PART III: CHEMISTRY

SECTION 1 (Maximum Marks: 24)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, **truncate/round off** the value to **TWO** decimal places.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 **ONLY** if the correct numerical value is entered;
  Zero Marks : 0 In all other cases.

*Q1. 2 mol of Hg(*g*) is combusted in a fixed volume bomb calorimeter with excess of O_2 at 298 K and 1 atm into HgO(*s*). During the reaction, temperature increases from 298.0 K to 312.8 K. If heat capacity of the bomb calorimeter and enthalpy of formation of Hg(*g*) are 20.00 kJ K^{-1} and 61.32 kJ mol^{-1} at 298 K, respectively, the calculated standard molar enthalpy of formation of HgO(*s*) at 298 K is X kJ mol^{-1}. The value of |X| is _____.
[Given: Gas constant R = 8.3 J K^{-1} mol^{-1}]

Q2. The reduction potential $\left(E^0, \text{ in V}\right)$ of $MnO_4^-(aq) / Mn(s)$ is

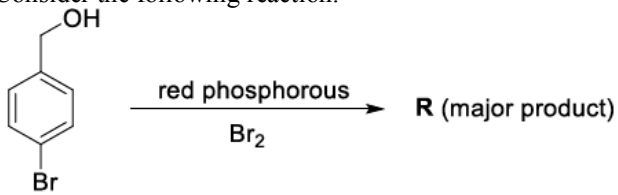
$$\left[\text{Given}: E^0_{\left(MnO_4^-(aq)/MnO_2((s))\right)} = 1.68\text{V}; E^0_{\left(MnO_2(s)/Mn^{2+}(aq)\right)} = 1.21\text{V}; E^0_{\left(Mn^{2+}(aq)/Mn((s))\right)} = -1.03\text{V}\right]$$

*Q3. A solution is prepared by mixing 0.01 mol each of H_2CO_3, $NaHCO_3$, Na_2CO_3, and NaOH in 100 mL of water. *p*H of the resulting solution is _____.
[Given: pKa_1 and pKa_2 of H_2CO_3 are 6.37 and 10.32, respectively; log 2 = 0.30]

*Q4. The treatment of an aqueous solution of 3.74 g of $Cu(NO_3)_2$ with excess KI results in a brown solution along with the formation of a precipitate. Passing H_2S through this brown solution gives another precipitate **X**. The amount of **X** (in g) is _____.
[Given: Atomic mass of H = 1, N = 14, O = 16, S = 32, K = 39, Cu = 63, I = 127]

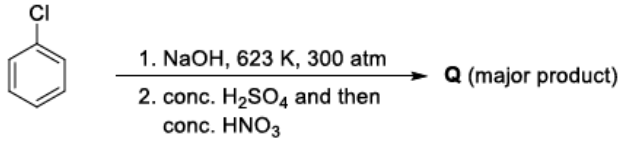
*Q5 Dissolving 1.24 g of white phosphorous in boiling NaOH solution in an inert atmosphere gives a gas **Q**. The amount of $CuSO_4$ (in g) required to completely consume the gas **Q** is _____.
[Given: Atomic mass of H = 1, O = 16, Na = 23, P = 31, S = 32, Cu = 63]

Q6. Consider the following reaction.



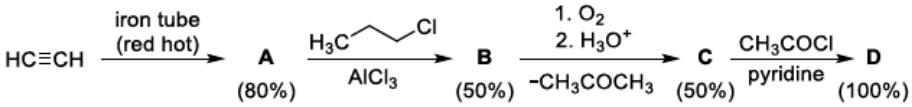
On estimation of bromine in 1.00 g of **R** using Carius method, the amount of AgBr formed (in g) is _____.
[Given: Atomic mass of H = 1, C = 12, O = 16, P = 31, Br = 80, Ag = 108].

Q7. The weight percentage of hydrogen in **Q**, formed in the following reaction sequence, is _____.



[Given: Atomic mass of H = 1, C = 12, N = 14, O = 16, S = 32, Cl = 35]

Q8. If the reaction sequence given below is carried out with 15 moles of acetylene, the amount of the product **D** formed (in g) is _____.



The yields of **A**, **B**, **C** and **D** are given in parentheses.

[Given: Atomic mass of H = 1, C = 12, O = 16, Cl = 35]

SECTION 2 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MOER THAN ONE** of these four option(s) is (are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated <u>according to the following marking scheme</u>:

Full Mark	:	+4	If only (all) the correct option(s) is(are) chosen;
Partial Marks	:	+3	If all the four options are correct but ONLY three options are chosen;
Partial Marks	:	+2	If three or more options are correct but ONLY two options are chosen, both of which are correct;
Partial Marks	:	+1	If two or more options are correct but ONLY one option is chosen and it is a correct option;
Zero Marks	:	0	If unanswered;
Negative Marks	:	–2	In all other cases.

