sol. $\Delta U = qE \times \Delta x$

$\Rightarrow$ Energy will increase

8. Two planets revolve around Sun such that their time periods of revolution T_A and T_B are related by $T_A = 2T_B$. If their radii of revolution are r_A and r_B, then

(1) $4r_A^3 = r_B^3$

(2) $r_A^3 = 4r_B^3$

(3) $4r_A^2 = r_B^2$

(4) $r_A^2 = 4r_B^2$

Answer (2)

Sol. We know that

$T^2 \propto r^3$

$\Rightarrow \left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_A}{r_B}\right)^3$

$\Rightarrow r_A^3 = 4r_B^3$

9. The minimum deviation for a prism having refractive index $\mu = \cot\left(\frac{A}{2}\right)$ and A is angle of prism is

(1) $180° - 2A$

(2) $180° - 3A$

(3) $90° - A$

(4) $180° - 4A$

Answer (1)

Sol. $\cot\left(\frac{A}{2}\right) = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$\Rightarrow \cos\left(\frac{A}{2}\right) = \sin\left(\frac{\delta_m + A}{2}\right)$

$\Rightarrow 90° - \frac{A}{2} = \frac{\delta_m + A}{2}$

$\Rightarrow 180° - 2A = \delta_m$

10. A man of mass 60 kg is running and then jumps into a trolley of mass 120 kg initially at rest and goes at the speed of 2 m/s find initial speed of man.

(1) 12 m/s

(2) 6 m/s

(3) 20 m/s

(4) 3 m/s

Answer (2)

Sol. Let u : initial speed of man

Conserving momentum:

$60u = (60 + 120) \times 2$

$\Rightarrow \quad u = 6$ m/s

11. Column I contains description of axis of a rigid body and column II contains its moment of inertia about the axis then choose the correct option.

	Column I		Column II
A.	Moment of inertia of solid cylinder about its tangent (parallel to axis)	(i)	$\frac{7}{5}MR^2$
B.	Moment of inertia of solid sphere about its tangent	(ii)	$\frac{MR^2}{2}$
C.	Moment of inertia of ring about its diameter	(iii)	$\frac{MR^2}{4}$
D.	Moment of inertia of disc about its diameter	(iv)	$\frac{3}{2}MR^2$

(1) A → (i), B → (ii), C → (iii), D → (iv)

(2) A → (i), B → (iv), C → (ii), D → (iii)

(3) A → (iv), B → (iii), C → (i), D → (ii)

(4) A → (iv), B → (i), C → (ii), D → (iii)

Answer (4)

Sol. $I_A = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$

$I_B = \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2$

$I_C = \frac{1}{2} \times \left(MR^2\right) = \frac{MR^2}{2}$

$I_D = \frac{1}{2} \times \left(\frac{MR^2}{2}\right) = \frac{MR^2}{4}$

12. If work function of metal is ϕ = 6.63 eV then its cut off wave length is

(1) 363 nm

(2) 187 nm

(3) 285 nm

(4) 91 nm

Answer (2)

Sol. $\because \quad \phi = \frac{hc}{\lambda_0}$

$\Rightarrow \quad \lambda_0 = \frac{hc}{\phi}$

$= \frac{1242}{6.63}$ nm

= 187 nm

13. Co-ordinates of a particle are given by:

$x = 4 \sin\left(\frac{\pi}{2} - \omega t\right)$

$y = 4 \sin(\omega t)$

What is the trajectory of the particle in x-y plane?

(1) Parabolic

(2) Eliptical

(3) Circular

(4) Coiled

Answer (3)

Sol. $x(t) = 4 \cos\omega t$

and $y(t) = 4 \sin\omega t$

$\Rightarrow \quad x^2 + y^2 = 16$

$\Rightarrow$ Trajectory is a circle.

14. Kinetic energies photon and electrons are same. If λ_p and λ_e denote de-Broglie wavelength respectively, then

(1) $\lambda_e \propto \lambda_p$

(2) $\lambda_e \propto \sqrt{\lambda_p}$

(3) $\lambda_e \propto \frac{1}{\sqrt{\lambda_p}}$

(4) $\lambda_e \propto \lambda_p^2$

Answer (2)

Sol. Given that :

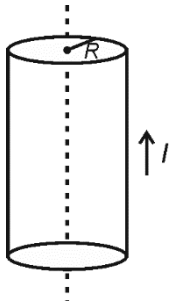
$E_p = E_e$

$\Rightarrow \quad \frac{hc}{\lambda_p} = \frac{p_e^2}{2m_e}$

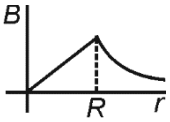
$\Rightarrow \quad \frac{hc}{\lambda_p} = \frac{h^2}{2m_e\lambda_e^2}$

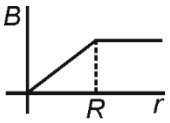
$\Rightarrow \quad \lambda_e \propto \sqrt{\lambda_p}$

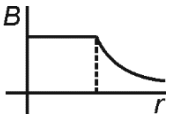
15. A hollow cylinder contains current uniformly distributed over the circumference parallel to the axis. Then correct graph between magnetic field (B) and distance from the axis (r) is



(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. From Ampere's law

$B \times 2\pi r = \mu_0 I_{in}$

$\Rightarrow B_{inside} = 0$ and

$$B_{outside} = \frac{\mu_0 I}{2\pi r}$$

$\therefore$ 

16. One mole of a gas expands adiabatically, work done by the gas is W_0. Find out change in temperature during process (γ = adiabatic coefficient of gas)

