PART –A (PHYSICS)

1. A particle of mass m is moving along a trajectory given by

$x = x_0 + a \cos \omega_1 t$

$y = y_0 + b \sin \omega_2 t$

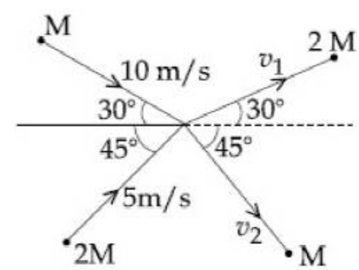
The torque, acing on the particle about the origin, at t = 0 is:

(A) $my_0 a\omega_1^2 \hat{k}$
(B) $m(-x_0 b + y_0 a)\omega_1^2 \hat{k}$
(C) $-m(-x_0 b\omega_2^2 - y_0 a\omega_1^2)\hat{k}$
(D) Zero

2. A stationary source emits sound waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 480 Hz and 530 Hz. Their respective speeds are, in ms^{-1} (Given speed of sound = 300 m/s)

(A) 16, 14
(B) 12, 16
(C) 8, 18
(D) 12, 18

3. Two particles, of masses M and 2M, moving as shown, with speeds of 10 m/s and 5 m/s, collide elastically at the origin. After the collision, they move along the indicated directions with speeds v_1 and v_2 respectively. The value of v_1 and v_2 are nearly:



(A) 3.2 m/s and 12.6 m/s
(B) 6.5 m/s and 6.3 m/s
(C) 6.5 m/s and 3.2 m/s
(D) 3.2 m/s and 6.3 m/s

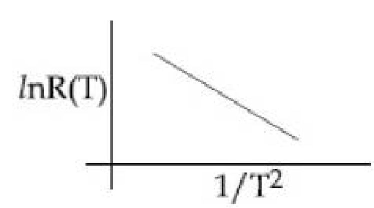
4. Given below in the left column are different modes of communication using the kinds of waves given in the right column.

A. Optical Fibre Communication	P. Ultrasound
B. Radar	Q. Infrared Light
C. Sonar	R. Microwaves
D. Mobile Phones	S. Radio Waves

From the options given below, find the most appropriate match between entries in the left and the right column.

(A) A – S, B – Q, C – R, D – P
(B) A – Q, B – S, C – P, D – R
(C) A – R, B – P, C – S, D – Q
(D) A – Q, B – S, C – R, D – P

5. In an experiment, the resistance of a material is plotted as a function of temperature (in some range). As shown in the figure, it is a straight line. One may conclude that:



(A) $R(T) = R_0 e^{T^2/T_0^2}$

(B) $R(T) = \dfrac{R_0}{T^2}$

(C) $R(T) = R_0 e^{-T^2/T_0^2}$

(D) $R(T) = R_0 e^{T_0^2/T^2}$

6. A cylinder with fixed capacity of 67.2 lit contains helium gas at STP. The amount of heat needed to raise the temperature of the gas by 20°C is: [Given that R = 8.31 J mol^{-1} K^{-1}]

(A) 350 J (B) 700 J

(C) 748 J (D) 374 J

7. A ball is thrown upward with an initial velocity V_0 from the surface of the earth. The motion of the ball is affected by a drag force equal to $m\gamma v^2$ (where m is mass of the ball, v is its Instantneous velocity and γ is a constant). Time taken by the ball to rise to its zenith is:

(A) $\frac{1}{\sqrt{\gamma g}} \ln\left(1+\sqrt{\frac{\gamma}{g}}V_0\right)$ (B) $\frac{1}{\sqrt{\gamma g}} \tan^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$

(C) $\frac{1}{\sqrt{\gamma g}} \sin^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$ (D) $\frac{1}{\sqrt{2\gamma g}} \tan^{-1}\left(\sqrt{\frac{2\gamma}{g}}V_0\right)$

8. A thin disc of mass M and radius R has mass per unit area $\sigma(r) = kr^2$ where r is the distance from its centre. Its moment of inertia about an axis going through its centre of mass and perpendicular to its plane is:

(A) $\frac{MR^2}{2}$ (B) $\frac{MR^2}{3}$

(C) $\frac{MR^2}{6}$ (D) $\frac{2MR^2}{3}$

9. Two coaxial discs, having moments of inertia I_1 and $\frac{I_1}{2}$, area rotating with respectively angular velocities ω_1 and $\frac{\omega_1}{2}$, about their common axes. They are brought in contact with each other and thereafter they rotate with a common angular velocity. If E_f and E_i are the final and initial total energies, then $(E_f - E_i)$ is:

(A) $\frac{I_1\omega_1^2}{6}$ (B) $\frac{3}{8}I_1\omega_1^2$

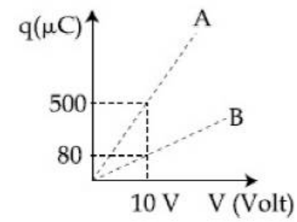
(C) $-\frac{I_1\omega_1^2}{12}$ (D) $-\frac{I_1\omega_1^2}{24}$

10. The ratio of surface tensions of mercury and water is given to be 7.5 while the ratio of their densities is 13.6. Their contact angles, with glass, are close to 135° and 0°, respectively. It is observed that mercury gets depressed by an amount h in a capillary tube of radius r_1, while water rises by the same amount h in a capillary tube of radius r_2. The ratio, (r_1/r_2), is then close to:

(A) 3/5 (B) 4/5

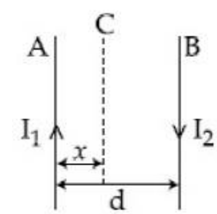
(C) 2/3 (D) 2/5

11. Figure shows charge (q) versus voltage (V) graph for series and parallel combination of to given capacitors. The capacitances are:



(A) 40 μF and 10 μF
(B) 50 μF and 30 μF
(C) 60 μF and 40 μF
(D) 20 μF and 30 μ F

12. Two wires A and B are carrying currents I_1 and I_2 as shown in the figure. The separation between them is d. A third wire C carrying a current I is to be kept parallel to them at a distance x from A such that the net force acting on it is zero. The possible values of x are:



(A) $x = \left(\frac{I_1}{I_1 - I_2}\right)d$ and $x = \frac{I_2}{(I_1 + I_2)}d$
(B) $x = \pm\frac{I_2 d}{(I_1 - I_2)}$
(C) $x = \left(\frac{I_2}{I_1 + I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 - I_2}\right)d$
(D) $x = \left(\frac{I_1}{I_1 + I_2}\right)d$ and $x = \left(\frac{I_2}{I_1 - I_2}\right)d$

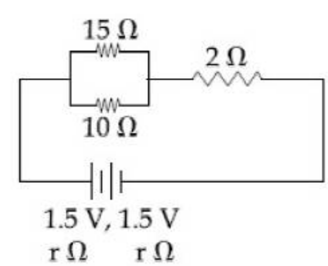
13. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbitals in a plane due to magnetic field perpendicular to the plane. Let r_p, r_e and r_{He} be their respective radii, then,

(A) $r_e > r_p = r_{He}$
(B) $r_e > r_p > r_{He}$
(C) $r_e < r_p < r_{He}$
(D) $r_e < r_p = r_{He}$

14. The value of acceleration due to gravity at Earth's surface is 9.8 ms^{-2}. The altitude above its surface at which the acceleration due to gravity decreases to 4.9 ms^{-2}, is close to: (Radius of earth = 6.4×10^6 m)

(A) 6.4×10^6 m
(B) 9.0×10^6 m
(C) 2.6×10^6 m
(D) 1.6×10^6 m

15. In the given circuit, an ideal voltmeter connected across the 10 Ω resistance reads 2 V. The internal resistance r, of each cell is:



(A) 1 Ω
(B) 0.5 Ω
(C) 1.5 Ω
(D) 0 Ω

16. The electric field of a plane electromagnetic wave is given by

$$\vec{E} = E_0 \hat{i} \cos(kz) \cos(\omega t)$$

The corresponding magnetic field $\vec{B}$ is then given by:

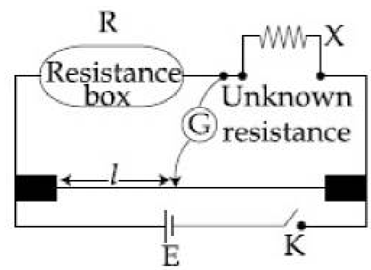
(A) $\vec{B} = \frac{E_0}{C} \hat{j} \sin(kz) \cos(\omega t)$
(B) $\vec{B} = \frac{E_0}{C} \hat{k} \sin(kz) \cos(\omega t)$
(C) $\vec{B} = \frac{E_0}{C} \hat{j} \cos(kz) \sin(\omega t)$
(D) $\vec{B} = \frac{E_0}{C} \hat{j} \sin(kz) \sin(\omega t)$

17. An npn transistor operates as a common emitter amplifier, with a power gain of 60 dB. The input circuit resistance Is 100 Ω and the output load resistance is 10 kΩ. the common emitter current gain β is:

(A) 6×10^2 (B) 10^2

(C) 60 (D) 10^4

18. In a meter bridge experiment, the circuit diagram and the corresponding observation table are shown in figure.



Sl. No.	R (Ω)	l (cm)
1.	1000	60
2.	100	13
3.	10	1.5
4.	1	1.0

Which of the readings is inconsistent?

(A) 4 (B) 3

(C) 2 (D) 1

19. A transformer consisting of 300 turns in the primary and 150 turns in the secondary gives output power of 2.2 kW. If the current in the secondary coils is 10 A, then the input voltage and current in the primary coil are:

(A) 440 V and 5 A (B) 440 and 20 A

(C) 220 V and 20 A (D) 220 V and 10 A

20. A uniformly charged ring of radius 3a and total charge q is placed in xy-plane centered at origin. A point charge q is moving towards the ring along the z-axis and has speed v at

z = 4a. The minimum value of v such that it crosses the origin is:

(A) $\sqrt{\frac{2}{m}}\left(\frac{1}{5}\frac{q^2}{4\pi\epsilon_0 a}\right)^{1/2}$ (B) $\sqrt{\frac{2}{m}}\left(\frac{1}{15}\frac{q^2}{4\pi\epsilon_0 a}\right)^{1/2}$

(C) $\sqrt{\frac{2}{m}}\left(\frac{4}{15}\frac{q^2}{4\pi\epsilon_0 a}\right)^{1/2}$ (D) $\sqrt{\frac{2}{m}}\left(\frac{2}{15}\frac{q^2}{4\pi\epsilon_0 a}\right)^{1/2}$

21. A current of 5 A passes through a copper conductor (resistivity = 1.7×10^{-8} Ωm) of radius of cross-section 5 mm. Find the mobility of the charges if their drift velocity is 1.1×10^{-3} m/s.

