

FIITJEE

Solutions to JEE(Main) -2023

Test Date: 24th January 2023 (First Shift)

PHYSICS, CHEMISTRY & MATHEMATICS

Paper - 1

Time Allotted: 3 Hours

Maximum Marks: 300

- Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose.

Important Instructions:

1. The test is of 3 hours duration.
2. This test paper consists of 90 questions. Each subject (PCM) has 30 questions. The maximum marks are 300.
3. This question paper contains **Three Parts**. **Part-A** is Physics, **Part-B** is Chemistry and **Part-C** is Mathematics. Each part has only two sections: **Section-A** and **Section-B**.
4. **Section – A** : Attempt all questions.
5. **Section – B** : Do any 5 questions out of 10 Questions.
6. **Section-A (01 – 20)** 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.
7. **Section-B (1 – 10)** contains 10 Numerical based questions. The answer to each question is rounded off to the nearest integer value. Each question carries **+4 marks** for correct answer and **–1 mark** for wrong answer.

PART – A (PHYSICS)

SECTION - A

(One Options Correct Type)

This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.

Q1. Match List I with List II

List – I

- (A) Planck's constant (h)
- (B) Stopping potential (V_s)
- (C) Work function (ϕ)
- (D) Momentum (p)

List – II

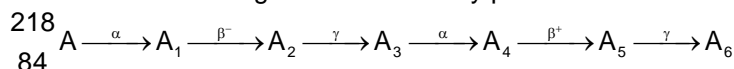
- (I) $[M^1L^2T^{-2}]$
- (II) $[M^1L^1T^{-1}]$
- (III) $[M^1L^2T^{-1}]$
- (IV) $[M^1L^2T^{-3}A^{-1}]$

Choose the correct answer from the options given below :

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

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

Q2. Consider the following radioactive decay process



The mass number and the atomic number of A_6 are given by:

- (A) 210 and 84
- (B) 210 and 82
- (C) 210 and 80
- (D) 211 and 80

Q3. The maximum vertical height to which a man can throw a ball is 136m. The maximum horizontal distance upto which he can throw the same ball is :

- (A) 136 m
- (B) 272 m
- (C) 68 m
- (D) 192 m

Q4. Given below are two statements :

Statement I : An elevator can go up or down with uniform speed when its weight is balanced with the tension of its cable.

Statement II : Force exerted by the floor of an elevator on the foot of a person standing on it is more than his/her weight when the elevator goes down with increasing speed.

In the light of the above statements, choose the correct answer from the options given below :

- (A) Statement I is false but Statement II is true
- (B) Both Statement I and Statement II are true
- (C) Both Statement I and Statement II are false
- (D) Statement I is true but Statement II is false

Q5. The weight of a body at the surface of earth is 18N. The weight of the body at an altitude of 3200km above the earth's surface is (given, radius of earth $R_e = 6400$ km):

- (A) 19.6 N
- (B) 4.9 N
- (C) 9.8 N
- (D) 8 N

Q6. 1g of a liquid is converted to vapour at 3×10^5 Pa pressure. If 10% of the heat supplied is used for increasing the volume by 1600 cm^3 during this phase change, then the increase in internal energy in the process will be :

- (A) $4.32 \times 10^8 \text{ J}$
- (B) 4800 J
- (C) 432000 J
- (D) 4320 J

Q7. Given below are two statements:

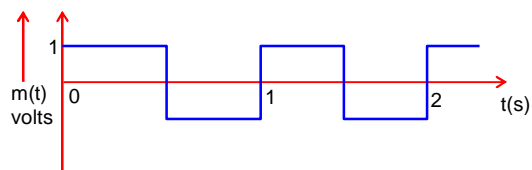
Statement I : If the Brewster's angle for the light propagation from air to glass is θ_B , then the Brewster's angle for the light propagating from glass to air is $\frac{\pi}{2} - \theta_B$

Statement II : The Brewster's angle for the light propagating from glass to air is $\tan^{-1}(\mu_g)$ where μ_g is the refractive index of glass.

In the light of the above statements, choose the correct answer from the options given below :

- (A) Statement I is false but Statement II is true
 (B) Both Statements 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

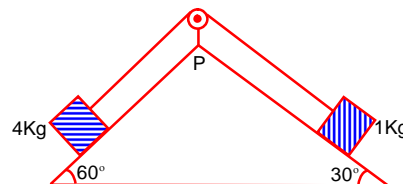
Q8. A modulating signal is a square wave, as shown in the figure. If the carrier wave is given as $c(t) = 2 \sin(8\pi t)$ volts, the modulation index is :



- (A) $\frac{1}{4}$ (B) 1
 (C) $\frac{1}{2}$ (D) $\frac{1}{3}$

Q9. As per given figure, a weightless pulley P is attached on a double inclined frictional surfaces. The tension in the string (massless) will be (if $g = 10 \text{ m/s}^2$)

- (A) $4(\sqrt{3} - 1)\text{N}$
 (B) $4(\sqrt{3} + 1)\text{N}$
 (C) $(4\sqrt{3} - 1)\text{N}$
 (D) $(4\sqrt{3} + 1)\text{N}$



Q10. A conducting circular loop of radius $\frac{10}{\sqrt{\pi}} \text{ cm}$ is placed perpendicular to a uniform magnetic field of 0.5 T. The magnetic field is decreased to zero in 0.5 s at a steady rate. The induced emf in the circular loop at 0.25s is :

- (A) emf = 1 mV (B) emf = 10 mV
 (C) emf = 100 mV (D) emf = 5 mV

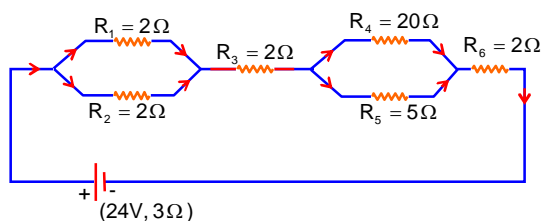
Q11. A circular loop of radius r is carrying current IA . The ratio of magnetic field at the centre of circular loop and at a distance r from the centre of the loop on its axis is :

- (A) $2\sqrt{2} : 1$ (B) $3\sqrt{2} : 2$
 (C) $1 : 3\sqrt{2}$ (D) $1 : \sqrt{2}$

Q12. A 100 m long wire having cross-sectional area $6.25 \times 10^{-4} \text{ m}^2$ and Young's modulus is 10^{10} Nm^{-2} is subjected to a load of 250 N, then the elongation in the wire will be :

- (A) $4 \times 10^{-3} \text{ m}$ (B) $4 \times 10^{-4} \text{ m}$
 (C) $6.25 \times 10^{-3} \text{ m}$ (D) $6.25 \times 10^{-6} \text{ m}$

- Q13.** As shown in the figure, a network of resistors is connected to a battery of 24V with an internal resistance of 3Ω . The currents through the resistors R_4 and R_5 are I_4 and I_5 respectively. The values of I_4 and I_5 are :



- (A) $I_4 = \frac{8}{5} \text{ A}$ and $I_5 = \frac{2}{5} \text{ A}$ (B) $I_4 = \frac{6}{5} \text{ A}$ and $I_5 = \frac{24}{5} \text{ A}$
 (C) $I_4 = \frac{2}{5} \text{ A}$ and $I_5 = \frac{8}{5} \text{ A}$ (D) $I_4 = \frac{24}{5} \text{ A}$ and $I_5 = \frac{6}{5} \text{ A}$
- Q14.** Two long straight wires P and Q carrying equal current 10A each were kept parallel to each other at 5cm distance. Magnitude of magnetic force experienced by 10cm length of wire P is F_1 . If distance between wires is halved and currents on them are doubled, force F_2 on 10cm length of wire P will be :
- (A) $\frac{F_1}{10}$ (B) $\frac{F_1}{8}$
 (C) $10F_1$ (D) $8F_1$
- Q15.** If two charges q_1 and q_2 are separated with distance 'd' and placed in a medium of dielectric constant K. What will be the equivalent distance between charges in air for the same electrostatic force ?
- (A) $d\sqrt{k}$ (B) $2d\sqrt{k}$
 (C) $k\sqrt{d}$ (D) $1.5d\sqrt{k}$
- Q16.** From the photoelectric effect experiment, following observations are made. Identify which of these are correct.
- (A) The stopping potential depends only on the work function of the metal.
 (B) The saturation current increases as the intensity of incident light increases.
 (C) The maximum kinetic energy of a photo electron depends on the intensity of the incident light.
 (D) Photoelectric effect can be explained using wave theory of light.

Choose the correct answer from the options given below:

- (A) B,C only (B) A,C,D only
 (C) A,B,D only (D) B only
- Q17.** Given below are two statements :
- Statement I :** The temperature of a gas is -73°C . When the gas is heated to 527°C , the root mean square speed of the molecules is doubled.

Statement II : The product of pressure and volume of an ideal gas will be equal to translational kinetic energy of the molecules.

In the light of the above statements, choose the correct 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 false
 (D) Both Statement I and Statement II are true

- Q18.** In \vec{E} and \vec{K} represent electric field and propagation vectors of the EM waves in vacuum, then magnetic field vector is given by :
(ω – angular frequency):

(A) $\frac{1}{\omega}(\vec{K} \times \vec{E})$ (B) $\omega(\vec{K} \times \vec{E})$
(C) $\vec{K} \times \vec{E}$ (D) $\omega(\vec{E} \times \vec{K})$

- Q19.** Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**

Assertion A : Photodiodes are preferably operated in reverse bias condition for light intensity measurement.

Reason R : The current in the forwards bias is more than the current in the reverse bias for a p – n junction diode.

In the light of the above statements, choose the correct answer from the options given below :

- (A) A is false but R is true
(B) A is true but R is false
(C) Both A and R are true but R is Not the correct explanation of A
(D) Both A and R are true and R is the correct explanation of A

- Q20.** A travelling wave is described by the equation

$$y(x,t) = [0.05 \sin(8x - 4t)] \text{ m}$$

The velocity of the wave is : [all the quantities are in SI unit]

- (A) 0.5 ms^{-1} (B) 8 ms^{-1}
(C) 2 ms^{-1} (D) 4 ms^{-1}

SECTION - B**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

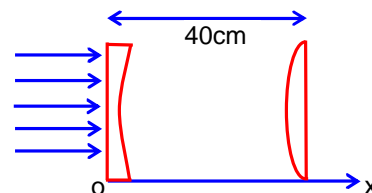
- Q1.** Assume that protons and neutrons have equal masses. Mass of a nucleon is 1.6×10^{-27} kg and radius of nucleus is $1.5 \times 10^{-15} A^{1/3}$ m. The approximate ratio of the nuclear density and water density is $n \times 10^{13}$. The value of n is _____.

- Q2.** A block of a mass 2kg is attached with two identical springs of spring constant 20N/m each. The block is placed on a frictionless surface and the ends of the springs are attached to rigid supports (see figure). When the mass is displaced from its equilibrium position, it executes a simple harmonic motion. The time period of oscillation is $\frac{\pi}{\sqrt{x}}$ in SI unit. The value of x is _____.



- Q3.** A spherical body of mass 2kg starting from rest acquires a kinetic energy of 10000 J at the end of 5th second. The force acted on the body is _____ N.