(1) $\frac{\gamma W_0}{R}$ (2) $(\gamma+1)\frac{W_0}{R}$

(3) $(\gamma-1)\frac{W_0}{R}$ (4) $(1-\gamma)\frac{W_0}{R}$

Answer (4)

Sol. $\because \quad W_{adi} = \frac{-nR\Delta T}{(\gamma-1)}$

$$\Rightarrow W_0 = \frac{1\times R\times \Delta T}{(1-\gamma)}$$

$$\Delta T = (1-\gamma)\frac{W_0}{R}$$

17. If centripetal acceleration of a particle of mass m in a circular path of radius r is $a_c = k^2rt^2$. Where k is constant and t is time, then power is given by

(1) 0

(2) mk^2r^2t

(3) $mk^2r^2t^2$

(4) mk^2rt^2

Answer (2)

Sol. $\frac{U^2}{r} = k^2rt^2$

$\Rightarrow v = krt$

$\Rightarrow a_i = \frac{dv}{dt} = kr$

$\therefore$ Power = $F_i \times v$

$= (mkr) \times (krt)$

$= mk^2r^2t$

18. An observer is moving towards a stationary light source with the speed of $\frac{c}{5}$. What is the percentage change in the frequency?

(1) 22.5% (2) 15.4%

(3) 20% (4) 18.5%

Answer (1)

Sol. $\nu' = \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}\times\nu$

$$= \sqrt{\frac{1+\frac{1}{5}}{1-\frac{1}{5}}}\times\nu$$

$$= \sqrt{\frac{6}{4}}\times\nu = 1.225\,\nu$$

% change in ν = 22.5%

19. A container has 2 moles of a monoatomic gas at temperature of 300 K. Find the internal energy of this sample of the gas.

(1) 1800R

(2) 1500R

(3) 900R

(4) 450R

Answer (3)

Sol. We know that

$U = nC_vT$

$\Rightarrow \quad U = 2 \times \frac{3R}{2} \times 300$

$= 900R$

20. Column 1 contains wave of different type and column 2 contains their maximum frequency. Then choose the correct option.

	Column 1		Column 2
A.	Television wave	(1)	3 kHz
B.	Radio wave	(2)	20 kHz
C.	Human voice	(3)	30 MHz
D.	High pitch music	(4)	60 MHz

(1) A → (4), B → (3), C → (1), D → (2)

(2) A → (4), B → (3), C → (2), D → (1)

(3) A → (3), B → (4), C → (1), D → (2)

(4) A → (3), B → (4), C → (2), D → (1)

Answer (1)

Sol. Frequency match

Human voice → 3 kHz

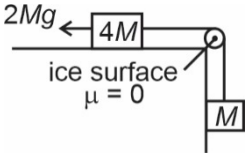
High pitch music → 20 kHz

Radio wave → 30 MHz

Television → 60 MHz

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. 

In the shown diagram, if tension in string is $\frac{x}{5}Mg$.

Find value of x.

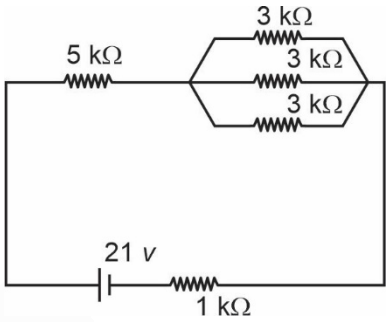
Answer (6)

Sol. Equation for $4M$: $2Mg - \frac{xMg}{5} = 4Ma$ …(i)

Equation for M : $\frac{xMg}{5} - Mg = Ma$ …(ii)

$\Rightarrow \quad \frac{g}{2} - \frac{xg}{20} = \frac{xg}{5} - g$

$\Rightarrow \quad x = 6$

22. 

The current in 5 kΩ resistor in the circuit shown (in mA) is

Answer (3)

Sol. $R_{eq} = 6 + \frac{3}{3} = 7\ k\Omega$

$\therefore \quad$ current $I = \frac{21}{7}$

$= 3$ mA

23. Wavelength of a wave in vacuum is 7200 Å. If the wave enters a medium of refractive index 1.5, the new wavelength is $x \times 100$ Å. Find the value of x.

Answer (48)

Sol. We know that

$\lambda' = \frac{\lambda}{n}$

$\Rightarrow \quad \lambda' = \frac{7200}{1.5}$ Å

$= 4800$ Å

$\Rightarrow \quad x = 48$

24.

25.

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. $CuO \xrightarrow{H_2}$ (P)

Product P is

(1) $Cu(OH)_2$

(2) Cu(s)

(3) Cu_2O

(4) All of these

Answer (2)

Sol. CuO is reduced by H_2 to Cu.

$$CuO + H_2 \longrightarrow Cu + H_2O$$

2. Which of the following will show minimum synergic bonding?

(1) $[Mn(CO)_5]$

(2) $[Mn_2(CO)_{10}]$

(3) $[Cr(CO)_6]$

(4) $[Fe(CO)_5]$

Answer (3)

Sol. As the number of *d* electron decreases, extent of synergic bonding decreases.