(A) 1.8 m^2/Vs (B) 1.0 m^2/Vs

(C) 1.3 m^2/Vs (D) 1.5 m^2/Vs

22. n-moles of an ideal gas with constant volume heat capacity C_V undergo an isobaric expansion by certain volume. The ratio of the work done in the process, to the heat supplied is

(A) $\frac{nR}{C_V - nR}$ (B) $\frac{nR}{C_V + nR}$

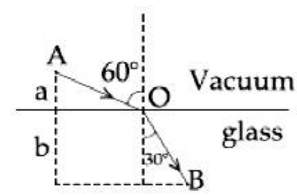
(C) $\frac{4nR}{C_V + nR}$ (D) $\frac{4nR}{C_V - nR}$

23. A message signal of frequency 100 MHz and peak voltage 100 V is used to execute amplitude modulation on a carrier wave of frequency 300 GHz and peak voltage 400 V. The modulation index and difference between the two side band frequencies are:

(A) 4 ; 2×10^8 Hz (B) 4 ; 1×10^8 Hz

(C) 0.25 ; 1×10^8 Hz (D) 0.25 ; 2×10^8 Hz

24. A ray of light AO in vacuum is incident on a glass slab at angle 60° and refracted at angle 30° along OB as shown in the figure. The optical path length of light ray from A to B is :



(A) $2a + \frac{2b}{\sqrt{3}}$ (B) $2a + \frac{2b}{3}$

(C) $\frac{2\sqrt{3}}{a} + 2b$ (D) 2a + 2b

25. The displacement of a damped harmonic oscillator is given by

$x(t) = e^{-0.1\,t}\cos(10\pi t + \varphi)$. Here t is in seconds.

The time taken for its amplitude of vibration to drop to half of its initial value is close to:

(A) 13 s (B) 27 S

(C) 4 s (D) 7 s

26. Two radioactive materials A and B have decay constants 10λ and λ, respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of a to that of B will be 1/e after a time:

(A) $\frac{1}{11\lambda}$ (B) $\frac{1}{10\lambda}$

(C) $\frac{1}{9\lambda}$ (D) $\frac{11}{10\lambda}$

27. A 25×10^{-3} m^3 volume cylinder is filled with 1 mol of O_2 gas at room temperature (300 K). The molecular diameter of O_2, and its root mean square speed, are found to be 0.3 nm and 200 m/s, respectively. What is the average collision rate (per second) for an O_2 molecule?

(A) $\sim 10^{10}$ (B) $\sim 10^{11}$

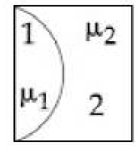
(C) $\sim 10^{12}$ (D) $\sim 10^{13}$

28. In a photoelectric effect experiment the threshold wavelength of incident light is 260 nm, the maximum kinetic energy of emitted electrons will be: Given E (in eV) = $\frac{1237}{\lambda\,(\text{in nm})}$

(A) 15.1 eV (B) 1.5 eV

(C) 4.5 eV (D) 3.0 eV

29. One plano-convex and one plano-concave lens of same radius of curvature 'R' but of different materials are joined side by side as shown in the figure. If the refractive index of the material of 1 is μ_1 and that of 2 is μ_2, then the focal length of the combination is



(A) $\frac{R}{2(\mu_1 - \mu_2)}$
(B) $\frac{2R}{\mu_1 - \mu_2}$
(C) $\frac{R}{\mu_1 - \mu_2}$
(D) $\frac{R}{2 - (\mu_1 - \mu_2)}$

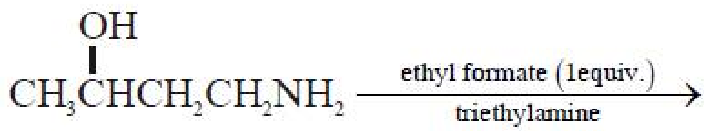
30. A moving coil galvanometer allows a full scale current of 10^{-4} A. A series resistance of 2 MΩ is required to convert the above galvanometer into a voltmeter of range 0 – 5 V. Therefore the value of shunt resistance required to convert the above galvanometer into a ammeter of range 0–10 mA is:

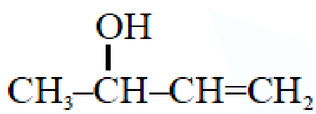
(A) 200 Ω
(B) 100 Ω
(C) 10 Ω
(D) 500 Ω

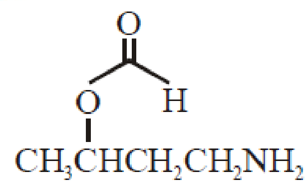
PART –B (CHEMISTRY)

31. The species that can have a trans-isomer is:
(en = ethane-1,2-diamine, ox = oxalate)
(A) $[Pt(en)Cl_2]$
(B) $[Pt(en)_2Cl_2]^{2+}$
(C) $[Cr(en)_2(ox)]^{+}$
(D) $[Zn(en)Cl_2]$

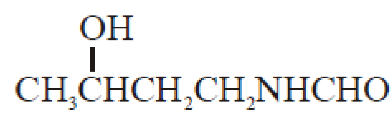
32. The major product of the following reaction is



(A) 

(B) 

(C) $CH_3CH = CH – CH_2NH_2$

(D) 

33. The synonym for water gas when used in the production of methanol is
(A) syn gas
(B) natural gas
(C) fuel gas
(D) laughing gas

34. The regions of the atmosphere, where clouds form and where we live, respectively, are:
(A) Troposphere and Stratosphere
(B) Troposphere and Troposphere
(C) Stratosphere and Stratosphere
(D) Stratosphere and Troposphere

35. Consider the hydrated ions of Ti^{2+}, V^{2+}, Ti^{3+} and Sc^{3+}. The correct order of their spin-only magnetic moments is:
(A) $Ti^{3+} < T^{2+} < Sc^{3+} < V^{2+}$
(B) $Sc^{3+} < Ti^{3+} < Ti^{2} < V^{2+}$
(C) $V^{2+} < Ti^{2+} < Ti^{3+} < Sc^{3+}$
(D) $Sc^{3+} < Ti^{3+} < V^{2+} < Ti^{2+}$

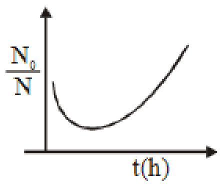
36. Amylopectin is composed of
(A) α-D-glucose, C_1–C_4 and C_2–C_6 linkages
(B) β-D-glucose, C_1–C_4 and C_2–C_6 linkages
(C) α-D-glucose, C_1–C_4 and C_1–C_6 linkages
(D) β-D-glucose, C_1–C_4 and C_1–C_6 linkages

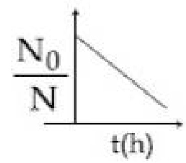
37. A gas undergoes physical adsorption on a surface and follows the given Freundlich adsorption isotherm equation

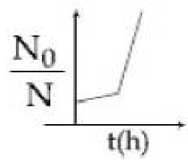
$$\frac{x}{m} = kp^{0.5}$$

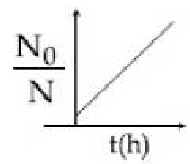
Adsorption of the gas increases with:
(A) Increase in p and decrease in T
(B) Increase in p and increase in T
(C) Decrease in p and increase in T
(D) Decrease in p and decrease in T

38. A bacterial infection in an internal would grows as $N'(t) = N_0 \exp(t)$, where the time t is in hours. A dose of antibiotic, taken orally, needs 1 hour to reach the wound. Once it reaches there, the bacterial population goes down as $\frac{dN}{dt} = -5N^2$. What will be the plot of $\frac{N_0}{N}$ vs, t after 1 hour?

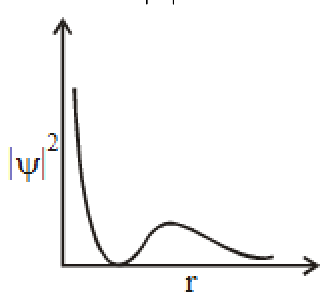
(A) 

(B) 

(C) 

(D) 

39. The graph between $|\psi|^2$ and r(radial distance) is shown below. This represents:



(A) 1s orbital
(B) 3s orbital
(C) 2s orbital
(D) 2p orbital

40. Consider the following table:

Gas	a/ (k Pa dm^6 mol^{-1})	b/ (dm^3 mol^{-1})
A	642.32	0.05196
B	155.21	0.04136
C	431.91	0.05196
D	155.21	0.4382

a and b a van der Waals constants. The correct statement about the gases is:

(A) Gas C will occupy more volume than gas A ; gas B will be lesser compressible than gas D
(B) Gas C will occupy lesser volume than gas A ; gas B will be more compressible than gas D.
(C) Gas C will occupy lesser volume than gas A ; gas B will be lesser compressible than gas D
(D) Gas C will occupy more volume than gas A; gas B will be more compressible than gas D.

41. During the change of O_2 to O_2^-, the incoming electron goes to the orbital:

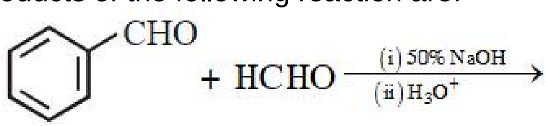
(A) $\pi 2p_y$
(B) $\pi 2p_x$
(C) $\sigma * 2p_z$
(D) $\sigma * 2p_x$

42. The principle of column chromatography is
(A) Differential absorption of the substances on the solid phase.
(B) Differential adsorption of the substances on the solid phase.
(C) Gravitational force.
(D) Capillary action.