- Q4.** As shown in the figure, a combination of a thin plano concave lens and a thin plano convex lens is used to image an object placed at infinity. The radius of curvature of both the lenses is 30cm and refraction index of the material for both the lenses is 1.75. Both the lenses are placed at distance of 40cm from each other. Due to the combination, the image of the object is formed at distance $x =$ _____ cm, from concave lens.



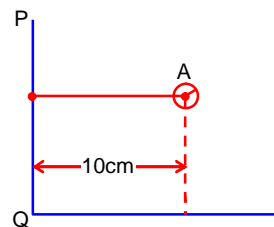
- Q5.** A hollow cylindrical conductor has length of 3.14m, while its inner and outer diameters are 4mm and 8 mm respectively. The resistance of the conductor of the conductor is $n \times 10^{-3} \Omega$. If the resistivity of the material is $2.4 \times 10^{-8} \Omega \text{m}$. The value of n is _____.

- Q6.** Vectors $a\hat{i} + b\hat{j} + \hat{k}$ and $2\hat{i} - 3\hat{j} + 4\hat{k}$ are perpendicular to each other when $3a + 2b = 7$, the ratio of a to b is $\frac{x}{2}$. The value of x is _____.

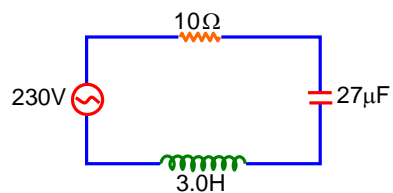
- Q7.** A hole is drilled in a metal sheet. At 27°C , the diameter of hole is 5cm. When the sheet is heated to 177°C , the change in the diameter of hole is $d \times 10^{-3}$ cm. The value of d will be _____ if coefficient of linear expansion of the metal is $1.6 \times 10^{-5} / ^\circ\text{C}$.

- Q8.** A stream of a positively charged particles having $\frac{q}{m} = 2 \times 10^{11} \frac{\text{C}}{\text{kg}}$ and velocity $\vec{v}_0 = 3 \times 10^7 \hat{i} \text{ m/s}$ is deflected by an electric field $1.8\hat{j} \text{ kV/m}$. The electric field exists in a region of 10cm along x direction. Due to the electric field, the deflection of the charge particles in the y direction is _____ mm.

- Q9.** Solid sphere A is rotating about an axis PQ. If the radius of the sphere is 5cm then its radius of gyration about PQ will be \sqrt{x} cm. The value of x is _____.



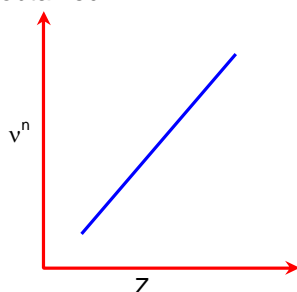
- Q10.** In the circuit shown in the figure, the ratio of the quality factor and the band width is _____ s.



PART – B (CHEMISTRY)**SECTION - A****(One Options Correct Type)**

This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.

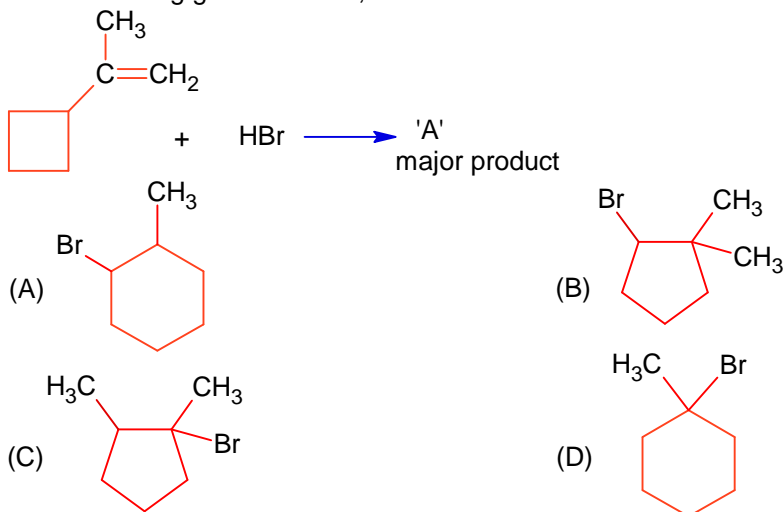
- Q1.** It is observed that characteristic X-ray spectra of elements show regularity. When frequency to the power “n” i.e ν^n of X-rays emitted is plotted against atomic number “Z”, following graph is obtained.



The value of “n” is

- (A) 1 (B) $\frac{1}{2}$
(C) 2 (D) 3
- Q2.** **Assertion A:** Hydrolysis of an alkyl chloride is a slow reaction but in the presence of NaI, the rate of the hydrolysis increases.
Reason R: I^- is a good nucleophile as well as a good leaving group.
In the light of the above statements choose **correct** answer from options given below:
(A) **A** is false but **R** is true
(B) Both **A** and **R** are true and **R** is the correct explanation of **A**
(C) Both **A** and **R** are true but **R** is **NOT** the correct explanation of **A**
(D) **A** is true but **R** is false
- Q3.** In the depression of freezing point experiment
A. Vapour pressure of the solution is less than that of pure solvent
B. Vapour pressure of the solution is more than that of pure solvent
C. Only solute molecules solidify at the freezing point
D. Only solvent molecules solidify at the freezing point.
Choose the most appropriate answer from the options given below:
(A) A and D only (B) A only
(C) B and C only (D) A and C only
- Q4.** An ammoniacal metal salt solution gives a brilliant red precipitate on addition of dimethylglyoxime. The metal ion is?
(A) Fe^{2+} (B) Co^{2+}
(C) Cu^{2+} (D) Ni^{2+}
- Q5.** Which of the Phosphorus oxoacid can create silver mirror from $AgNO_3$ solution?
(A) $H_4P_2O_7$ (B) $(HPO_3)_n$
(C) $H_4P_2O_6$ (D) $H_4P_2O_5$

Q6. In the following given reaction, 'A' is



Q7. Order of Covalent bond;

- A. $KF > KI$; $LiF > KF$
 B. $KF < KI$; $LiF > KF$
 C. $SnCl_4 > SnCl_2$; $CuCl > NaCl$
 D. $LiF > KF$; $CuCl < NaCl$
 E. $KF < KI$; $CuCl > NaCl$

Choose the correct answer from the options given below:

- (A) B, C only
 (B) C, E only
 (C) A, B only
 (D) B, C, E only

Q8. The primary and secondary valencies of cobalt respectively in $[Co(NH_3)_5Cl]Cl_2$ are:

- (A) 2 and 8
 (B) 3 and 6
 (C) 3 and 5
 (D) 2 and 6

Q9. **Statement I:** For colloidal particles, the values of colligative properties are of small order as compared to values shown by true solutions at same concentration.

Statement II: For colloidal particles, the potential difference between the fixed layer and the diffused layer of same charges is called the electrokinetic potential or zeta potential. In the light of the above statements, choose the correct answer from the options given below.

- (A) Statement I is true but Statement II is false
 (B) Both Statement I and Statement II are false
 (C) Both Statement I and Statement II are true
 (D) Statement I is false but Statement II is true

Q10. Match List I with List II

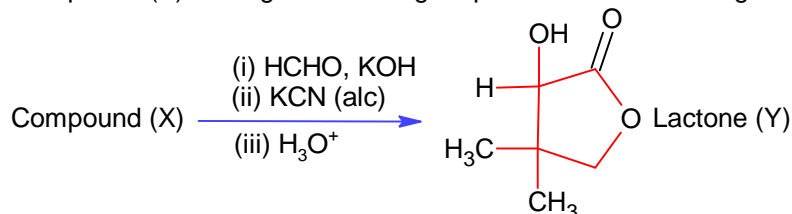
List-I		List-II	
A.	Chlorophyll	I.	Na_2CO_3
B.	Soda ash	II.	$CaSO_4$
C.	Density, Ornamental work	III.	Mg^{2+}
D.	Used in white washing	IV.	$Ca(OH)_2$

Choose the correct answer from the options given below:

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

- Q11.** Decreasing order of the hydrogen bonding in following forms of water is correctly represented by
 A. Liquid water
 B. Ice
 C. Impure water
 Choose the correct answer from the options given below:
 (A) $A > B > C$
 (B) $A = B > C$
 (C) $B > A > C$
 (D) $C > B > A$

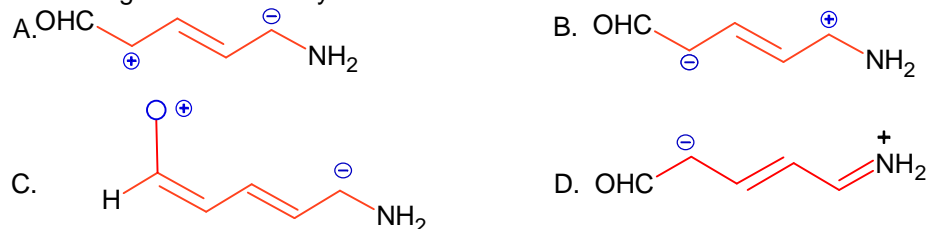
- Q12.** Compound (X) undergoes following sequence of reactions to give the Lactone (Y).



Compound (X) is

- (A)
- (B)
- (C)
- (D)

- Q13.** Increasing order of stability of the resonance structures is:



Choose the correct answer from the options given below:

- (A) D, C, B, A
 (B) C, D, A, B
 (C) D, C, A, B
 (D) C, D, B, A

- Q14.** Match List I with List II

List – I		List-II	
A.	Reverberatory furnace	I.	Pig iron
B.	Electrolytic cell	II.	Aluminium
C.	Blast furnace	III.	Silicon
D.	Zone Refining furnace	IV.	Copper

Choose the correct answer from the options given below:

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

- Q15.** Reaction of BeO with ammonia and hydrogen fluoride gives A which on thermal decomposition gives BeF_2 and NH_4F . what is 'A'?
- (A) $(\text{NH}_4)_2\text{BeF}_4$
 (B) $(\text{NH}_4)\text{Be}_2\text{F}_5$
 (C) H_3NBeF_3
 (D) $(\text{NH}_4)\text{BeF}_3$

Q16. Given below are two statements:

Statement I: Noradrenaline is a neurotransmitter.

Statement II: Low level of noradrenaline is not the cause of depression in human.