$Mn(CO)_5 = d^7$

$Mn2(CO)_{10} = d^7$

$Cr(CO)_6 = d^6$

$Fe(CO)_5 = d^8$

3. Which is not a copolymer?

(1) Neoprene

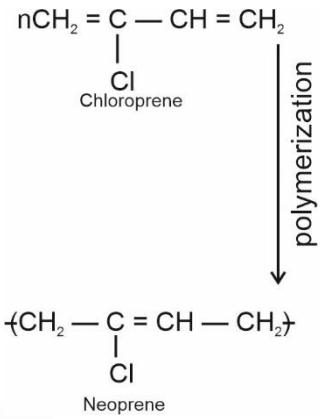
(2) Buna-N

(3) Buna-S

(4) Nylon-6, 6

Answer (1)

Sol. Neoprene is a homopolymer

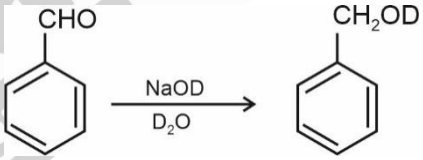


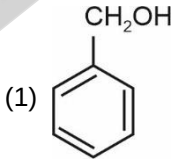
Buna-N has two monomers : Copolymer 1, 3-Butadiene and Acrylonitrile

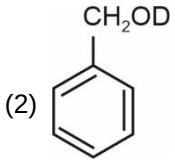
Buna-S has two monomers : Copolymer 1, 3-Butadiene and styrene

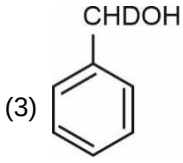
Nylon-6,6 has two monomers : copolymer hexamethylenediamine and adipic acid

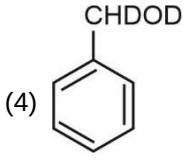
4. Identify the product of the following reaction



(1) 

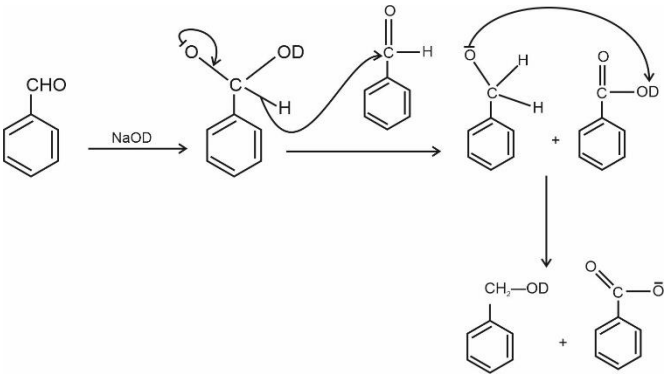
(2) 

(3) 

(4) 

Answer (3)

Sol.



5. Which of the following is not a pesticide?

(1) DDT

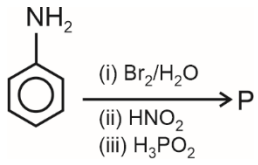
(2) Dieldrin

(3) Organophosphates

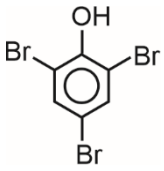
(4) Sodium Arsinite

Answer (4)

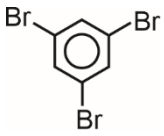
Sol. Na_3AsO_3 – Sodium arsinite is a herbicide whereas, DDT, Dieldrin and Organophosphates are pesticides.

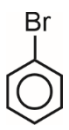
6. 

P is ?

(1) 

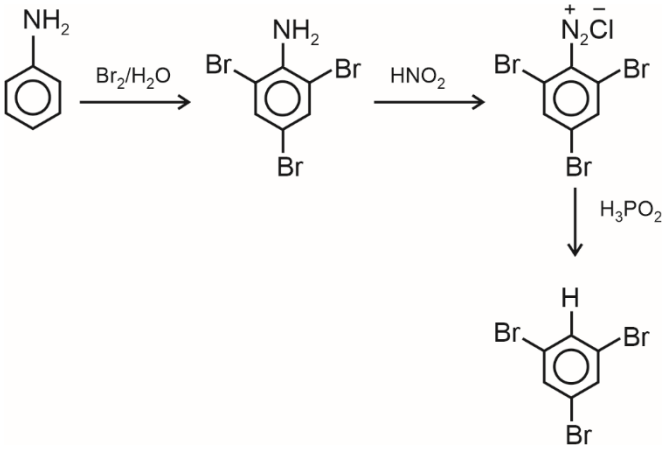
(2) 

(3) 

(4) 

Answer (3)

Sol.



7. Decomposition of which of the following compound gives N_2

(1) $NaNO_2$

(2) $NaNO_3$

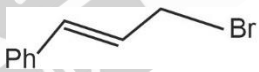
(3) $Ba(N_3)_2$

(4) $Ba(NO_3)_2$

Answer (3)

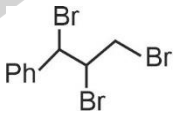
Sol. Barium azide decomposes on heating to give N_2

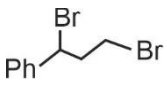
$$Ba(N_3)_2 \xrightarrow{\Delta} Ba + 3N_2$$

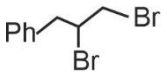
8. 

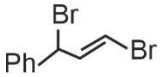
Major product.

Major product is?

(1) 

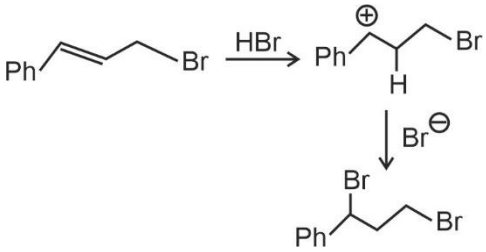
(2) 

(3) 

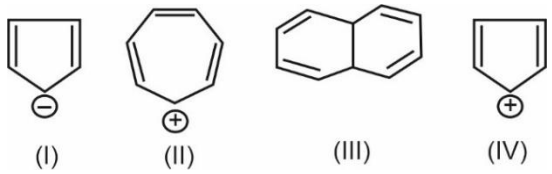
(4) 

Answer (2)

Sol.