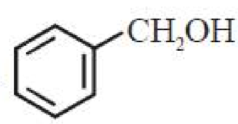
43. At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O_2 for complete combustion, and 40 mL of CO_2 is formed. The formula of the hydrocarbon is:
(A) C_4H_{10} (B) C_4H_6
(C) C_4H_7Cl (D) C_4H_8

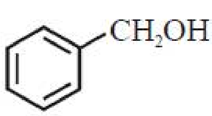
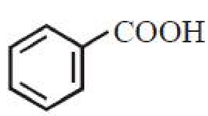
44. Three complexes,
$[CoCl(NH_3)_5]^{2+}$ (I), $[co(NH_3)_5H_2O]^{3+}$ (II) and $[Co(NH_3)_6]^{3+}$ (III)
Absorb light in the visible region. The correct order of the wavelength of light absorbed by them is
(A) (II) > (I) > (III) (B) (III) > (II) > (I)
(C) (I) > (II) > (III) (D) (III) > (I) > (II)

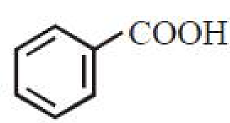
45. Major products of the following reaction are:



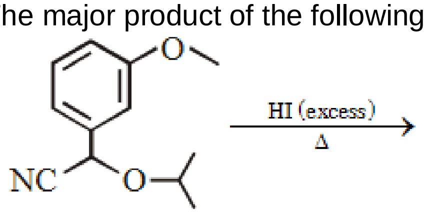
(A) CH_3OH and HCO_2H

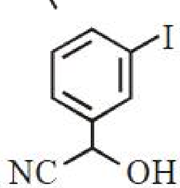
(B) HCOOH and 

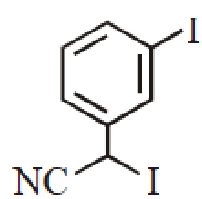
(C)  and 

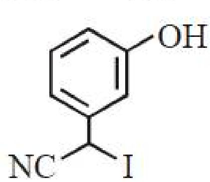
(D) CH_3OH and 

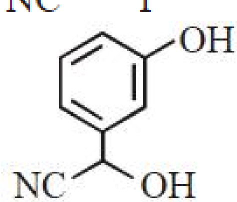
46. The major product of the following reaction is:



(A) 

(B) 

(C) 

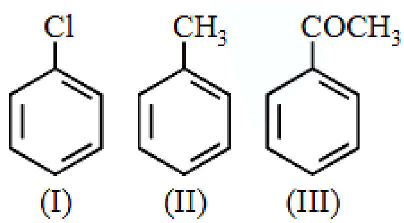
(D) 

47. Match the refining methods (Column I) with metals (Column II).

Column I (Refining methods)	Column II (Metals)
(I) Liquation	(a) Zr
(II) zone Refining	(b) Ni
(III) Mond process	(C) Sn
(IV) Van Arkel Method	(d) Ga

(A) (I) – (b); (II) – (c); (III) – (d); (IV) – (a)
(B) (I) – (b); (II) – (d); (III) – (a); (IV) – (c)
(C) (I) – (c); (II) – (a); (III) – (b); (IV) – (d)
(D) (I) – (c); (II) – (d); (III) – (b); (IV) – (a)

48. The increasing order of the reactivity of the following compounds towards electrophilic aromatic substitution reaction is:



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

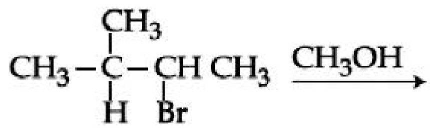
49. A process will be spontaneous at all temperatures if:
(A) $\Delta H < 0$ and $\Delta S < 0$
(B) $\Delta H < 0$ and $\Delta S > 0$
(C) $\Delta H > 0$ and $\Delta S > 0$
(D) $\Delta H > 0$ and $\Delta S < 0$

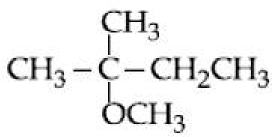
50. Consider the following statements
(a) The pH of a mixture containing 400 mL of 0.1 M H_2SO_4 and 400 mL of 0.1 M NaOH will be approximately 1.3.
(b) Ionic product of water is temperature dependent.
(c) A monobasic acid with $K_a = 10^{-5}$ has a pH = 5. the degree of dissociation of this acid is 50%.
(d) The Le Chatelier's principle is not applicable to common-ion effect.
The correct statements are:
(A) (a) and (b)
(B) (a), (b) and (c)
(C) (b) and (c)
(D) (a), (b) and (d)

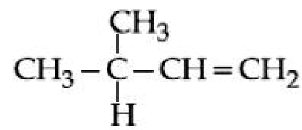
51. Ethylamine ($C_2H_5NH_2$) can be obtained from N-ethylphthalimide on treatment with:
(A) CaH_2
(B) H_2O
(C) $NaBH_4$
(D) NH_2NH_2

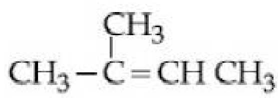
52. The correct order of catenation is:
(A) C > Sn > Si ≈ Ge
(B) Ge > Sn > Si > C
(C) Si > Sn > C > Ge
(D) C > Si > Ge ≈ Sn

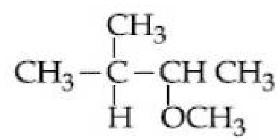
53. The major product of the following reaction is



(A) 

(B) 

(C) 

(D) 

54. Which of the following is a condensation polymer?

(A) Nylon 6, 6
(B) Neoprene
(C) Buna–S
(D) Teflon

55. Consider the statements S1 and S2:

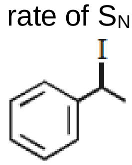
S1: Conductivity always increases with decrease in the concentration of electrolyte.

S2: Molar conductivity always increases with decrease in the concentration of electrolyte.

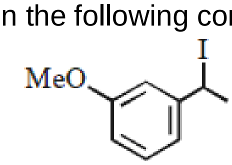
The correct option among the following is:

(A) S1 is wrong and S2 is correct
(B) Both S1 and S2 are wrong
(C) S1 is correct and S2 is wrong
(D) Both S1 and S2 are correct

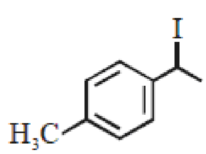
56. Increasing rate of S_N1 reaction in the following compounds is



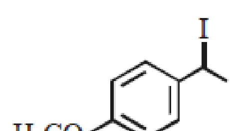
(A)



(B)



(C)



(D)

(A) (A) < (B) < (C) < (D)
(B) (A) < (B) < (D) < (C)
(C) (B) < (A) < (D) < (C)
(D) (B) < (A) < (C) < (D)

57. The oxoacid of sulphur that does not contain bond between sulphur atoms is:

(A) $H_2S_2O_3$
(B) $H_2S_2O_4$
(C) $H_2S_2O_7$
(D) $H_2S_4O_6$

58. The isoelectronic set of ions is

(A) Li^+, Na^+, O^{2-} and F^-
(B) F^-, Li^+, Na^+ and Mg^{2+}
(C) N^{3-}, O^{2-}, F^- and Na^+
(D) N^{3-}, Li^+, Mg^{2+} and O^{2-}

59. The alloy used in the construction of aircrafts is

(A) Mg–Mn (B) Mg-Zn

(C) Mg-Al (D) Mg-Sn

60. At room temperature, a dilute solution of urea is prepared by dissolving 0.60 g of urea in 360 g of water. If the vapour pressure of pure water at this temperature is 35 mm Hg, lowering of vapour pressure will be: (molar mass of urea = 60 g mol^{-1})

(A) 0.027 mmHg (B) 0.031 mmHg

(C) 0.028 mmHg (D) 0.017 mmHg

PART–C (MATHEMATICS)

61. If Q(0, –1, –3) is the image of the point P in the plane 3x – y, 1.4z = 2 and R is the point (3, –1, –2), then the area (in square units) of ΔPQR is:

(A) $\frac{\sqrt{91}}{2}$ (B) $2\sqrt{13}$

(C) $\frac{\sqrt{65}}{2}$ (D) $\frac{\sqrt{91}}{4}$

62. If the coefficients of x^2 and x^3 are both zero, in the expansion of the expression $(1 + ax + bx^2)(1 - 3x)^{t5}$ in powers of x, then the ordered pair (a, b) is equal to

(A) (–54, 315) (B) (28, 861)

(C) (28, 315) (D) (–21, 714)

63. The sum

$$\frac{3\times1}{1^2}+\frac{5\times(1^3+2^3)}{1^2+2^2}+\frac{7\times(1^3+2^3+3^3)}{1^2+2^2+3^2}+........$$

Upto 10^{th} term, is

(A) 620 (B) 660

(C) 680 (D) 600

64. If the length of the perpendicular from the point (β, 0, β) (β = 0) to the line, $\frac{x}{1}=\frac{y-1}{0}=\frac{z+1}{-1}$ is $\sqrt{\frac{3}{2}}$, then β is equal to:

(A) 1 (B) –1

(C) 2 (D) –2

65. If $f(x) = \begin{cases} \frac{\sin(p+1)x+\sin x}{x} & , \ x<0 \\ q & , \ x=0 \\ \frac{\sqrt{x+x^2}-\sqrt{x}}{x/2} & , \ x>0 \end{cases}$

Is continuous at x = 0, then the ordered pair (p, d) is equal to

(A) $\left(-\frac{3}{2},-\frac{1}{2}\right)$ (B) $\left(\frac{5}{2}, \frac{1}{2}\right)$

(C) $\left(-\frac{1}{2}, \frac{3}{2}\right)$ (D) $\left(-\frac{3}{2},\frac{1}{2}\right)$

66. Which one of the following Boolean expressions is a tautology?

(A) $(p \vee q) \wedge (p \vee \sim q)$ (B) $(p \wedge q) \vee (p \wedge \sim q)$

(C) $(p \vee q) \wedge (\sim p \vee \sim q)$ (D) $(p \vee q) \vee (p \vee \sim q)$

67. If α and β are the roots of the quadratic equation, $x^2 + x\sin\theta - 2\sin\theta = 0$, $\theta \in \left(0, \frac{\pi}{2}\right)$ then $\frac{\alpha^{12}+\beta^{12}}{(\alpha^{-12}+\beta^{-12})(\alpha-\beta)^{24}}$ is equal to:

(A) $\frac{2^{12}}{(\sin\theta+8)^{12}}$
(B) $\frac{2^{12}}{(\sin\theta-4)^{12}}$
(C) $\frac{2^{12}}{(\sin\theta-8)^{6}}$
(D) $\frac{2^{6}}{(\sin\theta+8)^{12}}$

68. ABC is a triangular park with AB = AC = 100 metres. A vertical tower is situated at the mid-point of BC. If the angles of elevation of the top of the tower at A and B are $\cot^{-1}(3\sqrt{2})$ and $\operatorname{cosec}^{-1}(2\sqrt{2})$ respectively, then the height of the tower (in metres) is:

(A) 25
(B) $10\sqrt{5}$
(C) $\frac{100}{3\sqrt{3}}$
(D) 20

69. If $a > 0$ and $z = \frac{(1+i)^2}{a-i}$, has magnitude $\sqrt{\frac{2}{5}}$, then $\bar{z}$ is equal to:

(A) $-\frac{3}{5}-\frac{1}{5}i$
(B) $-\frac{1}{5}-\frac{3}{5}i$
(C) $-\frac{1}{5}+\frac{3}{5}i$
(D) $\frac{1}{5}-\frac{3}{5}i$

70. If $\Delta_1 = \begin{vmatrix} x & \sin\theta & \cos\theta \\ \sin\theta & -x & 1 \\ \cos\theta & 1 & x \end{vmatrix}$ and

$\Delta_2 = \begin{vmatrix} x & \sin 2\theta & \cos 2\theta \\ \sin 2\theta & -x & 1 \\ \cos 2\theta & 1 & x \end{vmatrix}, x \neq 0$; then

for all $\theta \in \left(0, \frac{\pi}{2}\right)$:

(A) $\Delta_1 - \Delta_2 = -2x^3$
(B) $\Delta_1 + \Delta_2 = -2(x^3 + x - 1)$
(C) $\Delta_1 - \Delta_2 = x(\cos 2\theta - \cos 4\theta)$
(D) $\Delta_1 + \Delta_2 = -2x^3$

71. If y = 1f(x) is the solution of the differential equation $\frac{dy}{dx} = (\tan x - y)\sec^2 x$, $x \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$, such that y(0) = 0, then $y\left(-\frac{\pi}{4}\right)$ is equal to

(A) $\frac{1}{2} - e$
(B) $\frac{1}{e} - 2$
(C) $e - 2$
(D) $2 + \frac{1}{e}$

72. Let f: R $\rightarrow$ R be differentiable at c $\in$ R and f(c) = 0. If g(x) = $|f(x)|$, then at x =c, g is:

(A) differentiable if $f'(c) = 0$
(B) differentiable if $f'(c) \neq 0$
(C) not differentiable
(D) not differentiable if $f'(c) = 0$

73. Let f(x) = x^2, x $\in$ R. For any A $\subseteq$ R, define g(A) = {x $\in$ R : f(x) $\in$ A}. If S = [0, 4], then which one of the following statements is not true?

(A) f(g(S) $\neq$ f(S)
(B) f(g(S)) = S
(C) g(f(S)) $\neq$ S
(D) g(f(S)) = g(S)

74. If the system of linear equations

$x + y + z = 5$
$x = 2y + 2z = 6$
$x + 3y + \lambda z = u$ (λ μ $\in$ R), has infinitely many solutions then the value of $\lambda + \mu$ is:

(A) 12
(B) 7
(C) 10
(D) 9

75. The number of 6 digit numbers hat can be formed using the digits 0, 1, 2, 5, 7 and 9 which are divisible by 11 and no digits is repeated, is

(A) 36
(B) 60
(C) 72
(D) 48

76. The line x = y touches a circle at the point (1, 1). If the circle also passes through the point (1, –3), then its radius is

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

77. Let f(x) = $e^x - x$ and g(x) = $x^2 - x$, $\forall$ x $\in$ R. Then the set of all x $\in$ R, where the function h(x) = (fog) (x) is increasing is:

(A) $\left[0, \frac{1}{2}\right] \cup [1, \infty)$
(B) $\left[1, \frac{1}{2}\right] \cup \left[\frac{1}{2}, \infty\right)$
(C) $\left[\frac{-1}{2}, 0\right] \cup [1, \infty)$
(D) $[0, \infty)$

78. The value of $\int_0^{2\pi} [\sin 2x(1+\cos 3x)]\, dx$ where [t] denotes the greatest integer function, is:

(A) π
(B) -2π
(C) 2π
(D) $-\pi$

79. If the circles $x^2 + y^2 + 5Kx + 2y + K = 0$ and $2(x^2 + y^2) + 2Kx + 3y - 1 = 0$, (K$\in$R), intersect at the points P and Q, then the line 4x + 5y – K = 0 passes through P and Q for:

(A) exactly one value of K
(B) not value of K
(C) infinitely many values of K
(D) exactly two values of K

80. If the lines x – 2y = 12 is tangent to the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ at the point $\left(3, \frac{9}{2}\right)$, then the length of the latus rectum of the ellipse is

(A) $12\sqrt{2}$
(B) 9
(C) $8\sqrt{3}$
(D) 5

81. If a_1, a_2, a_3 ……….. a_n are in A.P and $a_1 + a_4 + a_7 +$ ………….. $+ a_{16} = 114$, then $a_1 + a_6 + a_{11} + a_{16}$ is equal to
(A) 76
(B) 64
(C) 98
(D) 38

82. If for some $x \in R$, the frequency distribution of the marks obtained by 20 students in a test is

Marks	2	3	5	7
Frequency	$(x+1)^2$	$2x - 5$	$x^2 - 3x$	x

Then the mean of the marks is:
(A) 2.8
(B) 3.2
(C) 2.5
(D) 3.0

83. If $\lim\limits_{x \to 1} \dfrac{x^4 - 1}{x - 1} = \lim\limits_{x \to k} \dfrac{x^3 - k^3}{x^2 - k^2}$, then k is
(A) $\dfrac{3}{8}$
(B) $\dfrac{8}{3}$
(C) $\dfrac{4}{3}$
(D) $\dfrac{3}{2}$

84. All the pairs (x, y) that satisfy the inequality
$2^{\sqrt{\sin^2 x - 2\sin x + 5}} \cdot \dfrac{1}{4^{\sin^2 y}} \le 1$ also
Satisfy the equation:
(A) $2|\sin x| = 3\sin y$
(B) $\sin x = |\sin y|$
(C) $2\sin x = \sin y$
(D) $\sin x = 2\sin y$

85. $\lim\limits_{n \to \infty} \left(\dfrac{(n+1)^{1/3}}{n^{4/3}} + \dfrac{(n+2)^{1/3}}{n^{4/3}} + ... + \dfrac{(2n)^{1/3}}{n^{4/3}} \right)$
is equal to:
(A) $\dfrac{3}{4}(2)^{4/3} - \dfrac{3}{4}$
(B) $\dfrac{4}{3}(2)^{3/4}$
(C) $\dfrac{3}{4}(2)^{4/3} - \dfrac{4}{3}$
(D) $\dfrac{4}{3}(2)^{4/3}$

86. If a directrix of a hyperbola centered at the origin and passing through the point $(4, -2\sqrt{3})$ is $5x = 4\sqrt{5}$ and its eccentricity is e, then
(A) $4e^4 + 8e^2 - 35 = 0$
(B) $4e^4 - 24e^2 + 35 = 0$
(C) $4e^4 - 12e^2 - 27 = 0$
(D) $4e^4 - 24e^2 + 27 = 0$

87. The region represented by $|x - y| \le 2$ and $|x + y| \le 2$ is bounded by a:
(A) rhombus of area $8\sqrt{2}$ sq. units
(B) square of area 16 sq. units
(C) rhombus of side length 2 units
(D) square of side length $2\sqrt{2}$ units

88. Assume that each born child is equally likely to be a boy or a girl. If two families have two children each, then the conditional probability that all children are girls given that at least two are girls is:

(A) $\frac{1}{10}$ (B) $\frac{1}{17}$

(C) $\frac{1}{12}$ (D) $\frac{1}{11}$

89. Let A(3, 0, –1), B(2, 10, 6) and C(1, 2, 1) be the vertices of a triangle and M be the midpoint of AC. If G divides BM in the ratio, 2 : 1, then cos($\angle$GOA) (O being he origin) is equal to:

(A) $\frac{1}{\sqrt{30}}$ (B) $\frac{1}{2\sqrt{15}}$

(C) $\frac{1}{6\sqrt{10}}$ (D) $\frac{1}{\sqrt{15}}$

90. If $\int \frac{dx}{(x^2-2x+10)^2}$

$= A\left(\tan^{-1}\left(\frac{x-1}{3}\right)+\frac{f(x)}{x^2-2x+10}\right)+C$

Where C is a constant of integration, then:

(A) $A=\frac{1}{27}$ and $f(x)=-(x-1)$ (B) $A=\frac{1}{54}$ and $f(x)=9(x-1)^2$

(C) $A=\frac{1}{54}$ and $f(x)=3(x-1)$ (D) $A=\frac{1}{81}$ and $f(x)=3(x-1)$

HINTS AND SOLUTIONS
PART A – PHYSICS

1. $\vec{F} = m\vec{a} = m[-a\omega_1^2 \cos\omega_1 t\hat{i} - b\omega_2^2 \sin\omega_2 t\hat{j}$

$\vec{f}_{t=0} = -ma\omega_1^2\hat{i}$

$\vec{r}_{t=0} = (x_0 + a)\hat{i} + y\,\hat{j}$

$\vec{\tau} = \vec{r} \times \vec{F} = my_0 a\omega_1^2\hat{k}$

2. $\nu = \dfrac{v + v_o}{v}\nu_o$

$\Rightarrow \quad v_o = \left(\dfrac{\nu}{\nu_0} - 1\right)v$

$v_o = \left(\dfrac{530}{500} - 1\right)300$ = 18 m/s

$v_o = \left|\left(\dfrac{480}{500} - 1\right)300\right|$ = 12 m/s

3. 2MV, cos 30° + Mv$_2$ cos 45° = 10 M cos 30° + 10 cos 45°

$\Rightarrow \quad v_1\sqrt{3} + \dfrac{v_2}{\sqrt{2}} = 5\sqrt{3} + 5\sqrt{2}$ …(i)