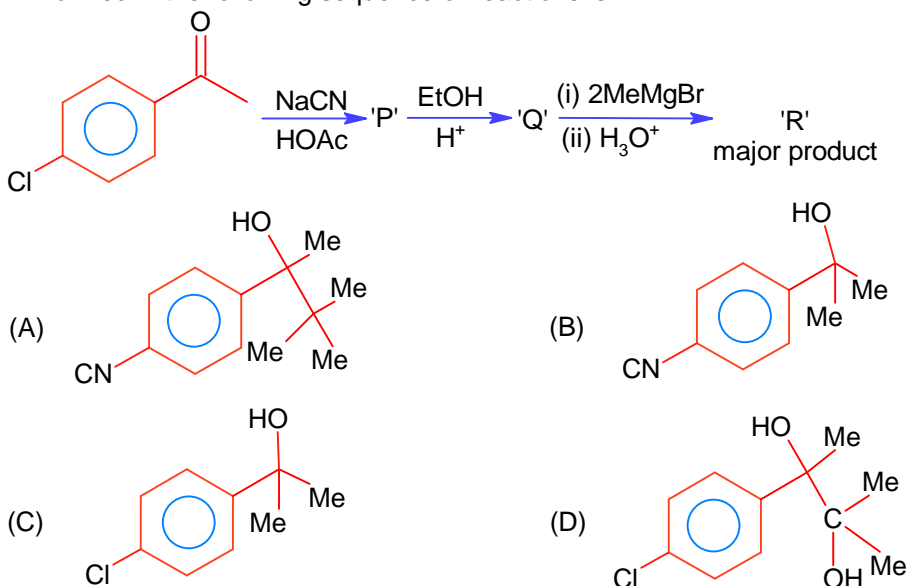
In the light of the above statements, choose the correct answer from the options given below.

- (A) Statement I is correct but Statement II is incorrect
 (B) Statement I is incorrect but Statement II is correct
 (C) Both Statement I and Statement II are correct
 (D) Both Statement I and Statement II are incorrect

Q17. The magnetic moment of a transition metal compound has been calculated to be 3.87 B.M. The metal ion is

- (A) V^{2+} (B) Mn^{2+}
 (C) Cr^{2+} (D) Ti^{2+}

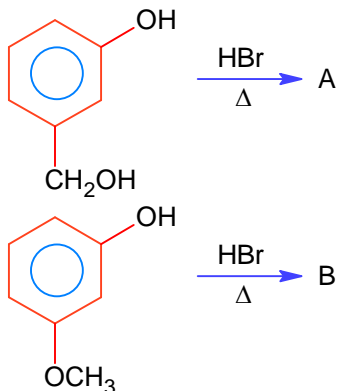
Q18. 'R' formed in the following sequence of reactions is:

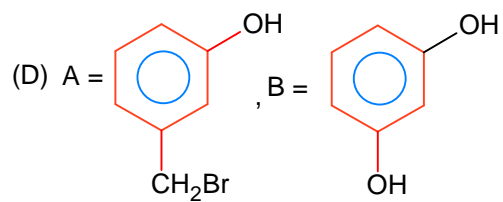
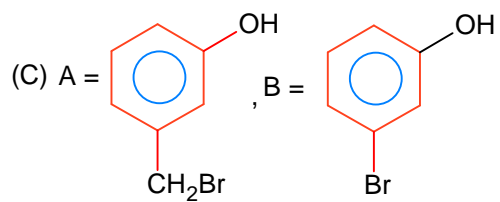
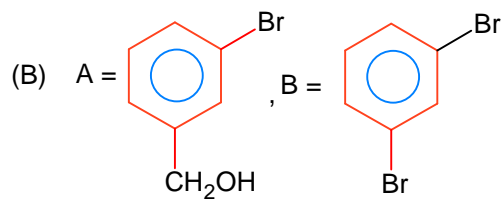
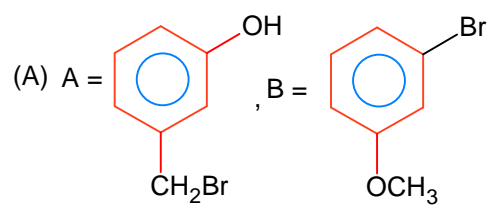


Q19. Which of the following is true about freons?

- (A) These are chlorofluorocarbon compounds
 (B) All radicals are called freons
 (C) These are chemicals causing skin cancer
 (D) These are radicals of chlorine and chlorine monoxide

Q20. 'A' and 'B' formed in the following set of reactions are

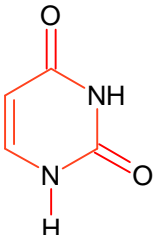




SECTION - B**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

- Q1.** Uracil is a base present in RNA with the following structure % of N in uracil is_____



Given:

Molar mass N = 14 g mol^{-1}

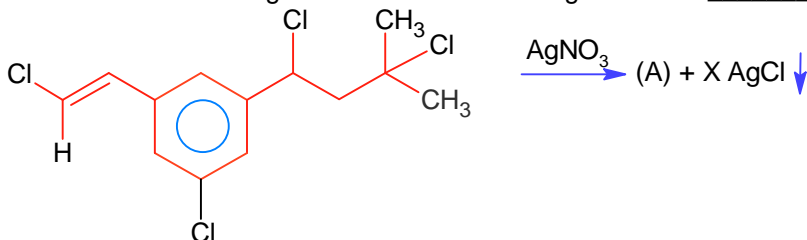
O = 16 g mol^{-1}

C = 12 g mol^{-1}

H = 1 g mol^{-1}

- Q2.** 5 g of NaOH was dissolved in deionized water to prepare a 450 mL stock solution. What volume (in mL) of this solution would be required to prepare 500 mL of 0.1 M solution? _____
Given: Molar mass of Na, O and H is 23,16 and 1 g mol^{-1} respectively

- Q3.** Number of moles of AgCl formed in the following reaction is _____



- Q4.** The dissociation constant of acetic acid is $x \times 10^{-5}$. When 25 mL of 0.2 M CH_3COONa solution is mixed with 25 mL of 0.02 M CH_3COOH solution, the pH of the resultant solution is found to be equal to 5. The value of x is_____.
- Q5.** The d-electronic configuration of $[\text{CoCl}_4]^{2-}$ in tetrahedral crystal field is $e^m t_2^n$. Sum of “m” and “number of unpaired electrons” is_____.
- Q6.** The number of correct statement/s from the following is_____
- A. Larger the activation energy, smaller is the value of the rate constant.
 - B. The higher is the activation energy, higher is the value of the temperature coefficient.
 - C. At lower temperatures, increase in temperature causes more change in the value of k than at higher temperature
 - D. A plot of $\ln k$ vs $\frac{1}{T}$ is a straight line with slope equal to $-\frac{E_a}{R}$
- Q7.** If wavelength of the first line of the Paschen series of hydrogen atom is 720 nm, then the wavelength of the second line of this series is _____nm. (nearest integer)

Q8. When $\text{Fe}_{0.93}\text{O}$ is heated in presence of oxygen, it converts to Fe_2O_3 . The number of correct statement/s from the following is _____

- A. The equivalent weight of $\text{Fe}_{0.93}\text{O}$ is $\frac{\text{Molecular weight}}{0.79}$
- B. The number of moles of Fe^{2+} and Fe^{3+} in 1 mole of $\text{Fe}_{0.93}\text{O}$ is 0.79 and 0.14 respectively
- C. $\text{Fe}_{0.93}\text{O}$ is metal deficient with lattice comprising of cubic closed packed arrangement of O^{2-} ions
- D. The % composition of Fe^{2+} and Fe^{3+} in $\text{Fe}_{0.93}\text{O}$ is 85% and 15% respectively

Q9. At 298 K, a 1 litre solution containing 10 mmol of $\text{Cr}_2\text{O}_7^{2-}$ and 100 mmol of Cr^{3+} shows a Ph of 3.0

Given: $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+}; E^\circ = 1.330\text{V}$

and $\frac{2.303RT}{F} = 0.059\text{V}$

The potential for the half cell reaction is $x \times 10^{-3}\text{V}$. The value of x is _____.

Q10. For independent processes at 300K

Process	$\Delta H/\text{kJ mol}^{-1}$	$\Delta S/\text{JK}^{-1}$
A	-25	-80
B	-22	40
C	25	-50
D	22	20

The number of non-spontaneous processes from the following is _____

PART – C (MATHEMATICS)**SECTION - A****(One Options Correct Type)**

This section contains **20 multiple choice questions**. Each question has **four choices** (A), (B), (C) and (D), out of which **ONLY ONE** option is correct.

Q1. $\tan^{-1}\left(\frac{1+\sqrt{3}}{3+\sqrt{3}}\right) + \sec^{-1}\left(\sqrt{\frac{8+4\sqrt{3}}{6+3\sqrt{3}}}\right)$ is equal to :

(A) $\frac{\pi}{6}$

(B) $\frac{\pi}{3}$

(C) $\frac{\pi}{4}$

(D) $\frac{\pi}{2}$

Q2. $\lim_{t \rightarrow 0} \left(1^{\frac{1}{\sin^2 t}} + 2^{\frac{1}{\sin^2 t}} + \dots + n^{\frac{1}{\sin^2 t}} \right)^{\sin^2 t}$ is equal to

(A) $n^2 + n$

(B) n^2

(C) $\frac{n(n+1)}{2}$

(D) n

Q3. Let a tangent to the curve $y^2 = 24x$ meet the curve $xy = 2$ at the points A and B. Then the mid points of such line segments AB lie on a parabola with the

(A) directrix $4x = -3$

(B) length of latus rectum 2

(C) directrix $4x = 3$

(D) length of latus rectum $\frac{3}{2}$

Q4. The value of $\sum_{r=0}^{22} {}^{22}C_r {}^{23}C_r$ is

(A) ${}^{44}C_{23}$

(B) ${}^{45}C_{23}$

(C) ${}^{44}C_{22}$

(D) ${}^{45}C_{24}$

Q5. If A and B are two non-zero $n \times n$ matrices such that $A^2 + B = A^2B$, then

(A) $A^2B = BA^2$

(B) $A^2B = I$

(C) $A^2 = I$ or $B = I$

(D) $AB = I$

Q6. Let N denote the number that turns up when a fair die is rolled. If the probability that the system of equations

$$x + y + z = 1$$

$$2x + Ny + 2z = 2$$

$$3x + 3y + Nz = 3$$

has unique solution is $\frac{k}{6}$, then the sum of value of k and all possible values of N is

(A) 18

(B) 21

(C) 19

(D) 20

- Q7.** Let PQR be a triangle. The points A, B and C are on the sides QR, RP and PQ respectively such that $\frac{QA}{AR} = \frac{RB}{BP} = \frac{PC}{CQ} = \frac{1}{2}$. Then $\frac{\text{Area}(\Delta PQR)}{\text{Area}(\Delta ABC)}$ is equal to
 (A) 4 (B) 3
 (C) $\frac{5}{2}$ (D) 2
- Q8.** Let $\vec{u} = \hat{i} - \hat{j} - 2\hat{k}$, $\vec{v} = 2\hat{i} + \hat{j} - \hat{k}$, $\vec{v} \cdot \vec{w} = 2$ and $\vec{v} \times \vec{w} = \vec{u} + \lambda \vec{v}$. Then $\vec{u} \cdot \vec{w}$ is equal to
 (A) 2 (B) $\frac{3}{2}$
 (C) $-\frac{2}{3}$ (D) 1
- Q9.** Let α be a root of the equation $(a-c)x^2 + (b-a)x + (c-b) = 0$ where a, b, c are distinct real numbers such that matrix $\begin{bmatrix} \alpha^2 & \alpha & 1 \\ 1 & 1 & 1 \\ a & b & c \end{bmatrix}$ is singular. Then, the value of $\frac{(a-c)^2}{(b-a)(c-b)} + \frac{(b-a)^2}{(a-c)(c-b)} + \frac{(c-b)^2}{(a-c)(b-a)}$ is
 (A) 12 (B) 3
 (C) 9 (D) 6
- Q10.** Let $p, q \in \mathbb{R}$ and $(1 - \sqrt{3}i)^{200} = 2^{199}(p + iq)$, $i = \sqrt{-1}$. Then $p + q + q^2$ and $p - q + q^2$ are roots of the equation.
 (A) $x^2 - 4x + 1 = 0$ (B) $x^2 + 4x - 1 = 0$
 (C) $x^2 + 4x + 1 = 0$ (D) $x^2 - 4x - 1 = 0$
- Q11.** The distance of the point $(7, -3, -4)$ from the plane passing through the points $(2, -3, 1)$, $(-1, 1, -2)$ and $(3, -4, 2)$ is :
 (A) $4\sqrt{2}$ (B) 5
 (C) $5\sqrt{2}$ (D) 4
- Q12.** Let $y = y(x)$ be the solution of the differential equation $x^3 dy + (xy - 1)dx = 0$, $x > 0$, $y\left(\frac{1}{2}\right) = 3 - e$. Then $y(1)$ is equal to
 (A) 1 (B) $2 - e$
 (C) e (D) 3
- Q13.** Let Ω be the sample space and $A \subseteq \Omega$ be an event. Given below are two statements :
 (S1): If $P(A) = 0$, then $A = \phi$
 (S2): If $P(A) = 1$, then $A = \Omega$
 Then
 (A) both (S1) and (S2) are true (B) only (S2) is true
 (C) both (S1) and (S2) are false (D) only (S1) is true

