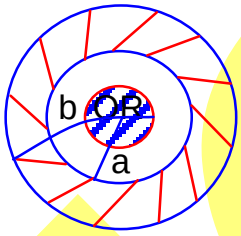
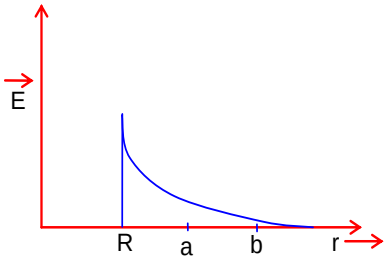
JEE Main- 26-08-2021-Morning
PHYSICS
Section-A

Q1. A solid metal sphere of radius R having charge q is enclosed inside the concentric spherical shell of inner radius a and outer radius b as shown in figure. The approximate variation electric field $\vec{E}$ as a function of distince r from centre O is given by:



(A)


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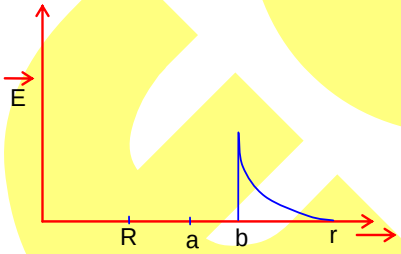

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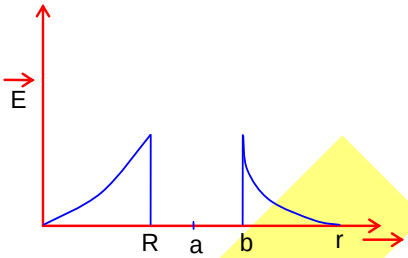
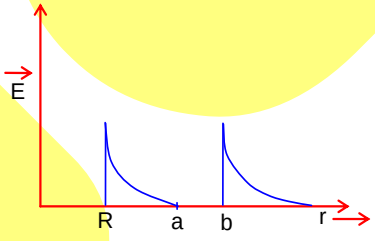


(D)


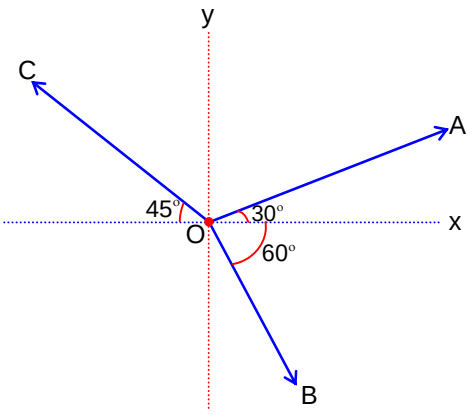
Q2. The rms speed of the molecules of Hydrogen, Oxygen and Carbondioxide at the same temperature are V_H, V_O and V_C respectively then:

(A) $V_C > V_O > V_H$
(B) $V_H > V_O > V_C$
(C) $V_H = V_O = V_C$
(D) $V_H = V_O > V_C$

Q3. In a Screw Gauge, fifth division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation the reading on the main scale is 5 mm and the 20th division of the circular scale coincides with reference line. Calculate the true reading.

(A) 5.25 mm
(B) 5.15 mm
(C) 5.20 mm
(D) 5.00 mm

Q4. The magnitude of vectors $\vec{OA}, \vec{OB}$ and $\vec{OC}$ in the given figure are equal. The direction of $\vec{OA}+\vec{OB}-\vec{OC}$ with x-axis will be :-



(A) $\tan^{-1}\dfrac{\left(\sqrt{3}-1+\sqrt{2}\right)}{\left(1-\sqrt{3}+\sqrt{2}\right)}$

(B) $\tan^{-1}\dfrac{\left(1+\sqrt{3}-\sqrt{2}\right)}{\left(1-\sqrt{3}-\sqrt{2}\right)}$

(C) $\tan^{-1}\dfrac{\left(1-\sqrt{3}-\sqrt{2}\right)}{\left(1+\sqrt{3}+\sqrt{2}\right)}$

(D) $\tan^{-1}\dfrac{\left(\sqrt{3}-1+\sqrt{2}\right)}{\left(1+\sqrt{3}-\sqrt{2}\right)}$

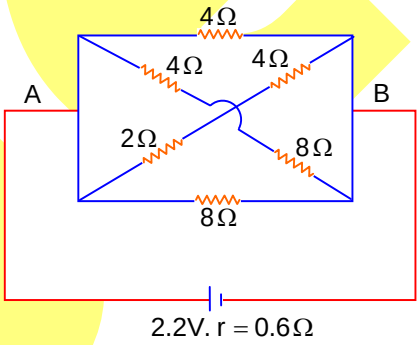
Q5. The fractional change in the magnetic field intensity at a distance 'r' from centre on the axis of current carrying coil of radius 'a' to the magnetic field intensity at the centre of the same coil is : (Take r < a)

(A) $\dfrac{2}{3}\dfrac{a^2}{r^2}$ (B) $\dfrac{2}{3}\dfrac{r^2}{a^2}$

(C) $\dfrac{3}{2}\dfrac{a^2}{r^2}$ (D) $\dfrac{3}{2}\dfrac{r^2}{a^2}$

Q6. In the given figure, the emf of the cell is 2.2V and if internal resistance is 0.6Ω. Calculate the power dissipated in the whole circuit :

(A) 2.2 W
(B) 0.65 W
(C) 4.4 W
(D) 1.32 W



Q7. An inductor coil stores 64 J of magnetic field energy and dissipates energy at the rate of 640 W when a current of 8A is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit in seconds :

(A) 0.8 (B) 0.2
(C) 0.125 (D) 0.4

Q8. If E, L, M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $P = EL^2M^{-5}G^{-2}$ are :-

(A) $\left[M^0L^0T^0\right]$ (B) $\left[M^1L^1T^{-2}\right]$

(C) $\left[M^0L^1T^0\right]$ (D) $\left[M^{-1}L^{-1}T^2\right]$

Q9. A series LCR circuit driven by 300 V at a frequency of 50 Hz contains a resistance $R = 3k\Omega$, an inductor of inductive reactances $X_L = 250\pi\ \Omega$ and an unknown capacitor. The value of capacitance to maximize the average power should be :

(Take $\pi^2 = 10$)

(A) $400\mu F$ (B) $4\ \mu F$

(C) $40\ \mu F$ (D) $25\ \mu F$

Q10. Inside a uniform spherical shell :

(a) the gravitational field is zero
(b) the gravitational potential is zero
(c) the gravitational field is same everywhere
(d) the gravitation potential is same everywhere

(e) all the above

Choose the most appropriate answer from the options given below :

(A) (e) only
(B) (a), (c) and (d) only
(C) (b), (c) and (d) only
(D) (a), (b) and (c) only

Q11. In a photoelectric experiment ultraviolet light of wavelength 280 nm is used with lithium cathode having work function $\phi = 2.5\,eV$. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential. $\left(h = 6.63\times10^{-34}\ Js, c = 3\times10^{8}\ ms^{-1}\right)$

(A) 1.3 V
(B) 1.1 V
(C) 0.6 V
(D) 1.9 V

Q12. Car B overtakes another car A at a relative speed of 40 ms^{-1}. How fast will the image of car B appear to move in the mirror of focal length 10 cm fitted in car A, when the car B is 1.9 m away from the car A?

(A) $0.1\,ms^{-1}$
(B) $0.2ms^{-1}$
(C) $4ms^{-1}$
(D) $40\ ms^{-1}$

Q13. An electric appliance supplies 6000 J/min heat to the system. If the system delivers a power of 90W. How long it would take to increase the internal energy by 2.5×10^3 J ?

(A) $4.1\times10^{1}\,s$
(B) $2.4\times10^{3}\,s$
(C) $2.5\times10^{1}\,s$
(D) $2.5\times10^{2}\,s$

Q14. A particular hydrogen like ion emits radiation of frequency 2.92×10^{15} Hz when it makes transition from n = 3 to n = 1. The frequency in Hz of radiation emitted in transition from n = 2 to n = 1 will be :

(A) 2.46×10^{15}
(B) 4.38×10^{15}
(C) 6.57×10^{15}
(D) 0.44×10^{15}

Q15. The material filled between the plates of a parallel plate capacitor has resistivity $200\ \Omega m$. The value of capacitance of the capacitor is 2 pF. If a potential difference of 40 V is applied across the plates of the capacitor, then the value of leakage current flowing out of the capacitor is : (given the value of relative permitivity of material is 50)

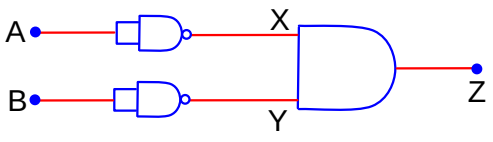
(A) $0.9\,\mu A$
(B) $9.0\,mA$
(C) $9.0\,\mu A$
(D) $0.9\,mA$

Q16. Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.
[Take surface tension of water T = 7.3×10^{-2} Nm^{-1}, angle of contact = 0, g = 10 ms^{-2} and density of water = 1.0×10^3 kg m^{-3}]

(A) 2.19 mm
(B) 4.97 mm
(C) 5.34 mm
(D) 3.62 mm

Q17. Identify the logic operation carried out by the given circuit :-

(A) NAND
(B) NOR
(C) AND
(D) OR



Q18. The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of $20\,ms^{-2}$. The gases come out at a relative speed of $500\,ms^{-1}$ with respect to the rocket :[Use $g = 10 m/s^2$]

(A) $500\,kgs^{-1}$ (B) $10\,kgs^{-1}$

(C) $6.0\times10^2\,kg\,s^{-1}$ (D) $60kg\,s^{-1}$

Q19. **Statement-I:** By doping silicon semiconductor with pentavalent material, the electrons density increases.
Statement-II: The n-type semiconductor has net negative charge.
In the light of the above statements, choose the most appropriate answer from the options given below :
(A) Both Statement-I and Statement-II are true.
(B) Statement-I is true but Statement-II is false.
(C) Statement-I is false but Statement-II is true.
(D) Both Statement-I and Statement-II are false.

