

# MELUHA INTERNATIONAL SCHOOL

HYDERABAD

(UT1+UT2)

JEE ADVANCE

Date: 25-04-2020

Time: 3 Hours

IIT 2016 PAPER-1 MODEL – (54 BITS)

Max. Marks: 186

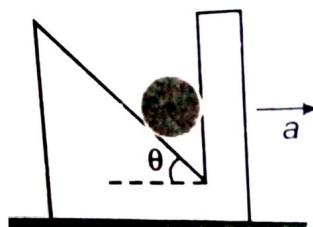
## PHYSICS

**Syllabus:** Mechanics ( Kinematics (1D and 2D), Laws of Motion, Work, Energy and Power and Rotational Motion, Gravitation, Oscillations and waves.

### Section – 1 : (Maximum Marks : (15)

- This section contains **FIVE** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each questions, marks will be awarded in one of the following categories :  
*Full Marks* : +3 If only the bubble corresponding to the correct option is darkened.  
*Zero Marks* : 0 If none of the bubbles is darkened.  
*Negative Marks* : -1 In all other cases.

1. The relation between time  $t$  and displacement  $x$  is  $t = \alpha x^2 + \beta x$ , where  $\alpha$  and  $\beta$  are constants. The retardation is  
A)  $2\alpha v^3$                       B)  $2\beta v^3$                       C)  $2\alpha\beta v^3$                       D)  $2\beta^2 v^3$
2. In the figure, the minimum value of  $a$  at which the cylinder starts rising up the inclined surface is



- A)  $g \tan \theta$                       B)  $g \cot \theta$                       C)  $g \sin \theta$                       D)  $g \cos \theta$
3. Initially the system shown in figure is in equilibrium. At the moment, the string is cut the downward acceleration of blocks A and B are respectively  $a_1$  and  $a_2$ . The magnitudes of  $a_1$  and  $a_2$  are

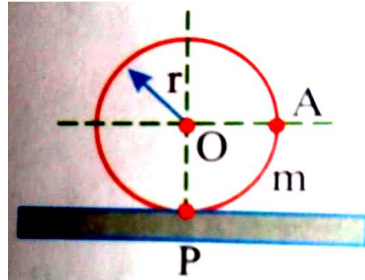


- A) zero and zero                      B)  $2g$  and zero                      C)  $g$  and zero                      D) None of the above
4. Two satellites  $S_1$  and  $S_2$  are revolving round a planet in coplanar and concentric circular orbits of radii  $R_1$  and  $R_2$  in the same direction respectively. Their respective periods of

revolution are 1 hr and 8 hr. The radius of the orbit of satellite  $S_1$  is equal to  $10^4$  km. Their relative speed when they are closest, in kmph is

- A)  $\frac{\pi}{2} \times 10^4$                       B)  $\pi \times 10^4$                       C)  $2\pi \times 10^4$                       D)  $4\pi \times 10^4$

5. A particle of mass 'm' is rigidly attached at 'A' to a ring of mass '3m' and radius 'r'. The system is released from rest and rolls without sliding. The angular acceleration of ring just after release is



- A)  $\frac{g}{4r}$                       A)  $\frac{g}{6r}$                       C)  $\frac{g}{8r}$                       D)  $\frac{g}{2r}$

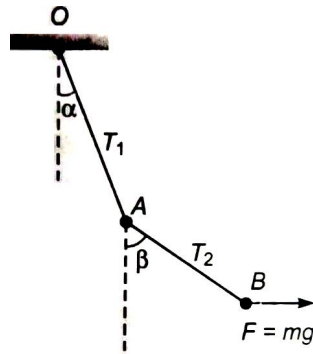
**Section – 2 : (Maximum Marks : (32))**

- This section contains **EIGHT** questions
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.
- For each questions, marks will be awarded in one of the following categories :
  - Full Marks* : +4 If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.
  - Partial Marks* : +1 For darkening a bubble corresponding to **each correct option**, provided **NO** incorrect option is darkened.
  - Zero Marks* : 0 If none of the bubbles is darkened.
  - Negative Marks* : -2 In all other cases.
- For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will result in +4 Marks; darkening only (A) and (D) will result in +2 marks and darkening (A) and (B) will result in -2 marks, as a wrong option is also darkened.

6. A particle having a velocity  $v = v_0$  at  $t=0$  is decelerated at the rate  $|a| = \alpha\sqrt{v}$ , where  $\alpha$  is positive constant

- A) The particle comes to rest at  $t = \frac{2\sqrt{v_0}}{\alpha}$
- B) The particle will come to rest at infinity
- C) The distance travelled by the particle before coming to rest is  $\frac{2v_0^{3/2}}{\alpha}$
- D) The distance travelled by the particle before coming to rest is  $\frac{2v_0^{3/2}}{3\alpha}$

7. Two particles A and B, each of mass m are kept stationary by applying a horizontal force = mg on particle B as shown in figure. Then

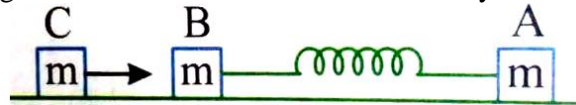


- A)  $\tan \beta = 2 \tan \alpha$       B)  $2T_1 = 5T_2$       C)  $\sqrt{2}T_1 = \sqrt{5}T_2$       D)  $\alpha = \beta$