9. Which of the following is aromatic?



(1) I & III (2) II & IV

(3) I & II (4) III & IV

Answer (3)

Sol. (I)  = Aromatic

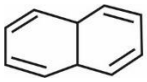
$6\pi\ e^-s$

(II)  = Aromatic

$6\pi e^-s$

(III)  = Antiaromatic

$4\pi e^-s$

(IV)  = Non-Aromatic as not planar

10. Following sequence of reaction is provided.

$$\text{Primary amine} \xrightarrow[273^\circ C]{HNO_2\,(aq)} A \xrightarrow[H_2O]{283^\circ C} B$$

What is B?

(1) Alcohol (2) Amine

(3) Nitro compound (4) Alkyl nitride

Answer (1)

Sol. $R\text{–}NH_2 \xrightarrow[273^\circ C]{HNO_2\,(aq)} RN_2^{\oplus} \xrightarrow[H_2O]{283^\circ C} R-OH + N_2$

11. **Statement-I :** $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$ are paramagnetic

Statement-II : $[Ni(Cl)_4]^{2-}$ and $[Ni(CO)_4]$ are having same geometry and same structure.

The correct statements are

(1) Both (I) and (II) (2) Only (I)

(3) Only (II) (4) Neither (I) nor (II)

Answer (3)

Sol. $[Ni(CN)_4]^{2-}$ Ni^{2+} $3d^8$; dsp^2 hybridisation – Square planar shape

$\mu = 0$

$[Ni(CO)_4]$ Ni $3d^8 4s^2$; sp^3 hybridisation – Tetrahedral shape

$\mu = 0$

Both the complexes are diamagnetic. So, statement-I is false.

$[NiCl_4]^{2-}$ Ni^{2+} $3d^8$; sp^3 hybridisation – Tetrahedral shape

$[Ni(CO)_4]$ Tetrahedral shape

So, statement-II is correct.

12. Zeta potential is related to

(1) Brownian motion

(2) Tyndall effect

(3) Colour

(4) Charge on surface of colloid

Answer (4)

Sol. The combination of two layers of opposite charges around the colloidal particle is called **Helmholtz Electrical double layer**.

The potential difference between fixed layer and diffused layer of opposite charges is called **zeta potential**.

Thus, it is related to charge on surface of colloid.

13. Which defect will not affect density?

(1) Frenkel defect (2) Schottky defect

(3) Interstitial defect (4) Vacancy defect

Answer (1)

Sol. Frenkel defect is a type of point defect in crystalline solids which is created when an atom or cation leaves its original place in the lattice structure to create a vacancy while occupying another interstitial position within the solid crystal. Density of crystal remains same.

14. An organic sample of 0.5 g contains Br, it yields 0.4 g of AgBr in a certain reaction. What is % weight of Br in the sample approx?

(Atomic weight of Ag = 108 g/mol, Br = 80 g/mol)

(1) 34

(2) 45

(3) 54

(4) 26

Answer (1)

Sol. % weight of bromine $= \frac{80}{188} \times \frac{0.4}{0.5} \times 100 \simeq 34\%$

15. **Statement-I:** E_2O_5 is less acidic than E_2O_3.

Statement-II: In group 15, acidity of E_2O_3 decreases down the group.

Correct statements are,

(1) Both (I) and (II) (2) Only (I)

(3) Only (II) (4) Neither (I) nor (II)

Answer (3)

Sol. Group-15 elements form two types of oxides: E_2O_3 and E_2O_5. The oxide in higher oxidation state (E_2O_5) of the element is more acidic than that of lower oxidation state (E_2O_3).

$\therefore$ Statement-I is false.

The acidic character of oxides of the type E_2O_3 of Group-15 elements decreases down the group.

$\therefore$ Statement-II is correct.

16. Element E belong to period 4 and group 16 in modern periodic table.

The valence electronic configuration of element lie just above this element E in the same group is

(1) $3d^{10}\,4s^2\,4p^4$ (2) $4s^2\,4p^4$

(3) $3s^2\,3p^4$ (4) $3d^{10}\,3s^2\,3p^4$

Answer (3)

Sol. Element E is selenium.

Hence element just above selenium in modern periodic table is sulphur.

Valence electronic configuration of sulphur is $3s^2\,3p^4$.

17. α-Helix structure of protein is stabilized by

(1) H-bonding

(2) van der-Waals interactions

(3) Ionic bonding

(4) None of these

Answer (1)

Sol. α-Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right-handed screw (helix) with the –NH group of each amino acid residue hydrogen bonded to the $>C=O$ of an adjacent turn of helix.

18. **A :** Purple colour obtained on treatment of Lassaigne's extract with a reagent is a test of sulphur.

R : Sodium nitroprusside is the reagent that gives a purple coloured complex $[Fe(CN)_5NOS]^{4-}$.

(1) Assertion is correct, reason is correct and reason is the correct explanation for assertion

(2) Assertion is correct, reason is correct and reason is not the correct explanation for assertion

(3) Assertion is incorrect and reason is incorrect

(4) Both assertion and reason are incorrect

Answer (1)

Sol. $\underset{\text{Lassaigne's extract}}{Na_2S} + Na_2[Fe(CN)_5NO] \longrightarrow \underset{\text{Purple colour}}{Na_4[Fe(CN)_5NOS]}$

19. Statement-I : Mg reduces Al_2O_3 below 1350°C and Al reduces MgO after 1350°C.

Statement-II : Boiling point and melting point of Mg are lower than those of Al.

The correct statement(s) is/are

(1) Statement-I only

(2) Both statement-I and statement-II

(3) Statement-II only

(4) Neither statement-I nor statement-II.