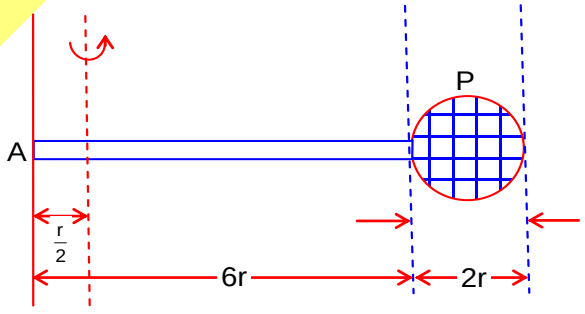
Q20. What equal length of an iron wire and a copper-nickel alloy wire, each of 2 mm diameter connected parallel to give an equivalent resistance of 3Ω?
(Given resistivities of iron and copper-nickel alloy wire are $12\mu\Omega$ cm and $51\mu\Omega$ cm respectively)
(A) 110 m (B) 90 m
(C) 82 m (D) 97 m

Section-B

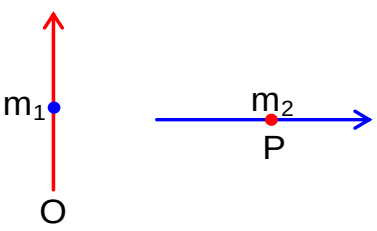
Q1. Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3s with the same initial velocity of 35 m/s, then these balls collide at a height of ..... m. (Take g = 10 m/s^2)

Q2. A source and a detector move away from each other in absence of wind with a speed of 20 m/s with respect to the ground. If the detector detects a frequency of 1800 Hz of the sound coming from the source, then the original frequency of source considering speed of sound in air 340 m/s will be .....Hz.

Q3. Consider a badminton racket with length scales as shown in the figure. If the mass of the linear and circular portions of the badminton racket are same (M) and the mass of the threads are negligible, the moment of inertia of the racket about an axis perpendicular to the handle and in the plane of the ring at, $\frac{r}{2}$ distance from the end A of the handle will _____ Mr^2.



Q4. Two short magnetic dipoles m1 and m2 each having magnetic moment of 1 Am^2 are placed at point O and P respectively. The distance between OP is 1 meter. The torque experienced by the magnetic dipole m2 due to the presence of m_1 is



_____ $\times 10^{-7}$ Nm.

Q5. White light is passed through a double slit and interference is observed on a screen 1.5 m away. The separation between the slits is 0.3 mm. The first violet and red fringes are formed 2.0 mm and 3.5 mm away from the central white fringes. The difference in wavelengths of red and voilet light is ..... nm.

Q6. A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is _____cm.

Q7. A uniform chain of length 3 meter and mass 3 kg overhangs a smooth table with 2 meter laying on the table. If k is the kinetic energy of the chain in joule as it completely slips off the table, then the value of k is _____(Take g = 10 m/s^2)

Q8. The electric field in a plane electromagnetic wave is given by

$$\vec{E} = 200\cos\left[\left(\frac{0.5\times10^3}{m}\right)x - \left(1.5\times10^{11}\frac{rad}{s}\times t\right)\right]\frac{V}{m}\hat{j}$$

If this wave falls normally on a perfectly reflecting surface having an area of 100 cm2. If the radiation pressure exerted by the E.M. wave on the surface during a 10 minute exposure is . $\frac{x}{10^9}\frac{N}{m^2}$. Find the value of x

Q9. An amplitude modulated wave is represented by

$C_m(t) = 10(1+0.2\cos 12560t)\sin(111\times10^4 t)$ volts.

The modulating frequency in kHz will be ..... .

Q10. Two travelling waves produces a standing wave represented by equation, $y = 1.0\ mm\cos(1.57\,cm^{-1})x\sin(78.5\,s^{-1})t$. The node closest to the origin in the region $x > 0$ will be at x = _____cm.

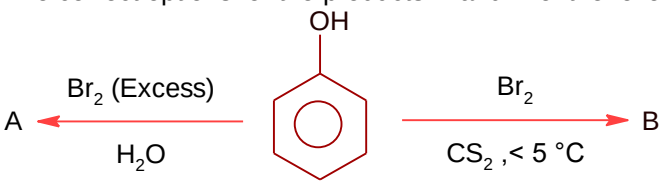
CHEMISTRY
Section-A

Q1. The polymer formed on heating Novolac with formaldehyde is :

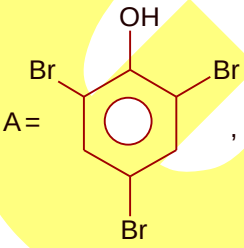
(A) Polyester (B) Bakelite

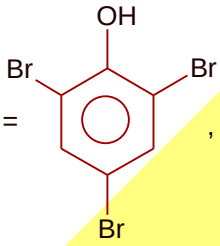
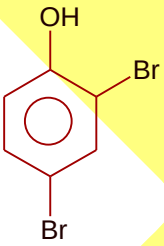
(C) Nylon 6,6 (D) Melamine

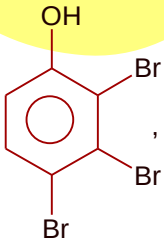
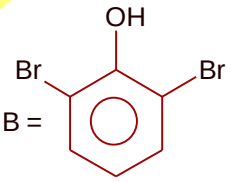
Q2. The correct options for the products **A** and **B** of the following reactions are



(A) A =  , B = 

(B) A =  , B = 

(C) A =  , B = 

(D) A =  , B = 

Q3. What are the products formed in sequence when excess of CO_2 is passed in slaked lime?

(A) $Ca(HCO_3)_2, CaCO_3$ (B) $CaO, CaCO_3$

(C) $CaCO_3, Ca(HCO_3)_2$ (D) $CaO, Ca(HCO_3)_2$

Q4. Which one of the following methods is most suitable for preparing deionized water?

(A) Permutit method (B) Synthetic resin method

(C) Calgon's method (D) Clark's method

Q5. Given below are two statements.

Statement I: In the titration between strong acid and weak base methyl orange is suitable as an indicator.

Statement II: For titration of acetic acid with NaOH phenolphthalein is not a suitable indicator.

In the light of the above statements, choose the **most appropriate** answer from the options given below:

(A) Both **Statement I** and **Statement II** are false

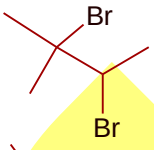
(B) Both **Statement I** and **Statement II** are true

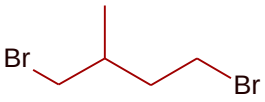
(C) **Statement I** is true but **Statement II** is false

(D) **Statement I** is false but **Statement II** is true

Q6. The major product formed in the following reaction is:

(A) 

(B) 

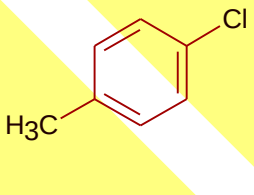
(C) 

(D) 

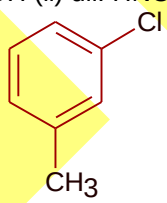
Q7. Given below are two statements.
Statement I: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in positive charges on the nucleus as there is no strong hold on the electron by the nucleus.
Statement II: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in principal quantum number.
In the light of the above statements, choose the **most appropriate** answer from the options given below:
(A) **Statement I** is false but **Statement II** is true
(B) **Statement I** is true but **Statement II** is false
(C) Both **Statement I** and **Statement II** are true
(D) Both **Statement I** and **Statement II** are false

Q8. Which one of the following is correct for the adsorption of a gas at a given temperature on a solid surface?
(A) $\Delta H < 0, \Delta S > 0$
(B) $\Delta H > 0, \Delta S > 0$
(C) $\Delta H < 0, \Delta S < 0$
(D) $\Delta H > 0, \Delta S < 0$

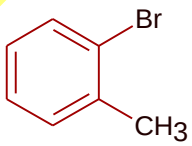
Q9. Among the following compounds I-IV, which one forms a yellow precipitate on reacting sequentially with (i) NaOH (ii) dil. HNO_3 (iii) $AgNO_3$?



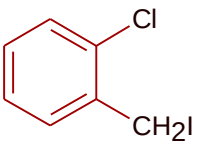
I



II



III



IV

(A) II
(B) IV
(C) III
(D) I

Q10. The conversion of hydroxyapatite occurs due to presence of F^- ions in water. The correct formula of hydroxyapatite is:
(A) $\left[Ca_3(PO_4)_2.CaF_2\right]$
(B) $\left[3Ca_3(PO_4)_2.Ca(OH)_2\right]$
(C) $\left[3Ca_3(PO_4)_2.CaF_2\right]$
(D) $\left[3Ca(OH)_2.CaF_2\right]$

Q11. The correct sequential addition of reagents in the preparation of 3-nitrobenzoic acid from benzene is:

(A) Br_2 / $AlBr_3$, HNO_3 / H_2SO_4, Mg / ether, CO_2, H_3O^+

(B) Br_2 / $AlBr_3$, HNO_3 / H_2SO_4, NaCN, H_3O^+

(C) HNO_3 / H_2SO_4, Br_2 / $AlBr_3$, Mg / ether, CO_2, H_3O^+

(D) Br_2 / $AlBr_3$, NaCN, H_3O^+, HNO_3 / H_2SO_4

Q12. Given below are two statements:
Statement I : The limiting molar conductivity of KCl (strong electrolyte) is higher compared to that of CH_3COOH (weak electrolyte).
Statement II : Molar conductivity decreases with decrease in concentration of electrolyte.
In the light of the above statements, choose the **most appropriate** answer from the options given below :
(A) **Statement I** is false but **Statement II** is true.
(B) Both **Statement I** and **Statement II** are false.
(C) Both **Statement I** and **Statement II** are true.
(D) **Statement I** is true but **Statement II** is false.

Q13. Which one of the following when dissolved in water gives coloured solution in nitrogen atmosphere?

(A) Cu_2Cl_2 (B) $ZnCl_2$

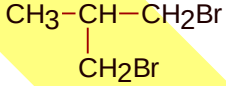
(C) AgCl (D) $CuCl_2$

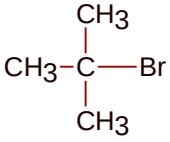
Q14. Which one of the following complexes is violet in colour?

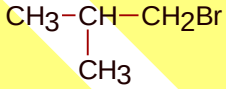
(A) $\left[Fe(CN)_5NOS\right]^{4-}$ (B) $\left[Fe(SCN)_6\right]^{4-}$

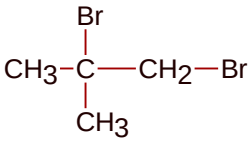
(C) $Fe_4\left[Fe(CN)_6\right]_3.H_2O$ (D) $\left[Fe(CN)_6\right]^{4-}$

Q15. Excess of isobutane on reaction with Br_2 in presence of light at 125°C gives which one of the following, as the major product?