- Q14.** The relation $R = \{(a,b) : \gcd(a,b) = 1, 2a \neq b, a,b \in \mathbb{Z}\}$ is :
 (A) symmetric but not transitive (B) neither symmetric nor transitive
 (C) reflexive but not symmetric (D) transitive but not reflexive
- Q15.** For three positive integers p, q, r , $x^{pq^2} = y^{qr} = z^{p^2r}$ and $r = pq + 1$ such that $3, 3\log_x x, 3\log_y y, 7\log_z z$ are in A.P. with common difference $\frac{1}{2}$. The $r - p - q$ is equal to
 (A) 12 (B) 6
 (C) 2 (D) -6
- Q16.** The distance of the point $(-1, 9, -16)$ from the plane $2x + 3y - z = 5$ measured parallel to the line $\frac{x+4}{3} = \frac{2-y}{4} = \frac{z-3}{12}$ is
 (A) $13\sqrt{2}$ (B) $20\sqrt{2}$
 (C) 31 (D) 26
- Q17.** The area enclosed by the curves $y^2 + 4x = 4$ and $y - 2x = 2$ is :
 (A) $\frac{25}{3}$ (B) $\frac{23}{3}$
 (C) 9 (D) $\frac{22}{3}$
- Q18.** The equation $x^2 - 4x + [x] + 3 = x[x]$, where $[x]$ denotes the greatest integer function, has :
 (A) a unique solution in $(-\infty, \infty)$ (B) no solution
 (C) a unique solution in $(-\infty, 1)$ (D) exactly two solutions in $(-\infty, \infty)$
- Q19.** The compound statement $(\sim (P \wedge Q)) \vee ((\sim P) \wedge Q) \Rightarrow ((\sim P) \wedge (\sim Q))$ is equivalent to
 (A) $(\sim P) \vee Q$ (B) $((\sim P) \vee Q) \wedge ((\sim Q) \vee P)$
 (C) $((\sim P) \vee Q) \wedge (\sim Q)$ (D) $(\sim Q) \vee P$
- Q20.** Let $f(x) = \begin{cases} x^2 \sin\left(\frac{1}{x}\right), & x \neq 0 \\ 0, & x = 0 \end{cases}$ then at $x = 0$
 (A) f' is continuous but not differentiable (B) f and f' both are continuous
 (C) f is continuous but not differentiable (D) f is continuous but f' is not continuous

SECTION - B**(Numerical Answer Type)**

This section contains **10** Numerical based questions. The answer to each question is rounded off to the nearest integer value.

- Q1.** The value of $12 \int_0^3 |x^2 - 3x + 2| dx$ is.....
- Q2.** Suppose $\sum_{r=0}^{2023} r^2 {}^{2023}C_r = 2023 \times \alpha \times 2^{2022}$. Then the value of α is.....
- Q3.** The value of $\frac{8}{\pi} \int_0^{\frac{\pi}{2}} \frac{(\cos x)^{2023}}{(\sin x)^{2023} + (\cos x)^{2023}} dx$ is.....
- Q4.** Let a tangent to the curve $9x^2 + 16y^2 = 144$ intersect the coordinate axes at the points A and B. Then, the minimum length of the line segment AB is.....
- Q5.** Let $\lambda \in \mathbb{R}$ and let the equation E be $|x^2| - 2|x| + |\lambda - 3| = 0$. Then the largest element in the set $S = \{x + \lambda : x \text{ is an integer solution of E}\}$ is.....
- Q6.** The 4th term of GP is 500 and its common ratio is $\frac{1}{m}$, $m \in \mathbb{N}$. Let S_n denote the sum of the first n terms of this GP. If $S_6 > S_5 + 1$ and $S_7 < S_6 + \frac{1}{2}$, then the number of possible values of m is.....
- Q7.** The shortest distance between the lines $\frac{x-2}{3} = \frac{y+1}{2} = \frac{z-6}{2}$ and $\frac{x-6}{3} = \frac{1-y}{2} = \frac{z+8}{0}$ is equal to.....
- Q8.** A boy needs to select five courses from 12 available courses, out of which 5 courses are language course. If he can choose at most two language courses, then the number of ways he can choose five courses is
- Q9.** The number of 9 digit numbers, that can be formed using all the digits of the number 123412341 so that the even digits occupy only even places, is.....
- Q10.** Let C be the largest circle centered at (2,0) and inscribed in the ellipse $\frac{x^2}{36} + \frac{y^2}{16} = 1$. If $(1, \alpha)$ lies on C, then $10\alpha^2$ is equal to.....

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KEYS to JEE (Main)-2023

PART - A (PHYSICS)

SECTION - A

1. C	2. C	3. B	4. D
5. D	6. D	7. D	8. C
9. B	10. B	11. A	12. A
13. C	14. D	15. A	16. D
17. B	18. A	19. C	20. A

SECTION - B

1. 11	2. 5	3. 40	4. 120
5. 2	6. 1	7. 12	8. 2
9. 110	10. 10		

PART - B (CHEMISTRY)

SECTION - A

1. B	2. B	3. A	4. D
5. D	6. C	7. D	8. B
9. A	10. A	11. C	12. A
13. B	14. B	15. A	16. A
17. A	18. D	19. A	20. D

SECTION - B

1. 25	2. 180	3. 2	4. 10
5. 7	6. 3	7. 492	8. 4
9. 917	10. 2		

PART – C (MATHEMATICS)

SECTION - A

- | | | | | | | | |
|-----|---|-----|---|-----|---|-----|---|
| 1. | B | 2. | D | 3. | C | 4. | B |
| 5. | A | 6. | D | 7. | B | 8. | D |
| 9. | B | 10. | A | 11. | C | 12. | A |
| 13. | C | 14. | B | 15. | C | 16. | D |
| 17. | C | 18. | A | 19. | B | 20. | D |

SECTION - B

- | | | | | | | | |
|----|-----------|-----|-------------|----|-----------|----|------------|
| 1. | 22 | 2. | 1012 | 3. | 2 | 4. | 7 |
| 5. | 5 | 6. | 12 | 7. | 14 | 8. | 546 |
| 9. | 60 | 10. | 118 | | | | |

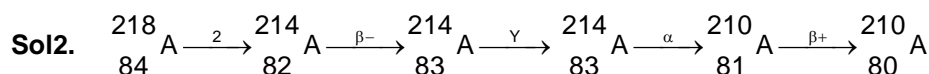
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Solutions to JEE (Main)-2023

PART - A (PHYSICS)

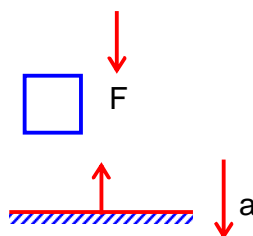
SECTION - A

Sol1. Momentum = $mv = [MLT^{-1}]$
 Work function (ϕ) $\Rightarrow E = K.E + \phi$
 $\Rightarrow [ML^2T^{-2}]$



Sol3. $\frac{u^2 \sin^2 \theta}{2g} = \text{for main } h \rightarrow \frac{u^2}{2g} = 136$
 $\frac{u^2}{g} \sin 2\theta \Rightarrow \text{for max } R \Rightarrow \frac{u^2}{g} = 136 \times 2 = 272\text{m}$

Sol4. Statement 1 : True
 When $a = 0$,
 \Rightarrow uniform speed
 Statement 2 : False
 Elevator goes down with increasing
 speed \Rightarrow downward one.
 \therefore Weight $>$ force



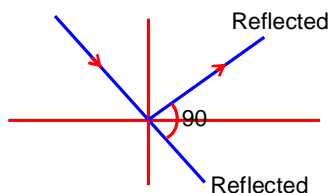
Sol5. $g = \frac{GM}{R^2}$
 $g' = \frac{GM}{(R + 3200)^2} = \frac{GM}{\left(R + \frac{R}{2}\right)^2} = \frac{4GM}{(3R)^2} = \frac{4}{9} \frac{GM}{R^2}$
 $= \frac{4}{9} \times 182 = 8\text{N}$

Sol6. $\theta = \Delta U + W$
 $\frac{10}{100} \times \theta = W = 3 \times 10^5 \times 1600 \times 10^{-6} = 480 = W$
 $\Rightarrow \theta = 4800$
 $\rightarrow 4800$
 $\quad \underline{-480} = \Delta U$
 $\quad 4320$
 $\Rightarrow \Delta U = 4320\text{J}$

Sol7. Statement 1 is false

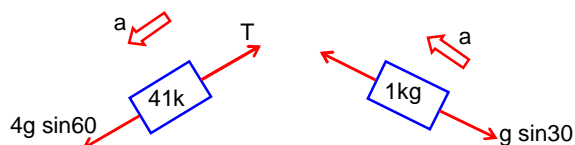
$$\frac{\pi}{2} + \theta_B \text{ will be } \theta_u < \theta.$$

Statement 2 is true.