8. The potential energy of a particle is given by formula  $U = 100 - 5x + 100x^2$ , where U and x are in SI units. If mass of the particle is 0.1 kg then magnitude of its acceleration

- A) At 0.05 m from the origin is  $50 \text{ ms}^{-2}$       B) At 0.05 m from the mean position is  $100 \text{ ms}^{-2}$   
 C) At 0.05 m from the origin is  $150 \text{ ms}^{-2}$       D) At 0.05 m from the mean position is  $200 \text{ ms}^{-2}$

9. Two blocks A and B each of mass m are connected by a massless spring of natural length l and spring constant K. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length as shown. A third identical block C also of mass m, moves on the floor with a speed v along line joining B and A and collides with B elastically. Then



- A) The frequency of oscillation of the system AB is  $\frac{1}{2\pi} \sqrt{\frac{2K}{m}}$   
 B) The K.E of the system at maximum compression of the spring is  $mv^2 / 4$   
 C) The maximum compression of the spring is  $v \sqrt{\frac{m}{K}}$   
 D) The maximum compression of the spring is  $v \sqrt{\frac{m}{2K}}$

10. When a wave travels from a denser to rarer medium, then

- A) speed of wave increases      B) Wavelength of wave decreases  
 C) Amplitude of wave increases      D) there is no change in phase angle

11. A solid cylinder is rolling down the inclined plane without slipping. Which of the following is/are correct

- A) The friction force is dissipative      B) The friction force is necessarily changing  
 C) The friction force will aid rotation but opposes translation  
 D) The friction force is reduced if  $\theta$  is reduced

12. A double star consists of two stars having masses M and 2M. The distance between their centres is equal to r. They revolve under their mutual gravitational interaction. Then, which of the following statements are not correct?

- A) Heavier star revolves in orbit of radius  $2r/3$   
 B) Both the stars revolve with same speed, period of which is equal to  $(2\pi / r^3) (2GM^2 / 3)$   
 C) Kinetic energy of the heavier star is twice that of the other star  
 D) Heavier star revolves in orbit of radius  $r/3$

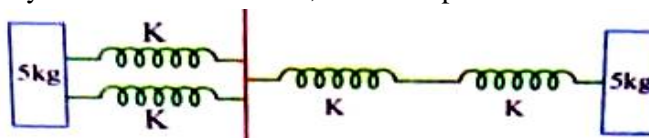
13. Second overtone frequency of a closed pipe and fourth harmonic frequency of an open pipe are same. Then, choose the correct options

- A) Fundamental frequency of closed pipe is more than the fundamental frequency of open pipe  
 B) First overtone frequency of closed pipe is more than first overtone frequency of open pipe  
 C) Fifteenth harmonic frequency of closed pipe is equal to twelfth harmonic frequency of open pipe  
 D) Tenth harmonic frequency of closed pipe is equal to eighth harmonic frequency of open pipe

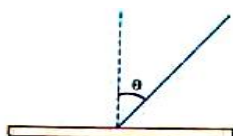
### Section – 3 : (Maximum Marks : (15))

- This section contains **FIVE** questions
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive.
- For each question, darken the bubble corresponding to the correct integer in the ORS.
- For each questions, marks will be awarded in one of the following categories :  
*Full Marks* : +3 If only the bubble corresponding to the correct answer is darkened  
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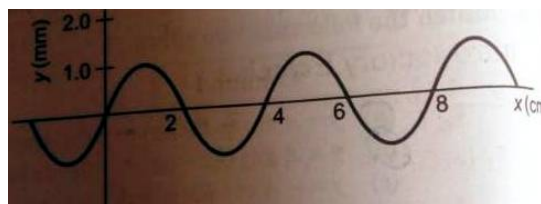
14. In the given spring blocks system if  $k = 25\pi^2 Nm^{-1}$ , find time period of oscillation.



15. A rod of mass  $m$  and length  $l$  is released from rest from vertical position as shown in the figure. The normal force as a function of  $\theta$ , which is exerted on the rod by the ground as it falls downward, assuming that it does not slip is  $mg\left(\frac{3\cos\theta - 1}{n}\right)^2$  then  $n =$



16. Figure shows a plot of the transverse displacement of the particle of a string at  $t=0$  through which a travelling wave is passing in the positive  $x$ -direction. The wave speed is 20 cm/s. Find the frequency of the wave.



17. Two satellites of mass ratio 1:2 are revolving around the earth in circular orbits such that the distance of the second satellite is four times as compared to the distance of the first satellite. Find the ratio of their centripetal forces.
18. An infinite collection of equal masses of 2 kg are kept on a horizontal line ( $x$ -axis) at positions  $x = 1, 2, 4, 8, \dots$ . Find the gravitational potential at  $x = 0$  in GJ units.