(A) 

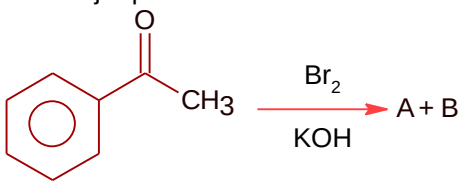
(B) 

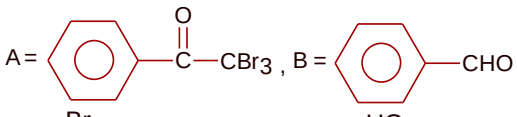
(C) 

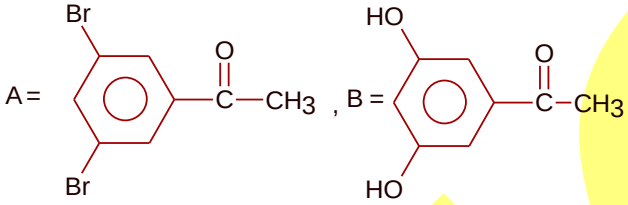
(D) 

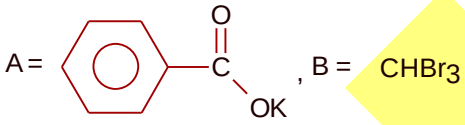
Q16. Given below are two statements.
Statement I: Frenkel defects are vacancy as well as interstitial defects.
Statement II: Frenkel defect leads to colour in ionic solids due to presence of F-centres.
Choose the **most appropriate** answer for the statements from the options given below:
(A) Both **Statement I** and **Statement II** are true
(B) **Statement I** is false but **Statement II** is true
(C) Both **Statement I** and **Statement II** are false
(D) **Statement I** is true but **Statement II** is false

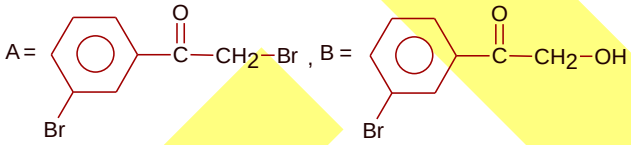
Q17. The major products formed in the following reaction sequence **A** and **B** are :



(A) 

(B) 

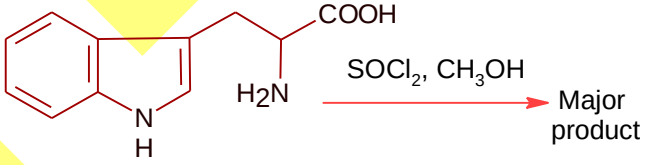
(C) 

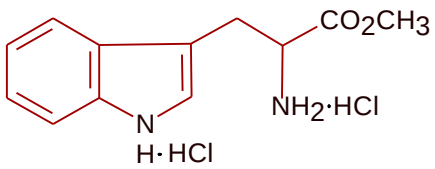
(D) 

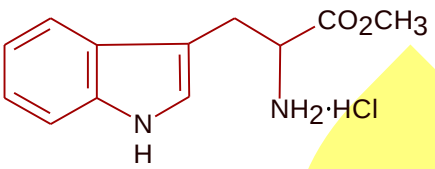
Q18. Given below are two statements.
Statement I: The choice of reducing agents for metals extraction can be made by using Ellingham diagram, a plot of ΔG vs temperature.
Statement II: The value of ΔG increases from left to right in Ellingham diagram.
In the light of the above statements, choose the **most appropriate** answer from the options given below:
(A) Both **Statement I** and **Statement II** are false
(B) **Statement I** is false but **Statement II** is true
(C) **Statement I** is true but **Statement II** is false
(D) Both **Statement I** and **Statement II** are true

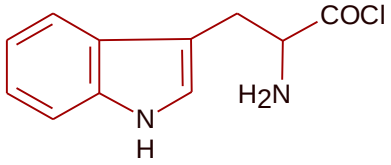
Q19. The **incorrect** statement is:
(A) F_2 is a stronger oxidizing agent than Cl_2 in aqueous solution
(B) On hydrolysis ClF forms HOCl and HF.
(C) Cl_2 is more reactive than ClF.
(D) F_2 is more reactive than ClF.

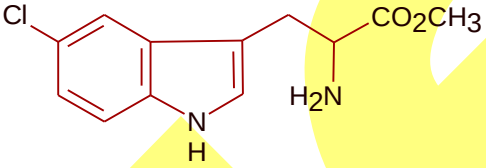
Q20. The major product formed in the following reaction is :



(A) 

(B) 

(C) 

(D) 

Section-B

Q1. The Born-Haber cycle for KCl is evaluated with the following data:

$\Delta_f H^\Theta$ for $KCl = -436.7 kJmol^{-1}$; $\Delta_{sub} H^\Theta$ for $K = 89.2 kJmol^{-1}$;

$\Delta_{ionization} H^\Theta$ for $K = 419.0 kJmol^{-1}$; $\Delta_{electrongain} H^\Theta$ for $Cl_{(g)} = -348.6 kJmol^{-1}$;

$\Delta_{bond} H^\Theta$ for $Cl_2 = 243.0 kJmol^{-1}$

The magnitude of lattice enthalpy of KCl in kJ mol^{-1} is _____ (Nearest integer)

Q2. Of the following four aqueous solutions, total number of those solutions whose freezing point is lower than that of 0.10 M C_2H_5OH is _____
(Integer answer)

(A) 0.10M $Ba_3(PO_4)_2$

(B) 0.10M Na_2SO_4

(C) 0.10 M KCl

(D) 0.10 M Li_3PO_4

Q3. The ratio of number of water molecules in Mohr's salt and potash alum is ____ × 10^{-1}
(Integer answer)

Q4. The following data was obtained for chemical reaction given below at 975 K.

$2NO_{(g)} + 2H_{2(g)} \rightarrow N_{2(g)} + 2H_2O_{(g)}$

	$[NO]$	$[H_2]$	Rate
	$molL^{-1}$	$molL^{-1}$	$molL^{-1}s^{-1}$
(A)	8×10^{-5}	8×10^{-5}	7×10^{-9}
(B)	24×10^{-5}	8×10^{-5}	2.1×10^{-8}
(C)	24×10^{-5}	32×10^{-5}	8.4×10^{-8}

The order of the reaction with respect to NO is _____. [Integer answer]

Q5. The OH^- concentration in a mixture of 5.0 mL of 0.0504 M NH_4Cl and 2 mL of 0.0210 M NH_3 solution is x × 10^{-6} M. The value of x is _____. (Nearest integer)
[Given $K_w = 1\times10^{-14}$ and $K_b = 1.8\times10^{-5}$]

Q6. An aqueous KCl solution of density 1.2 g mL^{-1} has a molality of 3.30 mol kg^{-1}. The molarity of the solution in mol L^{-1} is _____ (Nearest integer)
[Molar mass of KCl = 74.5]

Q7. The total number of negative charge in the tetrapeptide, Gly-Glu-Asp-Tyr, at pH 12.5 will be _____. (Integer answer)

Q8. The number of 4*f* electrons in the ground state electronic configuration of Gd^{2+} is _____.
[Atomic number of Gd = 64]

Q9. These are physical properties of an element
(A) Sublimation enthalpy
(B) Ionisation enthalpy
(C) Hydration enthalpy
(D) Electron gain enthalpy
The total number of above properties that affect the reduction potential is _____
(Integer answer)

Q10. AB_3 is an interhalogen T-shaped molecule. The number of lone pairs of electrons on A is _____. (Integer answer)

MATHEMATICS
Section-A

Q1. The sum of solutions of the equation $\frac{\cos x}{1+\sin x} = |\tan 2x|$, $x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right) - \left\{\frac{\pi}{4}, -\frac{\pi}{4}\right\}$ is:

(A) $-\frac{\pi}{15}$ (B) $\frac{\pi}{10}$

(C) $-\frac{7\pi}{30}$ (D) $-\frac{11\pi}{30}$

Q2. Let $f(x) = \cos\left(2\tan^{-1}\sin\left(\cot^{-1}\sqrt{\frac{1-x}{x}}\right)\right)$, $0 < x < 1$. Then:

(A) $(1-x)^2 f'(x) + 2(f(x))^2 = 0$ (C) $(1-x)^2 f'(x) - 2(f(x))^2 = 0$

(B) $(1+x)^2 f'(x) + 2(f(x))^2 = 0$ (D) $(1+x)^2 f'(x) - 2(f(x))^2 = 0$

Q3. Out of all the patients in a hospital 89% are found to be suffering from heart ailment and 98% are suffering from lungs infection. If K% of them are suffering from both ailments, then K can not belong to the set:

(A) $\{80, 83, 86, 89\}$ (B) $\{84, 87, 90, 93\}$

(C) $\{84, 86, 88, 90\}$ (D) $\{79, 81, 83, 85\}$

Q4. The equation $\arg\left(\frac{z-1}{z+1}\right) = \frac{\pi}{4}$ represents a circle with:

(A) centre at (0, 1) and radius 2 (B) centre at (0, 1) and radius $\sqrt{2}$

(C) centre at (0, –1) and radius $\sqrt{2}$ (D) centre at (0, 0) and radius $\sqrt{2}$

Q5. Let $\theta \in \left(0, \frac{\pi}{2}\right)$. If the system of linear equations.

$(1+\cos^2\theta)x + \sin^2\theta\, y + 4\sin 3\theta\, z = 0$

$\cos^2\theta\, x + (1+\sin^2\theta)y + 4\sin 3\theta\, z = 0$

$\cos^2\theta x + \sin^2\theta\, y + (1+4\sin 3\theta)z = 0$

has a non trivial solution, then the value of θ is:

(A) $\frac{4\pi}{9}$ (B) $\frac{7\pi}{18}$

(C) $\frac{\pi}{18}$ (D) $\frac{5\pi}{18}$

Q6. A plane P contains the line $x + 2y + 3z + 1 = 0 = x - y - z - 6$, and is perpendicular to the plane $-2x + y + z + 8 = 0$. Then which of the following points lies on P?

(A) (2, –1, 1) (B) (0, 1, 1)

(C) (–1, 1, 2) (D) (1, 0, 1)

Q7. The sum of the series $\frac{1}{x+1}+\frac{2}{x^2+1}+\frac{2^2}{x^4+1}+....+\frac{2^{100}}{x^{2^{100}}+1}$ when $x=2$ is:

(A) $1-\frac{2^{100}}{4^{100}-1}$ (B) $1-\frac{2^{101}}{4^{101}-1}$

(C) $1+\frac{2^{100}}{4^{101}-1}$ (D) $1+\frac{2^{101}}{4^{101}-1}$

Q8. If ${}^{20}C_r$ is the co-efficient of x^r in the expansion of $(1+x)^{20}$, then the value of $\sum_{r=0}^{20} r^2\,{}^{20}C_r$ is equal to

(A) 380×2^{18} (B) 420×2^{18}

(C) 420×2^{19} (D) 380×2^{19}

Q9. If $A=\begin{pmatrix}\frac{1}{\sqrt{5}} & \frac{2}{\sqrt{5}}\\ \frac{-2}{\sqrt{5}} & \frac{1}{\sqrt{5}}\end{pmatrix}, B=\begin{pmatrix}1 & 0\\ i & 1\end{pmatrix}, i=\sqrt{-1}$, and $Q=A^TBA$, then the inverse of the matrix $AQ^{2021}A^T$ is equal to

(A) $\begin{pmatrix}1 & 0\\ 2021i & 1\end{pmatrix}$ (B) $\begin{pmatrix}\frac{1}{\sqrt{5}} & -2021\\ 2021 & \frac{1}{\sqrt{5}}\end{pmatrix}$