Sol8. $\mu = \frac{A_m}{A_c} = \frac{1}{2}$

Sol9. $40 \frac{\sqrt{3}}{2} - T = 4a$
 $+ T - 5 = a$
 $20\sqrt{3} - 5 = 5a$
 $a = 4\sqrt{3} - 1$
 $\therefore T = a + 5$
 $= 4\sqrt{3} + 4$
 $= 4(\sqrt{3} + 1)N$

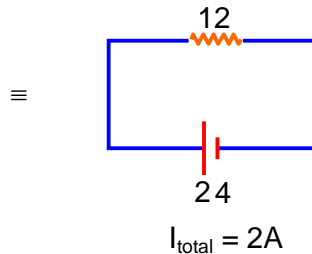
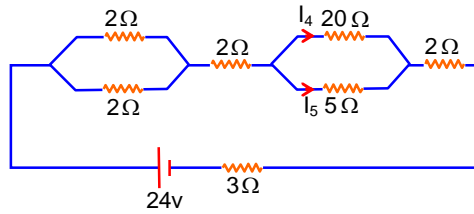


Sol10. $e = \frac{d\phi}{dt} = \frac{0.5}{0.5} \times a \times \frac{10 \times 10}{a} \times 10^{-4}$
 $= 10^{-2} V = 10 \text{ mV}$

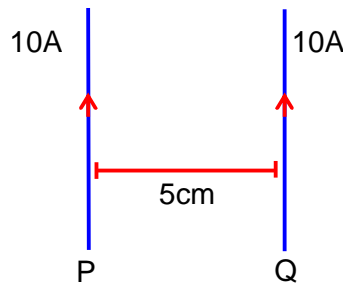
Sol11. $\frac{B_{\text{centre}}}{B_r} = \frac{\mu_0 I}{2\mu} \div \frac{\mu_0 I \mu}{2(\mu^2 + \mu^2)^{3/2}}$
 $= \frac{\mu_0 I}{2a} \times \frac{2 \times (2\mu^2)^{3/2}}{\mu_0 1}$
 $= \frac{1}{\mu^2} \times 2\sqrt{2}$
 $= 2\sqrt{2} : 1$

Sol12. $\frac{F}{A} = Y \frac{\Delta \ell}{\ell}$
 $\frac{250}{6.25} \times 10^4 = 10^{10} \times \frac{\Delta \ell}{100}$
 $\frac{250}{625} \times 10^6 = 10^8 \times \Delta \ell$
 $\frac{10}{25} \times 10^{-2} = \Delta \ell$
 $4 \times 10^{-3} \text{ m} = \Delta \ell$
 $\frac{1}{5} + \frac{1}{20} = \frac{5}{20}$
 $R_{\text{eq}} = 1 + 2 + 4 + 2 + 3 = 12$

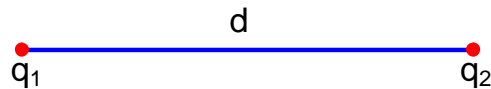
Sol13. $v_4 = v_5 \Rightarrow I_4 \times 20 = I_5 \times 5$
 $\Rightarrow 4 I_4 = I_5$
 $I_4 + I_5 = 2$
 $5I_4 = 2 \Rightarrow I_4 = 2/5$
 $I_5 = 8/5$



Sol14. $F_p = F_1 = I \times \ell \times B$
 $= I \times \ell \times \frac{\mu_0 I}{2\pi\mu}$
 $\mu' \rightarrow \mu/2$
 $I' \rightarrow 2I$
 $F_2 = 2I \times \ell \times \frac{\mu_0 \times 2I \times 2}{2\pi \times \mu}$
 $= 8F_1$



Sol15. $F = \frac{1}{K} \frac{k q_1 q_2}{d^2}$
 $\frac{1}{K} \frac{q_1 q_2}{d^2} = \frac{q_1 q_2}{d'^2}$
 $\Rightarrow d'^2 = K d^2$
 $\Rightarrow d' = \sqrt{K} d$



Sol16. Photoelectric effect can be explained using wave theory
 $K.E = E - \phi \Rightarrow K.E$ doesn't depend on intensity so opt B is only correct.

Sol17. $v = \sqrt{\frac{3RT}{M}}$
 $T_i = 200K$
 $T_f = 800K$
 $T_f = 4T_i$
 $\therefore v$ gets doubled
 $PV \neq KE_T$

Sol18. $\vec{E} \rightarrow$ electric field
 $\vec{k} \rightarrow$ direction EM wave
 Magnitude field $\rightarrow \vec{k} \times \vec{E}$

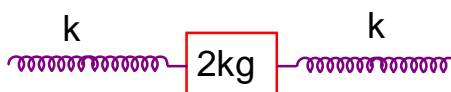
Sol19. Photodiodes used in reverse bias current in forward bias is more. Than current in reverse bias.

Sol20. $y(x,t) = [0.05 \sin(8x - 4t)]$

SECTION - B

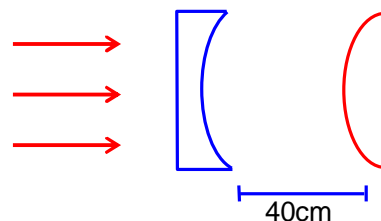
Sol1. Nuclear density = $\frac{1.6 \times 10^{-27}}{\frac{4}{3} \pi \times 1.5 \times 1.5 \times 1.5 \times 10^{-45} \text{ A}}$

Sol2. $T = 2\pi \sqrt{\frac{m}{k_{eq}}}$
 $T = 2\pi \sqrt{\frac{2}{2k}} \Rightarrow 2\pi \sqrt{\frac{1}{k}}$
 $\Rightarrow 2\pi \sqrt{\frac{1}{20}}$
 $\therefore x = 5$



Sol3. $F = \frac{dp}{dt}$
 $\frac{1}{2} \times 2 \times v^2 = 10^4$
 $v = 100 \text{ m/s}$
 $\Delta = 100 \text{ m/s}$
 $\Delta P = 200$
 $t = 5$
 $\therefore F = \frac{200}{5} = 40$

Sol4. $\frac{1}{f_{converge}} = (1.75 - 1) \left(\frac{1}{\infty} - \frac{1}{30} \right) = \frac{-0.75}{30}$
 $f_{converge} = -40 \text{ cm}$
 $\frac{1}{v_1} - \frac{1}{\infty} = \frac{-1}{40} \Rightarrow v_1 = -40 \text{ cm}$
 $\frac{1}{v} + \frac{1}{80} = \frac{1}{40} \Rightarrow \frac{1}{v} = \frac{1}{80} \Rightarrow v = 80$
 $\therefore \text{distance from converge lens } 80 + 40 = 120 \text{ cm}$



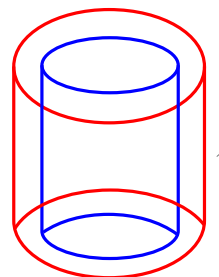
Sol5. $R = \frac{\delta \ell}{A}$

$$\Rightarrow n \times 10^{-3} \geq \frac{2.4 \times 10^{-8} \times 3.14}{2 \times 3.14 \times (4-2) \times 10^{-3} \times 3.14}$$

$$n \times 10^{-3} = \frac{2.4 \times 10^{-8} \times 3.14}{\pi(16-4) \times 10^{-6}}$$

$$= \frac{24}{12} \times 10^{-3}$$

$$\Rightarrow n = 2$$



Sol6. $2a - 3b + 4 = 0$

$$2a - 3b = -4 \Rightarrow 6a - 9b = -12$$

$$3a + 2b = 7 \quad 6a + 4b = 14$$

$$\Rightarrow 13b = 26$$

$$a = 1$$

$$\therefore \frac{a}{b} = \frac{x}{2} = \frac{1}{2} \Rightarrow x = 1$$

Sol7. $d \times 10^{-3} = 1.6 \times 10^{-5} \times 150 \times 100$

$$d = \frac{1.6 \times 15 \times 10^{-4}}{10^{-3}}$$

$$= \frac{16 \times 15}{100}$$

$$= \frac{240}{100} \times 5 \Rightarrow \frac{120}{10} = 12$$

Sol8. $F = Fq$

$$a = \frac{qE}{m} = 2 \times 10^{11} \times 1.8 \times 10^3$$

$$= 36 \times 10^{13}$$

$$\text{Time} = \frac{10 \times 10^{-2}}{3 \times 10^7} = \frac{1}{3} \times 10^{-8}$$

$$\therefore y = \frac{1}{2} at^2$$

$$= \frac{1}{2} \times 36 \times 10^{13} \times \frac{1}{9} \times 10^{-16}$$

$$= 2 \times 10^{-3} \text{m}$$

$$= 2 \text{mm}$$

Sol9. $I_{\text{about}} = PQ = \frac{2}{5} MR^2 + M \times 10 \times 10 = \frac{2}{5} \times 25M + 100M$

$$\Rightarrow 110M$$

$$MR^2 = 110M$$

$$\Rightarrow R = \sqrt{110}$$

$$x = 110$$

Sol10. $\theta = \frac{WL}{R}$, Bandwidth $\Rightarrow \Delta W = \frac{R}{L}$
 $= \frac{1}{R} \sqrt{\frac{L}{C}}$
 $\frac{\theta}{\Delta \omega} = \frac{L}{R^2 \sqrt{C}} = \frac{3\sqrt{3}}{100 \times (3\sqrt{3} \times 10^{-3})} = 10$

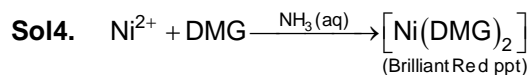
PART – B (CHEMISTRY)

SECTION – A

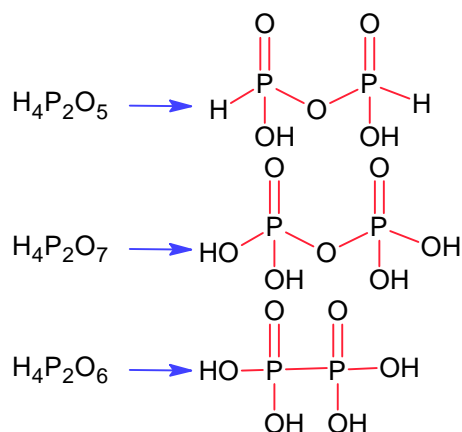
Sol1. $\nu^n \propto Z$ (according to graph)
 According to moseley theory
 $\sqrt{\nu} = a(z - b)$ where a & b are constants
 $(\nu)^{1/2} \propto Z$
 $\therefore n = \frac{1}{2}$

Sol2. Hydrolysis of R-Cl is slow reaction but hydrolysis increases due to better nucleophilicity of I⁻

Sol3. Vapour pressure of solvent is greater than vapour pressure of solution, only solvent freezes at this condition.

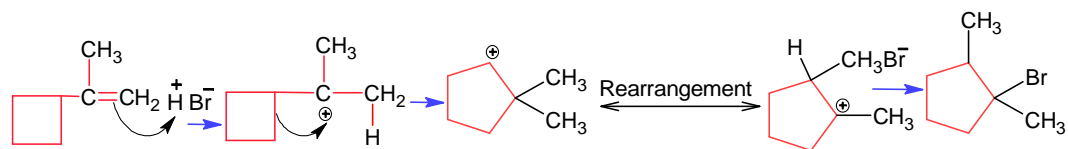


Sol5.



H₂P₂O₅ has P-H bond so it can reduce AgNO₃ to Ag.

Sol6.

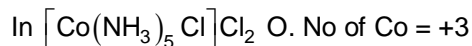


Sol7. According to Fajjans rule

$$\text{Polarisation} \propto \frac{1}{\text{Size of cation}} \propto \text{size of anion} \propto \text{Covalent character}$$

- (a) $\text{KF} > \text{KI}$ & $\text{LiF} > \text{KF}$ (Incorrect)
- (b) $\text{KI} > \text{KF}$ & $\text{LiF} > \text{KF}$ (Correct)
- (c) $\text{SnCl}_4 > \text{SnCl}_2$ & $\text{CuCl} > \text{NaCl}$ (Correct)
- (d) $\text{LiF} > \text{KF}$ & $\text{CuCl} < \text{NaCl}$ (Incorrect)
- (e) $\text{KI} > \text{KF}$ & $\text{CuCl} > \text{NaCl}$ (Correct)

Sol8. Primary valency = Oxidation number of central metal = 3



Secondary valency = co-ordination No = 6

Sol9. Statement-I For colloidal particles, the values of colligative properties are of small order as compared to values shown by true solution at same concentration (True)

Statement-II Zeta potential or electrokinetic potential

Zeta potential – The potential difference between the fixed layer and the diffused layer is called electrokinetic potential or zeta potential

Sol10. (a) Chlorophyll $\rightarrow \text{Mg}^{+2}$ complex.