### CHEMISTRY

**Syllabus:** 1<sup>st</sup> and 2<sup>nd</sup> year Organic Chemistry.

### Section – 1 : (Maximum Marks : (15))

- This section contains **FIVE** questions
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- C) HgS, CuS, PbS, CoS, NiS, FeS are black ppt. ZnS- dirty white ppt. Sb<sub>2</sub>S<sub>3</sub> –Orange ppt.  
 D) CdS, SnS<sub>2</sub>, As<sub>2</sub>S<sub>3</sub> – yellow, SnS-Chocolate colour ppt. Bi<sub>2</sub>S<sub>3</sub> –brown ppt.
28. The correct reactions among these are:  
 A)  $C_2H_5OH + 6KOH + 4I_2 \rightarrow CHI_3 + HCOOK + 5KI + 5H_2O$   
 B)  $2HgO + 2I_2 \rightarrow HgI_2 \cdot HgO + 2HIO$   
 C)  $4Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_6S_8O_{12}$   
 D)  $8NH_3 \cdot NI_3 \rightarrow 5N_2 + 6NH_4I + 9I_2$
29. In which of the following reactions iodine is liberated?  
 A)  $CuSO_4 + KI \rightarrow$  B)  $NaIO_3 + NaI + H_2SO_4 \rightarrow$   
 C)  $KI + H_2O + O_3 \rightarrow$  D)  $KI + MnO_2 + H_2SO_4 \rightarrow$
30. The correct ones among these are:  
 A)  $I_3^-$ ,  $I_5^-$ ,  $I_7^-$ ,  $I_8^-$ ,  $Cl_3^-$ ,  $Br_3^-$  are known and are stabilized by large cations.  
 B)  $2KI + 2Cl_2 \rightarrow 2KICl_4$  C)  $CsI_3 \rightarrow CsI + I_2$   
 D)  $I(ClO_4)_3$ ,  $I(CH_3COO)_3$ ,  $IPO_4$ ,  $ICl_3$ ,  $I(NO_3)_3$  contain  $I^{3+}$  ion.
31. Which of the following pairs can be reduced by  $H_2$ ?  
 A) CuO, MoO<sub>3</sub> B) UO<sub>3</sub>, In<sub>2</sub>O<sub>3</sub> C) Cr<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O D) Fe<sub>3</sub>O<sub>4</sub>, Ag<sub>2</sub>O

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<i>Zero Marks</i>	: 0 In all other cases

32. Hot /conc. NaOH reacts with Cl<sub>2</sub> to give --- moles of NaClO<sub>3</sub>  
 33. The number of oxygens shared in frame work silicates is :  
 34. In the formation of inorganic benzene ---- moles of H<sub>2</sub> is liberated.  
 35. The moles of sodiumtetrathionate produced when hypo reacts with one mole of I<sub>2</sub> is \_\_\_\_  
 36. CaCO<sub>3</sub> decomposes to give fire extinguisher. It is passed through BaO<sub>2(aq)</sub>, the product formed converts black lead sulphide to white lead sulphate. The moles of oxidising agent required for the process is :

## MATHEMATICS

### **Syllabus:**

**MATHS: Ut-1 & 2 Syllabus**

### Section – 1 : (Maximum Marks : (15)

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46. If  $\sin \theta + \sqrt{3} \cos \theta = 6x - x^2 - 11$ ,  $0 \leq \theta \leq 4\pi$ ,  $n \in R$  then holds for  
 A) no value of  $x$  and  $\theta$  B) one value of  $x$  and two values of  $\theta$   
 C) two values of  $x$  and two values of  $\theta$  D) two pairs of values of  $(x, \theta)$ .
47. The equation  $1 + x^2 + 2x \sin(\cos^{-1} y) = 0$  is satisfied by  $(\forall x \in R)$   
 A) exactly one value of  $x$  B) exactly two values of  $x$   
 C) exactly one value of  $y$  D) exactly two values of  $y$
48. If sides of triangle ABC are  $a, b, c$  such that  $2b = a + c$  then  
 A)  $\frac{b}{c} > \frac{2}{3}$  B)  $\frac{b}{c} > \frac{1}{3}$  C)  $\frac{b}{c} < 2$  D)  $\frac{b}{c} < \frac{3}{2}$
49. If  $z_1, z_2, z_3$  and  $z_4$  are roots of the equation  $a_0 z^4 + a_1 z^3 + a_2 z^2 + a_3 z + a_4 = 0$  where  $a_0, a_1, a_2$  &  $a_4$  are real, then  
 A)  $\bar{z}_1, \bar{z}_2, \bar{z}_3, \bar{z}_4$  are also roots of equation  
 B)  $\bar{z}_1$  is equal to atleast one of  $\bar{z}_1, \bar{z}_2, \bar{z}_3, \bar{z}_4$   
 C)  $-\bar{z}_1, -\bar{z}_2, -\bar{z}_3, -\bar{z}_4$  are also roots of equation  
 D) None of the above

**Section – 3 : (Maximum Marks : (15))**

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50. If the matrix  $A = \begin{bmatrix} 1 & 2 & 3 & 0 \\ 2 & 4 & 3 & 2 \\ 3 & 2 & 1 & 3 \\ 6 & 8 & 7 & \alpha \end{bmatrix}$  is of rank 3, then  $\alpha =$  \_\_\_\_\_
51. The number of solutions of  $\sec x \cdot \cos 5x + 1 = 0$  in the interval  $[0, 2\pi]$  is \_\_\_\_\_
52. If  $K = \sin\left(\frac{\pi}{18}\right) \sin\left(\frac{5\pi}{18}\right) \sin\left(\frac{7\pi}{18}\right)$  then  $\frac{1}{K} =$  \_\_\_\_\_
53. If  $f(\theta) = (\sin \theta + \sec \theta)^2 + (\cos \theta + \sec \theta)^2$ , then minimum value of  $f(\theta)$  is \_\_\_\_\_
54. In  $\Delta ABC$ ,  $\sin A \sin B + \sin B \sin C + \sin C \sin A = \frac{9}{4}$  and  $a = 2$ , then the value of  $\sqrt{3}\Delta$ , where  $\Delta$  is area of triangle is \_\_\_\_\_