(C) $\begin{pmatrix}1 & 0\\ -2021i & 1\end{pmatrix}$ (D) $\begin{pmatrix}1 & -2021i\\ 0 & 1\end{pmatrix}$

Q10. The value of $\int_{\frac{-1}{\sqrt{2}}}^{\frac{1}{\sqrt{2}}}\left(\left(\frac{x+1}{x-1}\right)^2+\left(\frac{x-1}{x+1}\right)^2-2\right)^{1/2}dx$ is:

(A) $\log_e 16$ (B) $2\log_e 16$

(C) $\log_e 4$ (D) $4\log_e\left(3+2\sqrt{2}\right)$

Q11. On the ellipse $\frac{x^2}{8}+\frac{y^2}{4}=1$ let P be a point in the second quadrant such that the tangent at P to the ellipse is perpendicular to the line $x+2y=0$. Let S and S' be the foci of the ellipse and e be its eccentricity. If A is the area of the triangle SPS' then, the value of $\left(5-e^2\right)$. A is:

(A) 24 (B) 6

(C) 12 (D) 14

Q12. Let A and B be independent events such that P (A) = p, P(B) = 2p. The largest value of p, for which P (exactly one of A, B occurs) $= \frac{5}{9}$, is:

(A) $\frac{5}{12}$ (B) $\frac{2}{9}$

(C) $\frac{4}{9}$ (D) $\frac{1}{3}$

Q13. If a line along a chord of the circle $4x^2 + 4y^2 + 120x + 675 = 0$, passes through the point (–30, 0) and is tangent to the parabola $y^2 = 30x$, then the length of this chord is:

(A) 7 (B) 5

(C) $5\sqrt{3}$ (D) $3\sqrt{5}$

Q14. If the truth value of the Boolean expression $((p \vee q) \wedge (q \rightarrow r) \wedge (\sim r)) \rightarrow (p \wedge q)$ is false, then the truth values of the statements p, q, r respectively can be:

(A) F T F (B) F F T

(C) T F F (D) T F T

Q15. The mean and standard deviation of 20 observations were calculated as 10 and 2.5 respectively. It was found that by mistake one data value was taken as 25 instead of 35. If α and $\sqrt{\beta}$ are the mean and standard deviation respectively for correct data, then (α, β) is:

(A) (11, 25) (B) (11, 26)

(C) (10.5, 26) (D) (10.5, 25)

Q16. Let ABC be a triangle with A (–3, 1) and $\angle ACB = \theta, 0 < \theta < \frac{\pi}{2}$. If the equation of the median through B is $2x + y - 3 = 0$ and the equation of angle bisector of C is $7x - 4y - 1 = 0$, then $\tan\theta$ is equal to:

(A) $\frac{4}{3}$ (B) $\frac{3}{4}$

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

Q17. Let $y = y(x)$ be a solution curve of the differential equation $(y+1)\tan^2 x\,dx + \tan x\,dy + y\,dx = 0, x \in \left(0, \frac{\pi}{2}\right)$. If $\lim_{x \to 0^+} xy(x) = 1$, then the value of $y\left(\frac{\pi}{4}\right)$ is:

(A) $\frac{\pi}{4}$ (B) $-\frac{\pi}{4}$

(C) $\frac{\pi}{4} + 1$ (D) $\frac{\pi}{4} - 1$

Q18. Let $\vec{a}=\hat{i}+\hat{j}+\hat{k}$ and $\vec{b}=\hat{j}-\hat{k}$. If $\vec{c}$ is a vector such that $\vec{a}\times\vec{c}=\vec{b}$ and $\vec{a}.\vec{c}=3$, then $\vec{a}.\left(\vec{b}\times\vec{c}\right)$ is equal to

(A) –2 (B) –6
(C) 6 (D) 2

Q19. If the sum of an infinite GP $a, ar, ar^2, ar^3, ...$ is 15 and the sum of the squares of its each term is 150, then the sum of $ar^2, ar^4, ar^6, ...$ is:

(A) $\frac{1}{2}$ (B) $\frac{25}{2}$
(C) $\frac{5}{2}$ (D) $\frac{9}{2}$

Q20. The value of $\lim\limits_{n\to\infty}\frac{1}{n}\sum\limits_{r=0}^{2n-1}\frac{n^2}{n^2+4r^2}$ is:

(A) $\frac{1}{4}\tan^{-1}(4)$ (B) $\frac{1}{2}\tan^{-1}(2)$
(C) $\tan^{-1}(4)$ (D) $\frac{1}{2}\tan^{-1}(4)$

Section-B

Q1. A wire of length 36 m is cut into two pieces, one of the pieces is bent to form a square and the other is bent to form a circle. If the sum of the areas of the two figures is minimum, and the circumference of the circle is k (meter), then $\left(\frac{4}{\pi}+1\right)k$ is equal to_____ .

Q2. The sum of all integral values of k $(k\neq 0)$ for which the equation $\frac{2}{x-1}-\frac{1}{x-2}=\frac{2}{k}$ in x has no real roots, is _____

Q3. The area of the region $S=\left\{(x,y):3x^2\le 4y\le 6x+24\right\}$ is _____

Q4. If ${}^1P_1+2.{}^2P_2+3.{}^3P_3+.....+15.{}^{15}P_{15}={}^qP_r-s, 0\le s\le 1$, then ${}^{q+s}C_{r-s}$ is equal to

Q5. Let the line L be the projection of the line $\frac{x-1}{2}=\frac{y-3}{1}=\frac{z-4}{2}$ in the plane $x-2y-z=3$. If d is the distance of the point (0, 0, 6) from L, then d^2 is equal to _____.

Q6. If $y=y(x)$ is an implicit function of x such that $\log_e(x+y)=4xy$, then $\frac{d^2y}{dx^2}$ at $x=0$ is equal to

Q7. The locus of a point which moves such that the sum of squares of its distances from the points (0, 0), (1, 0), (0, 1), (1, 1) is 18 units, is a circle of diameter d. Then d^2 is equal to _____.

Q8. Let $z=\frac{1-i\sqrt{3}}{2}, i=\sqrt{-1}$. Then the value of $21+\left(z+\frac{1}{z}\right)^3+\left(z^2+\frac{1}{z^2}\right)^3+\left(z^3+\frac{1}{z^3}\right)^3+.....+\left(z^{21}+\frac{1}{z^{21}}\right)^3$ is _____.

Q9. Let $a,b\in R, b\neq 0$. Define a function $f(x)=\begin{cases} a\sin\frac{\pi}{2}(x-1), & \text{for } x\leq 0 \\ \frac{\tan 2x-\sin 2x}{bx^3}, & \text{for } x>0 \end{cases}$

If f is continuous at $x=0$, then $10-ab$ is equal to _____

Q10. The number of three digit even numbers, formed by the digits 0, 1, 3, 4, 6, 7 if the repetition of digits is not allowed, is _____,

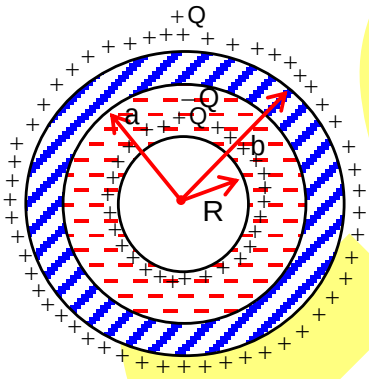
ANSWER- KEY

ANSWER: JEE Main- 26-08-2021-Morning

PHYSICS	CHEMISTRY	MATHEMATICS
Section-A	**Section-A**	**Section-A**
Ans1. D	**Ans1.** B	**Ans1.** D
Ans2. B	**Ans2.** B	**Ans2.** A
Ans3. B	**Ans3.** C	**Ans3.** D
Ans4. C	**Ans4.** B	**Ans4.** B
Ans5. D	**Ans5.** C	**Ans5.** B
Ans6. A	**Ans6.** D	**Ans6.** B
Ans7. B	**Ans7.** A	**Ans7.** B
Ans8. A	**Ans8.** C	**Ans8.** B
Ans9. B	**Ans9.** B	**Ans9.** C
Ans10. B	**Ans10.** B	**Ans10.** A
Ans11. A	**Ans11.** C	**Ans11.** B
Ans12. A	**Ans12.** B	**Ans12.** A
Ans13. D	**Ans13.** D	**Ans13.** D
Ans14. A	**Ans14.** A	**Ans14.** C
Ans15. D	**Ans15.** B	**Ans15.** C
Ans16. A	**Ans16.** D	**Ans16.** A
Ans17. B	**Ans17.** C	**Ans17.** A
Ans18. D	**Ans18.** C	**Ans18.** A
Ans19. B	**Ans19.** C	**Ans19.** A
Ans20. D	**Ans20.** B	**Ans20.** D
Section-B	**Section-B**	**Section-B**
Ans1. 50	**Ans1.** 718	**Ans1.** 36
Ans2. 2025	**Ans2.** 4	**Ans2.** 66
Ans3. 52	**Ans3.** 5	**Ans3.** 27
Ans4. 1	**Ans4.** 1	**Ans4.** 136
Ans5. 300	**Ans5.** 3	**Ans5.** 26
Ans6. 2	**Ans6.** 3	**Ans6.** 40
Ans7. 40	**Ans7.** 4	**Ans7.** 16
Ans8. 354	**Ans8.** 7	**Ans8.** 13
Ans9. 2	**Ans9.** 3	**Ans9.** 14
Ans10. 1	**Ans10.** 2	**Ans10.** 52

SOLUTION: JEE Main- 26-08-2021-Morning
PHYSICS
Section-A

Sol1. Assuming shell to be conducting



For $\dfrac{0 \le r < R}{q_{in} = 0}$,

$E = 0$

$\dfrac{R \le r < a}{q_{in} = Q}$

$E = \dfrac{kQ}{r^2}$

$\dfrac{a \le r < b}{q_{in} = Q - Q = 0}$

$E = 0$

$\dfrac{r \ge b}{q_{in} = Q}$

$E = \dfrac{kQ}{r^2}$

Sol2. $V_{rms} = \sqrt{\dfrac{3RT}{M}}$

$V_{rms} \propto \dfrac{1}{\sqrt{M}}$ at constant T

$V_H : V_O : V_{Co_2} = \dfrac{1}{\sqrt{1}} : \dfrac{1}{\sqrt{16}} : \dfrac{1}{\sqrt{44}}$

$= 1 : \dfrac{1}{4} : \dfrac{1}{2\sqrt{11}}$

$V_H > V_O > V_{Co_2}$

Sol3. Pitch $= 0.5\text{mm}$

Least count $= \dfrac{\text{pitch}}{\text{division}} = \dfrac{0.5\text{mm}}{50} = 0.01\text{mm}$