(b) Soda ash $\rightarrow \text{Na}_2\text{CO}_3$

(c) Density & ornamental work $\rightarrow \text{CaSO}_4$

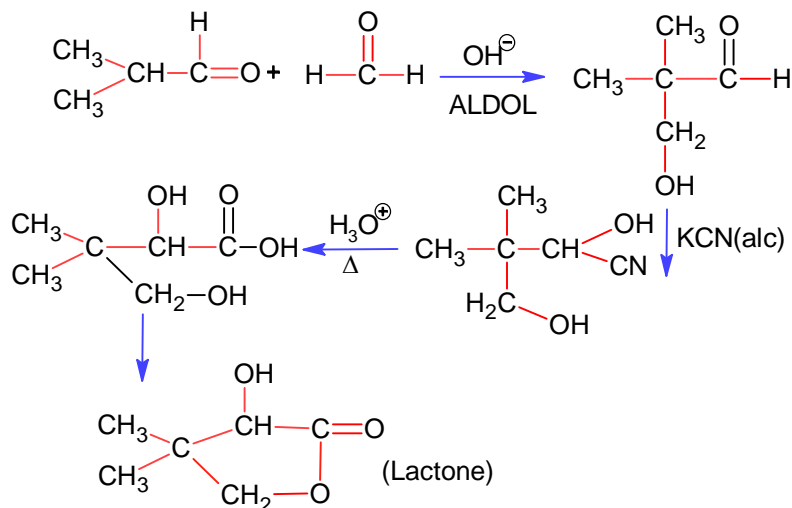
(d) Used in white washing $\rightarrow \text{Ca}(\text{OH})_2$

Sol11. Extent of hydrogen bonding

Ice > liquid H_2O > Impure water

Extent of H-bonding decreases in impure water due to impurity present in it.

Sol12.



Sol13. $\text{C} < \text{A} < \text{B} < \text{D}$

In (D) octet of each atom is complete (D) is more stable than (C)

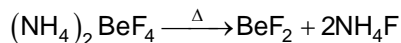
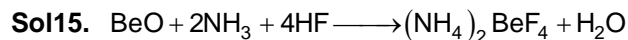
Any answer is not correct (BONUS)

Sol14. Reverberatory furnace \rightarrow Used for roasting Cu- ore

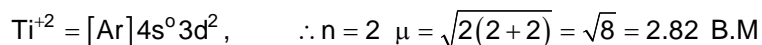
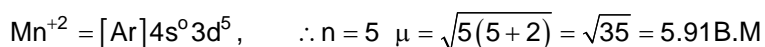
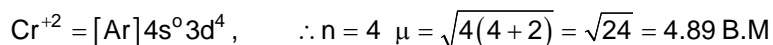
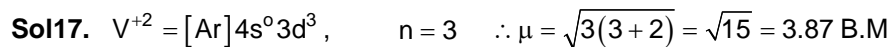
Electrolytic cell \rightarrow Used for reactive metal (Al)

Blast furnace \rightarrow Used for haematite (Fe_2O_3) ore to pig iron formation

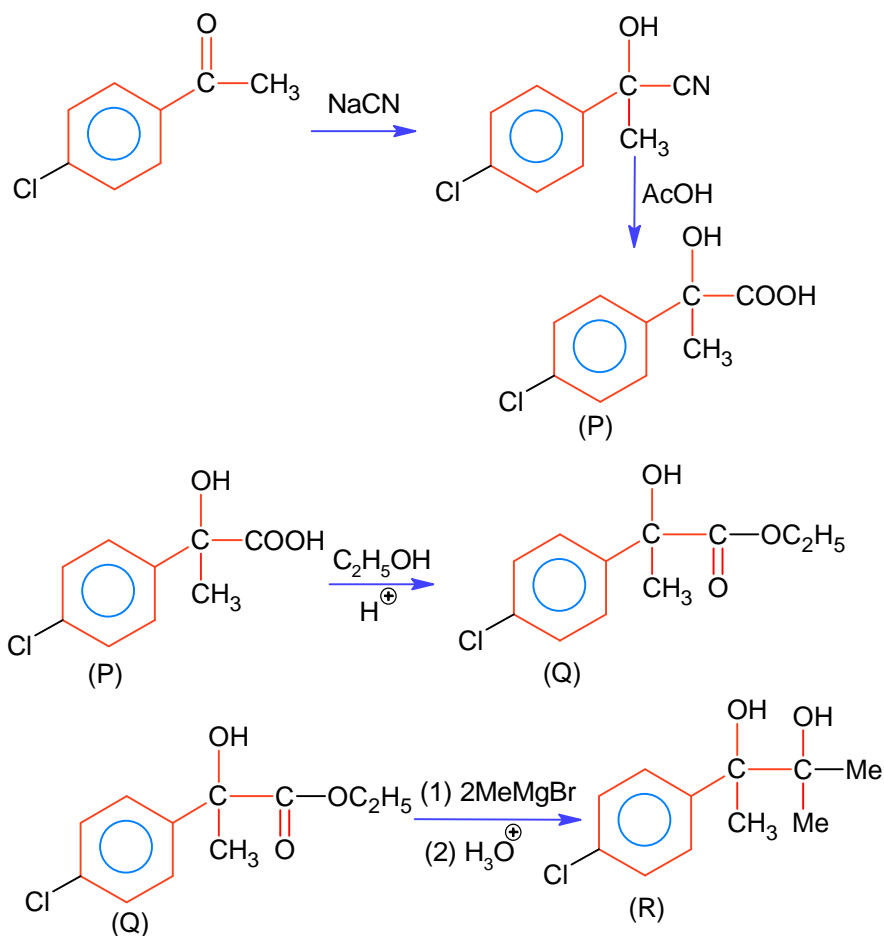
Zone-Refining furnace → Used for semiconductors or ultra pure element like Si.



Sol16. Noradrenaline also known as norepinephrine. It is both neurotransmitter and a hormone. Its role as fight or flight in body.

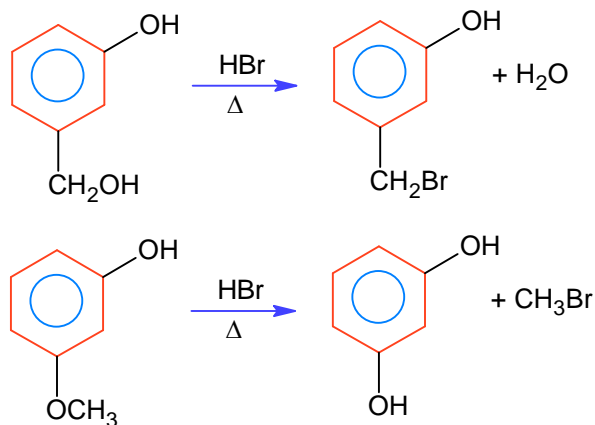


Sol18.

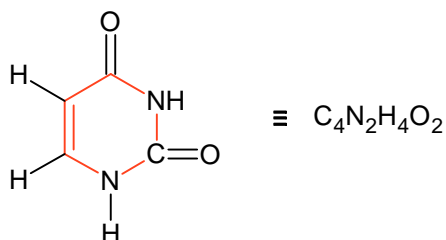


Sol19. Freons is chlorofluorocarbon compounds
 CFCl_3 , CF_2Cl_2 , CF_3Cl

Sol20.

SECTION – B

Sol1. Molecular formula of Uracil



$$\begin{aligned}\text{Molecular mass} &= 12 \times 4 + 14 \times 2 + 1 \times 4 + 16 \times 2 \\ &= 48 + 28 + 4 + 32 \\ &= 112\end{aligned}$$

$$\therefore \% \text{ of N in uracil} = \frac{28}{112} \times 100 = 25\%$$

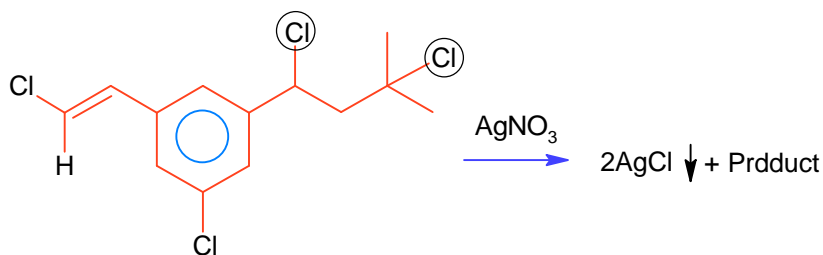
Sol2. M of NaOH solution = $\frac{5}{40} \times \frac{1000}{450} = \frac{5}{18}$ M

$$M_1V_1 = M_2V_2$$

$$\frac{5}{18} \times V = 500 \times 0.1$$

$$\therefore V = \frac{500 \times 0.1 \times 18}{5} = 180 \text{ ml.}$$

Sol3.



3° and benzylic carbocations are more stable, thus only circled chlorine removed as AgCl.

Sol4. $\text{pH} = \text{pK}_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$

$$5 = -\log(x \times 10^{-5}) + \log\left(\frac{5}{0.5}\right)$$

$$5 = 5 - \log x + \log\left(\frac{5}{0.5}\right)$$

$$\log x = \log(10)$$

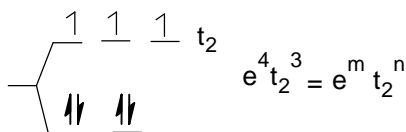
$$x = 10$$

Sol5. $[\text{CoCl}_4]^{-2} \longrightarrow \text{W.F.L complex}$

$$\text{Co}^{+2} = [\text{Ar}] 4s^0 d^7$$



Number of unpaired $e^- = 3$



$$e^4 t_2^3 = e^m t_2^n$$

$$\therefore m + \text{no. of unpaired } e^- = 4 + 3 = 7$$

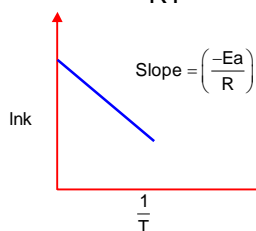
Sol6. (a) $K = A \cdot e^{-E_a/RT}$ When E_a increases K decreases

(b) Temperature co-efficient $= \frac{K_{(T+10)}}{K_T}$

(c) K only depends on Temperature $\longrightarrow k = A \cdot e^{-\frac{E_a}{RT}}$