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## KEY SHEET

### PHYSICS

- 1) **A**      2) **A**      3) **B**      4) **B**      5) **B**  
6) **A, D**    7) **A, C**    8) **A, B, C**    9) **A, B, D**    10) **A, C, D**  
11) **C, D**    12) **A, C**    13) **B, C, D**    14) **1**      15) **2**  
16) **5**      17) **8**      18) **4**

### CHEMISTRY

- 19) **C**      20) **D**      21) **B**      22) **C**      23) **B**  
24) **A, B, D**    25) **A, B, C, D**    26) **A, B, C, D**    27) **A, B, C, D**    28) **A, B, D**  
29) **A, B, C, D**    30) **A, B, C, D**    31) **A, B, D**      32) **1**      33) **4**  
34) **12**      35) **1**      36) **4**

### MATHS

- 37) **B**      38) **A**      39) **A**      40) **B**      41) **A**  
42) **A, B, C**    43) **A, B, C**    44) **A, B, C, D**    45) **A, D**      46) **B, D**  
47) **A, C**      48) **A, C, D**    49) **A, B**      50) **5**      51) **8**  
52) **8**      53) **9**      54) **3**

**HINTS & SOLUTIONS**

1.  $\frac{dt}{dx} = (2\alpha x + \beta)$

$$\frac{dx}{dt} = v = \left[ \frac{1}{2\alpha x + \beta} \right]$$

$$a = \frac{dv}{dt} = -2\alpha \left[ \frac{1}{2\alpha x + \beta} \right]^2 \frac{dx}{dt}$$

$$= 2\alpha (V^2)(V) = 2\alpha V^3$$

2. On the cylinder

If N = Normal reaction between cylinder and inclined plane

$$N \sin \theta = \text{horizontal component of } N = ma \dots \dots \dots (1)$$

$$N \cos \theta = \text{vertical component of } N = mg \dots \dots \dots (2)$$

$$\frac{(1)}{(2)} \frac{N \sin \theta}{N \cos \theta} = \frac{ma}{mg}$$

$$\tan \theta = \frac{a}{g}$$

$$\tan \theta = \frac{a}{g}$$

$$a = g \tan \theta$$

3. T = 2 mg

As soon as string is cut T on A suddenly becomes zero. Therefore a force of 2 mg acting on upward direction on A suddenly becomes zero

So net force on it will become 2 mg down wards

$$a_1 = \frac{2mg}{m} = 2g (\downarrow)$$

Spring force does not become instantly zero. So acceleration of B will not change  $a_2 = 0$

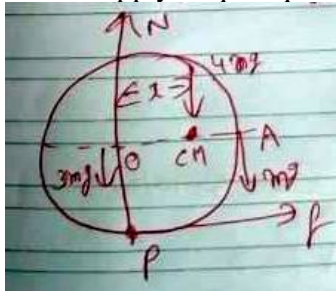
4.  $T^2 \alpha R^3, V_0 = \frac{2\pi R}{T}$

$$\text{Rel velocity} = V_{01} - V_{02}$$

5. The distance of CM from the ring centre O

$$x = \frac{3m(0) + m(n)}{3m + m} = \frac{r}{4}$$

We can apply torque equation about point of contact as the ring is rolling



$$\tau_p = I_p \alpha$$

$$4mg \left( \frac{r}{4} \right) = \left[ (3mr^2 + mr^2) + m(AP)^2 \right] \alpha$$

$$mgr = [4mr^2 + m(\sqrt{2}r)^2] \alpha$$

$$mgr = 6mr^2 \alpha$$

$$mgr = 6mr^2 \alpha$$

6. a)  $a = -\alpha \sqrt{v}$

$$\frac{dv}{dt} = -\alpha \sqrt{v}$$

$$\int_0^t dt = -\frac{1}{2} \int_{v_0}^0 v^{-\frac{1}{2}} dv$$

$$t = \frac{2\sqrt{v_0}}{\alpha}$$

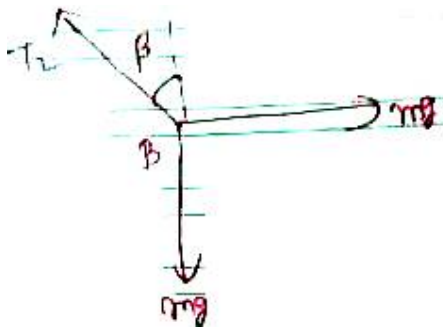
b)  $a = -\alpha \sqrt{v}$

$$v \frac{dv}{ds} = -\alpha \sqrt{v}$$

$$\int_0^s ds = \frac{1}{\alpha} \int_{v_0}^0 v^{\frac{1}{2}} dv$$

$$S = \frac{2v_0^{\frac{3}{2}}}{3\alpha}$$

7.