True Reading $= 5\text{mm} + 20 \times 0.01 - 5 \times 0.01 = 5.15\text{mm}$

Sol4. Let's say $\left|\overrightarrow{OA}\right| = \left|\overrightarrow{OB}\right| = \left|\overrightarrow{OC}\right| = \ell$

$\overrightarrow{OA} = \ell\cos 30^\circ \hat{i} + \ell \sin 30^\circ \hat{j}$

$\overrightarrow{OB} = \ell\cos 60^\circ \hat{i} + \ell \sin 60^\circ \left(-\hat{j}\right)$

$\overrightarrow{OC} = \ell\cos 45^\circ \left(-\hat{i}\right) + \ell \sin 45^\circ \left(+\hat{j}\right)$

$\overrightarrow{OA} + \overrightarrow{OB} - \overrightarrow{OC}$

$= \left[\ell\cos 30^\circ \hat{i} + \ell \sin 30^\circ \hat{j}\right] + \left[\ell\cos 60^\circ \hat{i} + \ell \sin 60^\circ \left(-\hat{j}\right)\right] - \left[\ell\cos 45^\circ \left(-\hat{i}\right) + \ell \sin 45^\circ \left(+\hat{j}\right)\right]$

$$= \left(\ell\cos 30^\circ + \ell\cos 60^\circ + \ell\cos 45^\circ\right)\hat{j} + \left(\ell\sin 30^\circ - \ell\sin 60^\circ - \sin 45^\circ\right)\hat{j}$$

$$= \ell\left(\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{1}{\sqrt{2}}\right)\hat{i} + \ell\left[\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}\right]\hat{j}$$

$$\tan\theta = \frac{\ell\left[\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{\sqrt{2}}{2}\right]}{\ell\left[\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{\sqrt{2}}{2}\right]} = \frac{1-\sqrt{3}-\sqrt{2}}{1+\sqrt{3}+\sqrt{2}}$$

Sol5. $B_{axis} = \dfrac{\mu_0 NIa^2}{2\left(a^2 + r^2\right)^{3/2}}$

$$B_{cent} = \frac{\mu_0 NI}{2a}$$

$$\text{Fractional change} = \frac{B_{centre} - B_{axis}}{B_{centre}}$$

$$= 1 - \frac{B_{axis}}{B_{centre}}$$

$$= 1 - \frac{\dfrac{\mu_0 NIa^2}{2\left(a^2 + r^2\right)^{3/2}}}{\dfrac{\mu_0 NI}{2a}}$$

$$= 1 - \frac{a^3}{a^3\left(1 + \dfrac{r^2}{a^2}\right)^{3/2}}$$

$$= 1 - \left(1 + \frac{r^2}{a^2}\right)^{-3/2}$$

$$= 1 - \left(1 - \frac{3r^2}{2a^2}\right)\left[r \ll a\right]$$

$$= \frac{3r^2}{2a^2}$$

Sol6. $R_{eq} = 0.6\Omega + \dfrac{\dfrac{4\times 12}{4+12} \times \dfrac{6\times 8}{6+8}}{\dfrac{4\times 12}{4+12} + \dfrac{6\times 8}{6+8}}\,\Omega$

$$= 0.6\Omega + \frac{3 \times \dfrac{48}{14}}{3 + \dfrac{48}{14}}\,\Omega$$

$$= 0.6\Omega + \frac{(144/14)\Omega}{\left(\dfrac{90}{14}\right)}$$

$$= 0.6\Omega + 1.6\Omega$$

$$= 2.2\Omega$$

$$P = \frac{v^2}{R_{eq}} = \frac{(2.2V)^2}{2.2\Omega} = 2.2W$$

Sol7. $U_B = \frac{1}{2}LI^2$ .....(i)

$P_R = I^2R$

$\Rightarrow 640 = (8)^2 R$

$R = 10\Omega$

from (i) $64 = \frac{1}{2} \times L \times (8)^2$

$L = 2H$

$I = \frac{L}{R} = \frac{2}{10} = 0.2\,\text{second}$

Sol8. $P = EL^2M^{-5}G^{-2}$

$= \left[ML^2T^{-2}\right]\left[ML^2T^{-1}\right]^2\left[M^{-5}\right]\left[M^{-1}L^3T^{-2}\right]^{-2}$

$= M^0L^0T^0$

Sol9. Power is maximum at resonance

So, $X_L = X_C = \frac{1}{\omega C}$

$\Rightarrow C = \frac{1}{\omega \times X_L}$

$= \frac{1}{(2\pi f) \times X_L}$

$= \frac{1}{2\pi \times 50 \times 250\pi}$

$= \frac{1}{250 \times 100 \times \pi^2}$

$= 4\mu F \quad \left[\pi^2 = 10\right]$

Sol10. Inside a uniform spherical shell, electric field is zero every where & electric potential is constant but not zero, every where

Sol11. $\frac{hc}{\lambda_1} = W + eV_1$

$\frac{hc}{\lambda_2} = W + eV_2$

$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$

$V_1 - V_2 = \frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$

$= 12400\left(\frac{1}{2800} - \frac{1}{4000}\right)$ $\left[\lambda_1 \& \lambda_2 \text{ are taken in } A^\circ\right]$

$= 4.4 - 3.1$

$= 1.3\,V$

Sol12. For mirror

$\vec{V}_{I_1M} = -m^2\vec{V}_{O_1}$

$\vec{V}_{I_1M} \rightarrow$ Velocity of image w.r.t mirror

$\vec{V}_{0M} \rightarrow$ Velocity of object w.r.t mirror

$m \rightarrow$ magnification

$$\frac{1}{v} + \frac{1}{-1.9} = \frac{1}{-0.1}$$

$$\frac{1}{v} = \frac{1}{1.9} - \frac{1}{0.1}$$

$$= \frac{0.1 - 1.9}{1.9 \times 0.1}$$

$$v = \frac{1.9 \times 0.1}{-1.8} = \frac{0.19}{-1.8} = -0.105$$

$$m = -\frac{v}{u} = -\left(\frac{-0.1}{-1.9}\right)$$

$$\left|\vec{V}_{I_1M}\right| = \left(\frac{1}{19}\right)^2 \left|\vec{V}_{O_1M}\right|$$

$$= \frac{1}{(19)^2} \times 40 = 0.1\,m/s$$

Sol13. $$\frac{\Delta U}{t} = \frac{6000}{60} - 90$$

$= 10J$

$$t = \frac{\Delta U}{10} = \frac{2.5 \times 10^3}{10} = 2.5 \times 10^2 \text{ second}$$

Sol14. $$hf_1 = R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = R \times \frac{8}{9}$$

$$hf_2 = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R \times \frac{3}{4}$$

$$\frac{f_1}{f_2} = \frac{8/9}{3/4} = \frac{32}{27}$$

$$f_2 = f_1 \times \left(\frac{27}{32}\right)$$

$$= \left(2.92 \times 10^{15}\right) \times \left(\frac{27}{32}\right)$$

$= 2.46 \times 10^{15} Hz$

Sol15. for discharging RC-circuit

$q = q_0 e^{-t/\tau}$

$$I = \frac{dq}{dt} = \frac{q_0}{\tau} e^{-t/\tau}$$

$$\tau = CR = \left(\frac{k\varepsilon_0 A}{d}\right)\left(\rho\frac{d}{A}\right)[\because \ell = d]$$

$$= (\rho k\varepsilon_0)$$

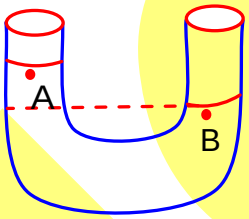
$$I = \frac{q_0}{\rho k\varepsilon_0} e^{-t/\tau}$$

$$I_{max} = \frac{q_0}{\rho k\varepsilon_0} = \frac{2\times10^{-12}\times40}{200\times50\times8.85\times10^{-12}}$$

$$= 0.9mA$$

Sol16. $P_B - P_A = \rho gh$

$$\Rightarrow \left(P_0 - \frac{2T}{r_2}\right) - \left(P_0 - \frac{2T}{r_1}\right) = \rho gh$$



$$h = \frac{2T\left(\frac{1}{r_1} - \frac{1}{r_2}\right)}{\rho g}$$

$$= \frac{2\times7\cdot3\times10^{-2}\times\left(\frac{1}{2.5\times10^{-3}} - \frac{1}{4\times10^{-3}}\right)}{1000\times10}$$

$$= 2.19\times10^{-3} m$$

$$= 2.19 mm$$

Sol17.

A	B	X	Y	Z
1	1	0	0	0
1	0	0	1	0
0	1	1	0	0
0	0	1	1	1

Sol18. $V_{re\ell}\frac{dm}{dt} - mg = F_{ext}$

$$\Rightarrow 500\frac{dm}{dt} - 1000\times10 = 1000\times20$$

$$\frac{dm}{dt} = 60 kg/s$$

Sol19. Pentavalent materials have more electrons and so electron density increase. But overall semiconductor is neutral

Sol20. $\frac{R_1R_2}{R_1+R_2} = 3$

$$\Rightarrow \frac{\left(\rho_1\frac{\ell}{A}\right)\left(\rho_2\frac{\ell}{A}\right)}{\left(\frac{\rho_1\ell}{A}\right)+\left(\frac{\rho_2\ell}{A}\right)} = 3$$

$$\Rightarrow \ell = \frac{3A(\rho_1 + \rho_1)}{\rho_1 \rho_2}$$

$$= \frac{3 \times \left[\frac{\pi}{4} \times \left(2 \times 10^{-3}\right)^2\right][12 + 51] \times 10^{-6} \times 10^{-2}}{12 \times 10^{-6} \times 10^{-2} \times 51 \times 10^{-6} \times 10^{-2}}$$

$$= 97\text{m}$$

Section-B

Sol1. $y_1 = y_2$

$$\Rightarrow 35t - \frac{1}{2}gt^2 = 35(t-3) - \frac{1}{2}g(t-3)^2$$

$$\Rightarrow 35 \times 3 = \frac{1}{2}g(t + t - 3) \times 3$$

$$105 = \frac{10}{2} \times 3 \times (2t - 3)$$

$$t = 5$$

$$y_1 = 35 \times 5 - \frac{1}{2} \times 10 \times 5^2$$

$$= 50\text{m}$$

Sol2. $f' = \frac{340 - 20}{340 + 20} \times f_0$

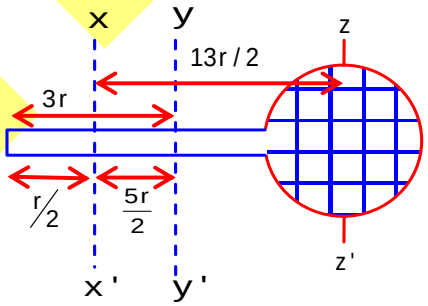
$$\Rightarrow 1800 = \frac{320}{360} \times f_0$$

$$f_0 = 2025\text{Hz}$$

Sol3. $I_{xx'} = \left[I_{yy'} + M\left(\frac{5r}{2}\right)^2\right] + \left[I_{zz'} + M\left(\frac{13r}{2}\right)^2\right]$

