FIITJEE

Solutions to JEE(Main) -2023

Test Date: 31st January 2023 (Second 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. Given below are two statements :

Statement I : For transmitting a signal, size of antenna (ℓ) should be comparable to wavelength of signal (at least $\ell = \frac{\lambda}{4}$ in dimension)

Statement II : In amplitude modulation, amplitude of carrier wave remains constant (uncharged).

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

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

Q2. Heat energy of 735 J is given to a diatomic gas allowing the gas to expand at constant pressure. Each gas molecule rotates around an internal axis but do not oscillate. The increase in the internal energy of the gas will be :

(A) 525 J (B) 735 J
(C) 572 J (D) 441 J

Q3. The number of turns of the a moving coil galvanometer is increased in order to increase current sensitivity by 50%. The percentage change in voltage sensitivity of the galvanometer will be :

(A) 100% (B) 50%
(C) 75% (D) 0%

Q4. A body weight W, is projected vertically upwards from earth's surface to each a height above the earth which is equal to nine times the radius of earth. The weight of the body at that height will be :

(A) $\frac{W}{91}$ (B) $\frac{W}{100}$
(C) $\frac{W}{9}$ (D) $\frac{W}{3}$

Q5. An alternative voltage V = 260 sin (628t) is connected across a pure inductor of 5 mH. Inductive reactance in the circuit is :

(A) $0.5\,\Omega$ (B) $6.28\,\Omega$
(C) $0.318\,\Omega$ (D) $3.14\,\Omega$

Q6. Match List I with List II

List I	**List II**
A. Angular momentum	I. $[ML^2T^{-2}]$
B. Torque	II. $[ML^{-2}T^{-2}]$
C. Stress	III. $[ML^2T^{-1}]$
D. Pressure gradient	IV. $[ML^{-1}T^{-2}]$

Choose the correct answer from the options given below :
(A) A – IV, B – II, C – I, D – III
(B) A – I, B – IV, C – III, D – II
(C) A – II, B – III, C – IV, D – I
(D) A – III, B – I, C – IV, D – II

Q7. Given below are statements :
Statement I : In a typical transistor, all three regions emitter, base collector have same doping level.
Statement II : In a transistor, collectors is the thickest and base is the thinnest segment.
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 incorrect
(B) **Statement I** is incorrect but **Statement II** is correct
(C) Both **Statement I** and **Statement II** are correct
(D) **Statement I** is correct but **Statement II** is incorrect

Q8. A body is moving with constant speed, in a circle of radius 10m. The body completes one revolution in 4 s. At the end of 3rd second, the displacement of body (in m) from its starting point is :
(A) $10\sqrt{2}$
(B) 5π
(C) 15π
(D) 30

Q9. Under the same load, wire A having length 5.0m and cross section $2.5\times10^{-5}m^2$ stretches uniformly by the same amount as another wire B of length 6.0m and a cross section of $3.0\times10^{-5}m^2$ stretches. The ratio of the Young's modulus of wire A to that of wire B will be :
(A) 1 : 1
(B) 1 : 4
(C) 1 : 10
(D) 1 : 2

Q10. A microscope is focused on an object at the bottom of a bucket. If liquid with refractive index $\frac{5}{3}$ is poured inside the bucket, then microscope have to be raised by 30cm to focus the object again The height of the liquid in the bucket is :
(A) 75 cm
(B) 12 cm
(C) 18 cm
(D) 50 cm

Q11. If the metals A and B are exposed to radiation of wavelength 350 nm. The work functions of metals A and B are 4.8eV and 2.2 eV. Then choose the correct option.
(A) Both metals A and B will emit photo-electrons
(B) Metal A will not emit photo-electrons
(C) Both metals A and B will not emit photo-electrons
(D) Metal B will not emit photo-electrons

Q12. A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5s due to friction between body and the floor. The value of the coefficient of friction is : (Take acceleration due to gravity g = 10 ms^{-2})
(A) 0.2
(B) 0.5
(C) 0.4
(D) 0.3

Q13. Match List I with List II

List I	**List II**
A. Microwaves	I. Physiotherapy
B. UV rays	II. Treatment of cancer
C. Infra-red light	III. Lasik eye surgery
D. X-ray	IV. Aircraft navigation

Choose the correct answer from the options given below :
(A) A – II, B – IV, C – III, D – I
(B) A – IV, B – III, C – I, D – II
(C) A – III, B – II, C – I, D – IV
(D) A – IV, B – I, C – II, D – III

Q14. A long conducting wire having a current I following through it is, bent into a circular of N turns. Then it is bent into a circular coil of n turns. The magnetic field is calculated at the centre of coils on both the case. The ratio of the magnetic field in first case to that of second case is :

(A) $n^2 : N^2$ (B) $N^2 : n^2$

(C) n : N (D) N : n

Q15. For a solid rod, the Young's modulus of elasticity is $3.2\times10^{11}Nm^{-2}$ and density is $8\times10^3kg\ m^{-3}$. The velocity of longitudinal wave in the rod will be.

(A) $3.65\times10^3\ ms^{-1}$ (B) $6.32\times10^3\ ms^{-1}$

(C) $145.75\times10^3\ ms^{-1}$ (D) $18.96\times10^3\ ms^{-1}$

Q16. The H amount of thermal energy is developed by a resistor in 10s when a current of 4A is passed through it. If the current is increased to 16A. the thermal energy developed by the resistor in 10s will be:

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

(C) H (D) 16H

Q17. A stone of mass 1kg is tied to end of a massless string of length 1m. If the breaking tension of the string is 400N, then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is :

(A) $20\ ms^{-1}$ (B) $400\ ms^{-1}$

(C) $40\ ms^{-1}$ (D) $10\ ms^{-1}$

Q18. The radius of electron's second stationary orbit in Bohar's stom is R. The radius of 3rd orbit will be

(A) $\frac{R}{3}$ (B) 9R

(C) 3R (D) 2.25R

Q19. Considering a group of positive charges, which of the following statements is correct?

(A) Net potential of the system at a point can be zero but net electric field can't be zero at the point.

(B) Both the net potential and the net electric field cannot be zero at a point.

(C) Net potential of the system cannot be zero at a point but net electric field can be zero at the point.

(D) Both the net potential and the net field can be zero at a point.

Q20. A hypothetical gas expands adiabatically such that its volume changes form 08 liters to 27 liters. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then ratio of $\frac{C_p}{C_v}$ will be.

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

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

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. Two bodies are projected from ground with same speeds $40ms^{-1}$ at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body projected at an angle of 60°, with horizontal then sun of the maximum heights, attained by the two projectiles, is_____m. (Given g = 10 ms^{-2})

Q2. A water heater pf power 2000W is used to heat water. The specific heat capacity of water is 4200J kg^{-1} K^{-1}. The efficiency of heater is 70%. Time required to heat 2kg of water from $10^{\circ}C$ to $60^{\circ}C$ is _____s.
(Assume that the specific heat capacity of water remains constant over the temperature range of the water).

Q3. A ball is dropped from a height of 20m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a heights to a height of _____m.

Q4. Two discs of same and different radii are made of different materials such that their thicknesses are 1cm and 0.5cm respectively. The densities of materials are in the ratio 3:5. The moment of inertia of these disc respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of x is _____.

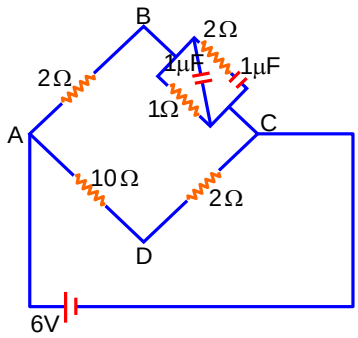
Q5. If the binding energy of ground state electron in a hydrogen atom is 13.6 eV, then, the energy required to remove the electron from the the second excited state of Li^{2+} will be : $x \times 10^{-1}$eV. The value of x is_____.

Q6. The displacement equations of two interfering waves are given by $y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$cm, $y_2 = 5\left[\sin\omega t + \sqrt{3}\cos\omega t\right]$ cm respectively.
The amplitude of the resultant wave is _____cm.

Q7. A series LCR circuit consists of $R = 80\Omega, X_L = 100\Omega$ and $X_C = 40\Omega$. The input voltage is 2500cos(100 π t)V. The amplitude of current, in the circuit, is _____A.

Q8. Two parallel plate capacitors C_1 and C_2 each having capacitance of $10\mu F$ are individually charged by a 100VD.C. source. Capacitor C_1 is kept connected to the source and a dielectric slab is inserted between it plates. Capacitor C_2 is disconnected from the source and then a dielectric slab is inserted in it. Afterwards the capacitor C_1 is also disconnected from the source and the two capacitors are finally connected in parallel combination. The common potential of the combination will be_____V.
(Assuming Dielectric constant = 10)

Q9. For the given circuit, in the steady state, $|V_B - V_D|$ =_____V.



Q10. Two light waves wavelengths 800 and 600nm are used in Young's double slit experiment to obtain interference fringes on a screen placed 7m away from plane of slits. If the two slits are separated by 0.35mm, then shortest distance from the central bright maximum to the where the bright fringes of the two wavelengths coincide will be _____mm.

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. In the following halogenated organic compounds the one with maximum number of chlorine atoms in its structure is:
(A) Chloral
(B) Gammaxene
(C) Chloropicrin
(D) Freon-12

Q2. Which one of the following statements is incorrect?
(A) Boron and Indium can be purified by zone refining method.
(B) van Arkel method is used to purify tungsten.
(C) Cast iron is obtained by melting pig iron with scrap iron and coke using hot air blast.
(D) The malleable iron is prepared from cast iron by oxidising impurities in a reverberatory furnace.