Answer (2)

Sol. In the Ellingham diagram, the plot of $\Delta G°$ vs temperature of Al_2O_3 is above that of MgO up to 1350°C and thereafter the plot of $\Delta G°$ vs temperature of MgO is above that of Al_2O_3. Therefore, Mg reduces Al_2O_3 up to 1350°C and thereafter Al reduces MgO.

$\Rightarrow$ Statement-I is true

Both the boiling point and melting point of Mg are lower than those of Al.

	Mg	Al
Melting point :	924 K	933 K
Boiling point :	1363 K	2740 K

$\Rightarrow$ Statement-II is true.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. The hybridisation of PF_5 is sp^xd^y. The value of y is

Answer (01.00)

Sol. Steric number of PF_5 is $\frac{V+M-C+A}{2}$

$$S.N=\frac{5+5}{2}=5$$

Hence hybridisation of PF_5 is sp^3d

Value of y is 1

22. 40 L of an ideal gas is allowed to expand isothermally against vacuum until the total volume because 20 L. The amount of heat absorbed in this expansion in L atm is

Answer (00.00)

Sol. From first law of thermodynamics,

$dq = dU - dW$

Since, work done is against vacuum.

Hence, $dW = 0$

For isothermal process, dU = 0 (Because $\Delta T = 0$)

Hence, dq = 0

Heat absorbed in this expansion is 0.

23. Two liquids A and B follow Raoult's law over entire range of concentration. If a solution of A and B (ideal solution) has mole fraction of A (x_A) as 0.3. Then $y_A = \frac{x}{17}$. The value of x is

Given P_A° = 50 torr and P_B° = 100 torr

Answer (03.00)

Sol. Since, $y_A = \frac{P_A^\circ x_A}{P_A^\circ x_A + P_B^\circ x_B}$

And, x_A = 0.3 and x_B = 0.7

$$y_A = \frac{50\times 0.3}{(50\times 0.3)+(100\times 0.7)}$$

$$y_A = \frac{15}{85}$$

$$\Rightarrow \frac{15}{85}=\frac{x}{17}$$

x = 3

24. Consider the following reaction

$$Cr_2O_7^{2-} \longrightarrow Cr^{3+}$$

The total charge required in Faraday to convert 1 mole of $Cr_2O_7^{2-}$ into Cr^{3+} is

Answer (06.00)

Sol. $\overset{+6}{Cr_2}O_7^{2-} + 6e^- \longrightarrow 2\overset{+3}{Cr}$

Hence, for 1 mole of $Cr_2O_7^{2-}$

Charge required is 6F

25. A first order reaction, the time taken for 67% completion is equal to $x \times 10^{-1} \times t_{1/2}$. Find the value of x (If value of K is 5.5 × 10)

Answer (16.00)

Sol. For first order reaction,

$$K=\frac{2.303}{t}\log\frac{100}{100-67}=\frac{2.303}{t}\log\frac{100}{33}$$

Since $K=\frac{2.303\log 2}{t_{1/2}}$

Hence, $\frac{2.303\log 2}{t_{1/2}}=\frac{2.303}{t}\log\frac{100}{33}$

$t = 1.6\ t_{1/2}$

And, $1.6\ t_{1/2} = x \times 10^{-1}\ t_{1/2}$

Hence, x = 16

26. The work function of a given metal is 6.63×10^{-19} J. Find wavelength (in nm) of incident light, if kinetic energy of ejected electron is zero.

[Take $h = 6.63 \times 10^{-34}$ Js]

Answer (300)

Sol. Since,

$E_{incident} = W_0 + K.E$

As K.E is zero.

$E_{incident} = W_0$

$$6.63\times10^{-19}=\frac{hc}{\lambda}=\frac{6.63\times10^{-34}\times3\times10^{8}}{\lambda}$$

$\lambda = 3\times10^{-7}$ m

Hence wavelength is 300 nm.

27.

28.

29.

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. A matrix 'A' of order 3 × 3 and det (A) = 2, then det(det A(adj (adj A))^3) is equal to

   (1) 2^{23}

   (2) 2^{13}

   (3) 2^{15}

   (4) 2^{12}

Answer (3)

Sol. $\because \quad |A| = 2$

So, $\left|\,|A|\,(\text{adj }(\text{adj } A))^3\right|$

$= |2\,(\text{adj }(\text{adj } A))^3|$

$= 2^3 \cdot |\text{adj }(\text{adj } A)|^3$

$= 2^3\left(|A|^{2^2}\right)^3$

$= 2^3 \cdot 2^{12}$

$= 2^{15}$

2. Number of real solutions of the equation $4x^7 + 3x^3 + 5x + 1 = 0$ is/are

   (1) 0

   (2) 1

   (3) 2

   (4) 3

Answer (2)

Sol. $\because \quad 4x^7 + 3x^3 + 5x + 1 = 0$

Here $f(x) = 4x^7 + 3x^3 + 5x + 1$

$\therefore \quad f'(x) = 28x^6 + 9x^2 + 5$

Here $f'(x) > 0$, then $f(x)$ is increasing and its range is R.

$\therefore$ Only one real solution is possible.