$$= M\left(\frac{36r^2}{12}\right) + \frac{M \times 25r^2}{4} + \frac{Mr^2}{2} + M \times \frac{169Mr^2}{4}$$

$$= 52Mr^2$$



Assuming circular portion to be disc

Sol4. $\tau_2 = B_1 M_2 S m 90^\circ$

$$= B_1 M_2$$

$$= \left(\frac{\mu_0}{4\pi} \times \frac{m_1}{r^3}\right) \times m_2$$

$$= 10^{-7} \frac{1}{1^3} \times 1$$

$$= 10^{-7}\text{N} - \text{m}$$

Sol5. For first fringe

$$\frac{dy_1}{D} = 1\times\lambda_1[n=1]\ \lambda_1 \rightarrow \text{Red wavelength}$$

$$\frac{dy_2}{D} = 1\times\lambda_2[n=1]\lambda_2 \rightarrow \text{violet wavelength}$$

$$\frac{d}{D}(y_1 - y_2) = \lambda_1 - \lambda_2$$

$$y_1 - y_2 = \frac{D}{d}(\lambda_1 - \lambda_2)$$

$$= \frac{0.3\times10^{-3}}{1.5}(3.5-2)\times10^{-3}$$

$$= 300\times10^{-9}$$

$$= 300\,\text{nm}$$

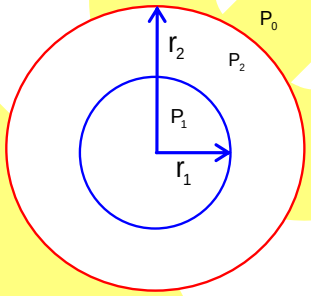
Sol6. $p_1 - p_2 = \frac{4T}{r_1}$ ...(1)

$$p_2 - p_0 = \frac{4T}{r_2} \quad ...(2)$$

(1) + (2), $p_1 - p_0 = 4T\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$

$$\Rightarrow \frac{4T}{r_{eq}} = 4T\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$$

$$r_{eg} = \frac{r_1 r_2}{r_1 + r_2} = \frac{3\times6}{3+6} = 2\,\text{cm}$$



Sol7. $[\lambda x\ 3\times g]\times\frac{3}{2} - [\lambda\times1\times g]\times\frac{1}{2} = K$

$$\lambda \Rightarrow \frac{\text{mass}}{\text{length}}$$

$$\Rightarrow \lambda g\left(\frac{9}{2}-\frac{1}{2}\right) = K$$

$$\Rightarrow \frac{3}{3}\times10\times4 = K$$

$$K = 40\,J$$

Sol8. $P = \frac{2I}{C}$ $P \rightarrow$ radiation pressure

$$= \frac{2}{C}\left(\frac{1}{2}\varepsilon_0 E_0^2 C\right)$$

$$= \varepsilon_0 E_0^2$$

$$= \left(8.85\times10^{-12}\right)\times\left(200\right)^2$$

$$= 354\times10^{-9}\,N/m^2$$

Sol9. $\omega_{modulation} = 2\pi f_{modulation}$

$$f_{modulation} = \frac{\omega_{modulation}}{2\pi}$$

$$= \frac{12560}{2\pi}$$

$$= 2000\,Hz$$

$$= 2\,kHz$$

Sol10. $kx = \pi/2$

$$\Rightarrow 1.57x = \frac{\pi}{2} = \frac{3.14}{2} = 1.57$$

$$x = 1\,cm$$

CHEMISTRY
Section-A

Sol1. Bakelite formed by the condensation reaction of phenol with formaldehyde and it is a thermosetting polymer/ plastics.

Sol2. CS_2 is non- polar, non- ionisable solvent and produce only para substituted compound due to the production of less Br^+ ion, while H_2O itself a polar solvent and produce sufficient concentration of Br^+ to attack on ortho and para position.

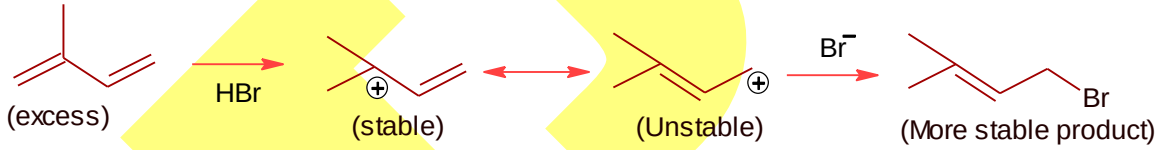
Sol3. $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$ (1st step of reaction)

$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$ (2nd step of reaction)

Sol4. De-ionised water means dissolved mineral free water which is prepared by synthetic resin method. Where cation exchanged by H^+ and anion exchanged by OH^- of resin.

Sol5. Statement I is true because methyl orange indicator has pH range (3.2 to 4.2) which is suitable for buffer produced by strong acid and weak base.
Statement II is false because phenolphthalein has pH range (8.4 to 10.2) and only suitable for equivalence point above than 7, In this case pH increased by the addition of NaOH on acetic acid.

Sol6.



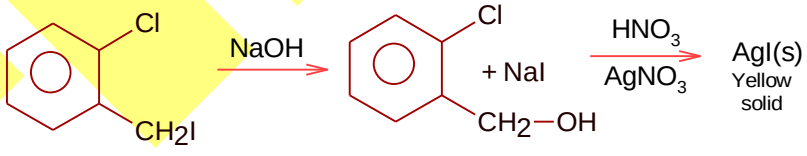
Sol7. According to Bohr's model, velocity of electron increases according to atomic number (z).

$V_e \propto \frac{z}{n}$ (z = Atomic number and n = number of shell / principal quantum number)

Similarly, velocity of electron decreases according to number of shell (i.e principal quantum number).

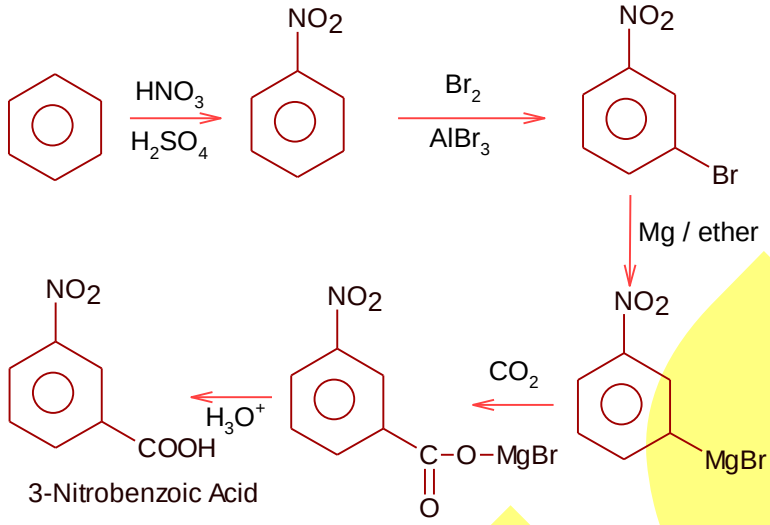
Sol8. During adsorption of a gas on solid surface, process is exothermic i.e. $\Delta H = -ve$ $(\Delta H < 0)$ and entropy decreased, because gas particle resides on solid surface. Hence $\Delta S < 0$.

Sol9. Yellow precipitate is AgI(s) which only produce by structure IV



Sol10. Hydroxyapatite is the calcium minerals whose molecular formula is $3Ca_3(PO_4)_2$. $Ca(OH)_2$ or $Ca_{10}(PO_4)_6(OH)_2$. During contact with water dissolved F^- ion, hydroxyapatite converted into $3Ca_3(PO_4)_2$. CaF_2 .

Sol11.

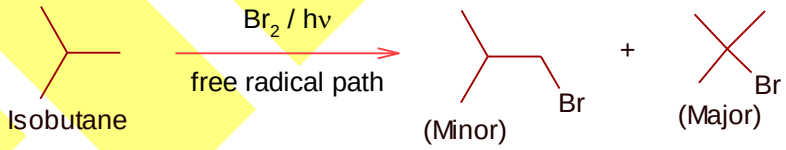


Sol12. Molar conductivity measured at infinite dilution is called limiting molar conductivity. Hence at infinite dilution stage, both strong electrolyte (KCl) and weak electrolyte (CH_3COOH) have identical value of conductivity. Therefore statement –I is false.
Statement-II is also false because molar conductivity increases by the decreasing the concentration of electrolyte.

Sol13. Cu_2Cl_2 + Water $\longrightarrow$ Insoluble
AgCl + Water $\longrightarrow$ Insoluble
$ZnCl_2$ + Water $\longrightarrow$ Colourless solution
$CuCl_2$ + Water $\longrightarrow$ Coloured solution due to $3d^9$ electronic configuration.

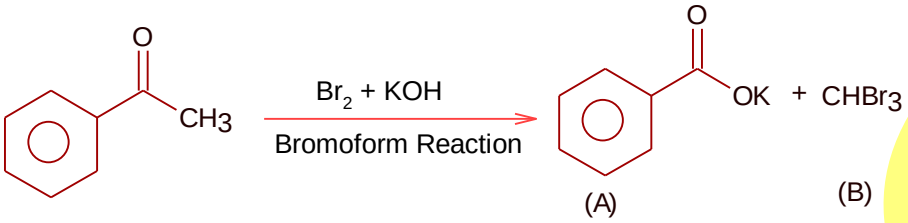
Sol14. $\left[Fe(CN)_5NOS\right]^{4-}$ $\longrightarrow$ Violet colour
$\left[Fe(SCN)_6\right]^{4-}$ $\longrightarrow$ Blood red colour
$Fe_4\left[Fe(CN)_6\right]_3.H_2O$ $\longrightarrow$ Prussian blue colour
$\left[Fe(CN)_6\right]^{4-}$ $\longrightarrow$ Yellow colour

Sol15.



Sol16. In Frenkel defect, cations are inserted in neighbouring site, therefore statement-I is correct, because vacancy developed by missing cations and interstitial sites are equal. Statement II is false because F-centre developed by metal excess defect due to anion vacancies.