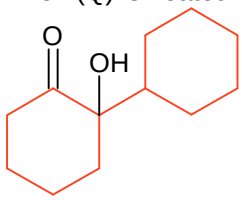
Q3. In Dumas method for the estimation of N_2. the sample is heated with copper oxide and the gas evolved is passed over:
(A) Ni
(B) Pd
(C) Copper gauze
(D) Copper oxide

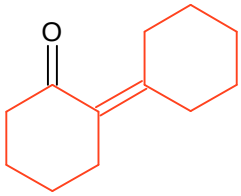
Q4. Given below are two statements, one is labelled as **Assertion (A)** and the other is labelled as **Reason (R) .**
Assertion (A): The first ionization enthalpy of 3d series elements is more than that of group 2 metals
Reason (R): In 3d series of elements successive filling of d- orbitals takes place. In the light of the above statements, choose the correct answer from the option given below:
(A) **(A)** is true but **(R)** is false
(B) **(A)** is false but (R) is true
(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)**

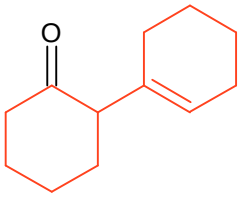
Q5. Which of the following compounds are not used as disinfectants?
A. Chloroxylenol
B. Bithional
C. Veronal
D. Prontosil
E. Terpineol
Choose the **correct** answer from the options given below :
(A) A, B
(B) A, B, E
(C) C, D
(D) B, D, E

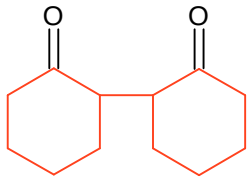
Q6. A hydrocarbon 'X' with formula C_6H_8 uses two moles of H_2 on catalytic hydrogenation of its one mole. on ozonolysis. 'X' yield two moles of methane dicarbaldhyde. The hydrocarbon 'X' is :
(A) hexa-1, 3, 5-triene
(B) cyclohexa-1, 3- diene
(C) 1- methylcyclopenta-1, 4-diene
(D) cyclohexa-1, 4-diene

Q7. Cyclohexylamine when treated with nitrous acid yields (P). On treating (P) with PCC results in (Q). When (Q) is heated with dil.NaOH we get (R) The final product (R) is:

(A) 

(B) 

(C) 

(D) 

Q8. The Lewis acid character of boron tri halides follows the order:

(A) $BF_3 > BCl_3 > BBr_3 > BI_3$ (B) $BI_3 > BBr_3 > BCl_3 > BF_3$

(C) $BBr_3 > BI_3 > BCl_3 > BF_3$ (D) $BCl_3 > BF_3 > BBr_3 > BI_3$

Q9. The normal rain water is slightly acidic and its pH value is 5.6 because of which one of the following?

(A) $2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$ (B) $CO_2 + H_2O \rightarrow H_2CO_3$

(C) $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ (D) $N_2O_5 + H_2O \rightarrow 2HNO_3$

Q10. Given below are two statements:

Statement I: Upon heating a borax bead dipped in cupric sulphate in a luminous flame, the colour of the bead becomes green

Statement II: The green colour observed is due to the formation of copper (I) metaborate

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

Q11. Given below are two statements:

Statement I: H_2O_2 is used in the synthesis of Cephalosporin.

Statement II: H_2O_2 is used for the restoration of aerobic conditions to sewage wastes.

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 correct

(B) **Statement I** is incorrect but **Statement II** is correct

(C) **Statement I** is correct but **Statement II** is incorrect

(D) Both **Statement I** and **Statement II** are incorrect.

Q12. When a hydrocarbon A undergoes complete combustion it requires 11 equivalents of oxygen and produces 4 equivalents of water. What is the molecular formula of A?

(A) C_5H_8 (B) $C_{11}H_4$

(C) $C_{11}H_8$ (D) C_9H_8

Q13. Evaluate the following statements for their correctness.

A. The elevation in boiling point temperature of water will be same for 0.1 M NaCl and 0.1 M urea.

B. Azeotropic mixture boil without change in their composition.

C. Osmosis always takes place from hypertonic to hypotonic solution.

D. The density of 32% H_2SO_4 solution having molarity 4.09 M is approximately 1.26 g mL^{-1}.

E. A negatively charged sol is obtained when KI solution is added to silver nitrate solution
Choose the correct answer from the options given below:
(A) B and D only
(B) A, B and D only
(C) A and C only
(D) B, D and E only

Q14. Arrange the following orbitals in decreasing order of energy
A. n = 3, l= 0, m = 0
B. n = 4, l= 0, m = 0
C. n = 3, l = 1, m = 0
D. n= 3, l = 2, m = 1
The correct option for the order is :
(A) D >B > A >C
(B) B > D > C > A
(C) A > C > B > D
(D) D > B > C > A

Q15. Incorrect statement for the use of indicators in acid-base titration is:
(A) Phenolphthalein is a suitable indicator for a weak acid vs strong base titration.
(B) Phenolphthalein may be used for a strong acid vs strong base titration.
(C) Methyl orange may be used for a weak acid vs weak base titration.
(D) Methyl orange is a suitable indicator for a strong acid vs weak base titration.

Q16. Which of the following elements have half- filled f-orbitals in their ground state?
(Given: atomic number Sm = 62; Eu = 63; Tb = 65; Gd = 64, Pm = 61)
A. Sm
B. Eu
C. Tb
D. Gd
E. Pm
Choose the **correct** answer from the options given below :
(A) C and D only
(B) A and B only
(C) B and D only
(D) A and E only

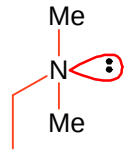
Q17. The element playing significant role in neuromuscular function and inter neuronal transmission is:
(A) Mg
(B) Li
(C) Ca
(D) Be

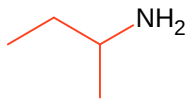
Q18. Match **List I** with **List II**

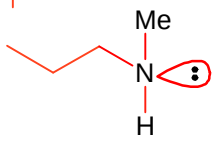
List-I		**List-II**	
A.	Physisorption	I.	Single Layer Adsorption
B.	Chemisorption	II.	20-40kJ mol^{-1}
C.	$N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$	III.	Chromatography
D.	Analytical Application or Adsorption	IV.	Heterogeneous catalysis

Choose the correct answer from the options given below:
(A) A- IV, B-II, C-III, D-I
(B) A-II, B-I, C-IV, D-III
(C) A-III, B-IV, C-I, D-II
(D) A-II, B-III, C-I, D-IV

Q19. An organic compound [A] ($C_4H_{11}N$), shows optical activity and gives N_2 gas on treatment with HNO_2. The compound [A] reacts with $PhSO_2Cl$ producing a compound which is soluble in KOH. The structure of A is:

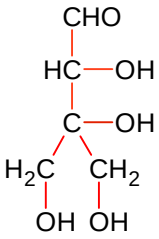
(A) 

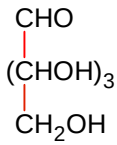
(B) 

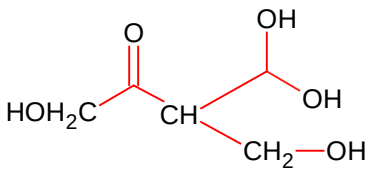
(C) 

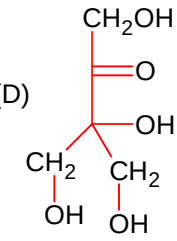
(D) 

Q20. Compound A, $C_5H_{10}O_5$. given a tetraacetate with Ac_2O and oxidation of A with Br_2-H_2O gives an acid,$C_5H_{10}O_6$. Reduction of A with HI gives isopentane. The possible structure of A is:

(A) 

(B) 

(C) 

(D) 

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 carbon burns according to following equation:

$2C_{(s)} + O_{2(g)} \rightarrow 2CO(g)$

When 12 g carbon is burnt in 48 g of oxygen, the volume of carbon monoxide produced is _____ $\times 10^{-1}$ L at STP [Nearest integer]

[Given: Assume CO as ideal gas, Mass of C is 12 g mol^{-1}, Mass of O is 16 g mol^{-1} and molar volume of an ideal gas at STP is 22.7 L mol^{-1}

Q2. Amongst the following, the number of species having the linear shape is_____.

$XeF_2, I_3^+, C_3O_2, I_3^-, CO_2, SO_2, BeCl_2$ and $BCl_2^{\ominus}$

Q3. The rate constant for a first order reaction is 20 min^{-1}. The time required for the initial concentration of the reactant to reduce to its $\frac{1}{32}$ level is_____ $\times 10^{-2}$ min.

(Nearest integer)
(Given: ln 10 = 2.303
Log 2 = 0.3010)

Q4. Enthalpies of formation of $CCl_4(g)$. $H_2O(g)$, $CO_2(g)$ and HCl(g) are –105, –242, –394 and –92 kJ mol^{-1} respectively. The magnitude of enthalpy of the reaction given below is _____ kJ mol^{-1}(nearest integer)

$CCl_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4HCl(g)$

Q5. The resistivity of a 0.8 M solution of an electrolyte is 5 $\times 10^{-3} \Omega$ cm. Its molar conductivity is _____ $\times 10^4 \Omega^{-1}$ cm^2 mol^{-1}. (Nearest integer)

Q6. At 298 K, the solubility of silver chloride in water is 1.434 $\times 10^{-3}$ gL^{-1}. The value of $-\log K_{sp}$ for silver chloride is_____.