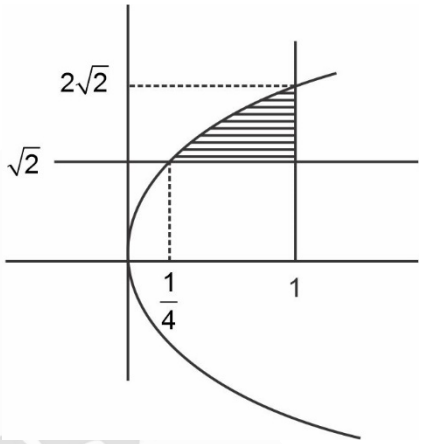
3. Area of region $S = \left\{(x,y) \mid y^2 \le 8x, y \ge \sqrt{2}, x \le 1\right\}$

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

   (3) $\frac{6}{\sqrt{2}}$ (4) $\frac{5}{6\sqrt{2}}$

Answer (4)

Sol. Required area

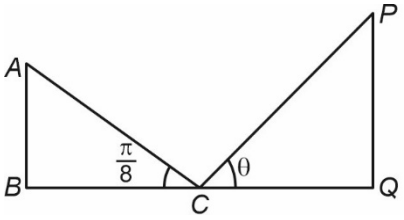


$$= \int_{\frac{1}{4}}^{1}\left(\sqrt{8x} - \sqrt{2}\right)dx$$

$$= 2\sqrt{2}\,\frac{x^{\frac{3}{2}}}{\frac{3}{2}} - \sqrt{2}x\Bigg|_{\frac{1}{4}}^{1}$$

$$= \frac{4\sqrt{2}}{3}\left(1 - \frac{1}{8}\right) - \sqrt{2}\left(1 - \frac{1}{4}\right)$$

$$= \frac{7}{3\sqrt{2}} - \frac{3}{2\sqrt{2}} = \frac{5}{6\sqrt{2}}$$

4. 

($PQ = 2AB$)

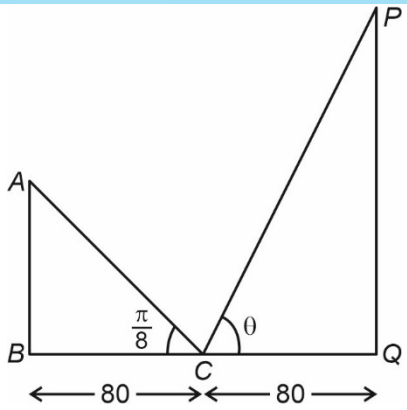
Two poles 160 m apart & C is the mid-point, then find $\tan^2\theta$.

(1) $2(\sqrt{2}+1)$ (2) $2(\sqrt{2}-1)$

(3) $4(3+2\sqrt{2})$ (4) $4(3-2\sqrt{2})$

Answer (4)

Sol.



$\because$ $PQ = 2AB$

If $AB = h$ then $PQ = 2h$.

$$\tan\theta = \frac{2h}{80}$$

and $$\tan\frac{\pi}{8} = \frac{h}{80}$$

$$\therefore \quad \frac{\tan\theta}{\tan\frac{\pi}{8}} = 2$$

$$\therefore \quad \tan\theta = 2(\sqrt{2}-1)$$

$$\Rightarrow \quad \tan^2\theta = 4(3-2\sqrt{2})$$

5. Eccentricity of hyperbola $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$ is $\frac{\sqrt{5}}{2}$ & length of latus rectum is $\frac{\sqrt{3}}{2}$. If tangent is $y = 2x + c$, then the value of c is

(1) $\pm\frac{3\sqrt{5}}{2}$ (2) $\pm\frac{5\sqrt{3}}{2}$

(3) $\pm\frac{3\sqrt{2}}{5}$ (4) $\pm\frac{5\sqrt{2}}{3}$

Answer (1)

Sol. $e^2 = 1+\frac{b^2}{a^2}=\frac{5}{4} \Rightarrow \frac{b^2}{a^2}=\frac{1}{4}$ ...(1)

Also $\frac{2b^2}{a}=\frac{\sqrt{3}}{2}$ ...(2)

By (1) and (2) $a=\sqrt{3}$ & $b^2=\frac{3}{4}$

$$H \equiv \frac{x^2}{3}+\frac{y^2}{\frac{3}{4}}=1$$

Condition for tangency on $y = 2x + c$

$$\Rightarrow \quad c = \pm\sqrt{3(4)-\frac{3}{4}} = \pm\frac{\sqrt{3}\sqrt{15}}{2} = \pm\frac{3\sqrt{5}}{2}$$

6. $\sum_{k=1}^{31} {}^{31}C_k \; {}^{31}C_{k-1} - \sum_{k=1}^{30} {}^{30}C_k \; {}^{30}C_{k-1}$ is equal to

(1) ${}^{62}C_{32} - {}^{39}C_{31}$

(2) ${}^{62}C_{32} - {}^{60}C_{31}$

(3) ${}^{62}C_{31} - 1$

(4) ${}^{62}C_{32}$

Answer (2)

Sol. $\because$ $(1 + x)^n = {}^nC_0 + {}^nC_1 x + {}^nC_2 x^2 + \ldots + {}^nC_n x^n$

$(x + 1)^n = {}^nC_0 x^n + {}^nC_1 x^{n-1} + {}^nC_2 x^{n-2} + \ldots + {}^nC_n$

$\therefore$ $\sum_{k=1}^{n} {}^nC_k \cdot {}^nC_{k-1}$ = coefficient of x^{n+1} in $(1 + x)^{2n}$

$= {}^{2n}C_{n+1}$

$\therefore$ $\sum_{k=1}^{31} {}^{31}C_k \cdot {}^{31}C_{k-1} - \sum_{k=1}^{30} {}^{30}C_k \cdot {}^{30}C_{k-1}$

$= {}^{62}C_{32} - {}^{60}C_{31}$

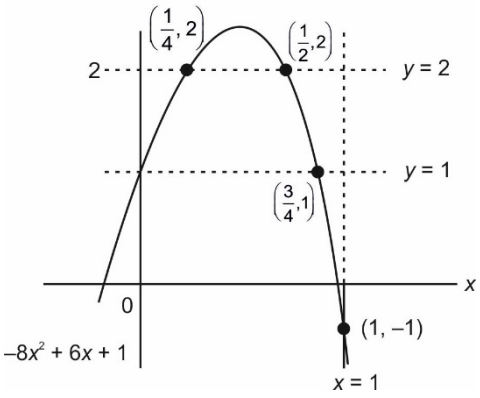
7. If $\int_0^1 \left[-8x^2+6x+1\right]dx = t$, where $[\cdot]$ denotes GIF then t equals to

(1) $\frac{\sqrt{17}-3}{8}$ (2) $\frac{3+\sqrt{17}}{8}$

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

Answer (2)

Sol.