$$T_2 \cos \beta = mg$$

$$T_2 \sin \beta = mg$$

8.  $F = \frac{-dV}{dx} = 5 - 200x$

At origin,  $x = 0$   $F = 5N$

$$a = \frac{F}{m} = \frac{5}{0.1} = 50 \text{ m/sec}^2$$

Mean position is at  $F=0$

$$x = \frac{5}{200} = 0.025m$$

$$a = \frac{F}{m} = \frac{5 - 200x}{0.1} = (50 - 2000x) \dots \dots \dots (1)$$

At 0.05 m from the origin

$$x = +0.05m$$

$$x = -0.05m$$

Substitute in equation (1) we have

$$|a| = |50m| \text{sec}^2$$

$$= 50m / \text{sec}^2$$

At 0.05 m from the mean position means

$$x = 0.075 \quad x = -0.025m$$

Substitute in equation (1) we have

$$|a| = 100 \text{ m/sec}^2$$

9. Let  $V_1$  is the velocity acquired by A and B then

$$mV = mV_1 + mV_1 \quad \therefore V_1 = \frac{V}{2}$$

$$\text{So, } \frac{1}{2}mV^2 = \frac{1}{2}mV_1^2 + \frac{1}{2}mV_1^2 + \frac{1}{2}KX^2$$

$$\text{Where } x \text{ is displacement } x = V \frac{M}{2K}$$

So (d) is correct.

At maximum compression, KE of A – B system is

$$\Rightarrow \frac{1}{2}mV_1^2 + \frac{1}{2}mV_1^2 = mV_1^2 = \frac{1}{2}mV^2$$

(6) is correct

10. Conceptual

11. Conceptual

$$12. \quad M(r - x) = 2Mx \quad Mr - Mx = 2Mx$$

$$\therefore l = \frac{n}{3}$$

13. Conceptual

$$14. \quad K_{eff} = \frac{2k \times \frac{k}{2}}{2k + \frac{k}{2}} = \frac{2k}{5}$$

$$\text{Refluxed mass of system} = \frac{5 \times 5}{5 + 5} = \frac{5}{2}$$

$$T = 2\pi \sqrt{\frac{\mu}{keq}} = 2\pi \sqrt{\frac{\frac{5}{2}}{2k}} = 5\pi \sqrt{\frac{1}{k}} = 5\pi \sqrt{\frac{1}{25\pi^2}} = 1$$

15. At angle  $\theta$

$$\frac{1}{2}IW^2 = mg \frac{l}{2}(1 - \cos \theta)$$

$$W^2 = \frac{3g}{l}(1 - \cos \theta) \dots \dots \dots (1)$$

Difference ate w.r.to  $\theta$

$$\alpha = \frac{mg \frac{1}{2} \sin \theta}{\frac{ml^2}{3}} = \frac{3g \sin \theta}{2l}$$

$$a_n = \frac{1}{2}\omega^2 = \frac{3g}{2}(1 - \cos \theta)$$

$$a_f = \frac{1}{2}\alpha = \frac{3}{4}g \sin \theta$$

$$f = ma_x = m(a_f \cos \theta - a_n \sin \theta)$$

$$= m \left( \frac{3}{4}g \sin \theta \cos \theta - \frac{3g \sin \theta}{2}(1 - \cos \theta) \right)$$

$$= \frac{3mg}{2} \sin \theta \left[ \frac{3}{2} \sin \theta - 1 \right]$$

$$N = m(g - a_f)$$

$$= \frac{mg}{4} (1 - 3 \cos \theta)^2 \quad \theta = \cos^{-1} \left( \frac{1}{3} \right)$$

16.  $V = f \lambda$

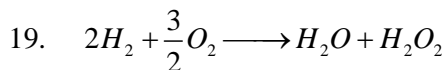
17. Centripetal force  $= \frac{mv^2}{r} - \frac{GMm}{r^2}$

Where m is the mass of the satellite and M is the mass of the satellite of earth

$$\frac{f_1}{f} = \frac{1}{2} \frac{(4r)^2}{r^2} = 8$$

18.  $V = -Gm \left[ 1 + \frac{1}{2} + \frac{1}{2^2} + \frac{1}{2^3} + \dots \right]$   
 $= \frac{GM}{1 - \frac{1}{2}} \quad V = 2m = 4$

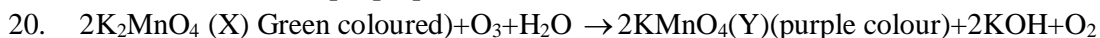
### CHEMISTRY



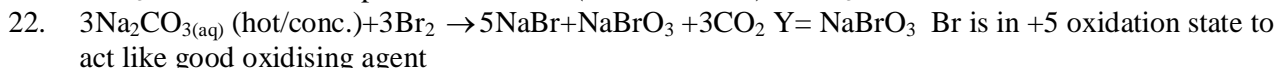
$H_2O:H_2O_2$  The wt. ratio of oxygen with fixed wt. of hydrogen

is 16:32=1:2 which is a simple multiple ratio hence it

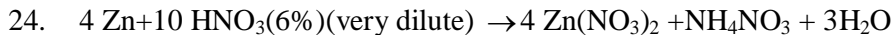
follows law of multiple proportions



Oxygenium ( $O_2$ ) allotrope is  $O_3$



23. zero as there is no d-orbital in both B and F.



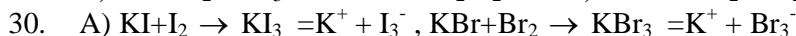
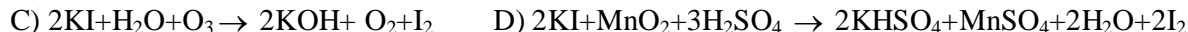
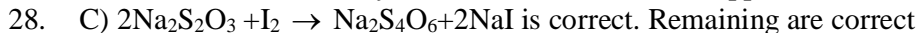
25. They are experimental observations. Hence are true.