(Given mass of Ag is 107.9 g mol^{-1} and mass of Cl is 35.5 g mol^{-1})

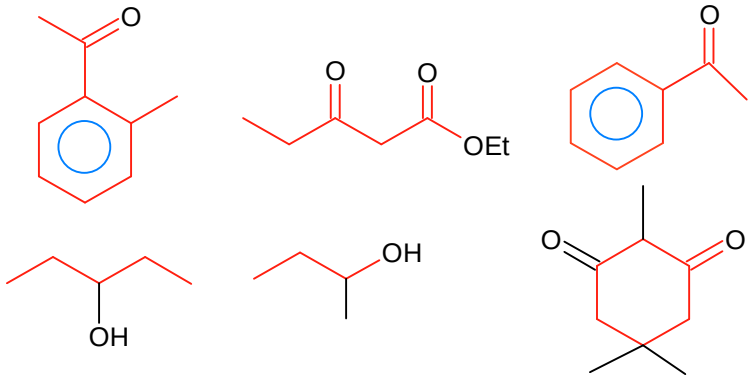
Q7. The number of alkali metal(s), from Li, K Cs, Rb having ionization enthalpy greater than 400kJ mol^{-1} and forming stable super oxide is_____.

Q8. A sample of a metal oxide has formula $M_{0.83}O_{1.00}$. The metal M can exist in two oxidation states +2 and +3, In the sample of $M_{0.83}O_{1.00}$, the percentage of metal ions existing in +2 oxidation state is_____ % (nearest integer)

Q9. If the CFSE of $[TiH_2O)_6]^{3+}$ is –96.0 kJ / mol, this complex will absorb maximum at wavelength _____nm. (nearest integer)

Assume Plank's constant (h) = 6.4×10^{-34} Js, speed of light (c) = 3.0 $\times 10^8$ m/s and Avogadro's constatn (N_A) = 6×10^{23} / mol.

Q10. The number of molecules which gives haloform test among the following molecules 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. If $\phi(x)=\frac{1}{\sqrt{x}}\int_{\frac{\pi}{4}}^{x}\left(4\sqrt{2}\sin t-3\phi'(t)\right)dt,\ x>0$, then $\phi'\left(\frac{\pi}{4}\right)$ is equal to :

(A) $\frac{8}{\sqrt{\pi}}$ (B) $\frac{4}{6+\sqrt{\pi}}$

(C) $\frac{4}{6-\sqrt{\pi}}$ (D) $\frac{8}{6+\sqrt{\pi}}$

Q2. Let the plane $P: 8x+a_1y+a_2z+12=0$ be parallel to the line $L: \frac{x+2}{2}=\frac{y-3}{3}=\frac{z+4}{5}$. If the intercept of P on the y-axis is 1, then the distance between P and L is :

(A) $\sqrt{\frac{7}{2}}$ (B) $\sqrt{\frac{2}{7}}$

(C) $\frac{6}{\sqrt{14}}$ (D) $\sqrt{14}$

Q3. $\lim\limits_{x\to\infty}\frac{\left(\sqrt{3x+1}+\sqrt{3x-1}\right)^6+\left(\sqrt{3x+1}-\sqrt{3x-1}\right)^6}{\left(x+\sqrt{x^2-1}\right)^6+\left(x-\sqrt{x^2-1}\right)^6}$

(A) is equal to 27 (B) is equal to $\frac{27}{2}$

(C) does not exist (D) is equal to 9

Q4. Let $f: R-\{2,6\}\to R$ be real valued function defined as $f(x)=\frac{x^2+2x+1}{x^2-8x+12}$. Then range of f is

(A) $\left(-\infty,-\frac{21}{4}\right]\cup[0,\infty)$ (B) $\left(-\infty,-\frac{21}{4}\right)\cup(0,\infty)$

(C) $\left(-\infty,-\frac{21}{4}\right]\cup[1,\infty)$ (D) $\left(-\infty,-\frac{21}{4}\right]\cup\left[\frac{21}{4},\infty\right)$

Q5. Let $\alpha>0$. If $\int_0^{\alpha}\frac{x}{\sqrt{x+\alpha}-\sqrt{x}}dx=\frac{16+20\sqrt{2}}{15}$, then α is equal to :

(A) 2 (B) 4

(C) $\sqrt{2}$ (D) $2\sqrt{2}$

Q6. Let H be the hyperbola, whose foci are $\left(1\pm\sqrt{2},0\right)$ and eccentricity is $\sqrt{2}$. Then the length of its latus rectum is…….

(A) 3 (B) $\frac{5}{2}$

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

Q7. The foot of perpendicular from the origin O to a plane P which meets the co-ordinate axes at the points A, B, C is $(2,a,4), a\in N$. If the volume of the tetrahedron OABC is 144 unit^3, then Which of the following points is NOT on P?

(A) $(3,0,4)$ (B) $(0,4,4)$

(C) $(0,6,3)$ (D) $(2,2,4)$

Q8. The number of values of $r\in\{p,q,\sim p,\sim q\}$ for which $((p\wedge q)\Rightarrow(r\vee q))\wedge((p\wedge r)\Rightarrow q)$ is a tautology is :

(A) 2 (B) 1

(C) 3 (D) 4

Q9. Let the mean and standard deviation of marks of class A of 100 students be respectively 40 and $\alpha(>0)$, and the mean and standard deviation of marks of class B of n students be respectively 55 and 30 - α. If the mean and variance of the marks of the combined class of $100+n$ students are respectively 50 and 350, then the sum of variances of classes A and B is :

(A) 500 (B) 650

(C) 900 (D) 450

Q10. Let $a_1,a_2,a_3,\ldots$ be an A.P. If $a_7=3$, the product a_1a_4 is minimum and the sum of its first n terms is zero, then $n!-4a_{n(n+2)}$ is equal to :

(A) $\frac{381}{4}$ (B) 9

(C) $\frac{33}{4}$ (D) 24

Q11. Among the relations

$S=\left\{(a,b):a,b\in R-\{0\},2+\frac{a}{b}>0\right\}$ and $T=\{(a,b):a,b\in R,a^2-b^2\in Z\}$,

(A) both S and T are symmetric (B) neither S nor T is transitive

(C) S is transitive but T is not (D) T is symmetric but S is not

Q12. The complex number $z=\frac{i-1}{\cos\frac{\pi}{3}+i\sin\frac{\pi}{3}}$ is equal to :

(A) $\sqrt{2}i\left(\cos\frac{5\pi}{12}-i\sin\frac{5\pi}{12}\right)$ (B) $\cos\frac{\pi}{12}-i\sin\frac{\pi}{12}$

(C) $\sqrt{2}\left(\cos\frac{5\pi}{12}+i\sin\frac{5\pi}{12}\right)$ (D) $\sqrt{2}\left(\cos\frac{\pi}{12}+i\sin\frac{\pi}{12}\right)$

Q13. If a point $P(\alpha,\beta,\gamma)$ satisfying

$(\alpha\ \beta\ \gamma)\begin{pmatrix}2 & 10 & 8\\ 9 & 3 & 8\\ 8 & 4 & 8\end{pmatrix}=(0\ 0\ 0)$ lies on the plane $2x+4y+3z=5$, then $6\alpha+9\beta+7\gamma$ is equal to :

(A) -1 (B) 11

(C) $\frac{11}{5}$ (D) $\frac{5}{4}$

Q14. The set of all values of a^2 for which the line $x+y=0$ bisects two distinct chords drawn from a point $P\left(\frac{1+a}{2},\frac{1-a}{2}\right)$ on the circle $2x^2+2y^2-(1+a)x-(1-a)y=0$, is equal to :

(A) $(8,\infty)$ (B) $(0,4]$

(C) $(4,\infty)$ (D) $(2,12]$

Q15. Let P be the plane, passing through the point $(1,-1,-5)$ and perpendicular to the line joining the points $(4,1,-3)$ and $(2,4,3)$. Then the distance of P from the point $(3,-2,2)$ is

(A) 7 (B) 4

(C) 6 (D) 5

Q16. Let $y=y(x)$ be the solution of the differential equation $(3y^2-5x^2)y\,dx+2x(x^2-y^2)dy=0$ such that $y(1)=1$. Then $\left|(y(2))^3-12y(2)\right|$ is equal to :

(A) $32\sqrt{2}$ (B) 32

(C) 64 (D) $16\sqrt{2}$

Q17. Let : $\vec{a}=\hat{i}+2\hat{j}+3\hat{k}, \vec{b}=\hat{i}-\hat{j}+2\hat{k}$ and $\vec{c}=5\hat{i}-3\hat{j}+3\hat{k}$ be there vectors. If $\vec{r}$ is a vector such that, $\vec{r}\times\vec{b}=\vec{c}\times\vec{b}$ and $\vec{r}\cdot\vec{a}=0$, then $25|\vec{r}|^2$ is equal to

(A) 339 (B) 560

(C) 449 (D) 336

Q18. Let $(a,b)\subset(0,2\pi)$ be the largest interval for which $\sin^{-1}(\sin\theta)-\cos^{-1}(\sin\theta)>0, \theta\in(0,2\pi)$, holds. If $\alpha x^2+\beta x+\sin^{-1}(x^2-6x+10)+\cos^{-1}(x^2-6x+10)=0$ and $\alpha-\beta=b-a$, then α is equal to :

(A) $\frac{\pi}{8}$ (B) $\frac{\pi}{16}$

(C) $\frac{\pi}{48}$ (D) $\frac{\pi}{12}$

Q19. The absolute minimum value, of the function $f(x)=|x^2-x+1|+[x^2-x+1]$, where $[t]$ denotes the greatest integer function, in the interval $[-1,2]$ is :

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

(C) $\frac{5}{4}$ (D) $\frac{1}{4}$

Q20. The equation $e^{4x} + 8e^{3x} + 13e^{2x} - 8e^{x} + 1 = 0, x \in R$ has :

(A) no solution

(B) four solutions two of which are negative

(C) two solutions and both are negative

(D) two solutions and only one of them is negative

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. Let $\vec{a},\vec{b},\vec{c}$ be three vectors such that $|\vec{a}|=\sqrt{31}, 4|\vec{b}|=|\vec{c}|=2$ and $2(\vec{a}\times\vec{b})=3(\vec{c}\times\vec{a})$. If the angle between $\vec{b}$ and $\vec{c}$ is $\frac{2\pi}{3}$, then $\left(\frac{\vec{a}\times\vec{c}}{\vec{a}\cdot\vec{b}}\right)^2$ is equal to…….