$\because \quad -8x^2+6x+1=0$

Then $x=\dfrac{3+\sqrt{17}}{8}$

$\therefore \quad \int_0^1\left[-8x^2+6x+1\right]dx$

$$=\int_0^{1/4}1\,dx+\int_{1/4}^{1/2}2\,dx+\int_{1/2}^{3/4}1\,dx+\int_{3/4}^{\frac{3+\sqrt{17}}{8}}0\,dx+\int_{\frac{3+\sqrt{17}}{8}}^{1}-1\,dx$$

$$=\frac{1}{4}+\frac{1}{2}+\frac{1}{4}-1+\frac{3+\sqrt{17}}{8}$$

$$=\frac{3+\sqrt{17}}{8}$$

8. Find the number of 5 digit numbers formed by choosing digits from 1, 2, 3, 5, 6, 7 without repetition, such that it is divisible by 6.

(1) 72 (2) 48

(3) 36 (4) 24

Answer (1)

Sol. Given digits 1, 2, 3, 5, 6, 7

If number is divisible by 6 then it should be divisible by 2 and 3 both.

Sum of all the given digits = 24

So digit of 3*k* type should be removed *i.e.*, 3 or 6

Case-I : When we exclude 3

$\_\_\ \_\_\ \_\_\_\_\ \ 2 \text{ or } 6 = 4!\times 2 = 48$

Case-II : When we exclude 6

$\_\_\ \_\_\ \_\_\_\_\ \ \underline{2} = 4! = 24$

$\therefore$ Total numbers = 72

9. Let $f: N \to N$ be defined as

$$f(n)=\begin{cases}2n & \text{if } n=2,4,6,\ldots\\ n-1 & \text{if } n=3,7,11,\ldots\\ \dfrac{n+1}{2} & \text{if } n=1,5,9,\ldots\end{cases}$$

Then $f(n)$ is

(1) One-one and onto

(2) One-one but not onto

(3) Onto but not one-one

(4) Neither one-one nor onto

Answer (1)

$\because \quad f(n)=\begin{cases}2n & \text{if } n=2,4,6,\ldots\\ n-1 & \text{if } n=3,7,11,\ldots\\ \dfrac{n+1}{2} & \text{if } n=1,5,9,\ldots\end{cases}$

When n is even then f(n) = $4n$, $n \in N$

When n is $4\lambda - 1$ type then $f(n) = 2(2n-1)$, $n \in N$

When n is $4\lambda + 1$ type the $f(n) = 2n \pm 1$, $n \in N$.

$\therefore$ $f(n)$ has all values of N

And $f(n)$ has unique value of for each n.

$\therefore$ $f(n)$ is one-one onto function

10. If $A_1, A_2, A_3 \ldots$ are in increasing G.P. and $A_1 A_3 A_5 A_7 = \dfrac{1}{1296}$ and $A_2 + A_4 = \dfrac{7}{36}$, then find the value of $A_6 + A_8 + A_{10}$

(1) 33

(2) 37

(3) 43

(4) 47

Answer (3)

Sol. Let the common ratio be 'r'.

$\because \quad A_1^4 \cdot r^{12} = \dfrac{1}{1296}$

$\Rightarrow \quad A_1 r^3 = \dfrac{1}{6} \qquad \ldots(1)$

and $A_1 r + A_1 r^3 = \dfrac{7}{36}$

$\Rightarrow \quad A_1 r = \dfrac{1}{36} \qquad \ldots(2)$

From (1) and (2), $r^2 = 6$

Now, $A_6 + A_8 + A_{10} = A_1 r^5 (1 + r^2 + r^4)$

$= A_1 r \cdot r^4 \cdot (1 + r^2 + r^4)$

$= \dfrac{1}{36} \cdot 6^2 \cdot (1+6+6^2)$

$= 43$

11. **S I:** $p \rightarrow (\varepsilon \vee q)$

S II: $(\sim p \vee q) \vee (\sim p \vee \varepsilon)$

Which of the following is incorrect?

(1) If S I is true then S II is true

(2) If S I is false then S II is true

(3) If S I is true then S II is false

(4) None of these

Answer (1)

Sol. **S I:** $p \rightarrow (\varepsilon \vee q) \equiv \sim p \vee (\varepsilon \vee q)$

$\equiv (\sim p \vee \varepsilon) \vee (\sim p \vee q)$ **: S II**

So, S I and S II are equivalent.

12. If a curve satisfies the differential equation $\left(e^{\frac{y}{x}} + \frac{x}{\sqrt{x^2 - y^2}}\right)(xdy - ydx) = xdx$ and passes through (1, 0) and $(2\alpha, \alpha)$. Find the value of α.