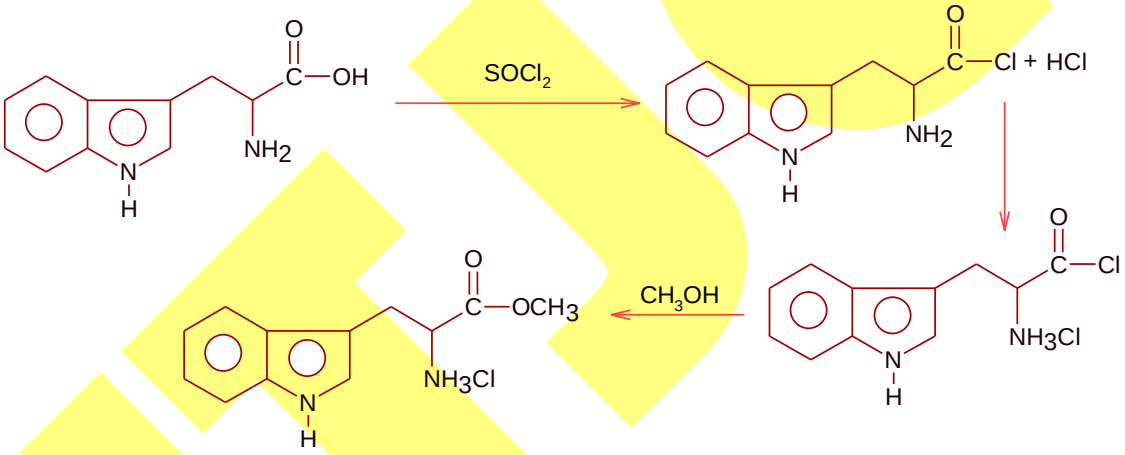
Sol17.



Sol18. Statement-I is true, because metal reduced by decreasing ΔG in Elligham diagram but statement-II is false, Ellingham diagram is ΔG vs temperature graph has no relation with ΔS.

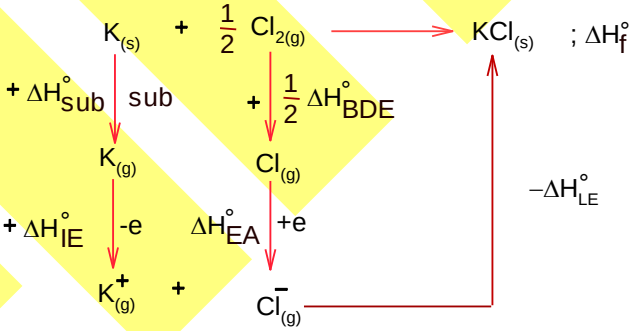
Sol19. Reactivity order of halogens and inter halogens are $F_2 > ClF > Cl_2$ and ClF forms HOCl and HF after the reaction with water.

Sol20.



Section-B

Sol1.



$$\Delta H_f^0 = \left(+\Delta H_{sub}^0\right) + \left(+\Delta H_{IE}^0\right) + \left(+\frac{1}{2}\Delta H_{BDE}^0\right) + \left(\Delta H_{EA}^0\right) + \left(-\Delta H_{LE}^0\right)$$

$$-436.7 = (89.2) + (419) + \left(\frac{1}{2}\times 243\right) + (-348.6) + \left(-\Delta H_{LE}^0\right)$$

OR $\Delta H_{LE}^0 = 89.2 + 419 + 121.5 - 348.6 + 436.7 kJmol^{-1}$

$\therefore$ Lattice energy = 717.8

Ans. = 718 (Nearest integer)

Sol2. All the solution have higher ion production with respect to 0.1M C_2H_5OH i.e 0.1 M $Ba_3(PO_4)_2$, 0.1M Na_2SO_4, 0.1 M KCl and 0.1 M Li_3PO_4. Hence all have lowered freezing point than 0.1 M C_2H_5OH (which is non- ionisable in aqueous medium).
Ans.= 4

Sol3. Molecular formula of Mohr' salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$.
Molecular formula of potash alum = $K_2SO_4.Al_2(SO_4)_3.24H_2O$. Overall molecular formula of potash alum = $KAl(SO_4)_2.12H_2O$. Ratio of water molecules in Mohr' salt and Potash alum

$= \frac{6}{12} = \frac{1}{2} = 0.5 = 5\times10^{-1}$

Ans = 5

Sol4. If $\text{Rate} = K[NO]^a[H_2]^b$

Case I $\Rightarrow 7\times10^{-9} = K\left(8\times10^{-5}\right)^a\left(8\times10^{-5}\right)^b$

Case II $\Rightarrow 2.1\times10^{-8} = K\left(24\times10^{-5}\right)^a\left(8\times10^{-5}\right)^b$

Therefore, $\frac{7\times10^{-1}}{2.1} = \left(\frac{1}{3}\right)^a$

or $\left(\frac{1}{3}\right)^1 = \left(\frac{1}{3}\right)^a \therefore a = 1$

Ans. = 1

Sol5. 0.0504 M NH_4Cl of 5ml $\Rightarrow$ millimole of $NH_4^+ = 0.0504\times5$

0.0210 M NH_3 of 2ml $\Rightarrow$ millimole of $NH_3 = 0.0210\times2$

It is a basic buffer.
Total volume = 7ml

Here, $K_b = \frac{\left[OH^-\right]\times\left[NH_4^+\right]}{\left[NH_4OH\right]}$

$\therefore 1.8\times10^{-5} = \frac{\left[OH^-\right]\times0.0504\times5}{0.0210\times2}$

$\therefore \left[OH^-\right] = \frac{1.8\times10^{-5}\times0.0210\times2}{0.0504\times5} = 0.3\times10^{-5}M$

$\therefore \left[OH^-\right] = 3\times10^{-6}M$

$\therefore x = 3$

Ans. = 3

Sol6. KCl solution has molality (m) = 3.3, [Means 3.3 mol of KCl dissolved in 1 kg of solvent]
Total mass of solution = mass of solute + mass of solvent

$= 3.3\times74.5 + 1000gm$

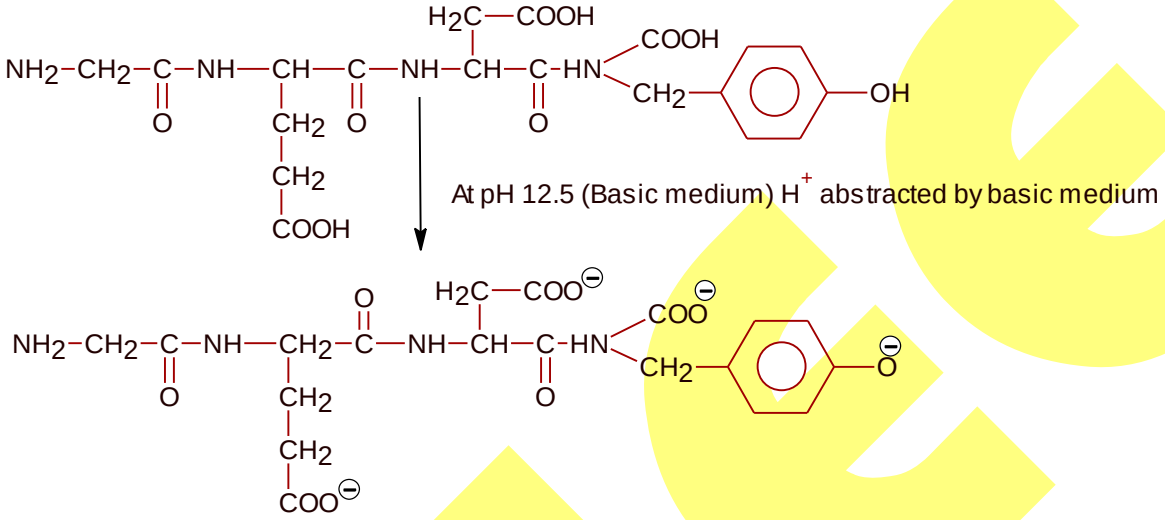
$= 1245.85gm$

Volume of solution = $\frac{\text{Mass}}{\text{density}} = = \frac{1245.85}{1.2} = 1038.20ml$

$M = \frac{\text{moles}\times1000}{V(ml)} = \frac{3.3\times1000}{1038.2} = 3.17M$

Ans. = 3 (Nearest integer)

Sol7. Molecular structure of tetrapeptide Gly-Glu-Asp -Tyr is;



Total negative charge developed at pH 12.5 = 4
Ans. = 4

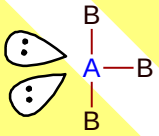
Sol8. Electronic configuration of
Gd is ; $Gd_{64} = [Xe]4f^7 5d^1 6s^2$

Hence $Gd_{64}^{++} = [Xe]4f^7 5d^1 6s^0$

Total number of electrons in 4f sub-shell = 7
Ans. = 7

Sol9. Except electron gain enthalpy all the physical properties like sublimation enthalpy, ionization enthalpy and hydration energy affected the value of reduction potential.
Ans. =3

Sol10. For AB_3 interhalogen compound, which is T- shaped, only two lone pair electrons are available on central atom.



Ans. = 2

MATHEMATICS
Section-A

Sol1. Given equation

$$\Rightarrow \frac{\cos x}{1+\sin x} = \frac{2|\sin x|\cos x}{|\cos^2 x - \sin^2 x|}$$

$$\Rightarrow |1-2\sin^2 x| = 2|\sin x|(1+\sin x)$$

Put sin x = t
then equation,

$$|1-2t^2| = 2|t|(1+t), t \in (-1,1) - \left\{\pm\frac{1}{\sqrt{2}}\right\}$$

Case I : For $t \geq \frac{1}{\sqrt{2}}$

the equation has no solution

Case II : For $0 \leq t < \frac{1}{\sqrt{2}}$

Equation $\Rightarrow t = \frac{\sqrt{5}-1}{4} \Rightarrow x = 18^o$

Case III : For $\frac{-1}{\sqrt{2}} < t < 0$

Equation $\Rightarrow t = \frac{-1}{2} \Rightarrow x = -30^o$

Case IV : For $t < -\frac{1}{\sqrt{2}}$

Equation $\Rightarrow t = -\frac{\sqrt{5}+1}{4} \Rightarrow x = -54^o$

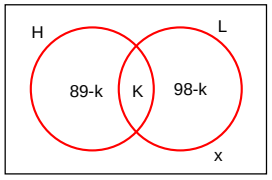
Sum of solutions = $18^o - 30^o - 54^o = -66^o$

Sol2. $f(x) = \frac{1-x}{1+x}, 0 < x < 1$ (on simplification)

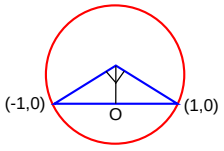
$$\Rightarrow f'(x) = \frac{-2}{(1+x)^2}$$

$$\Rightarrow (1-x)^2 f'(x) = -2(f(x))^2$$

Sol3. $89-k+k+98-k+x=100$
$\Rightarrow 87 \leq k \leq 89$



Sol4. Centre (0, 1)
Radius = $\sqrt{2}$



Sol5. $\Delta = 0$

$\Rightarrow \sin 3\theta = -\frac{1}{2}$

but $0 < \theta < \frac{\pi}{2}$

$\Rightarrow \theta = 70^{o}$

Sol6. $\perp^{r}$ planes

$\Rightarrow \vec{n}_1, \vec{n}_2 = 0 \Rightarrow \lambda = \frac{3}{4}$

Where required plane P is

$(1+\lambda)x + (2-\lambda)y + (3-\lambda)z + 1 - 6\lambda = 0$

$\Rightarrow 2x + y + 2z - 5 = 0$

Sol7. $S - \frac{1}{x-1} = \frac{-2^{101}}{\left(x^{2^{100}}\right)^2 - 1}$

For $x = 2, S = 1 - \frac{2^{101}}{4^{101} - 1}$

Sol8. $(1+x)^{20} = \sum_{r=0}^{20} {}^{20}C_r x^r$

(on differentiating both sides)