2MV, sin 30° – MV$_2$ sin 45° = –10 M sin 30° + 10 M sin 45°

$V_1 - \dfrac{V_2}{\sqrt{2}} = -5 + 5\sqrt{2}$ …(ii)

$V_1 = \dfrac{5(\sqrt{3} - 1) + 10\sqrt{2}}{\sqrt{3} + 1} = \dfrac{17.5}{2.7}$ = 6.5 m/s

V$_2$ = 6.3 m/s

4. Factual

5. $\dfrac{\frac{1}{T^2}}{\frac{1}{T_0^2}} + \dfrac{\ln R(T)}{\ln R(T_o)} = 1$

$\Rightarrow$ ln R(T) = ln R(T$_o$) $\left(1 - \dfrac{T_o^2}{T^2}\right)$

R(T) = $R_o e^{-\left(\frac{T_0^2}{T^2}\right)}$

6. $\Delta Q = nC_v\,\Delta T = n\frac{3}{2}R\Delta T$

$= \left(\frac{67.2}{22.4}\right)\left(\frac{3}{2}\times 8.31\right)(20)$

≈ 748 J

7. $-(g+\gamma v^2) = \frac{dv}{dt}$

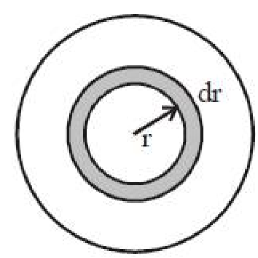
$-gdt = \frac{g}{\gamma}\left(\frac{dv}{\frac{g}{\gamma}+v^2}\right)$

Integrating $0 \to t$ and $V_0 \to 0$:

$-gt = -\sqrt{\frac{g}{\gamma}}\tan^{-1}\left(\frac{V_0}{\sqrt{\frac{g}{\gamma}}}\right)$

$t = \frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$

8. $I_{Disc} = \int_0^R (dm)r^2 \Rightarrow I_{Disc} = \int_0^R (\sigma 2\pi r dr)r^2$



$I_{Disc} = \int_0^R (kr^2\, 2\pi r dr)r^2$ Mass of disc

$I_{Disc} = 2\pi k\int_0^R r^2 dr$ $M = \int_0^R 2\pi r dr\; kr^2$

$I_{Disc} = 2\pi k\left(\frac{r^6}{6}\right)_0^R$ $M = 2\pi k\int_0^R r^3 dr$

$I_{Disc} = 2\pi k\frac{R^6}{6}$ $M = 2\pi k\left.\frac{r^4}{4}\right|_0^R$

$I_{Disc} = \frac{\pi k R^6}{3} = \left(\frac{\pi k R^4}{2}\right)\frac{R^2 2}{3}$ $M = 2\pi k\left.\frac{r^4}{4}\right|_0^R$

$I_{Disc} = \frac{M2R^2}{3}$; $I_{Disc} = \frac{2}{3}MR^2$

9. $$E_i = \frac{1}{2} I_I \times \omega_1^2 + \frac{1}{2}\frac{I}{2} \times \frac{\omega_1^2}{4}$$

$$= \frac{I_1\omega_1^2}{2}\left(\frac{9}{8}\right) = \frac{9}{16} I_1\omega_1^2$$

$$I_1\omega_1 + \frac{I_1\omega_1}{4} = \frac{3I_1}{2}\omega \quad ; \quad \frac{5}{4} I_1\omega_1 = \frac{3I_1}{2}\omega$$

$$\omega = \frac{5}{6}\omega_1 \quad ; \quad E_f = \frac{1}{2} \times \frac{3I_1}{2} \times \frac{25}{36}\omega_1^2$$

$$= \frac{25}{48} I_1\omega_1^2$$

$$\Rightarrow \quad E_f - E_i = I_1\omega_1^2 \frac{25}{49} - \frac{-2}{48} I_2\omega_1^2$$

$$= \frac{25}{48} I_1\omega_1^2$$

$$\Rightarrow \quad E_f - E_i = I_1\omega_1^2\left(\frac{25}{48} - \frac{9}{16}\right) = \frac{-2}{48} I_1\omega_1^2$$

$$= \frac{-I_1\omega_1^2}{24}$$

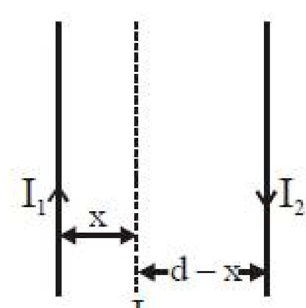
10. $$h = \frac{2S_1\cos\theta}{r_1\rho_1 g}$$

$$h = \frac{2s_2\cos\theta_2}{r_2\rho_2 g}$$

$$\Rightarrow \quad \frac{r_1}{r_2} = \frac{2}{5}$$

11. As q = CV
Hence slope of graph will give capacitance. Slope will be more in parallel combination. Hence capacitance in parallel should be 50 μF and in series combination must be 8 μF. Only in option 40 μf and 10 μF.
$C_{parallel}$ = 40 + 10 = 50 μF
$C_{series} = \dfrac{40 \times 10}{40 + 10} = 8\ \mu F$

12. Net force on wire carrying current I per unit length is



$$\frac{\mu_0 I_1 I}{2\pi x} + \frac{\mu_0 I_2 I}{2\pi(d - x)} = 0$$

$$\frac{I_1}{x} = \frac{I_2}{x - d}$$

$$\Rightarrow \quad x = \frac{I_1 d}{I_1 - I_2}$$

13. $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

$r_{He} = r_p > r_e$

14. $\frac{GM}{(R+h)^2} = \frac{GM}{2R^2}$

$R + h = \sqrt{2}R$

$h = (\sqrt{2} - 1)R$

$\simeq 2.6 \times 10^6$ m

15. $R_{eq} = \frac{15 \times 10}{25} + 2 + 2r$

$= 8 + 2r$

$i = \frac{3}{8 + 2r}$

$2 = iR_{eq} = \frac{3}{8 + 2r} \times 6$

$16 + 4r = 18$

$\Rightarrow r = 0.5\ \Omega$

16. $\because \vec{E}\times\vec{B} \,||\, \vec{v}$

Given that wave is propagating along positive z-axis and $\vec{E}$ along positive x-axis. Hence $\vec{B}$ along y-axis.

From Maxwell equation

$$\vec{V}\times\vec{E} = -\frac{\partial B}{\partial t}$$

i.e. $\frac{\partial E}{\partial Z} = -\frac{\partial B}{dt}$ and $B_0 = \frac{E_0}{C}$

17. $A_v \times \beta = P_{gain}$

$$60 = 10\log_{10}\left(\frac{P}{P_0}\right)$$

$$P = 10^6 = \beta^2 \times \frac{R_{out}}{R_{in}}$$

$$= \beta^2 \times \frac{10^4}{100}$$

$\beta^2 = 10^4$; $\beta = 100$

18. as $x = \frac{R(100-\ell)}{\ell}$

for (A) $x = \frac{1000\times(100-60)}{40} \approx 667$

for (B) $x = \frac{100\times(100-13)}{13} \approx 669$

for (C) $x = \frac{10\times(100-1.5)}{98.5} \approx 656$

for (D) $x = \frac{1\times(100-1)}{1} \approx 95$

So reading in serial no. (4) is completely different hence correct answer (A).

19. Given $N_P = 300$, $N_s = 150$, $P_0 = 2200W$

$I_s = 10$ A

$P_0 = V_0I_0 \Rightarrow 2200 = V_0 \times 10 \Rightarrow V_0 = 220$ V

$\because \frac{V_i}{V_0} = \frac{N_P}{N_s} \Rightarrow V_i = 2 \times 220 = 440$ V

Also, $P_0 = V_iI_i$

$\Rightarrow I_i = \frac{2200}{440} = 5$ A

20. $U_i + K_i = U_f + K_f$

$$\frac{kq^2}{\sqrt{16a^2+9a^2}} + \frac{1}{2}mv^2 = \frac{kq^2}{3a}$$

$$\frac{1}{2}mv^2 = \frac{kq^2}{a}\left(\frac{1}{3}-\frac{1}{5}\right) = \frac{2kq^2}{15a}$$

$$v = \sqrt{\frac{4kq^2}{15ma}}$$

21. $\mu = \frac{V_d}{E}$ $\quad E = \rho J$

$$= \frac{1.1\times10^{-3}}{1.7\times10^{-8}\times\frac{5}{\pi\times25\times10^{-6}}}$$

$$= \frac{1.1\times10^{-3}\times\pi\times25\times10^{-6}}{1.7\times10^{-8}\times5} \approx 1.01\ m^2/Vs$$

22. $w = nR\Delta T$

$\Delta H = (C_v + nR)\Delta T$

$$\frac{\omega}{\Delta H} = \frac{nR}{C_v + nR}$$

23 $f_m = 100$ MHz $= 10^8$ Hz, $(V_m)_0 = 100$ V

$f_c = 300$ GHz, $(V_c)_0 = 400$ V

$\therefore$ UBF – LBF $= 2f_m = 2\times10^8$ Hz

24. From Snell's law

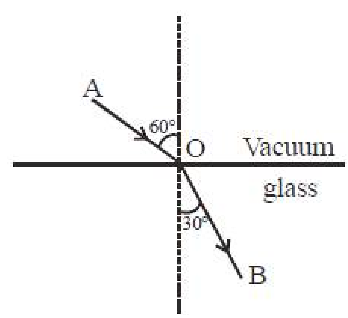
$1 \sin 60° = \mu \sin 30°$

$\Rightarrow \quad \mu = \sqrt{3}$

Optical path = AO + μ(OB)

$$= \frac{a}{\cos 60^o} + \sqrt{3}\frac{b}{\cos 30^o}$$

$= 2a + 2b$



25. $A = A_0e^{-0.1\,t} = \frac{A_0}{2}$

$\ln 2 = 0.1\ t$

$t = 10 \ln 2 = 6.93 \approx 7$ sec.