(d) $\ln k$ Vs $\left(\frac{1}{T}\right)$

$$\ln k = \ln A - \frac{E_a}{RT}$$



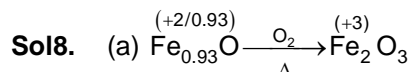
Sol7. For Paschen series

$$\text{For 1st line } \left(\frac{1}{\lambda_1}\right) = R_H Z^2 \left(\frac{1}{3^2} - \frac{1}{4^2}\right) = R_H Z^2 \left(\frac{1}{9} - \frac{1}{16}\right) = R_H Z^2 \left(\frac{7}{9 \times 16}\right)$$

$$\text{For 2nd line } \left(\frac{1}{\lambda_2}\right) = R_H Z^2 \left(\frac{1}{3^2} - \frac{1}{5^2}\right) = R_H Z^2 \left(\frac{1}{9} - \frac{1}{25}\right) = R_H Z^2 \left(\frac{16}{9 \times 25}\right)$$

$$\therefore \left(\frac{\lambda_2}{\lambda_1}\right) = \frac{7/9 \times 16}{16/9 \times 25}$$

$$\begin{aligned}
 &= \frac{7 \times 9 \times 25}{16 \times 9 \times 16} \\
 &= \frac{7 \times 25}{16 \times 16} \\
 \lambda_2 &= \frac{7 \times 25}{16 \times 25} \times 720 = \frac{7 \times 25 \times 90}{16 \times 2} \\
 &= \frac{7 \times 25 \times 45}{16} = 492.18 \text{ nm} \\
 &= 492 \text{ nm}
 \end{aligned}$$



$$\text{O.S of Fe in Fe}_{0.93}\text{O} = +\frac{2}{0.93}$$

$$\text{O.S of Fe in Fe}_2\text{O}_3 = +3$$

$$\begin{aligned}
 \therefore \text{n factor} &= \left(3 - \frac{2}{0.93}\right) \times 0.93 \\
 &= (3 - 2.15) \times 0.93 = 0.79
 \end{aligned}$$

$$\therefore \text{Eq. wt. of Fe}_{0.93}\text{O} = \left(\frac{\text{molar wt.}}{0.79}\right)$$

$$(b) 2x + (0.93 - x) \times 3 = 2$$

$$\therefore (x = 0.79)$$

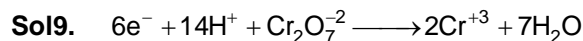
$$\therefore \text{Fe}^{+2} = 0.79$$

$$\text{Fe}^{+3} = 0.93 - 0.79 = 0.21$$

$$(c) \text{Fe}_{0.93}\text{O} \text{ is metal deficient lattice}$$

$$(d) \% \text{ of Fe}^{+2} = \frac{0.79}{0.93} \times 100 = 85\%$$

$$\% \text{ of Fe}^{+3} = (100 - 85) = 15\%$$



$$E = E^0 - \frac{0.059}{n} \log \frac{[\text{Cr}^{+3}]^2}{[\text{Cr}_2\text{O}_7^{2-}][\text{H}^+]^{14}}$$

$$= 1.33 - \frac{0.059}{6} \log \frac{(10^{-1})^2}{(10^{-2})(10^{-3})^{14}}$$

$$= 1.33 - \frac{0.059}{6} \log (10)^{42}$$

$$= 1.33 - \frac{0.059}{6} \times 42$$

$$= 1.33 - 0.413$$

$$= 0.917$$

$$E = 0.917$$

$$x \times 10^{-3} = 917 \times 10^{-3}$$

$$\therefore x = 917$$

Sol10. $\Delta G = \Delta H - T\Delta S$ (a) For process A

$$\Delta G = -25 \times 1000 - 80 = -2580 \text{ J} \rightarrow \text{Spontaneous process}$$

(b) For process B

$$\Delta G = -22 \times 1000 + 40 = -2200 + 40 \rightarrow \text{Spontaneous process}$$

(c) For process C

$$\Delta G = 25 \times 1000 - 50 = 2500 - 50$$

$$= 2450 \text{ J}$$

\rightarrow Non spontaneous process

(d) For process D

$$\Delta G = 22 \times 1000 + 20$$

$$= 2200 + 20 = 2220 \text{ J} \rightarrow \text{Non spontaneous process}$$

PART – C (MATHEMATICS)

SECTION – A

Sol1. Shortest distance = $\left| \frac{\vec{a}_2 - \vec{a}_1 \cdot \vec{b}_1 \vec{b}_2}{|\vec{b}_1 \times \vec{b}_2|} \right|$

$$\vec{b}_1 \times \vec{b}_2 = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 3 & 2 \\ 3 & 2 & 3 \end{vmatrix}$$

$$= 5\hat{i} - 3\hat{j} - 3\hat{k}$$

$$\text{Shortest distance} = \frac{|-5 - 3 - 3|}{\sqrt{25 + 9 + 9}} = \frac{11}{\sqrt{43}}$$

$$\tan^{-1} \left(\frac{1 + \sqrt{3}}{3 + \sqrt{3}} \right) + \sec^{-1} \sqrt{\frac{8 + 4\sqrt{3}}{6 + 3\sqrt{3}}}$$

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

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

$$= \frac{\pi}{6} + \frac{\pi}{6} = \frac{\pi}{3}$$

Sol2. As $t \rightarrow 0$

$$\sin^2 t \rightarrow 0$$

$$\frac{1}{\sin^2 t} \rightarrow \infty$$

$$\lim_{t \rightarrow 0} n \left[\left(\frac{1}{n} \right)^{\frac{1}{\sin^2 t}} + \left(\frac{2}{n} \right)^{\frac{1}{\sin^2 t}} + \left(\frac{3}{n} \right)^{\frac{1}{\sin^2 t}} + \dots + 1 \right]^{\sin^2 t} = n[0 + 0 + 0 + \dots + 1] = n$$

Sol3. $y^2 = 24x$

Equation of tangent to the parabola of slope 'm'

$$y = mx + \frac{a}{m}$$

$$y^2 = 24x$$

$$y^2 = 4.6x$$

$$a = 6$$

Equation of tangent $y = mx + \frac{6}{m}$

$$my = m^2x + 6$$

$$m^2x - my + 6 = 0 \dots\dots\dots(i)$$

Let mid point of AB is (h, k)

Equation of chord given mid point

$$T = S_1$$

$$\frac{xk + yh}{2} = hk$$

$$kx + hy - 2hk = 0 \dots\dots\dots(ii)$$

Now comparing (i) & (ii)

$$\frac{m^2}{k} = \frac{-m}{h} = \frac{3}{k}$$

$$m^2 = \frac{-3}{h}, m = \frac{3}{k}$$

$$\frac{3q}{k^2} = \frac{-3}{h}$$

$$k^2 = -3h \Rightarrow y^2 = -3x$$

$$y^2 = 4\left(\frac{-3}{4}\right)x$$

Sol4. $\sum_{r=0}^{22} {}^{22}C_r \cdot {}^{23}C_r$

Coefficient of x^{23} in the expansion of $(1+x)^{22}(1+x)^{23}$

$$= \sum_{r=0}^{22} {}^{22}C_r \cdot {}^{23}C_{23-r}$$

$$= {}^{45}C_{23}$$

Sol5. $A^2 + B = A^2B$

$$A^2 + B - A^2B - I = -I$$

$$A^2(I - B) + (B - I) = -I$$

$$(B - I)(A^2 - I) = I$$

Inverse of each other

$$(B - I)(A^2 - I) = (A^2 - I)(B - I)$$

$$BA^2 = A^2B$$

Sol6. $D \neq 0$

$$\begin{vmatrix} 1 & 1 & 1 \\ N & 1 & 1 \\ 3 & N-3 & 1 \end{vmatrix} \neq 0$$

$$\Rightarrow (N-1)(N-4) \neq 0$$

$$N \neq 1, 4$$

N can be 2, 3, 5, 6

$$\text{Required probability} = \frac{4}{6} \Rightarrow k = 4$$

$$\text{Sum} = (2 + 3 + 5 + 6) + 4 = 20$$

$$\text{Sol7. } A = \frac{2\vec{q} + \vec{r}}{3}, B = \frac{2\vec{r}}{3}, C = \frac{\vec{q}}{3}$$

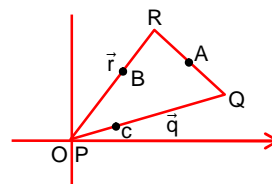
$$\text{Area of } \triangle PQR = \frac{1}{2} |\vec{q} \times \vec{r}|$$

$$\text{Area of } \triangle ABC = \frac{1}{2} |\overrightarrow{AB} \times \overrightarrow{AC}|$$

$$\overrightarrow{AB} = \frac{\vec{r} - 2\vec{q}}{3}, \overrightarrow{AC} = \frac{-\vec{r} - \vec{q}}{3}$$

$$\text{Area of } \triangle ABC = \frac{1}{6} |\vec{q} \times \vec{r}|$$

$$\therefore \frac{\text{Area of } \triangle PQR}{\text{Area of } \triangle ABC} = 3$$



$$\text{Sol8. } \vec{u} = \hat{i} - \hat{j} - 2\hat{k}, \vec{v} = 2\hat{i} + \hat{j} - \hat{k}$$

$$\vec{v} \cdot \vec{w} = 2, \vec{v} \times \vec{w} = \vec{u} + \lambda \vec{v}$$

$$\text{Now } \vec{v} \times \vec{w} = \vec{u} + \lambda \vec{v}$$

$$\vec{w} \cdot (\vec{v} \times \vec{w}) = \vec{u} \cdot \vec{w} + \lambda \vec{v} \cdot \vec{w}$$

$$\Rightarrow 0 = \vec{u} \cdot \vec{w} + 2\lambda$$

Now

$$\vec{v} \times \vec{w} = \vec{u} + \lambda \vec{v}$$

$$\vec{v} \cdot (\vec{v} \times \vec{w}) = \vec{u} \cdot \vec{v} + \lambda \vec{v} \cdot \vec{v}$$

$$\Rightarrow 0 = (2 - 1 + 2) + \lambda 6$$

$$\lambda = -\frac{1}{2}$$

$$\Rightarrow \vec{u} \cdot \vec{w} = -2\lambda = 1$$

Sol9. $\Delta = 0$

$$\begin{vmatrix} \alpha^2 & \alpha & 1 \\ 1 & 1 & 1 \\ a & b & c \end{vmatrix} = 0$$

$$\alpha^2(c-b) - \alpha(c-a) + (b-a) = 0$$

$$\begin{aligned}
& \frac{(a-c)^2}{(b-a)(c-b)} + \frac{(b-a)^2}{(a-c)(c-b)} + \frac{(c-b)^2}{(a-c)(b-a)} \\
&= \frac{(a-b)^3 + (b-c)^3 + (c-a)^3}{(a-b)(b-c)(c-a)} \\
&= \frac{3(c-b)(b-c)(c-a)}{(a-b)(b-c)(c-a)} = 3
\end{aligned}$$