26. A and B oxidising power of  $O_3$ , C and D are methods of preparation of "s"

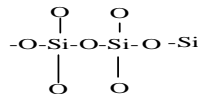
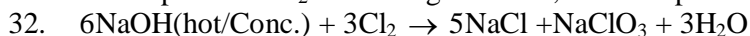
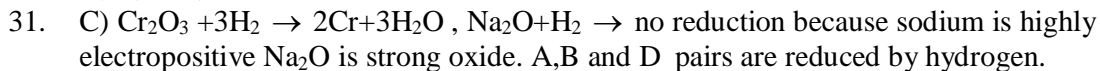
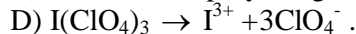


C)  $HgS, CuS, PbS, CoS, NiS, FeS$  are black ppt.  $ZnS$  - dirty white ppt.  $Sb_2S_3$  - Orange ppt

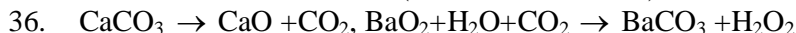
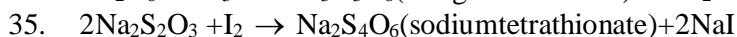
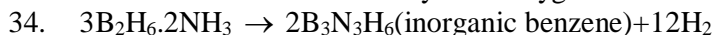
D)  $CdS, SnS_2, As_2S_3$  - yellow,  $SnS$  - Chocolate colour ppt.  $Bi_2S_3$  - brown ppt.

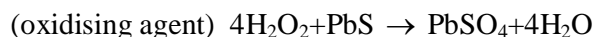


B) formation of polyhalogen compound C)  $CsI_3$  dissociates on heating to give  $I_2$



33. Each silicon is surrounded by four Oxygens. Each Si is surrounded by 4-oxygens





**MATHS**

37.  $n(A \cup B) = n(A) + n(B) - n(A \cap B)$   
 $= 200 + 300 - 100 = 400$   
 And  $n(A^1 \cap B^1) = n(A \cup B)^1$   
 $\Rightarrow 300 = n(X) - n(A \cup B)$   
 $\Rightarrow n(X) = 300 + 400 = 700$

38.  $(f \circ f)(x) = f(f(x)) = f\left(\frac{x}{x-1}\right) = \frac{\frac{x}{x-1}}{\frac{x}{x-1} - 1}$

$$= \frac{\frac{x}{x-1}}{\frac{x-x+1}{x-1}} = x$$

Now,  $(f \circ f \circ f)(x) = f((f \circ f)(x)) = f(x) = \frac{x}{x-1}$

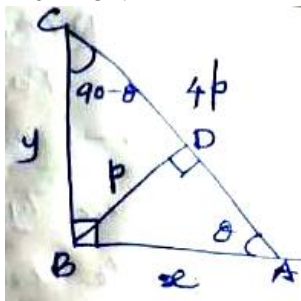
(i.e.,)  $(f \circ f \circ \dots \text{odd terms})(x) = \frac{x}{x-1}$

39. Let  $BP = p$  then given  
 $AC = 4P$  and  $AB = x, BC = y$   
 $\therefore x^2 + y^2 = 16p^2 \dots\dots\dots(1)$

From  $\triangle ABD, \sin \theta = \frac{p}{x}$   
 $\Rightarrow x = p \operatorname{cosec} \theta$

And from  $\triangle BCD, \sin(90 - \theta) = \frac{p}{y}$   
 $\Rightarrow y = p \sec \theta$

Now from (1),  $p^2 \operatorname{cosec}^2 \theta + p^2 \sec^2 \theta = 16p^2$   
 $\therefore \operatorname{cosec}^2 \theta + \sec^2 \theta = 16 \dots\dots\dots(2)$   
 $\therefore \theta = 15^\circ$



40. Given  $\tan A - \tan B = x$ ;  
 $y = \cot B - \cot A = \frac{1}{\tan B} - \frac{1}{\tan A} = \frac{\tan A - \tan B}{\tan A \tan B}$   
 $= \frac{x}{\tan A \tan B} \Rightarrow \tan A \tan B = \frac{x}{y}$   
 Now  $\cot(A - B) = \frac{1}{\tan(A - B)} = \frac{1 - \tan A \tan B}{\tan A - \tan B}$

$$\begin{aligned} &= \frac{1 - \frac{x}{y}}{x} = \frac{y - x}{xy} \\ &= \frac{1}{x} - \frac{1}{y} \end{aligned}$$

41. Given  $x_r = \text{cis}\left(\frac{\pi}{2^r}\right)$

$$\begin{aligned} \therefore x_1 \cdot x_2 \cdot x_3 \dots \infty &= \text{cis}\frac{\pi}{2} \cdot \text{cis}\frac{\pi}{2^2} \cdot \text{cis}\frac{\pi}{2^3} \dots \infty \\ &= \text{cis}\left(\frac{\pi}{2} + \frac{\pi}{2^2} + \frac{\pi}{2^3} \dots \infty\right) \\ &= \text{cis}\pi\left(\frac{1/2}{1-1/2}\right) = \text{cis}\pi = -1 \end{aligned}$$

42. Let  $x_1, x_2$  be the chosen numbers.

Let 'a' be the integer before  $x_1$ , 'b' be the integer between  $x_1$  and  $x_2$  and 'c' be the integer after  $x_2$ .

$$\therefore a + b + c = 98, \text{ where } a \geq 0, b \geq 10, c \geq 0.$$

Now, we consider the choices, where difference is atleast 11, then the no. of solutions is

$$88 + 3 - 1C_{3-1} = 90C_2$$

$\therefore$  The no. of ways in which 'b' is less than 10 is,  $100C_2 - 90C_2$ .