26. $N_1 = N_0e^{-10\lambda t}$; $\quad N_2 = N_0e^{-\lambda t}$

$$\frac{1}{e} = \frac{N_1}{N_2} = e^{-9\lambda t}$$

$\Rightarrow \ 9\lambda t = 1$

$\Rightarrow \ t = \frac{1}{9\lambda}$

27. $\nu = \frac{V_{av}}{\lambda}$

$\lambda = \frac{RT}{\sqrt{2}\,\pi\sigma^2 N_A P}$

$\sigma = 2 \times 0.3 \times 10^{-9}$

$P = \frac{RT}{V}$

$\Rightarrow \quad = \frac{V}{\sqrt{2}\,\pi\sigma^2 N_A}$

$V_{av} = \sqrt{\frac{8}{3\pi}} \times V_{rms}$

$\therefore \quad v = \frac{200 \times \sqrt{2}\,\pi \times \sigma^2 N_A}{25 \times 10^{-3}} \times \sqrt{\frac{8}{3\pi}}$

$= 17.68 \times 10^8$/sec

$= 0.1768 \times 10^{10}$/sec ~ 10^{10}

This answer does not match with JEE – Answer key

28. $K_{max} = \frac{hc}{\lambda} - \frac{hc}{\lambda_o}$

$\Rightarrow K_{max} = hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)$

$\Rightarrow K_{max} = (1237)\left(\frac{380 - 260}{380 \times 260}\right)$

$= 1.5$ eV

29. For 1st lens $\frac{1}{f_1} = \left(\frac{\mu_1 - 1}{1}\right)\left(\frac{1}{\infty} - \frac{1}{-R}\right) = \frac{\mu_1 - 1}{R}$

For 2nd lens $\frac{1}{f_2} = \left(\frac{\mu_2 - 1}{1}\right)\left(\frac{1}{-R} - 0\right) = -\frac{\mu_2 - 1}{R}$

$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$

$\frac{1}{f_{eq}} = \frac{\mu_1 - 1}{R} + \frac{-(\mu_2 - 1)}{R} \Rightarrow f_{eq} = \frac{R}{\mu_1 - \mu_2}$

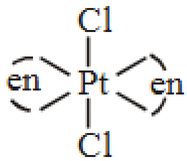
30. $200 + 10^{-4}$ G = 5

G = –ve

So, answer is Bonus.

PART B – CHEMISTRY

31. The trans-isomer of $[Pt(en)_2Cl_2]^{2+}$



32. $$CH_3-\underset{}{\overset{OH}{\overset{|}{C}}}H-CH_2-CH_2-NH_2 \xrightarrow[\text{triethylamine}]{\text{ethyl formate (1equiv.)}}$$

$$CH_3-\overset{OH}{\overset{|}{C}}H-CH_2-CH_2-NH-\overset{O}{\overset{\|}{C}}-H$$

as NH_2 is a better nucleophile than OH.

33. The synonoyms for water gas is syn gas.

34. Fact based.

35. $Ti^{+2} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2$

unpaired electrons = 2.

spin only magnetic moment $(\mu) = \sqrt{2(2+2)} = \sqrt{8}$ B.M

$Ti^{+3} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1$

unpaired electrons = 1

$\mu = \sqrt{1(1+2)} = \sqrt{3}$ B.M

$V^{+2} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$

$\mu = \sqrt{3(3+2)} = \sqrt{15}$ B.M

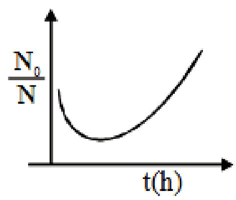
$Sc^{+3} = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

$\mu = 0$

36. Amylopetcin is a homopolymer of a-D-glucose where C_1–C_4 linkage and C_1 – C_6 linkage are present.

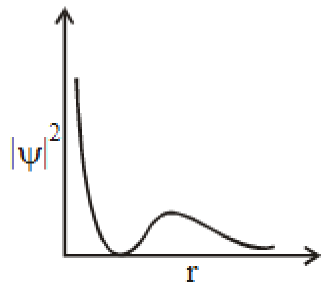
37. Increase in pressure leads to the increase in adsorption capacity and the physical adsorption is an exothermic process with the increase in temperature adsorption decrease.

38. Initially N > N_0 and ''N" is increasing through first-order kinetics. So N_0/N in initial time decreases.



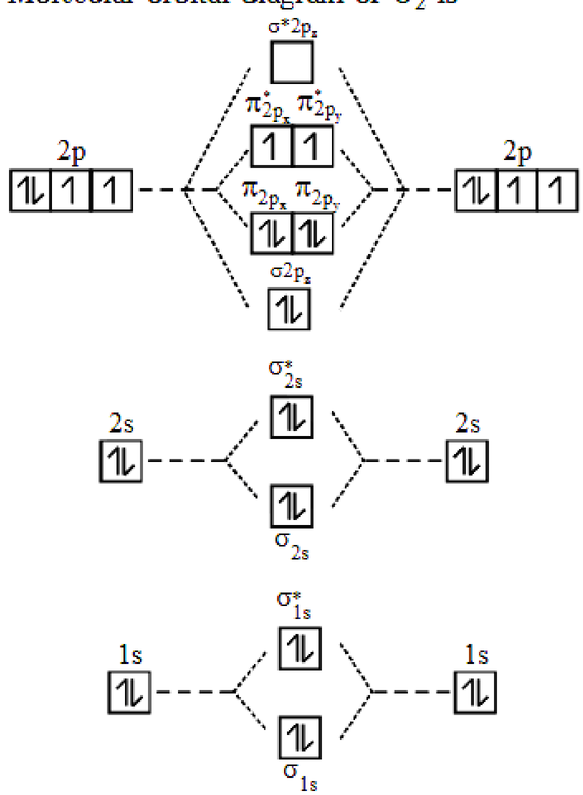
But after 1 hr the value of N decreases with a faster rate. So N_0/N will increases.

39. As we know that for s-orbital graph starts from top and no. of radial node = $n - \ell - 1$
For 2s orbital it will = 2 - 0 - 1 = 1.

∴ The graph  is of 2s

40. Gas A and C have same value of 'b' but different value of 'a' so gas having higher value of 'a' have more force of attraction so molecules will be more closer hence occupy less volume. Gas B and D have same value of 'a' but different value of 'b' so gas having lesser value of 'b' will be more compressible.

41. Molecular orbital diagram of O_2 is



An incoming electron will go in $\pi^*_{2p_x}$ orbital.

42. The principle of column chromatography is differential adsorption of substance and hence option 1 is correct.

43.

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

$$10 \qquad 10\left(x+\frac{y}{4}\right) \qquad\qquad 10x$$

By given data, $10\left(x+\frac{y}{4}\right) = 55$ .... (1)

$10x = 40$ .... (2)

$\therefore\ x = 4,\ y = 6 \Rightarrow C_4H_6$

44. As we known that

Strong ligand α CFSE α $E_{absorbed}$ $\alpha \dfrac{1}{\lambda_{absorbed}}$

We have

$[CoCl(NH_3)_5]^{2+}$, $[Co(NH_3)_5H_2O]^{3+}$ and $[CO(NH_3)_6]^{3+}$

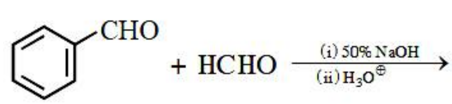
(I) (II) (III)

$\therefore$ III > II> I (as per $E_{absorbed}$)

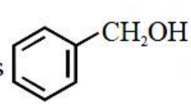
$\therefore \lambda_{absorbed}$

I > II > III

45.

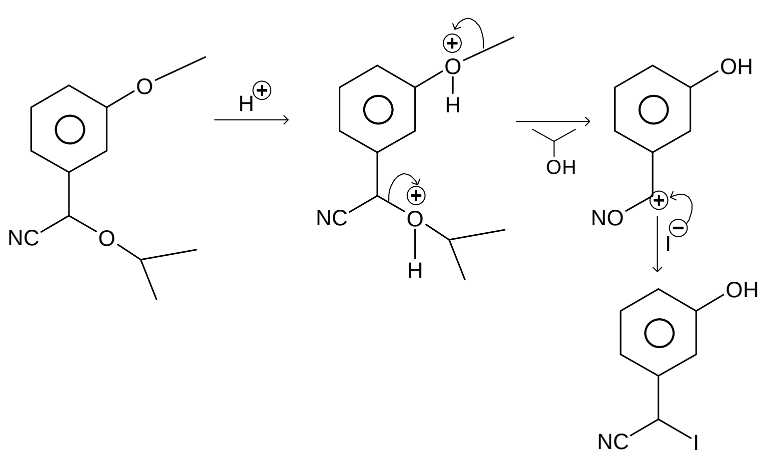


This is cross cannizaro reaction so more reactive carbonyl compound is oxidized and less reactive is reduced so answer is



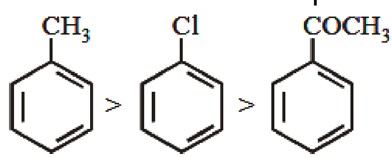
$+ HCO_2H$

46.



47. Liquation is used for Sn.
Zone refining is used for Ga.
Mond's process is used for Ni.
Van arkel process is used for Zr.

48. Rate of aromatic electrophilic substitution is



(II) (I) (III)

49. At constant P and T and for the process to be spontaneous we should have ΔG = -ve and we know that
$\Delta G = \Delta H - T\Delta S$
If ΔH = -ve and ΔS = +ve then at all the temperature the process will be spontaneous.

50. (a) $H_2SO_4 \quad + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$
$400 \times .1 = 40 \quad 400 \times .1 = 40$
$20 \qquad 0$

$$\therefore [H^+] = \frac{20 \times 2}{800} = \frac{1}{20} \Rightarrow pH = -\log\left(\frac{1}{20}\right)$$

$\therefore$ pH = 1.3 so (a) is correct

(b) $$\log\left(\frac{Kw_2}{Kw_1}\right) = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

so ionic product of water is temp. dependent
hence (b) is correct.