Sol10. $(1 - \sqrt{3}i)^{200} = 2^{199} (p + iq)$

$$2^{200} \left(\cos \frac{\pi}{3} - i \sin \frac{\pi}{3} \right)^{200} = 2^{199} (p + iq)$$

$$2 \left(-\frac{1}{2} - i \frac{\sqrt{3}}{2} \right) = p + iq$$

$$p = -1, q = -\sqrt{3}$$

$$\alpha = p + q + q^2 = 2 - \sqrt{3}$$

$$\beta = p - q + q^2 = 2 + \sqrt{3}$$

$$\alpha + \beta = 4$$

$$\alpha \cdot \beta = 1$$

$$\therefore x^2 - 4x + 1 = 0$$

Sol11. Equation of plane

$$\begin{vmatrix} x-2 & y+3 & z-1 \\ -3 & 4 & -3 \\ 4 & -5 & 4 \end{vmatrix} = 0$$

$$x - z - 1 = 0$$

$$\text{Distance of point } (7, -3, -4) = \left| \frac{7 + 4 - 1}{\sqrt{2}} \right| = 5\sqrt{2}$$

Sol12. $x^3 dy + (xy - 1) dx$

$$x^3 \cdot dy = -(xy - 1) \cdot dx$$

$$\frac{dy}{px} + py = \theta$$

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

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

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

$$y \cdot e^{-\frac{1}{x}} = \int \frac{-1}{x^3} \cdot e^{-\frac{1}{x}} dx$$

$$\text{Put } \frac{-1}{x} = t$$

$$y \cdot e^{-\frac{1}{x}} = \int -e^t \cdot t \cdot dt$$

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

$$\text{Put } x = \frac{1}{2}$$

$$3 - e = 2 + 1 + ce^2$$

$$c = \frac{1}{e}$$

$$y(1) = 1$$

Sol13. Logical based

Sol14. Reflexive $(a, a) \Rightarrow \gcd \text{ of } (a, a) = 1$

not true for $a \in \mathbb{Z}$

symmetric

$$a = 2, b = 1 \Rightarrow \gcd(2, 1) = 1$$

Sol15. $pq^2 = \log_x k$, $qr = \log_y k$, $p^2r = \log_z k$

$$\log_k x = \frac{1}{pq^2}, \log_k y = \frac{1}{qr}, \log_k z = \frac{1}{p^2r}$$

$$\log_y x = \frac{qr}{pq^2}, \log_z x = \frac{pq^2}{p^2r}, \log_z y = \frac{p^2r}{qr}$$

\therefore Now $3, 3\log_y x, 3\log_z y, 7\log_z z \rightarrow \text{AP}$ (As per question)

$$3, \frac{3r}{pq}, \frac{3p^2}{q}, \frac{7q^2}{pr} \text{ in AP}$$

$$\frac{3r}{pq} - 3 = \frac{1}{2} \rightarrow \text{common difference given}$$

$$r = \frac{7}{6}pq$$

$$r = pq + 1 \rightarrow \text{given}$$

$$\therefore pq = 6$$

$$r = 7$$

$$\frac{3p^2}{q} = 4$$

on solving $p = 2, q = 3$

Sol16. Equation of line

$$\frac{x+1}{3} = \frac{y-9}{-4} = \frac{z+16}{12} = \lambda$$

$$((3\lambda - 1), -4\lambda + 9, 12\lambda - 16)$$

point of intersection of line and plane

$$2(3\lambda - 1) + 3(-4\lambda + 9) - (12\lambda - 16) = 5$$

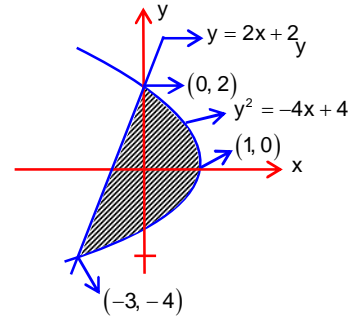
$$\lambda = 2$$

Point $(5, 1, 8)$

$$\text{Distance from } (-1, 9, -16) = \sqrt{36 + 64 + 576} = 26$$

Sol17. Required area

$$\begin{aligned}
 & \int_{-4}^2 \left(\frac{4-y^2}{4} - \frac{y-2}{2} \right) dy \\
 &= \left[2y - \frac{y^3}{12} - \frac{y^2}{4} \right]_{-4}^2 \\
 &= \left(4 - \frac{8}{12} - 1 \right) - \left(-8 + \frac{16}{3} - 4 \right) \\
 &= \left(3 - \frac{2}{3} \right) + 12 - \frac{16}{3} \\
 &= 9 \text{ sq. unit}
 \end{aligned}$$



Sol18. $x^2 - 4x + [x] + 3 = x[x]$
 $x^2 - 4x + 3 = x[x] - [x]$
 $x^2 - 4x + 3 = [x](x-1)$
 $(x-1)(x-3) = [x](x-1)$
 $x = 1$ or $(x-3) = [x]$
 $x - [x] = 3$
 $\{x\} = 3$ Not possible
 $x = 1$ is only one solution.

Sol19. $\underbrace{(\sim(p \wedge Q))}_A \vee \underbrace{((\sim p) \wedge Q)}_B \Rightarrow ((\sim p) \wedge (\sim Q))$

P	Q	$\sim P$	$\sim Q$	$\sim(P \wedge Q)$	$(\sim P) \wedge Q$	A	B	$A \rightarrow B$
T	T	F	F	F	F	F	F	T
T	F	F	T	T	F	T	F	F
F	T	T	F	T	T	T	F	F
F	F	T	T	T	F	T	T	T

Sol20. $f(x) = \begin{cases} x^2 \sin\left(\frac{1}{x}\right), & x \neq 0 \\ 0, & x = 0 \end{cases}$

$$f'(x) = \begin{cases} 2x \cdot \sin\left(\frac{1}{x}\right) - \cos\left(\frac{1}{x}\right), & x \neq 0 \\ 0, & x = 0 \end{cases}$$

$\therefore f'(x)$ is not continuous due to high oscillation of $\cos\left(\frac{1}{x}\right)$ at $x = 0$.

SECTION - B

Sol1. $12 \int_0^{13} |x^2 - 3x + 2| dx$
 $f(x) = x^2 - 2x - x + 2$
 $= x(x-2) - 1(x-2)$



$$\begin{aligned}
 &= (x-1)(x-2) \\
 &= 12 \left\{ \int_0^1 (x^2 - 3x + 2) dx + \int_1^2 (x^2 - 3x + 2) dx + \int_2^3 (x^2 - 3x + 2) dx \right\} \\
 &= 12 \left\{ \left[\frac{x^3}{3} - \frac{3x^2}{2} + 2x \right]_0^1 - \left[\frac{x^3}{3} - \frac{3x^2}{2} + 2x \right]_1^2 + \left[\frac{x^3}{3} - \frac{3x^2}{2} + 2x \right]_2^3 \right\} \\
 &= 12 \left(\frac{11}{16} \right) = 22
 \end{aligned}$$

Sol2. $\sum_{r=0}^{2023} r^2 \cdot {}^{2023}C_r$

$$\begin{aligned}
 &= \sum_{r=0}^{2023} (r(r-1) + r) \cdot \frac{{}^{2023}C_r}{r} \cdot \frac{{}^{2022}C_{r-2}}{(r-1)} \cdot {}^{2021}C_{r-2} \\
 &= 2023 \times 2024 \cdot 2^{2021} = 2023 \times 1012 \cdot 2^{2022} \\
 &\alpha = 1012
 \end{aligned}$$

Sol3. $I = \frac{8}{\pi} \int_0^{\pi/2} \frac{(\cos x)^{2023}}{(\sin x)^{2023} + (\cos x)^{2023}} dx \dots\dots\dots(i)$

As $\int_0^a f(x) = \int_0^a f(a-x)$

$$I = \frac{8}{\pi} \int_0^{\pi/2} \frac{(\sin x)^{2023}}{(\cos x)^{2023} + (\sin x)^{2023}} dx \dots\dots\dots(ii)$$

Adding (i) & (ii)

$$2I = \frac{8}{\pi} \int_0^{\pi/2} dx$$

$$2I = \frac{8}{\pi} [x]_0^{\pi/2}$$

$$2I = \frac{8}{\pi} \cdot \left[\frac{\pi}{2} \right]$$

$$I = 2$$

Sol4. $9x^2 + 16y^2 = 144$

$$\frac{x^2}{16} + \frac{y^2}{9} = 1$$

$$a = 4, b = 3$$

Point on ellipse $(4\cos\theta, 3\sin\theta)$

Equation of tangent to the ellipse

$$\frac{x\cos\theta}{4} + \frac{y\sin\theta}{3} = 1$$

Point of intersection with axes

$$A(4\sec\theta, 0), B(0, 3\csc\theta)$$

$$AB = \sqrt{25 + 16\tan^2\theta + 9\cot^2\theta}$$

Minimum value is 7

Sol5. $|x|^2 - 2|x| + |\lambda - 3| = 0$

$$|x|^2 - 2|x| + |\lambda - 3| + 1 = 1$$

$$(|x| - 1)^2 + |\lambda - 3| = 1$$

$$(|x| - 1)^2 = 1 - |\lambda - 3|$$

Maximum value $x + \lambda = 5$ (for integral solution)

Sol6. Common ratio = $\frac{1}{m}$

$$T_4 = 500$$

$$ar^3 = 500$$

$$\frac{a}{m^3} = 500$$

$$S_n - S_{n-1} = ar^{n-1}$$

$$S_6 > S_5 + 1 \text{ \& } S_7 - S_6 < \frac{1}{2} \text{ [given]}$$

$$S_6 - S_5 > 1$$

$$ar^5 > 1$$

$$\frac{500}{m^2} > 1$$

$$m^2 < 500$$

$$1000 < m^3$$

$$m > 10$$

$$m = 11, 12, 13, \dots, 22$$

Number of m is 12

$$\frac{a}{m^6} < \frac{1}{2}$$

$$\frac{a}{m^3 \cdot m^3} < \frac{1}{2}$$

$$\frac{500}{m^3} < \frac{1}{2}$$

Sol7. Shortest distance

$$= \frac{\begin{vmatrix} 4 & 2 & -14 \\ 3 & 2 & 2 \\ 3 & -2 & 0 \end{vmatrix}}{\begin{vmatrix} i & 3 & k \\ 3 & 2 & 2 \\ 3 & -2 & 0 \end{vmatrix}} = \frac{16 + 12 + 168}{-4\hat{i} + 6\hat{j} - 12\hat{k}} = \frac{196}{14} = 14$$

Sol8. ${}^5C_0 \cdot {}^7C_5 + {}^5C_1 \cdot {}^7C_4 + {}^5C_2 \cdot {}^7C_3 = 546$

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Sol9. Even place occupied by even digit

$$\frac{4!}{2! \times 2!} \times \frac{5!}{2!3!} = 60$$

Sol10. Equation of normal

$$3 \sec \theta x - 2 \operatorname{cosec} \theta y = 10$$

Passing through (2, 0)

$$\cos \theta = \frac{3}{5}, \sin \theta = \frac{4}{5}$$

$$\text{Point } P = \left(\frac{18}{5}, \frac{16}{5} \right)$$

$$\text{Radius of circle } \sqrt{\left(\frac{18}{5} - 2 \right)^2 + \left(\frac{16}{5} - 0 \right)^2}$$

$$= \frac{\sqrt{320}}{5}$$

$$\text{Equation of circle } (x - 2)^2 + y^2 = \frac{64}{5}$$

Passing through $(1, \alpha)$

$$\alpha^2 = \frac{59}{5}$$

$$10\alpha^2 = 118$$