$\therefore$  Options (A), (B), (C) are correct.

43. Since i, j, k are distinct.

$n - i + 1, n - j + 1, n - k + 1$  are also distinct and they lie between 1 to n.

$$\text{Now } S = \sum \sum \sum x_i \cdot x_j \cdot x_k$$

$$= \sum \sum \sum (-x_{n-i+1}) (-x_{n-j+1}) (-x_{n-k+1})$$

$$= -\sum \sum \sum x_{n-i+1} \cdot x_{n-j+1} \cdot x_{n-k+1}$$

$$= -\sum \sum \sum x_i \cdot x_j \cdot x_k$$

$$= -S \quad (\because \text{they are also distinct})$$

$$\Rightarrow S = 0 \text{ for all } n.$$

$\therefore$  (A), (B), (C) are all not correct.

44.  $x = \frac{-1 \pm \sqrt{1+4a}}{2} = \text{integer}$

$\therefore 1+4a$  should be a perfect square

But  $1+4a$  is an odd number

$$\Rightarrow 1+4a = (2n+1)^2, n \in \mathbb{Z}^+$$

$$\Rightarrow 4a = 4n^2 + 4n$$

$$\Rightarrow a = n(n+1)$$

$\therefore a = 2, 6, 12, 20$  all are possible

45.  $\sin(x-y) = \cos(x+y) = \frac{1}{2}$

$$\Rightarrow x-y = 30^\circ \text{ (or) } 150^\circ \text{ and } x+y = 60^\circ \text{ (or) } 300^\circ$$

$$\therefore x = 45^\circ \text{ (or) } 165^\circ \text{ (or) } 125^\circ \text{ (or) } 105^\circ$$

$$y = 15^\circ \text{ (or) } 135^\circ \text{ (or) } 95^\circ \text{ (or) } 75^\circ$$

But  $0 \leq x, y \leq 180^\circ$

$$\therefore x = 45^\circ, y = 15^\circ \text{ (or) } x = 165^\circ, y = 135^\circ$$

Satisfying given equations.

46. Given  $\sin \theta + \sqrt{3} \cos \theta = -x^2 + 6x - 11$

$$\sin \theta + \sqrt{3} \cos \theta \in [-2, 2]$$

$$\text{And } -x^2 + 6x - 11 = -(x^2 - 6x + 11)$$

$$= -(x^2 - 6x + 9 + 2)$$

$$= -(x-3)^2 - 2$$

$$\therefore -x^2 + 6x - 11 \leq -2 \text{ \& } \sin \theta + \sqrt{3} \cos \theta \geq -2$$

(i.e., Both are equal to -2.

But  $-x^2 + 6x - 11 = -2$  if  $x = 3$  only

$$\text{Now } \sin \theta + \sqrt{3} \cos \theta = -2$$

$$\Rightarrow \cos \left( \theta - \frac{\pi}{6} \right) = -1 = \cos \theta \text{ (or) } \cos 3\pi$$

$$\therefore \theta - \frac{\pi}{6} = \pi \text{ (or) } 3\pi$$

$$\therefore \theta - \frac{7\pi}{6} \text{ (or) } \frac{19\pi}{6}$$

$\therefore$  Two values for  $\theta$  ( $\because 0 \leq \theta \leq 4\pi$ )

47. Since 'x' is real,  $\Delta \geq 0$

$$\Rightarrow 4(\sin(\cos^{-1} y))^2 - 4 \geq 0$$

$$\Rightarrow (\sin(\cos^{-1} y))^2 - 1 \geq 0$$

$$\Rightarrow (\sin(\cos^{-1} y))^2 \geq 1$$

$$\text{But } (\sin(\cos^{-1} y))^2 = 1 \text{ (}\because \sin^2 \theta \in [0,1]\text{)}$$

$$\therefore \sin(\cos^{-1} y) = \pm 1$$

$$\Rightarrow \cos^{-1} y = \pm \frac{\pi}{2}$$

$$\Rightarrow y = 0$$

Put  $y = 0$  then the given equation is,

$$x^2 + 2x + 1 = 0 \Rightarrow x = -1.$$

48. w. k.t.  $a + b > c$

$$\Rightarrow 2b - c + b > c \text{ (}\because 2b = a + c\text{)}$$

$$\Rightarrow 3b > 2c$$

$$\Rightarrow \frac{b}{c} > \frac{2}{3}$$

$$\text{Now } b + c > a \Rightarrow b + c > 2b - c$$

$$\Rightarrow 2c > b \Rightarrow \frac{b}{c} < 2.$$

49. Since  $a_0, a_1, a_2, a_3$  &  $a_4$  are real and  $z_1, z_2, z_3$  and  $z_4$  are the roots of the equation

$$\Rightarrow \bar{z}_1, \bar{z}_2, \bar{z}_3, \bar{z}_4 \text{ are also roots.}$$