(1) $\frac{e^{\pi/6}}{2}$ (2) $\frac{e^{\sqrt{e}}}{2}$

(3) $\frac{e^{\sqrt{e}+\pi/6-1}}{2}$ (4) $\frac{e^{\sqrt{e}-\pi/6-1}}{2}$

Answer (3)

Sol. $\left(e^{\frac{y}{x}} + \frac{1}{\sqrt{1-\left(\frac{y}{x}\right)^2}}\right)\left(\frac{xdy - ydx}{x^2}\right) = \frac{dx}{x}$

$\Rightarrow \left(e^{\frac{y}{x}} + \frac{1}{\sqrt{1-\left(\frac{y}{x}\right)^2}}\right) d\left(\frac{y}{x}\right) = \frac{dx}{x}$

$\Rightarrow e^{\frac{y}{x}} + \sin^{-1}\left(\frac{y}{x}\right) = \ln x + C$

When $x = 1, y = 0 \Rightarrow 1 + 0 = 0 + C \Rightarrow C = 1$

When $x = 2\alpha, y = \alpha \Rightarrow e^{\frac{1}{2}} + \frac{\pi}{6} = \ln 2\alpha + 1$

$\Rightarrow 2\alpha = e^{\sqrt{e}+\frac{\pi}{6}-1}$

$\Rightarrow \alpha = \frac{1}{2}e^{\sqrt{e}+\frac{\pi}{6}-1}$

13.

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. Number of three digit numbers having atleast two digits odd is

Answer (475)

Sol. Numbers have two or three odd digits

So Cases can be OEO, OOE, EOO, OOO

So possible number for

OOE $\rightarrow$ $5 \times 5 \times 5 = 125$

OEO $\rightarrow$ $5 \times 5 \times 5 = 125$

EOO $\rightarrow$ $4 \times 5 \times 5 = 100$

OOO $\rightarrow$ $5 \times 5 \times 5 = 125$

Total 475 numbers

22. The term independent of x in $\left(2x^3 + \frac{3}{x^k}\right)^{12}$ is equal to $2^8 \cdot \ell$, where $\ell \in$ odd natural number, then find the number of value of k.

Answer (02)

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

$T_{r+1} = {}^{12}C_r \left(2x^3\right)^{12-r} \cdot \left(\frac{3}{x^k}\right)^r$

$= {}^{12}C_r \, 2^{12-r} \, 3^r \, x^{36-3r-kr}$

For the term independent from x

$36 - 3r - kr = 0 \Rightarrow r = \frac{36}{k+3}$

($\therefore$ k can be 0, 1, 3, 6, 9, 15, 33)

$\therefore$ Independent term ${}^{12}C_r \cdot 2^{12-r} 3^r = 2^8 \cdot \ell$ ($\ell \in$ odd)

So, only k = 3, 6 satisfies the above relation

23. Mean and standard deviation of 15 observations is 8 and 3 respectively. While calculation's observation 20 is misread as 5. What is the correct variance?

Answer (17)

Sol. Let $\bar{x} = 8, \sigma = 3$

Let correct mean is $\bar{x}_c$ and variance = σ_c^2

$\therefore \bar{x}_c = \bar{x} + \frac{20-5}{15} = 9$

and $\frac{\sum X_i^2}{1\delta} - (8)^2 = 9 \Rightarrow \sum X_i^2 = 1095$

For correct observation

$\sum X_{i\,(\text{correct})}^2 = 1095 - 25 + 400 = 1470$

So variance of correct observations is

$\frac{\sum X_{i\,(\text{correct})}^2}{15} - \left(\overline{X_C}\right)^2 = \frac{1470}{15} - \left(9^2\right)$

= 17

24. If $x(1-x^2)\frac{dy}{dx} = 4x^3 - 3x^2y + y$ and $y(2) = -2$, then $y(3)$ is equal to (here $x > 1$)

Answer (–18)

Sol. $\frac{dy}{dx} + \frac{y(3x^2-1)}{x(1-x^2)} = \frac{4x^3}{x(1-x^2)}$

I.F $= e^{\int \frac{3x^2-1}{x(1-x^2)}dx}$

$= e^{-\ln|x^3-x|} = \frac{1}{(x^3-x)}$

Solution of D.E is given by

$y \cdot \frac{1}{(x^3-x)} = \int \frac{4x^3}{x(1-x^2)(x)(x^2-1)}dx$

$\Rightarrow \quad y \cdot \frac{1}{(x^3-x)} = \int \frac{-4x}{(x^2-1)^2}dx$

Let $x^2 - 1 = t$

$\Rightarrow \quad 2xdx = dt$

$\frac{y}{(x^3-x)} = -2\int \frac{dt}{t^2} = \frac{2}{t} + C$

$\frac{y}{x^3-x} = \frac{2}{x^2-1} + C$

at $x = 2$, $y = -2$

$\frac{-2}{6} = \frac{2}{3} + C \Rightarrow C = -1$

At $x = 3$,

$\frac{y}{24} = \frac{1}{4} - 1 \Rightarrow y = -18$

25. Relation defined on set $A = \{1, 2, 3, \ldots, 50\}$.

Let $R_1 = \{(p, p^n)\} : p$ is a prime number, $n \in Z\}$.

$R_2 = \{(p, p^n) : p$ is a prime number, $n = 0, 1\}$.

Find $n(R_1) - n(R_2)$

Answer (08)

While counting $n(R_1) - n(R_2)$ only (p, p^2), (p, p^3), (p, p^4), … type of elements need to be calculated. We find only 8 elements which are $(2, 2^2)$, $(2, 2^3)$, $(2, 2^4)$, $(2, 2^5)$, $(3, 3^2)$, $(3, 3^3)$, $(5, 5^2)$, $(7, 7^2)$.

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