*Q9 For diatomic molecules, the correct statement(s) about the molecular orbitals formed by the overlap of two $2p_z$ orbitals is(are)

(A) σ orbital has a total of two nodal planes

(B) σ^* orbital has one node in the xz-plane containing the molecular axis.

(C) π orbital has one node in the plane which is perpendicular to the molecular axis and goes through the center of the molecule.

(D) π^* orbital has one node in the xy-plane containing the molecular axis.

Q10. The correct opion(s) related to adsorption process is (are)

(A) Chemisorption results in unimolecular layer.

(B) The enthalpy change during physisorption is in the range of 100 to 140 kJ mol^{-1}

(C) Chemisorption is an endothermic process

(D) Lowering the temperature favours physisorption process

Q11. The electrochemical extraction of aluminum from bauxite ore involves

(A) the reaction of Al_2O_3 with coke (C) at a temperature > 2500 ºC.

(B) the neutralization of aluminate solution by passing CO_2 gas to precipitate hydrated alumina ($Al_2O_3 \cdot 3H_2O$).

(C) the dissolution of Al_2O_3 in hot aqueous NaOH.

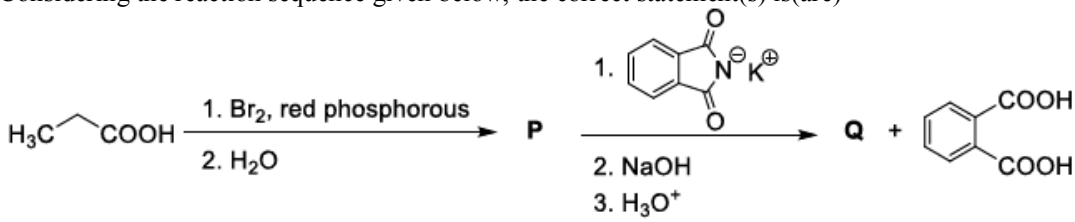
(D) the electrolysis of Al_2O_3 mixed with Na_3AlF_6 to give Al and CO_2.

Q12. The treatment of galena with HNO_3 produces a gas that is

(A) paramagnetic (B) bent in geometry

(C) an acidic oxide (D) colorless

Q13. Considering the reaction sequence given below, the correct statement(s) is(are)



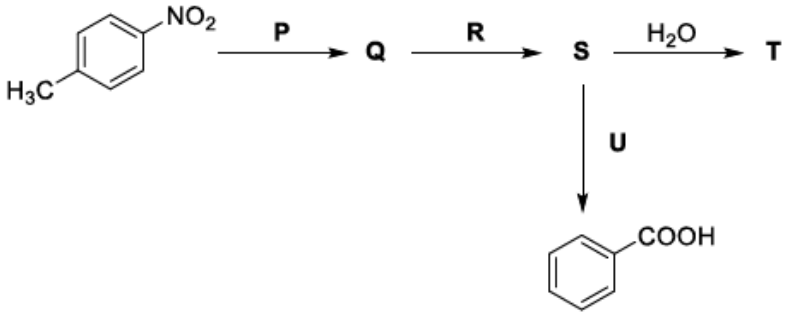
(A) **P** can be reduced to a primary alcohol using $NaBH_4$.

(B) Treating **P** with conc. NH_4OH solution followed by acidification gives **Q**.

(C) Treating **Q** with a solution of $NaNO_2$ in aq. HCl liberates N_2.

(D) **P** is more acidic than CH_3CH_2COOH.

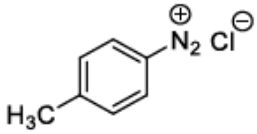
Q14. Considering the following reaction sequence,



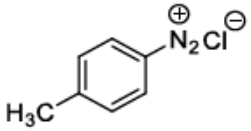
the correct option(s) is(are)

(A) $P = H_2 / Pd, ethanol$ $R = NaNO_2 / HCl$ $U = 1.H_3PO_2$ $2.KMnO_4.KOH, heat$

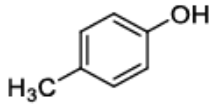
(B) **P** = Sn/HCl **R** = HNO_2 **S** =



(C) **S** =

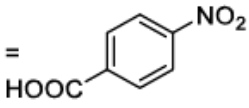


T =

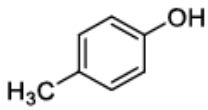


U = 1. CH_3CH_2OH
2. $KMnO_4$ – KOH, heat

(D) **Q** =



R = H_2/Pd, ethanol **T** =



SECTION 3 (Maximum Marks: 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List I** and **List II**.
- **List I** has **Four** entries (I), (II), (III) and (IV) and **List II** has **Five** entries (P), (Q), (R), (S) and (T).
- **FOUR** options are given in each Multiple Choice Question based on **List I** and **List II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;
  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
  Negative Marks : −1 In all other cases.

*Q15. Match the rate expressions in LIST-I for the decomposition of X with the corresponding profiles provided in LIST-II. X_s and k are constants having appropriate units.