Q2. Let A be the event that the absolute difference between two randomly choosen real numbers in the sample space $[0,60]$ is less than or equal to a. If $P(A)=\frac{11}{36}$, then a is equal to…….

Q3. If ${}^{2n+1}P_{n-1} : {}^{2n-1}P_n = 11:21$, then n^2+n+15 is equal to :

Q4. If the constant term in the binomial expansion of $\left(\frac{x^{\frac{5}{2}}}{2}-\frac{4}{x^{\ell}}\right)^9$ is –84 and the coefficient of $x^{-3\ell}$ is $2^{\alpha}\beta$, where $\beta<0$ is an odd number, then $|\alpha\ell-\beta|$ is equal to…….

Q5. Let A be a n x n matrix such that $|A|=2$. If the determinant of the matrix $\text{Adj}\left(2\cdot\text{Adj}\left(2A^{-1}\right)\right)\cdot$ is 2^{84}, then n is equal to…….

Q6. Let S be the set of all $a\in N$ such that the area of the triangle formed by the tangent at the point $P(b,c), b,c\in N$, on the parabola $y^2=2ax$ and the lines $x=b, y=0$ is 16 unit^2, then $\sum_{a\in S} a$ is equal to…….

Q7. The sum $1^2-2\cdot3^2+3\cdot5^2-4\cdot7^2+5\cdot9^2-.....+15\cdot29^2$ is…….

Q8. The coefficient of x^{-6}, in the expansion of $\left(\frac{4x}{5}+\frac{5}{2x^2}\right)^9$, is…….

Q9. Let the area of the region $\left\{(x,y):|2x-1|\le y\le|x^2-x|, 0\le x\le 1\right\}$ be A. Then $(6A+11)^2$ is equal to……

Q10. Let $A=[a_{ij}], a_{ij}\in Z\cap[0,4], 1\le i,j\le 2$. The number of matrices A such that the sum of all entries is a prime number $p\in(2,13)$ is…….

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KEYS to JEE (Main)-2023

PART – A (PHYSICS)

SECTION - A

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

SECTION – B

1.	80	2.	300	3.	5	4.	5
5.	136	6.	20	7.	25	8.	55
9.	1	10.	48				

PART – B (CHEMISTRY)

SECTION - A

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

SECTION - B

1.	227	2.	5	3.	17	4.	173
5.	25	6.	10	7.	2	8.	59
9.	480	10.	3				

PART – C (MATHEMATICS)

SECTION - A

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

SECTION - B

1.	3	2.	10	3.	45	4.	98
5.	5	6.	146	7.	6952	8.	5040
9.	125	10.	196				

FIITJEE

Solutions to JEE (Main)-2023

PART – A (PHYSICS)

SECTION – A

Sol1. $\ell_{min} = \frac{\lambda}{4}$ so statement 1 is true In amplitude modulation, frequency remains const. not amplitude of carrier wave.

Sol2. $735 = nCp\Delta T$

$735 = n \times \frac{7R}{2}\Delta T$

$\Delta U = n\ cv\ \Delta T = \frac{5R}{2} \times \frac{2 \times 735}{7R}$

= 525 J

Sol3. Current sanctity = Voltage senility $\times$ R current sensitivity is made 1.5 times R also increases 1.5 times so no change in voltage sensitivity change = 0%

Sol4. $g = \frac{GM}{R^2}$ u = 9 times R form surface

= 10R from centre.

$g' = \frac{GM}{100R^2}$

$\therefore$ Weight will be $= \frac{W}{100}$

Sol5. $X_L = WL = 628 \times 5 \times 10^{-3}$

$= \frac{3140}{1000} = 3.14\Omega$

Sol6. Regular momentum $\rightarrow mvr = ML^2T^{-1}$

Torque $\rightarrow ML^2T^{-2}$

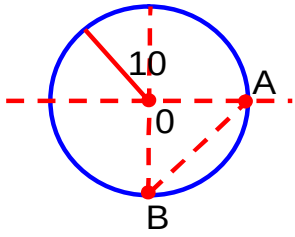
Stress $\rightarrow ML^{-1}T^{-2}$

Pressure gradient $\rightarrow ML^{-2}T^{-2}$

Sol7. Statement J is false as different regions have different regions have different doping level. Statement 2 is true.

Sol8. 1ren $\rightarrow 4$ s

$AB = \sqrt{10^2 + 10^2} = 10\sqrt{2}$



Sol9. $F = Y_A \frac{\Delta\ell}{5} \times 2.5 \times 10^{-5} = Y_B \times \frac{\Delta\ell}{6} \times 3 \times 10^{-5}$

$\Rightarrow \frac{Y_A}{Y_B} = 1:1$

Sol10. $\mu = \frac{\text{real depth}}{\text{apparent depth}}$ [shift = 30cm = $d - \frac{d}{\mu}$]

$\Rightarrow \frac{5}{3} = \frac{x}{x-30}$

$\Rightarrow 5x - 3x = 150 \quad \Rightarrow \quad x = 75\text{cm}$

Sol11. $E = \frac{1242}{350} \simeq 3.2\,\text{ev}$

$4.8 > 3.2 \quad \Rightarrow$ Metal A will net emit photo e.

Sol12. $v = u + at$

$\Rightarrow 0 = 20 - \mu \times 10 \times 5$

$\Rightarrow 20 = \mu \times 10 \times 5$

$\Rightarrow \mu = 0.4$

Sol13. Microwave – sis craft navigation
- Lasike eye surgery

Infra – red - Physiotheraky

X ray - Treatment of cancer

Sol14. $\ell = 2\pi r_1 \times N \qquad \ell = 2\pi r_2 \times n$

$B_1 = N\frac{\mu_0 I}{2\mu_1} \qquad B_2 = n\frac{\mu_0 I}{2\mu_2}$

$= N\frac{\mu_0 I}{\ell} \times \pi N \qquad = n\frac{\mu_0 I}{\ell} \times \pi n$

$\therefore \frac{B_1}{B_2} = \frac{N^2}{n^2}$

Sol15. $V = \sqrt{\frac{Y}{\delta}} = \sqrt{\frac{3.2 \times 10^n}{8 \times 10^3}}$

$= 2 \times 10^3 \sqrt{10}$

$\sim 6.32 \times 10^3$

Sol16. $H = I^2 Rt$

$= 16 \times R \times 10$

$H' = 16 \times 16 \times 10 \times R = 164$

Sol17. $\frac{mv^2}{R} = 400 \Rightarrow \frac{1 \times v^2}{1} = 400$

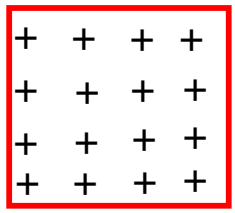
$\Rightarrow v = 20 m/s$

Sol18. $R = R_0 \times \frac{n^2}{z} \Rightarrow R = R_0 \times \frac{4}{z}$

$R' = R_0 \times \frac{9}{z} \Rightarrow R' = \frac{Rz}{4} \times \frac{9}{z} = \frac{9}{4}R$

$= 2.25R$

Sol19. Potential is scalar, so in this case it can't be zero whereas E can be zero due to cancellation effect.



Sol20. PV^Y = const.

$\Rightarrow 81 \times 8^Y = 16 \times 27^Y$

$\Rightarrow \frac{81}{16} = \left(\frac{27}{8}\right)^Y$

$\Rightarrow \frac{81}{16} = \left(\frac{3}{2}\right)^{3Y}$

$\Rightarrow \left(\frac{3}{2}\right)^4 = \left(\frac{3}{2}\right)^{3Y}$

$\Rightarrow 4 = 3Y \Rightarrow Y = 4/3$

SECTION – B

Sol1. If same range, then < us are complementary.

$H_1 = \frac{40 \times 40 \sin^2 60}{20} = 80 \times \frac{3}{4} = 60 m$

$H_2 = \frac{40 \times 40 \times \frac{1}{4}}{20} = 20 m$

$\therefore H_1 + H_2 = 60 + 20 = 80 m$

Sol2. $H = ms\Delta T$.