(c) $K_a = 10^{-5}$, pH = 5 $\Rightarrow [H^+] = 10^{-5}$

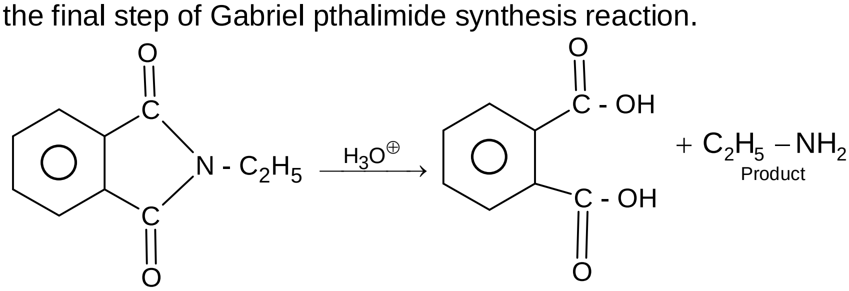
$$K_a = \frac{c\alpha^2}{(1-\alpha)} \Rightarrow K_a = \frac{[H^+].\alpha}{(1-\alpha)}$$

$$\therefore 10^{-5} = \frac{10^{-5}.\alpha}{(1-\alpha)} \Rightarrow 1 - \alpha = \alpha \Rightarrow \alpha = \frac{1}{2} = 50\%$$

so (c) is correct.

(d) Le-chatelier's principle is applicable to common –Ion effect so option (d) is wrong

51. It is the final step of Gabriel pthalimide synthesis reaction.

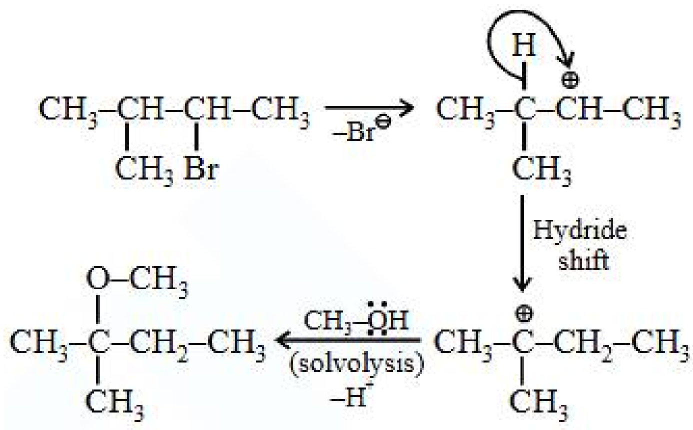


52. In this order of catenation is asked. Catenation is a self-linking property here and for group 14: Self-linking is through covalent bonding

$C > Si > Ge \approx Sn$

In C there is 2p – 2p overlapping further 3p – 3p, 4p-4p and so on and the extent of overlapping is more in 2p-2p > 3p-3p > 4p-4p ≈ 5p-5p

53. It is S_N1 reaction mechanism is favourable hence reaction complete via S_N1 mechanism



54. Nylon-6,6 is a condensation polymer of hexamethylene diamine and adipic acid. Buna-S, Teflon and Neoprene are addition polymer.

55. We know that

$\lambda_m = \frac{K}{C}$ Here λ_m = molar conductivity

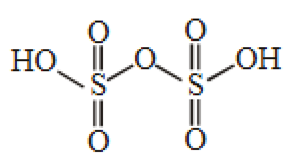
K = conductivity

C = concentration

When concentration increase conductivity always increases. The molar conductivity always increase with the decrease in the concentration.

56. Rate of S_N1 reaction α stability of $C^{\oplus}$ – I.M

57. $H_2S_2O_7$



58. In this we have to choose isoelectronic set of ions:
Isoelectronic species are those which have same no. of electron in total, so option 3 is correct.

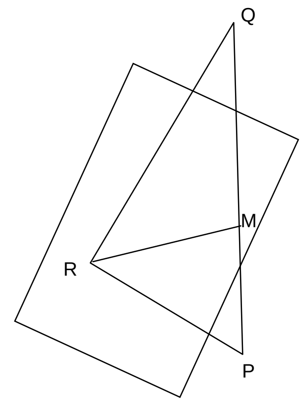
59. For aircraft construction aluminium and its alloys are used, because they are lighter.

60. Lowering of vapour pressure $= p^0 - p = p^0.x_{solute}$

$$\therefore \Delta p = 35 \times \frac{0.6/60}{\frac{0.6}{60}+\frac{360}{18}} = 35 \times \frac{.01}{.01+20} = 35\times\frac{.01}{20.01} = .017 \text{ mm Hg}$$

PART C – MATHEMATICS

61. $MQ = \frac{|1-12-2|}{\sqrt{9+1+16}} = \frac{13}{\sqrt{26}} = \sqrt{\frac{13}{2}}$



$PM = \sqrt{26}$

$RQ = \sqrt{9+1} = \sqrt{10}$

$RM = \sqrt{10 - \frac{13}{2}} = \sqrt{\frac{7}{2}}$

$Ar(\Delta PQR) = \frac{1}{2} \times \sqrt{26} \times \sqrt{\frac{7}{2}} = \frac{\sqrt{91}}{2}$

62. Coefficient of $x^2 = {}^{15}C_2 \times 9 - 3a\left({}^{15}C_1\right) + b = 0$

$\Rightarrow {}^{15}C_2 \times 9 - 45a + b = 0 \quad (1)$

Coefficient of $x^3 = -27 \times {}^{15}C_3 + 9a \times {}^{15}C_2 - 3b \times {}^{15}C_1 = 0$

$\Rightarrow -273 + 21a - b = 0 \quad (2)$

(1) + (2) give

$-24a + 672 = 0 \quad \Rightarrow \quad$ a = 28, b = 315

63. $T_n = \frac{(3+(n-1)\times 2)(1^3+2^3+.....+n^3)}{(1+2^2+....+n^2)}$

$= \frac{3}{2}n(n+1)$

$S_n = \sum T_n$

$= \sum \frac{3}{2}.n.(n+1)$

On solving $S_n = \frac{n(n+1)(n+2)}{2} \Rightarrow S_{10} = 660$

64. $\frac{x}{1}=\frac{y-1}{0}=\frac{z+1}{-1}=\lambda$

A point on this line is $A(0,1,-1)$

$\overrightarrow{AB}.\overrightarrow{BC}=0$

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

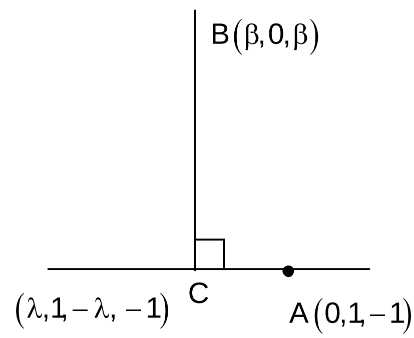
$\therefore C\equiv\left(-\frac{1}{2},1,\frac{-1}{2}\right)$

$\left|\overrightarrow{BC}\right|=\sqrt{\frac{2}{3}}$

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

$\therefore\beta=0,-1$

$\beta=-1\quad(\beta\neq0)$



65. $\text{RHL}=\lim_{x\to0^+}\frac{\sqrt{x+x^2}-\sqrt{x}}{x^{3/2}}$

$=\lim_{x\to0^+}\frac{\sqrt{1+x}-1}{x}=\frac{1}{2}$

$\text{LHL}=\lim_{x\to0^-}\frac{\sin(\beta+1)x+\sin x}{x}$

$=(p+1)+1$

$=p+2$

For function to be continuous

$\text{LHL}=\text{RHL}=f(0)$

$\Rightarrow(p,q)=\left(\frac{-3}{2},\frac{1}{2}\right)$

66. From options

$(p\vee q)\wedge(\sim p\vee\sim q)=(p\vee q)\wedge\sim(p\wedge q)\rightarrow$ Not a tautology

$(p\vee q)\vee(p\vee\sim q)=p\vee(q\vee\sim q)\rightarrow$ tautology

$(p\wedge q)\vee(p\wedge\sim q)\equiv p\wedge(q\vee\sim q)\rightarrow$ Not a tautology

$(p\vee q)\wedge(p\vee\sim q)\equiv p\vee(q\wedge\sim q)\rightarrow$ Not a tautology

67. $x^2+x\sin\theta-2\sin\theta=0$

$\alpha+\beta=-\sin\theta$

$\alpha\beta=-2\sin\theta$

Now, $\frac{\alpha^{12}+\beta^{12}}{\left(\frac{1}{\alpha^{12}}+\frac{1}{\beta^{12}}\right)(\alpha-\beta)^{24}}=\frac{(\alpha\beta)^{12}}{(\alpha-\beta)^{24}}$

$$=\frac{(\alpha\beta)^{12}}{\left((\alpha+\beta)^2-4\alpha\beta\right)^{12}}$$

$$=\left[\frac{\alpha\beta}{(\alpha+\beta)^2-4\alpha\beta}\right]^{12}$$

$$=\left(\frac{-2\sin\theta}{\sin^2\theta+8\sin\theta}\right)^{12}$$

$$=\frac{2^{12}}{(\sin\theta+8)^{12}}$$

68. $\operatorname{cosec}\beta=2\sqrt{2}$

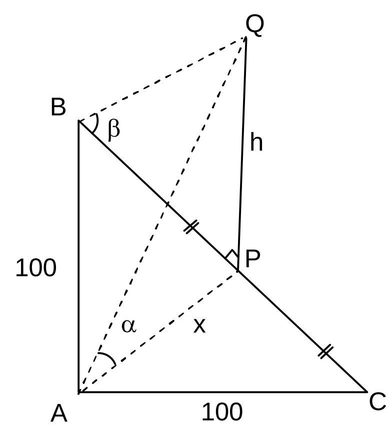
$\cot\alpha=3\sqrt{2}$

$\frac{x}{h}=3\sqrt{2}$ ….(i)

So $\frac{\alpha}{\sqrt{10^4-x^2}}=\frac{1}{\sqrt{7}}$ ….(ii)

From (i) and (ii)

h = 20



69. $z=\frac{(1+i)^2}{a-i}=\frac{2i(a+i)}{a^2+1}$

$|z|=\frac{2}{\sqrt{a^2+1}}=\sqrt{\frac{2}{5}}\Rightarrow a=3$

$\therefore\ \bar{z}=\frac{-2i(3-i)}{10}$

$\Rightarrow\frac{-1-3i}{5}$

70. $\Delta_1=\begin{vmatrix} x & \sin\theta & \cos\theta \\ -\sin\theta & -x & 1 \\ \cos\theta & 1 & x \end{vmatrix}$