$\Rightarrow 20(1+x)^{19} = \Sigma r.{}^{20}C_r x^{r-1}$

$\Rightarrow 20(1+x)^{19}.x = \Sigma r.{}^{20}C_r x^{r}$

$\Rightarrow 20\left[(1+x)^{19} + 19x(1+x)^{18}\right] = \Sigma r^2.{}^{20}C_r x^{r-1}$

$x = 1 \Rightarrow \sum_{r=0}^{20} r^2.{}^{20}C_r = 20.2^{18}.21$

Sol9. $AA^T = A^TA = I$

$A\left(A^TBA\right)^{2021}A^T$

$= B^{2021} = (I+P)^{2021} = I + 2021P = \begin{bmatrix} 1 & 0 \\ 2021i & 1 \end{bmatrix}$

$\Rightarrow \left(B^{2021}\right)^{-1} = \begin{bmatrix} 1 & 0 \\ -2021i & 1 \end{bmatrix}$

where $P = \begin{bmatrix} 0 & 0 \\ i & 0 \end{bmatrix}$

Sol10. $I = \int_{-\frac{1}{\sqrt{2}}}^{\frac{1}{\sqrt{2}}} \left(\frac{16x^2}{\left(x^2-1\right)^2}\right)^{\frac{1}{2}} dx$

$= 2\int_{0}^{\frac{1}{\sqrt{2}}} \frac{4x}{1-x^2} dx$

$= 4\ln 2$

Sol11. $T_{(P)} : \frac{xx_1}{8} + \frac{yy_1}{4} = 1,$

where $\frac{x_1 2}{8} + \frac{y_1 2}{4} = 1 \ldots\ldots\ldots(i)$

given : slope = 2

$\Rightarrow x_1 = -4y_1 \ldots\ldots\ldots(ii)$

(i) & (ii) $\Rightarrow P\left(-\frac{8}{3}, \frac{2}{3}\right)$

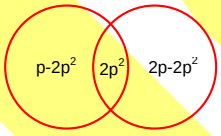
$e = \frac{1}{\sqrt{2}}$

$A = ar(PSS') = \frac{4}{3}$

$\left(5 - e^2\right)A = 6$

Sol12. $P - 2P^2 + 2P - 2P^2 = \frac{5}{9}$

$\Rightarrow P = \frac{5}{12}, \frac{1}{3}$



Sol13. $P\left(\frac{15}{2}t^2, 15t\right)$

$C(-15,0)$

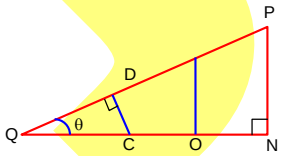
$Q(-30,0)$

$\tan\theta = \frac{PN}{QN}$

$\Rightarrow \frac{1}{t} = \frac{15t}{30 + \frac{15}{2}t^2}$

$\Rightarrow t = 2$

Tangent = $y = \frac{1}{2}(x + 30)$



PQ is the common tangent

Sol14.

p	q	r	$p \vee q$	$q \to r$	$A = (p \vee q) \wedge (q \to r)$	$B = \sim r$	$A \wedge B$	$C = p \wedge q$	$A \wedge B \to C$
F	T	F	T	F	F	T	F	F	T
F	F	T	F	T	F	F	F	F	T
T	F	F	T	T	T	T	T	F	F
T	F	T	T	T	T	F	F	F	F

Sol15. $\Sigma X = 200$

$\Sigma x^2 = 2125$

For new data

$\Sigma x = 200 - 25 + 35 = 210$

$\bar{x} = 10.5$

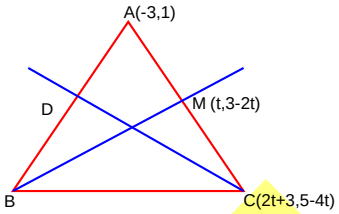
$\Sigma x^2 = 2725$

$$\sigma^2 = \frac{2725}{20} - (10.5)^2 = 26$$

Sol16. Line $BM: 2x + y = 3 \Rightarrow M(0,3)$

Line $CD: 7x - 4y = 1 \Rightarrow C(3,5)$

Mirror image of $A(-3,1)$ in the line CD is $\left(\frac{13}{5}, \frac{-11}{5}\right)$ and it will lie on BC.



Slope of AC is 2/3

Slope of BC is 18.

$$\tan\theta = \frac{18 - \frac{2}{3}}{1 + 18\left(\frac{2}{3}\right)} = \frac{4}{3}$$

where $\theta = \angle ACB$

Sol17. $\frac{dy}{dx} + \frac{\sec^2 x}{\tan x} y = -\tan x$

$IF = \tan x$

Solution : $y \tan x = x - \tan x + C$

$\lim\limits_{x \to 0^+} xy = 1 \Rightarrow C = 1$

For $x = \frac{\pi}{4}, y = \frac{\pi}{4}$

Sol18. $\vec{a}.\vec{b} \times \vec{c}$

$= \vec{b}.\vec{c} \times \vec{a}$

$= \vec{b}.(-\vec{b})$

$= -|\vec{b}|^2 = 2$

Sol19. $\frac{a}{1-r} = 15, \frac{a^2}{1-r^2} = 150$

$\Rightarrow r = \frac{1}{5}, a = 12$

$\Rightarrow \frac{ar^2}{1-r^2} = \frac{1}{2}$

Sol20. Given limit

$$= \int_0^2 \frac{dx}{1 + 4x^2}$$

$$= \left[\frac{1}{2}\tan^{-1} 2x\right]_0^2 = \frac{1}{2}\tan^{-1} 4$$

Section-B

Sol1. Side of square = a

Radius of circle = r

Given : $4a+2\pi r=36$

$S=a^2+\pi r^2$

$=\left(\frac{\pi^2}{4}+\pi\right)r^2-9\pi r+81$

$\frac{ds}{dr}=0\Rightarrow r=\frac{18}{\pi+4}$

Sol2. Equation : $2x^2-(6+k)x+4+3k=0$

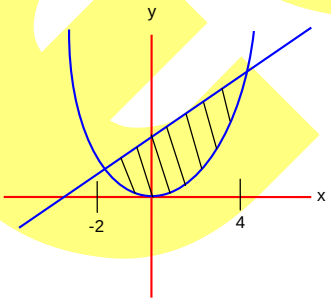
$D<0\Rightarrow 6-4\sqrt{2}<k<6+4\sqrt{2}$

Sum of integral values of K is 1+2+3+….+11 = 66

Sol3. Required area

$=\int_{-2}^{4}\left(\frac{3x}{2}+6-\frac{3x^2}{4}\right)dx=27$

$\frac{3x^2}{4}=\frac{3x}{2}+6\Rightarrow x=-2,4$



Sol4. LHS = $\sum_{r=1}^{15}r(r!)$

$=\Sigma(r+1-1)r!\quad=\sum_{r=1}^{15}(r+1)!-r!$

$=(2!-1!)+(3!-2!)+....+(16!-15!)$

$=16!-1$

$={}^{16}P_{16}-1$

Sol5. $B(1+2\lambda,3+\lambda,4+2\lambda)$

$x-2y-z=3\Rightarrow\lambda=-6\Rightarrow B(-11,-3,-8)$

$N(1+t,3-2t,4-t)$

$x-2y-z=3\Rightarrow t=2\Rightarrow N(3,-1,2)$

Line NB : $\frac{x-3}{7}=\frac{y+1}{1}=\frac{3-2}{5}$

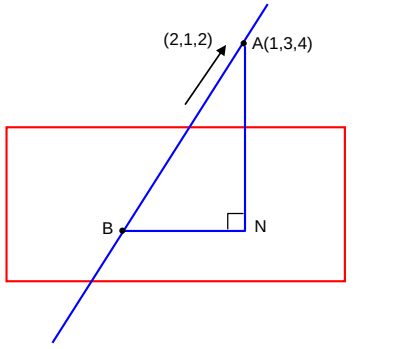
$d^2=PM^2=\frac{\left|\vec{PQ}\times\vec{R}\right|^2}{\left|\vec{R}\right|^2}$

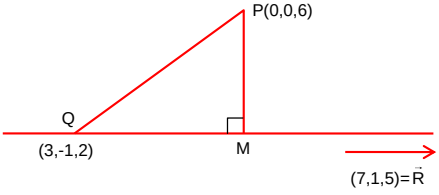
$\vec{PQ}\times\vec{R}=(-1,-43,10)$

$\left|\vec{PR}\times\vec{R}\right|^2=1950$

$\left|\vec{R}\right|^2=75$

$d^2=\frac{1950}{75}=26$





Sol6. $\ln(x+y)=4xy$

$$\Rightarrow \frac{dy}{dx}=\frac{4xy+4y^2-1}{1-4x^2-4xy},$$

$$\frac{d^2y}{dx^2}=\frac{(1-4x^2-4xy)(4y+4xy'+8yy')-(4xy+4y^2-1)(-8x-4y-4xy')}{(1-4x^2-4xy)^2}$$

For $x=0, y=1$

$$\frac{dy}{dx}=3, \frac{d^2y}{dx^2}=40$$

Sol7. $x^2+y^2+(x-1)^2+y^2+x^2+(y-1)^2+(x-1)^2+(y-1)^2=18$

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

$$r^2=\frac{1}{4}+\frac{1}{4}+\frac{7}{2}=4$$

Sol8. $S=21+\sum_{k=1}^{21}\left(z^k+\frac{1}{z^k}\right)^3=\sum\left(z^k+\bar{z}^k\right)^3=8\sum\left(\text{Re}\left(z^k\right)\right)^3$

(As $|z|=1\Rightarrow \frac{1}{z}=\bar{z}$)

$$S=2\sum_{k=1}^{21}\cos k\pi+6\sum_{k=1}^{21}\cos\frac{k\pi}{3}+21$$

$$=2(-1)+6\,\text{Re}\left(\alpha+\alpha^2+\alpha^3\right)+21$$

Where $\alpha=e^{i(2\pi/6)}$

$$=2(-1)+6\left(\frac{1}{2}-\frac{1}{2}-1\right)+21$$

$$=-8+21=13$$

Sol9. $f(0^-)=f(0)=-a$

$$f(0^+)=\lim_{x\to 0^+}\frac{\sin 2x\left(\frac{1}{\cos 2x}-1\right)}{bx^3}=\frac{4}{b}$$

$ab=-4\Rightarrow 10-ab=14$

Sol10. Total number = $20+8+24=52$