$= 2 \times 4200 \times 50$

$H = \frac{70}{100} \times P \times t$

$$\Rightarrow 2\times 42\times 50=\frac{70}{100}\times 2000\times t$$
$$\Rightarrow 2\times 6\times 5\times 5=t$$
$$\Rightarrow t=300\,s$$

Sol3. $v^2=2\times 10\times 20$
$v=20\,m/s$
$$0.5=\frac{Vs}{20}\Rightarrow Vs=10\,m/s$$
$$\Rightarrow 100=2\times 10\times s$$
$$\Rightarrow s=5\,m$$

Sol4. $I_{\text{about diameter}}=\frac{MR^2}{4}$
$$\frac{\delta_1}{\delta_2}=\frac{3}{5}=\frac{\pi r_2^2\times 0.5}{\pi r_1^2\times 1}$$
$$\Rightarrow \frac{3}{5}=\frac{r_2^2}{2r_1^2}$$
$$\Rightarrow \frac{r_1^2}{r_2^2}=\frac{5}{6}$$
$$\therefore\ \frac{I_1}{I_2}=\frac{MR_1^2}{4}\times\frac{4}{MR_2^2}=\frac{5}{6}=\frac{x}{6}$$
$$\therefore\ x=5$$

Sol5. $E=13.6\times 9\times\frac{1}{9}=13.6=x\times 10^{-1}$
$$\Rightarrow x=136$$

Sol6. $y_1=10\sin\left(\omega t+\frac{\pi}{3}\right)$
$$y_2=5\times 2\left(\frac{1}{2}\sin\omega t+\frac{\sqrt{3}}{2}\cos\omega t\right)$$
$$=10\left[\sin\left(\omega t+\frac{\pi}{3}\right)\right]$$
$\therefore$ similitude of resultant wave = 20cm

Sol7. $I=\frac{2500}{z}$ $\qquad z^2=6400+3600$
$= 10000$
$I=\frac{2500}{100}$ $\qquad z=100$
$= 25\ A$

Sol8. Change on $C_1 = KCE$

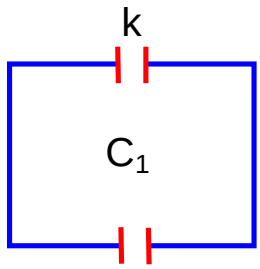
Change on $C_2 = CE$

Connected in parallel, so change is equally divided.

$\therefore$ change on $C_1 = \frac{(k+1)}{2} CE$

So $v = \frac{q}{kc} = \frac{(k+1)}{2k} E$

$= \frac{11}{20} \times 100 = 55\,v$



Sol9. In steady state, capacitor is shout eventide.

$\frac{3 \times 12}{15} = R_{eq} = 12/5$

$I = \frac{6 \times 5}{12} = 2.5\,A$

$3I_1 = 1/2\, I_2$

$I_1 + I_2 = 2.5$

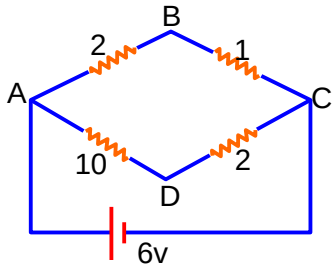
$5I_2 = 2.5$

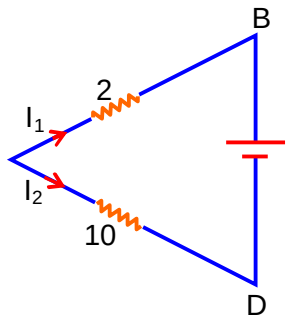
$I_2 = 0.5$

$I_1 = 2$

$4 + v - 5 = 0$

$v = 1$





Sol10. $\beta_1 = \frac{\lambda D}{d} = \frac{800\,nm \times 7m}{0.35\,mm} = \frac{8 \times 7 \times 10^{-2}}{35 \times 10}$

$= 1.6 \times 10^{-2} m$

$\beta_2 = \frac{600 \times 7}{0.35} = 12\,mm$ = 16mm

Bright fringes coincide $\Rightarrow$ LCM of 16, 12

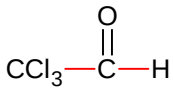
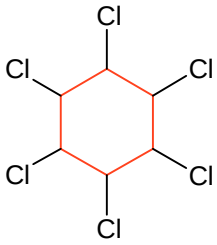
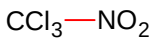
$\Rightarrow$ 45mm

$\therefore$ Dist from central bright maximum = 48mm

PART – B (CHEMISTRY)

SECTION – A

Sol1. Following are the structure of given molecule in which Gammaxene has maximum number of Cl-atoms.

Chloral	Gammaxene	Chloropicrin	Feron-12
			

Sol2. Van-Arkel refining process carried out by the iodide compound formation which is suitable for Ti, Zr and Hf.

Sol3. In Duma's method of nitrogen, nitrogen containing compound reacts with CuO and converted into N_2 gas.

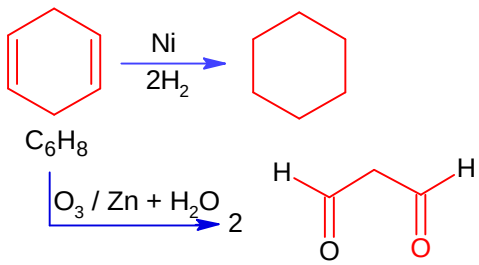
$$C_xH_yN_z + \left(2x + \frac{y}{2}\right)CuO \longrightarrow xCO_2 + \frac{y}{2}H_2O + \frac{z}{2}N_2 + \left(2x + \frac{y}{2}\right)Cu$$

Where, x, y and z are the respective number of carbon, hydrogen and nitrogen atom in a molecule.

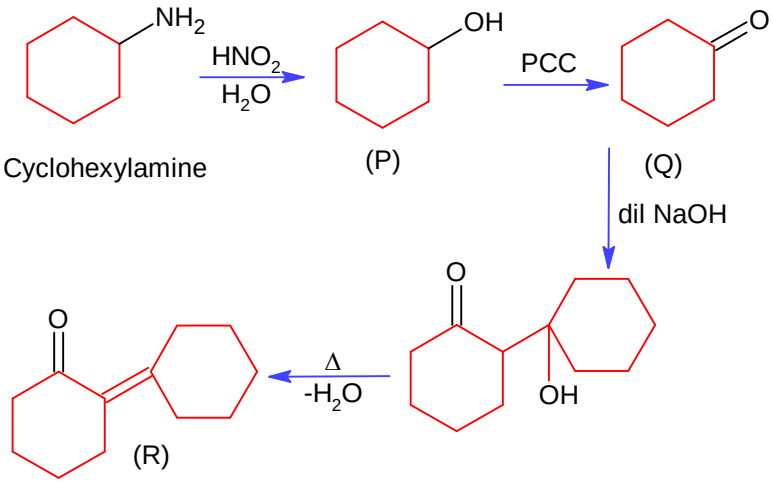
Sol4. There is no such trends of 1st ionization enthalpy of 3d- series elements higher than that of group-2 metals, Be and Mg have greater 1st ionization enthalpy than Sc, Ti, V, Cr ,Mn and Ni Here is irregular relation shown by these elements of 3d- series and group-2.

Sol5. Veronal and Prontosil are not used as disinfectants, they are neurological and antibiotic medicine.

Sol6.



Sol7.



Sol8. Due to back-bonding effect order of Lewis acid character of Boron halides are as follows:-
$BI_3 > BBr_3 > BCl_3 > BF_3$

Sol9. Rain water has acidic pH due to production of H^+ in water, H^+ produced by the formation of H_2CO_3 after dissolution of CO_2 gas in water.

Sol10. $$CuSO_4 + B_2O_3 \xrightarrow[\text{Luminous flame}]{\text{Non}} Cu(BO_2)_2 + SO_3$$

Blue – green colour

$CuSO_4$ forms metaborate of colourless form in luminous flame

Sol11. H_2O_2 used for the synthesis of many organic / in-organic compounds. It is also used for the synthesis of cephalosporin and restoration of aerobic sewage waste.

Sol12. General combustion of hydrocarbon reaction is following.

$$C_aH_b + \left(a + \frac{b}{4}\right)O_2 \longrightarrow aCO_2 + \frac{b}{2}H_2O$$

Here; $\frac{b}{2} = 4 \therefore b = 8$

and $a + \frac{8}{4} = 11 \therefore a = 9$

Hence formula is C_9H_8

Sol13. 0.1M NaCl and 0.1 M urea have different ΔT_b and azeotropic mixture boil without change in their composition.

$$M = \frac{wt}{Mol.wt} \times \frac{1000 \times d}{wt} = \frac{32}{98} \times \frac{1000}{100} \times 1.26 = 4.09M$$

Sol14. $n = 3, \ell = 0$ and $m = 0 \Rightarrow 3s$

$n = 4, \ell = 0$ and $m = 0 \Rightarrow 4s$

$n = 3, \ell = 1$ and $m = 0 \Rightarrow 3p_z$

$n = 3, \ell = 2$ and $m = 1 \Rightarrow 3d_{yz}$ or $3d_{xz}$

Energy order of orbitals are:-

$3d > 4s > 3p > 3s$

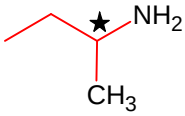
Sol15. According to the pH range and capability to change colour in medium, methyl orange used in the titration of S.A Vs S.B & S.A. Vs W.B, while phenolphthalein only useful for the titration of S.A Vs S.B- and W.A Vs S.B.

Sol16. Outer most electronic configuration of following elements are
At-No – 61 , Pm – [Xe] $4f^5\ 6s^2$
At-No. – 62 , Sm – [Xe]$4f^6\ 4s^2$
At-No. 63, Eu – [Xe] $4f^7\ 6s^2$
At-No – 64, Gd [Xe], $4f^7\ 5d^1\ 6s^2$
At-No. – 65, Tb [Xe] $4f^9\ 4s^2$

Sol17. Calcium element plays significant role in neuromuscular function and inter neuronal transmission.