And w.k.t. if coefficients of the equation are real then the roots occurs pairwise.

$$\therefore z_1 \text{ is equal to atleast one of } \bar{z}_1, \bar{z}_2, \bar{z}_3 \text{ \& } \bar{z}_4.$$

50.  $R_2 \rightarrow R_2 - 2R_1, R_3 \rightarrow R_3 - 3R_1, R_4 \rightarrow R_4 - 6R_1$



$$\square \begin{bmatrix} 1 & 2 & 3 & 0 \\ 0 & 0 & -3 & 2 \\ 0 & -4 & -8 & 3 \\ 0 & -4 & -11 & \alpha \end{bmatrix} \square \begin{bmatrix} 1 & 2 & 3 & 0 \\ 0 & -4 & -11 & \alpha \\ 0 & -4 & -8 & 3 \\ 0 & 0 & -3 & 2 \end{bmatrix}$$

$$R_2 \leftrightarrow R_4 \quad R_3 \rightarrow R_3 - R_2$$

$$\square \begin{bmatrix} 1 & 2 & 3 & 0 \\ 0 & -4 & 11 & \alpha \\ 0 & 0 & 3 & 3-\alpha \\ 0 & 0 & -3 & 2 \end{bmatrix} \square \begin{bmatrix} 1 & 2 & 3 & 0 \\ 0 & -4 & 11 & \alpha \\ 0 & 0 & 3 & 3-\alpha \\ 0 & 0 & 0 & 5-\alpha \end{bmatrix}$$

$$R_4 \rightarrow R_4 + R_3$$

Whose rank should be 3 if and only if  $5 - \alpha = 0 \Rightarrow \alpha = 5$

51.  $\sec x \cdot \cos 5x + 1 = 0$

$$\therefore x \neq (2n+1)\frac{\pi}{2}$$

$$\text{Now } \cos 5x + \cos x = 0 (\cos x \neq 0)$$

$$\Rightarrow 2 \cos 3x \cdot \cos 2x = 0$$

$$\Rightarrow \cos 3x = 0 \text{ (or) } \cos 2x = 0$$

$$\Rightarrow 3x = (2n+1)\frac{\pi}{2} \text{ (or) } 2x = (2n+1)\frac{\pi}{2}, n \in Z$$

$$\Rightarrow x = (2n+1)\frac{\pi}{6} \text{ (or) } x = (2n+1)\frac{\pi}{4}, n \in Z$$

$$\therefore x = \frac{\pi}{6}, \frac{3\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{9\pi}{6}, \frac{11\pi}{6} \rightarrow 4$$

$$\& x = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4} \rightarrow 4$$

$\therefore$  No. of solutions is 8 in  $[0, 2\pi]$

52. 
$$K = \sin\left(\frac{\pi}{18}\right) \sin\left(\frac{5\pi}{18}\right) \sin\left(\frac{7\pi}{18}\right)$$

$$= \cos\left(\frac{\pi}{2} - \frac{\pi}{18}\right) \cos\left(\frac{\pi}{2} - \frac{5\pi}{18}\right) \cos\left(\frac{\pi}{2} - \frac{7\pi}{18}\right)$$

$$= \cos\left(\frac{8\pi}{18}\right) \cos\left(\frac{4\pi}{18}\right) \cos\left(\frac{2\pi}{18}\right)$$

$$= \cos\frac{\pi}{9} \cdot \cos\left(\frac{2\pi}{9}\right) \cdot \cos\left(\frac{4\pi}{9}\right)$$

$$\text{Let } \frac{\pi}{9} = \theta \Rightarrow \pi = 9\theta$$

$$\therefore k = \cos(\theta) \cdot \cos(2\theta) \cdot \cos(2^2\theta)$$

$$= \frac{\sin(2^3\theta)}{2^3 \sin \theta} = \frac{\sin \frac{8\pi}{9}}{8 \sin \frac{\pi}{9}}$$

$$= \frac{\sin\left(\pi - \frac{\pi}{9}\right)}{8 \sin \frac{\pi}{9}} = \frac{\sin \frac{\pi}{9}}{8 \sin \frac{\pi}{9}}$$

$$\therefore \frac{1}{k} = 8$$

53.  $f(\theta) = \sin^2 \theta + \cos^2 \theta + 2 + \cos^2 \theta + \sec^2 \theta + 2$

$$= 5 + \cos^2 \theta + \sec^2 \theta$$

$$= 5 + \frac{1}{\sin^2 \theta \cos^2 \theta} = 5 + \frac{4}{\sin^2 2\theta}$$

$$0 \leq \sin^2 2\theta \leq 1 \Rightarrow \frac{1}{\sin^2 2\theta} \geq 1$$

$$\Rightarrow \frac{4}{\sin^2 \theta} \geq 4$$

$$\therefore f(\theta) \geq 5 + 4 = 9$$

$\therefore$  the minimum value of  $f(\theta)$  is 9.

54. Given  $4 \sin A \sin B + 4 \sin B \sin C + 4 \sin C \sin A = 9$

$$\therefore A = B = C = 60^\circ$$

$$\therefore \text{Area of triangle } \Delta = \frac{\sqrt{3}}{4} a^2 = \sqrt{3}$$

$$\therefore \sqrt{3} \Delta = \sqrt{3} \cdot \sqrt{3} = 3$$