$=x(-x^2-1)-\sin\theta(-x\sin\theta-\cos\theta)+\cos\theta(-\sin\theta+x\cos\theta)$

$\Rightarrow -x^3$

$\Delta_2=\begin{vmatrix} x & \sin 2\theta & \cos 2\theta \\ -\sin 2\theta & -x & 1 \\ \cos 2\theta & 1 & x \end{vmatrix}$

$\Rightarrow -x^3$

$\Delta_1+\Delta_2=-2x^3$

71. $\frac{dy}{dx} = (\tan x - y)\sec^2 x$

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

Let $\tan x = t \;\Rightarrow \sec^2 x = \frac{dt}{dx}$

$\therefore \frac{dy}{dt} = (t - y)$

$\frac{dy}{dt} + y = t$ (Linear differential equation)

After solving we get

$ye^t = e^t(t-1) + c$

$\Rightarrow y = (\tan x - 1) + ce^{-\tan x}$

$y(0) = 0 \Rightarrow c = 1$

$y = \tan x - 1 + e^{-\tan x}$

So, $y\left(\frac{-\pi}{4}\right) = e - 2$

72. $g'(c) = \lim\limits_{h\to 0} \frac{|f(c+h)| - |f(c)|}{h}$ $\qquad \because f(c) = 0$

$= \lim\limits_{h\to 0} \frac{|f(c+h)|}{h}$

$= \lim\limits_{h\to 0} \left|\frac{f(c+h) - f(c)}{h}\right| . \frac{|h|}{h}$

$= \lim\limits_{h\to 0} |f'(c)| \frac{|h|}{h} = 0$ if $f'(c) = 0$

i.e. $g(x)$ is differentiable at $x = c$ if $f'(c) = 0$

73. $g(s) = [-2, 2]$

$f(g(s)) = [0, 4] = 5$

$f(S) = [0, 16] \Rightarrow f(g(s)) \neq f(s)$

$g(f(s)) = [-4, 4] \neq g(s)$

therefore, $g(f(s)) \neq S$

74. $x + 3y + \lambda z - u = a(x + y + z - 5) + b(x + 2y + 2z - 6)$

Comparing coefficients we get

$a + b = 1$ and $a + 2b = 3$

$(a, b) = (-1, 2)$

So, $x + 3y + \lambda z - u = x + 3y + 3z - \lambda$

$\Rightarrow u = 7, \lambda = 3$

75. Let the six digit number be abcdef for this number to be divisible by 11

$|(a+c+e)-(b+d+f)|$ must be multiple of 11

$\therefore$ possibility is $a+c+c=b+d+f=12$

Case I $\{a,c,e\}=\{7,5,0\}$ and $\{b,d,f\}=\{9,2,1\}$

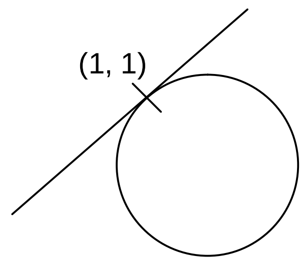
So, number of numbers $=2\times 2!\times 3!=24$

Case II $\{a,c,e\}=\{3,2,1\}$ $\{b,d,f\}=\{7,5,0\}$

So number of numbers $=3!\times 3!=36$

Total $\Rightarrow 24+36=60$

76. Equation of circle is given as $S+\lambda L=0$



$(x-1)^2+(y-1)^2+\lambda(x-y)=0$ passes through (1, –3)

$16+\lambda\times 4=0\Rightarrow \lambda=-4$

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

$r=2\sqrt{2}$

77. $h(x)=f(g(x))$

$\therefore h'(x)=f'(g(x))g'(x)$ and $f'(x)=e^x-1$

$h'(x)=\left(e^{g(x)}-1\right)g'(x)$

$h'(x)=\left(e^{x^2-x}-1\right)(2x-1)\ge 0$

Case : 1

$e^{x^2-x}\le 1$ and $2x-1\le 0$

$\Rightarrow x\in\left[0,\frac{1}{2}\right]$ .....(i)

Case : 2

$e^{x^2-x}\ge 1$ and $2x-1\ge 0$

$\Rightarrow x\in[1,\infty)$ ....(ii)

from (i) and (ii)

$x\in\left[0,\frac{1}{2}\right]\cup[1,\infty)$

78. $I=\int_0^{2\pi}\left[\sin 2x(1+\cos 3x)\right]dx$

$2I=\int_0^{2\pi}\left(\left[\sin 2x(1+\cos 3x)\right]+\left[-\sin 2x-\sin 2x\cos 3x\right]\right)dx$

$2I=\int_0^{2\pi}-dx$

$2I=2\int_0^{\pi}-dx$

$I=\int_0^{\pi}-dx\Rightarrow -\pi$

79. Equation of common chord $4kx+\frac{1}{2}y+k+\frac{1}{2}=0$ ....(i)

and given line $4x+5y-k=0$ .....(ii)

on comparing (i) and (ii) we get $k=\frac{1}{10}=\frac{k+\frac{1}{2}}{-k}$

$\Rightarrow$ No real value of k exist.

80. Tangent at $\left(3,\frac{-9}{2}\right)$

$\frac{3x}{a^2}-\frac{9y}{2b^2}=1$

Comparing with $x-2y=12$

$\frac{3}{a^2}=\frac{9}{4b^2}=\frac{1}{12}$

$\Rightarrow a=6$ and $b=3\sqrt{3}$

Length of latus rectum $=\frac{2b^2}{a}=9$

81. $a_1+a_4+a_7+a_{10}+a_{13}+a_{16}=114$

$\Rightarrow \frac{6}{2}(a_1+a_{16})=114$

$a_1+a_{16}=38$

So $a_1+a_6+a_{11}+a_{16}=\frac{4}{2}(a_1+a_{16})$

$=2\times 38\Rightarrow 76$

82. Mean $\bar{x}=\frac{\sum x_i f_i}{\sum f_i}$

$\because \sum f_i=(x+1)^2+(2x-5)+(x^2-3x)+x=20$

$\Rightarrow x=3,-4$ (rejected)

$\therefore \bar{x}=\frac{\sum x_i f_i}{\sum f_i}=2.8$

83. $\lim\limits_{x\to 1}\frac{x^4-1}{x-1}=\lim\limits_{x\to 1}(x+1)(x^2+1)$ ....(1)

$\lim\limits_{x\to k}\frac{x^3-k^3}{x^2-k^2}=\frac{k^2+k^2+k^2}{2k}$ ....(2)

(1) = (2)

$\Rightarrow k=\frac{8}{3}$

84. $2^{\sqrt{\sin^2 x - 2\sin x + 5}} . 4^{-\sin^2 y} \le 1$

$\Rightarrow 2^{\sqrt{(\sin x - 1)^2 + 4}} \le 4^{\sin^2 y}$

$$\underbrace{\sqrt{\underbrace{(\sin x - 1)^2}_{\ge 0} + 4}}_{\ge 2} \le \underbrace{2\sin^2 y}_{\le 2}$$

this is possible only if $\sin x = 1$ and $|\sin y| = 1$

85. $\lim\limits_{n \to \infty} \sum\limits_{r=1}^{n} \frac{1}{n}\left(\frac{n+r}{n}\right)^{1/3}$

$= \int_0^1 (1+x)^{1/3} dx = \frac{3}{4}\left(2^{4/3} - 1\right)$

86. Let hyperbola be $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ and passes through $\left(4, -2\sqrt{3}\right)$ therefore

$\frac{16}{a^2} - \frac{12}{b^2} = 1$ ....(i)

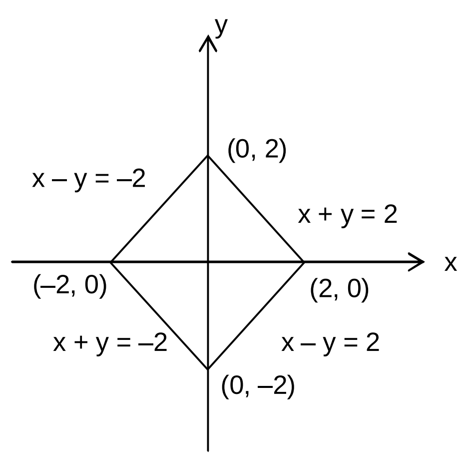
$\because b^2 = a^2\left(e^2 - 1\right)$

$x = \frac{4\sqrt{5}}{5} = \frac{a}{e} \Rightarrow a^2 = \frac{16}{5}e^2$ ....(ii)

On solving (i) and (ii)

$\Rightarrow 4e^4 - 24e^2 + 35 = 0$

87. Shown figure is square with side length $2\sqrt{2}$



88. P (Boy) = P (girl) $= \frac{1}{2}$

Required probability $= \frac{\text{all four girls}}{\text{Atleast two girls}}$

$$=\frac{\left(\frac{1}{2}\right)^4}{\left(\frac{1}{2}\right)^4+{}^4C_3\left(\frac{1}{2}\right)^4+{}^4C_2\left(\frac{1}{2}\right)^4}$$

$$=\frac{1}{11}$$

89. G will be centroid of ΔABC

$G\equiv(2,4,2)$

$\overrightarrow{OG}=2\hat{i}+4\hat{j}+2\hat{k}$

$\overrightarrow{OA}=3i-\hat{k}$

$$\cos(\angle GOA)=\frac{\overrightarrow{OG}.\overrightarrow{OA}}{\left|\overrightarrow{OG}\right|\left|\overrightarrow{OA}\right|}=\frac{1}{\sqrt{15}}$$

90. $$\int\frac{dx}{\left(x^2-2x+10\right)^2}=\int\frac{dx}{\left((x-1)^{21}+9\right)^2}$$

Let $x-1=3\tan\theta$

$dx=3\sec^2\theta\, d\theta$

$$\therefore\frac{1}{27}\int\cos^2\theta\, d\theta=\frac{1}{54}\int(1+\cos 2\theta)\,d\theta=\frac{1}{54}\left(\theta+\frac{\sin 2\theta}{2}\right)$$

$$=\frac{1}{54}\left(\tan^{-1}\left(\frac{x-1}{3}\right)+\frac{3(x-1)}{x^2-2x+10}\right)+C$$