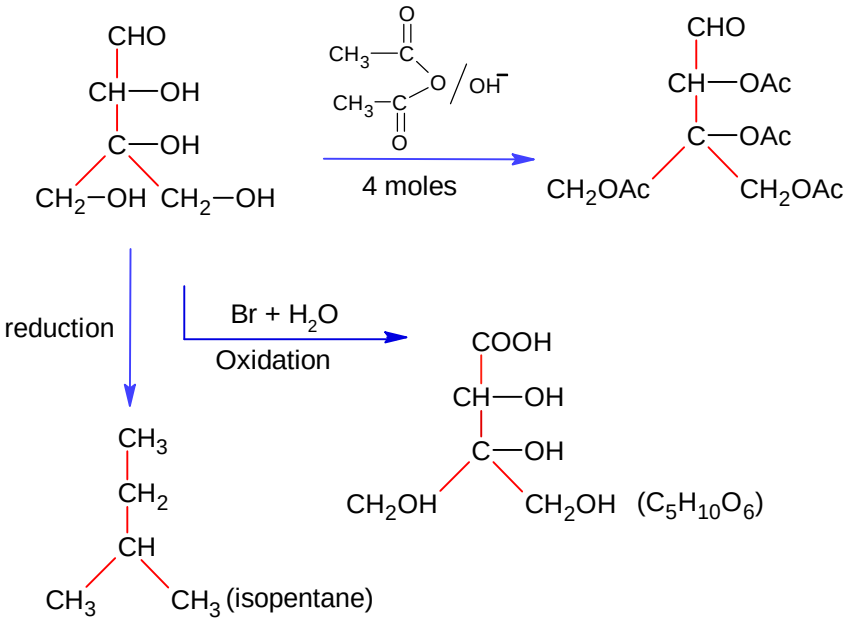
Sol18. Physisorption in multi-layered white chemisorption is uni molecular layered and ΔH for physisorption is 20-40 KJ / mol while chemisorption is 80-110 KJ / mol. Different phase in heterogeneous catalyst and chromatography used in adsorption principles.

Sol19.



Only capable to produces N_2 gas after the reaction with HNO_2 i.e via diazonium salt formation and itself on optically active molecule.

Sol20.



SECTION – B

Sol1. $2C_{(s)} + O_{2(g)} \longrightarrow 2CO_{(g)}$

$$\text{Mole} = \frac{12}{12} = \frac{48}{32}$$

Mole = 1.0 1.5

Here, limiting reagent of reaction is carbon, hence one mole of carbon will produce, one mole of CO gas. Hence produce volume of CO at STP = 22.7 Lit or $227\times10^{-1}\ell$it

Sol2. Following are the shape of molecules / ions

$XeF_2 \longrightarrow$ linear shape and sp^3d hybridisation

$C_3O_2 \longrightarrow$ linear shape, O=C=C=C=O

$I_3^- \longrightarrow$ linear shape and sp^3d hybridisation

$CO_2 \longrightarrow$ linear shape, O=C=O

$BeCl_2 \longrightarrow$ linear shape, sp hybridisation

$SO_2 \longrightarrow$ Bent shape and sp^2 hybridisation

$BCl_2^- \longrightarrow$ Bent shape and sp^2 hybridisation

Sol3. If the rate constant of first order reaction = 20 min^{-1}, the half life period $t_{1/2}=\left(\frac{0.693}{20}\right)$min

And number of half life from 1 to $\frac{1}{32}$ level = 5

Hence total time = number of $t_{1/2}\times\frac{0.693}{20}$

$$=5\times\frac{0.693}{20}=\frac{0.693}{4}$$

$$=0.17325=17.325\approx17$$

Sol4. $C_{(s)}+2Cl_{2(g)}\longrightarrow CCl_{4(g)}\ ;\ \Delta H=-105\ KJ/mol$ ---------- (i)

$H_{2(g)}+\frac{1}{2}O_{2(g)}\longrightarrow H_2O_{(g)}\ ;\ \Delta H=-242\ KJ/mol$ ---------- (ii)

$C_{(s)}+O_{2(g)}\longrightarrow CO_{2(g)}\ ;\ \Delta H=-394\ KJ/mol$ ---------- (iii)

$\frac{1}{2}H_{2(g)}+\frac{1}{2}Cl_{2(g)}\longrightarrow HCl(g)\ ;\ \Delta H=-92\ KJ/mol$ ----------(iv)

When equation are operated as following

[equation (iii) + equation (iv) $\times4$] – [equation (i) + equation (ii) $\times2$] ; we get

$CCl_{4(g)}+2H_2O_{(g)}\longrightarrow CO_2+4HCl_{(g)}$

$\left[-394-92\times4\right]-\left[-105-242\times2\right]=-173KJ/mol$

Sol5. Molar conductivity $(\mu)=\frac{K\times1000}{M}=\frac{1}{R}\times\frac{1000}{M}$

$\therefore\mu=\frac{1000}{5\times10^{-3}\times0.8}=\frac{10^6}{4}=25\times10^4\Omega^{-1}cm^2\,min^{-1}$

Sol6. Solubility of AgCl $=1.434\times10^{-3}$ gm/lit

$$=\frac{1.434\times10^{-3}}{143.4}=10^{-5}\ mol/lit$$

Hence Ksp of AgCl $\Rightarrow K_{sp}=(s)^2$

Or

$K_{sp}=\left(10^{-5}\right)^2=10^{-10}$

$-\log10K_{sp}=-\log10^{-10}=10$

Sol7. Above than 400 KJ / mol, only K and Rb form stable super oxide. KO_2 and RbO_2.

Sol8. Let us suppose % of M^{2+} is x and % of M^{3+} is (100-x)

Hence O.S. of M in $M_{0.83}O$ is $\frac{+200}{83}$

$$100\times\left(\frac{200}{83}\right)=\left(+2\times x\right)+\left(+3\times100-x\right)$$

$$100\times\left(\frac{200}{83}\right)=2x-3x+300$$

$$\therefore x=300-\frac{200\times100}{83}=59.036\approx59$$

Sol9. For complex , $\left[Ti\left(H_2O\right)_6\right]^{3+}$

$Ti^{3+}\longrightarrow 3d^1$

Here, C.F. S. E = $-0.4\times\Delta_0=\frac{-96\times1000}{6\times10^{23}}$ for one atom

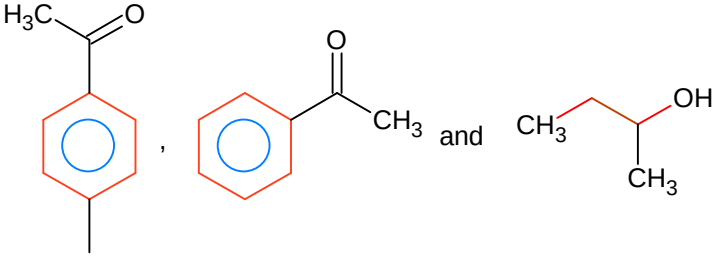
$$\therefore \Delta_0=\frac{96\times1000}{0.4\times6\times10^{23}}$$

$$\frac{hc}{\lambda}=\frac{96\times1000}{0.4\times6\times10^{23}}=\Delta_0$$

$$\therefore \lambda=\frac{6.4\times10^{-34}\times3\times10^{8}\times6\times10^{23}\times0.4}{96\times1000}$$

$$\therefore \lambda=0.48\times10^{-6}m=480\times10^{-9}m=480nm$$

Sol10. Following molecules can form the haloform



and

PART – C (MATHEMATICS)

SECTION – A

Sol1. $\phi'(x)=\frac{1}{\sqrt{x}}\left(4\sqrt{2}\sin x-3\phi'(x)\right)-\frac{1}{2}x^{-3/2}\,\phi(x)\cdot\sqrt{x}$

$\Rightarrow \phi'(\pi/4)=\frac{2}{\sqrt{\pi}}\left(4-3\phi'(\pi/4)\right)$

$\Rightarrow \phi'(\pi/4)=\frac{8}{6+\sqrt{\pi}}$

Sol2. $\because P\|L \Rightarrow 8\cdot 2+\alpha_1\cdot 3+5\cdot\alpha_2=0$

$\Rightarrow 3\alpha_1+5\alpha_2=-16$

$\because$ y-intercept = 1 $\Rightarrow \alpha_1=-12 \Rightarrow \alpha_2=4$

$P \Rightarrow 2x-3y+z+3=0$

$\therefore$ Distance of L from $P=\left|\frac{-4-9-4}{\sqrt{4+9+1}}\right|=\sqrt{14}$

Sol3. $\lim\limits_{x\to\infty} x^3\times\left\{\frac{x^3\left\{\left(\sqrt{3+\frac{1}{x}}+\sqrt{3-\frac{1}{x}}\right)^6+\left(\sqrt{3+\frac{1}{x}}-\sqrt{3-\frac{1}{x}}\right)^6\right\}}{x^6\left\{\left(1+\sqrt{1-\frac{1}{x^2}}\right)^6+\left(1-\sqrt{1-\frac{1}{x^2}}\right)^6\right\}}\right\}=\frac{\left(2\sqrt{3}\right)^6+0}{2^6+0}=27$

Sol4. Let $y=\frac{x^2+2x+1}{x^2-8x+12}$

$\Rightarrow x^2(y-1)-x(8y+2)+(12y-1)=0$

Case 1 : $y\neq 1, D\geq 0 \Rightarrow y(4y+21)\geq 0$

$\Rightarrow y\in\left(-\infty,\frac{-21}{4}\right]\cup[0,\infty)-\{1\}$

Case 2 : $y=1\Rightarrow x^2+2x+1=x^2-8x+12$

$\Rightarrow x=\frac{11}{10}$, so, y can be 1

$\therefore y\in\left(-\infty,\frac{-21}{4}\right]\cup[0,\infty)$

Sol5. $I=\int_0^{\alpha}\frac{x}{\alpha}\left(\sqrt{x+\alpha}+\sqrt{x}\right)dx=\int_0^{\alpha}\frac{1}{\alpha}\left[(x+\alpha)^{3/2}-\alpha(x+\alpha)^{1/2}+x^{3/2}\right]dx$

$=\frac{1}{\alpha}\left[\frac{2}{5}(\alpha+x)^{5/2}-\alpha\cdot\frac{2}{3}(x+\alpha)^{3/2}+\frac{2}{5}x^{5/2}\right]_0^{\alpha}$

$=\frac{\alpha^{3/2}}{15}\left(4\sqrt{2}+10\right)$

$\therefore \alpha=2$

Sol6. $2ae = \left|\left(1+\sqrt{2}-1+\sqrt{2}\right)\right| = 2\sqrt{2}$

$\therefore ae = \sqrt{2},\ a = 1$

$\Rightarrow b = 1$

$LR = \dfrac{2b^2}{a} = 2$

Sol7. Equation of plane : $\left(2\hat{i}+a\hat{j}+4\hat{k}\right)\cdot\left[(x-2)\hat{i}+(y-a)\hat{j}+(z-4)\hat{k}\right]=0$

$\Rightarrow 2x+ay+4z = 20+a^2$

$\therefore A = \left(\dfrac{20+a^2}{2},0,0\right), B = \left(0,\dfrac{20+a^2}{a},0\right); C = \left(0,0,\dfrac{20+a^2}{4}\right)$

$\therefore$ Volume of tetrahedron = $\dfrac{1}{6}\left[\vec{a}\vec{b}\vec{c}\right] = \dfrac{1}{6}\vec{a}\cdot\left(\vec{b}\times\vec{c}\right)$

$= \dfrac{1}{6}\left(\dfrac{20+a^2}{2}\right)\left(\dfrac{20+a^2}{a}\right)\left(\dfrac{20+a^2}{4}\right) = 144 \Rightarrow a = 2$

Equation of plane is $2x+2y+4z = 24$ or $x+y+2z = 12$

$\therefore (3, 0, 4)$ does not lie on given plane.

Sol8. $p \Rightarrow q$ is equivalent to $\sim p \vee q$

$\left(\sim(p\wedge q)\vee(r\vee q)\right)\wedge\left(\left(\sim(p\wedge r)\right)\vee q\right)$

$\Rightarrow \left(\sim p\vee\sim q\vee r\vee q\right)\wedge\left(\sim p\vee\sim r\vee q\right)$

$\Rightarrow \left(\sim p\vee r\vee t\right)\wedge\left(\sim p\vee\sim r\vee q\right)\Rightarrow (t)\wedge\left(\sim p\vee\sim r\vee q\right)$

For tautology, $\sim p\vee\sim r\vee q$ must be tautology

$\Rightarrow r = \sim p$ or r = q

Sol9.

A	B	A+B
$\bar{x}_i = 40$	$\bar{x}_2 = 55$	$\bar{x} = 50$
$\sigma_1 = \alpha$	$\sigma_2 = 30-\alpha$	$\sigma^2 = 350$
$n_1 = 100$	$n_2 = n$	$100+n$

$\bar{x} = \dfrac{100\times 40+55n}{100+n} \Rightarrow 5000+50n = 4000+55n$

$\Rightarrow n = 200$.

$\sigma_1^2 = \dfrac{\Sigma x_i^2}{100}-40^2, \quad \sigma_2^2 = \dfrac{\Sigma x_j^2}{100}-55^2$

$350 = \sigma^2 = \dfrac{\Sigma x_i^2+\Sigma x_j^2}{300}-\left(\bar{x}\right)^2$

$350 = \dfrac{\left(1600+\alpha^2\right)\times 100+\left[(30-\alpha)^2+3025\right]\times 200}{300}-50^2$

$\Rightarrow \alpha = 10, 30$

$\therefore \sigma_1^2+\sigma_2^2 = 10^2+20^2 = 500$

Sol10. $a+6d=3$,

Let $x=a(a+3d)$

$=(3-6d)(3-3d)=18d^2-27d+9$

Differentiate w.r.t d; $36d-27=0\Rightarrow d=\dfrac{3}{4}$

$\therefore a=\dfrac{-3}{2}$

Now, $S_n=\dfrac{n}{2}\left\{-3+(n-1)\dfrac{3}{4}\right\}=0\Rightarrow n=5$

Now, $n!-4a_{n(n+2)}=120-4a_{35}=120-4(a+34d)=24$

Sol11. For relation $T\equiv a^2-b^2=-1$

Then, (b,a) on relation $R\Rightarrow b^2-a^2=-1$

$\therefore$ T is symmetric.

$S=\left\{(a,b):a,b\in R-\{0\},2+\dfrac{a}{b}>0\right\}$

$2+\dfrac{a}{b}>0\Rightarrow\dfrac{a}{b}>-2\Rightarrow\dfrac{b}{a}<-\dfrac{1}{2}$

If $(b,a)\in S$ then $2+\dfrac{b}{a}$ is not necessarily positive.

$\therefore$ S is not symmetric.

Sol12. On simplifying, we get

$z=\dfrac{\sqrt{3}-1}{2}+\dfrac{\sqrt{3}+1}{2}i\Rightarrow\tan\theta=\dfrac{\sqrt{3}+1}{\sqrt{3}+1}$ & $r=\sqrt{2}$

Sol13. Solve to get $\beta=6\alpha,\gamma=-7\alpha$

$\Rightarrow\alpha=1,\beta=6,\gamma=-7$

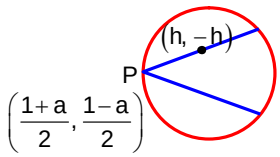
$\therefore 6\alpha+9\beta+7\gamma=11$

Sol14. $T=S_1\Rightarrow 2xh-2yh-\dfrac{(1+a)}{2}(x+h)-\dfrac{(1-a)}{2}(y+k)=0$

$=2h^2+2h^2-(1+a)h+(1-a)h$

Put $(x,y)=\left(\dfrac{1+a}{2},\dfrac{1-a}{2}\right)\rightarrow 7\left(\dfrac{1-a}{4}\right)^2+7\left(\dfrac{1+a}{4}\right)^2+18\left(\dfrac{1-a^2}{16}\right)<0$

Put $a^2=t$ to get $t>8\Rightarrow a^2>8$



Sol15. Equation of plane : $2(x-1)-3(y+1)-6(z+5)=0$ or $2x-3y-6z=35$

$\therefore$ Required distance = $\dfrac{|2(3)-3(-2)-6(2)-35|}{\sqrt{4+9+36}}=5$

Sol16. $\dfrac{dy}{dx}=\dfrac{y(5x^2-3y^2)}{2x(x^2-y^2)}$

Put $y = vx$ to get $v + x\dfrac{dv}{dx} = \dfrac{v\left(5-3v^2\right)}{2\left(1-v^2\right)}$

$\Rightarrow \dfrac{dx}{x} = \dfrac{2/3}{v} + \int \dfrac{2}{3}\cdot\dfrac{2v}{v^2-3}dv$

$\Rightarrow \ell n|x| = \dfrac{2}{3}\ell n|v| + \dfrac{2}{3}\ell n\left|v^2-3\right| + c$

$\Rightarrow \ell n|x| = \dfrac{2}{3}\ell n\left|\dfrac{y}{x}\right| + \dfrac{2}{3}\ell n\left|\dfrac{y^2}{x^2}-3\right| + c$

Put $x = 1, y = 1$ to get $c = -\dfrac{2}{3}\ell n2$

Put x = 2 to get, $\left|y\left(y^2-12\right)\right| = \left|32\sqrt{2}\right| = 32\sqrt{2}$

Sol17. $\left(\vec{r}-\vec{c}\right)\times\vec{b} = 0$ & $\vec{r}\cdot\vec{a} = 0$

$\Rightarrow \vec{r} = \vec{c} + \lambda\vec{b}$

$\therefore \left(\vec{c}+\lambda\vec{b}\right)\cdot\vec{a} = 0 \Rightarrow \lambda = -\dfrac{\vec{a}\cdot\vec{c}}{\vec{a}\cdot\vec{b}} = -\dfrac{8}{5}$

$\therefore \vec{r} = \dfrac{17\hat{i}-7\hat{j}+\hat{k}}{5} \Rightarrow \left|\vec{r}\right|^2 = \dfrac{339}{25}$

Sol18. $\sin^{-1}\sin\theta - \left(\dfrac{\pi}{2} - \sin^{-1}\sin\theta\right) > 0 \Rightarrow \sin^{-1}\sin\theta > \pi/4$

$\Rightarrow \sin\theta > \dfrac{1}{\sqrt{2}}$

$\therefore \theta \in \left(\dfrac{\pi}{4}, \dfrac{3\pi}{4}\right) = (a,b); (b-a) = \dfrac{\pi}{2} = \alpha - \beta$

$\Rightarrow \beta = \alpha - \dfrac{\pi}{2}$

$\therefore \alpha x^2 + \beta x + \sin^{-1}\left[(x-3)^2+1\right] + \cos^{-1}\left[(x-3)^2+1\right] = 0$

$x = 3, \Rightarrow 9\alpha + 3\beta + \dfrac{\pi}{2} = 0$

$\Rightarrow 9\alpha + 3\left(\alpha - \dfrac{\pi}{2}\right) + \dfrac{\pi}{2} = 0 \Rightarrow \alpha = \dfrac{\pi}{12}$

Sol19. $x^2 - x + 1 = \left(x - \dfrac{1}{2}\right)^2 + \dfrac{3}{4}$

$\because \left|x^2-x+1\right|$ & $\left[x^2-x+1\right]$ both have min. value at $x = \dfrac{1}{2}$

$\therefore \min f(x) = \dfrac{3}{4} + 0 = \dfrac{3}{4}$

Sol20. Let $e^x = t$, we've : $\underbrace{t^4+8t^3+13t^2-8t+1=0}_{f(t)}$, $t > 0$

By Descartes rule of sign, $f(t)$ has at most 2 positive roots.

$f(0)>0$, $f\left(\frac{1}{5}\right)<0$ & $f\left(\frac{2}{5}\right)>0$

$\therefore$ By intermediate value theorem, one root lies between 0 and $\frac{1}{5}$ & other between $\frac{1}{5}$ and $\frac{2}{5}$.

Now, $e^x = t$ holds for 2 t's both in $(0,1)$

$\therefore x$ is negative.

SECTION – B

Sol1. $2\left(\vec{a}\times\vec{b}\right)=3\left(\vec{c}\times\vec{a}\right)$

$\Rightarrow \vec{a}\times\left(2\vec{b}+3\vec{c}\right)=0$

$\therefore \vec{a}=\lambda\left(2\vec{b}+3\vec{c}\right)$

$\therefore \left|\vec{a}\right|^2=\lambda^2\left|2\vec{b}+3\vec{c}\right|^2 \Rightarrow \left|\vec{a}\right|^2=\lambda^2\left(4\left|\vec{b}\right|^2+9\left|\vec{c}\right|^2+12\vec{b}\cdot\vec{c}\right)$

$\therefore 31=31\lambda^2 \Rightarrow \lambda=\pm1$

$\vec{a}=\pm\left(2\vec{b}+3\vec{c}\right)$

$$\therefore \frac{\left|\vec{a}\times\vec{c}\right|}{\left|\vec{a}\cdot\vec{b}\right|}=\frac{2\left|\vec{b}\times\vec{c}\right|}{2\vec{b}\cdot\vec{b}+3\vec{c}\cdot\vec{b}}=\frac{2\left\{\left|\vec{b}\right|^2\left|\vec{c}\right|^2-\left(\vec{b}\cdot\vec{c}\right)^2\right\}^{\frac{1}{2}}}{2\vec{b}\cdot\vec{b}+3\vec{c}\cdot\vec{b}}=\frac{2\cdot\sqrt{3}/2}{2\cdot\frac{1}{4}-\frac{3}{2}}=\sqrt{3}$$

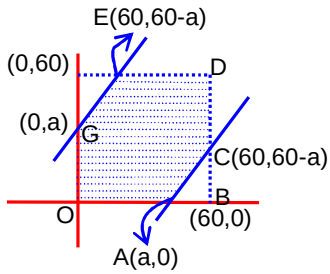
Sol2. $|x-y|<a \Rightarrow -a<x-y<a$

$\Rightarrow x-y<a$ and $x-y>-a$

$$P(A)=\frac{\text{ar}(OA\,CD\,EG)}{\text{ar}(OBDF)}$$

$$\Rightarrow \frac{11}{36}=\frac{60^2-\frac{1}{2}(60-a)^2-\frac{1}{2}(60-a)^2}{3600}$$

$\Rightarrow a=10$



Sol3. $$\frac{(2n+1)!(n-1)!}{(n+2)!(2n-1)!}=\frac{11}{21}$$

$$\Rightarrow \frac{(2n+1)\cdot 2n}{(n+2)(n+1)n}=\frac{11}{21}\Rightarrow n=5$$

$\Rightarrow n^2+n+15=45$

Sol4. $T_{r+1}=(-1)^r\cdot\frac{{}^9C_r}{2^{9-r}}\cdot 4^r\cdot x^{\frac{45}{2}-\frac{5r}{2}-\ell r}$

Now, $45-5r-2\ell r=0 \Rightarrow r=\frac{45}{5+2\ell}$ ……..(i)

Now, $(-1)^r \cdot \frac{{}^9C_r}{2^{9-r}} \cdot 4^r = -84$

$\Rightarrow (-1)^r \cdot {}^9C_r \cdot 2^{3r-9} = -21 \times 4$

One possibility is r = 3 & ${}^9C_3 = 84$

$\therefore$ from (i), $\ell = 5$

Coeff. of $x^{-3\ell}$ = coeff. of x^{-15} (for r = 5)

$= {}^9C_5(-1) \cdot \frac{4^5}{2^4}$

$\Rightarrow \alpha = 7, \beta = -63 \Rightarrow |\alpha\ell - \beta| = 98$.

Sol5. $\left|\text{adj}\left(2\,\text{adj}\left(2A^{-1}\right)\right)\right|$

$= \left|2\left(\text{adj}\left(2A^{-1}\right)\right)\right|^{n-1}$

$= 2^{n(n-1)}\left|\text{adj}\left(2A^{-1}\right)\right|^{n-1} = 2^{n(n-1)} \cdot \left|2A^{-1}\right|^{(n-1)(n-1)}$

$= 2^{n(n-1)} \cdot 2^{n(n-1)(n-1)} \cdot \left|A^{-1}\right|^{(n-1)(n-1)}$

$= 2^{n(n-1)+n(n-1)(n-1)} \cdot \frac{1}{|A|^{(n-1)^2}} = \frac{2^{n(n-1)+n(n-1)(n-1)}}{2^{(n-1)^2}}$

$\therefore n(n-1) + n(n-1)^2 - (n-1)^2 = 84 \Rightarrow n = 5$

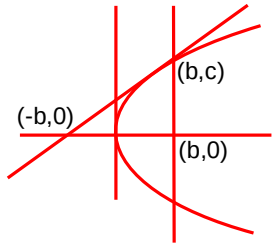
Sol6. Tangent : $yc = a(x+b)$

Area = $\frac{1}{2} \times 2b \times c = 16$

$\Rightarrow bc = 16$

Possible (b,c) are $(1,16), (2,8)$ & $(4,4)$

Also, $a = \frac{c^2}{2b} \Rightarrow \Sigma a = 128 + 16 + 2 = 146$



Sol7. $S = \left(1 \cdot 1^2 + 3 \cdot 5^2 + \ldots.. + 15 \cdot (29)^2\right) - \left(2 \cdot 3^2 + 4 \cdot 7^2 + \ldots..14(27)^2\right)$

$S = \sum_{n=1}^{8}(2n-1)(4n-3)^2 - \sum_{n=1}^{7} 2n(4n-1)^2$

$= 29856 - 22904 = 6952$

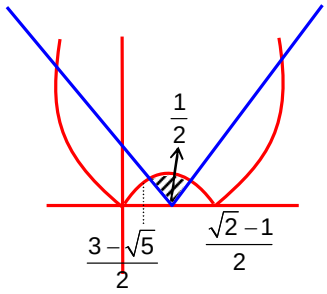
Sol8. $T_{r+1} = {}^9C_r \cdot \left(\frac{4x}{5}\right)^{9-r} \cdot \left(\frac{5}{2x^2}\right)^r$

$= {}^9C_r \cdot \left(\frac{4}{5}\right)^{9-r}\left(\frac{5}{2}\right)^r \cdot x^{9-3r}$

Coeff. of x^{-6}, i.e. $9 - 3r = -6 \Rightarrow r = 5$

Coeff. = ${}^9C_5 \cdot \left(\frac{4}{5}\right)^4 \cdot \left(\frac{5}{2}\right)^5 = 5040$

Sol9. Area is symmetrical about $x = \frac{1}{2}$



$$\therefore A = 2\int_{\frac{3-\sqrt{5}}{2}}^{\frac{1}{2}} \left(x - x^2 - 1 + 2x\right)dx$$

$$\Rightarrow A = 2\left(\frac{-x^3}{3} + \frac{3}{2}x^2 - x\right)_{\frac{3-\sqrt{5}}{2}}^{\frac{1}{2}}$$

$$\Rightarrow 6A + 11 = 5\sqrt{5}$$

$$\Rightarrow (6A + 11)^2 = 125$$

Sol10. $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$

$a, b, c, d \in \{0, 1, 2, 3, 4\}$

$a + b + c + d = 3$ or 5 or 7 or 11.

$\rightarrow$ If sum = 3

Coeff. of x^3 in $\left(1 + x + x^2 + x^3 + x^4\right)^4 = \left(1 - x^5\right)^4 (1 - x)^{-4}$ is ${}^6C_3 = 20$

$\rightarrow$ If sum = 5

Coeff. of x^5 in $\left(1 - x^5\right)^4 (1 - x)^{-4}$

or $\left(1 - 4x^5\right)(1 - x)^{-4}$

$\Rightarrow {}^8C_5 - 4 = 52$

$\rightarrow$ If sum = 7

Coeff. of x^7 in $\left(1 - 4x^5\right)(1 - x)^{-4} = {}^{10}C_7 - 4 \times {}^5C_2 = 80$

$\rightarrow$ If sum = 11

Coeff. of x^{11} in $\left(1 - 4x^5 + 6x^{10}\right)(1 - x)^{-4}$

$= {}^{14}C_{11} - 4 \times {}^9C_6 + 6 \times {}^4C_1$

$= 364 - 336 + 24 = 52$