LIST- I

(I) $\text{rate} = \dfrac{k[X]}{X_s + [X]}$
under all possible initial concentrations of X

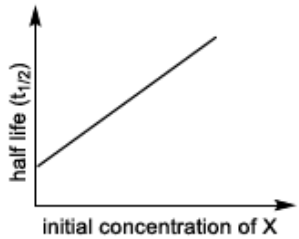
(II) $\text{rate} = \dfrac{k[X]}{X_s + [X]}$
where initial concentrations of X are much less than X_s

(III) $\text{rate} = \dfrac{k[X]}{X_s + [X]}$
where initial concentrations of X are much higher than X_s

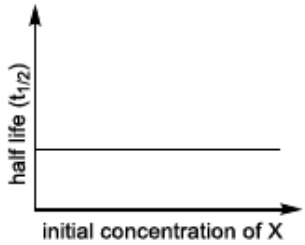
(IV) $\text{rate} = \dfrac{k[X]^2}{X_s + [X]}$
where initial concentration of X is much higher than X_s

LIST-II

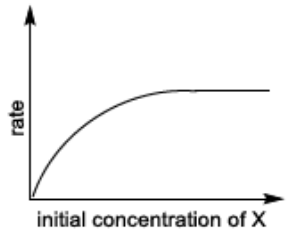
(P)



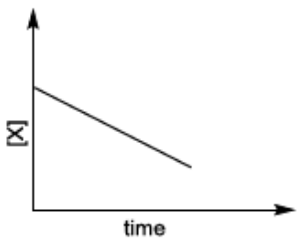
(Q)



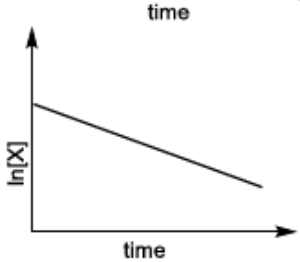
(R)



(S)



(T)



(A) I→ P; II→ Q; III → S; IV → T
(B) I→ R; II→ S; III → S; IV → T
(C) I→ P; II→ Q; III → Q; IV → R
(D) I→ R; II→ S; III → Q; IV → R

*Q16. LIST-I contains compounds and LIST-II contains reactions.

	LIST- I		LIST-II
(I)	H_2O_2	(P)	$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow$
(II)	$Mg(OH)_2$	(Q)	$BaO_2 + H_2SO_4 \rightarrow$
(III)	$BaCl_2$	(R)	$Ca(OH)_2 + MgCl_2 \rightarrow$
(IV)	$CaCO_3$	(S)	$BaO_2 + HCl \rightarrow$
		(T)	$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow$

Match each compound in LIST-I with its formation reaction(s) in LIST-II, and choose the correct option

(A) I → Q; II → P; III → S; IV → R
(B) I → T; II → P; III → Q; IV → R
(C) I → T; II → R; III → Q; IV → P
(D) I → Q; II → R; III → S; IV → P

Q17. LIST-I contains metal species and LIST-II contains their properties.

	LIST- I		LIST-II
(I)	$[Cr(CN)_6]^{4-}$	(P)	t_{2g} orbitals contain 4 electrons
(II)	$[RuCl_6]^{2-}$	(Q)	$\mu(\text{spin} - \text{only}) = 4.9\text{BM}$
(III)	$[Cr(H_2O_6)]^{2+}$	(R)	Low spin complex ion
(IV)	$[Fe(H_2O)_6]^{2+}$	(S)	Metal ion in 4+ oxidation state
		(T)	d^4 species

[Given: Atomic number of Cr = 24, Ru = 44, Fe = 26]

Match each metal species in LIST-I with their properties in LIST-II, and choose the correct option

(A) I → R, T; II → P, S; III → Q, T; IV → P, Q
(B) I → R, S; II → P, T; III → P, Q; IV → Q, T
(C) I → P, R; II → R, S; III → R, T; IV → P, T
(D) I → Q, T; II → S, T; III → P, T; IV → Q, R

Q18. Match the compounds in LIST-I with the observations in LIST-II, and choose the correct option.

	LIST- I		LIST-II
(I)	Aniline	(P)	Sodium fusion extract of the compound on boiling with $FeSO_4$, followed by acidification with conc. H_2SO_4, gives Prussian blue color.
(II)	*o*-Cresol	(Q)	Sodium fusion extract of the compound on treatment with sodium nitroprusside gives blood red color.
(III)	Cysteine	(R)	Addition of the compound to a saturated solution of $NaHCO_3$ results in effervescence.
(IV)	Caprolactam	(S)	The compound reacts with bromine water to give a white precipitate.
		(T)	Treating the compound with neutral $FeCl_3$ solution produces violet color.

(A) I→P,Q; II→S; III→Q,R; IV→P
(B) I→P; II→R,S; III→R; IV→Q,S
(C) I→Q,S; II→P,T; III→P; IV→S
(D) I→P,S; II→T; III→Q,R; IV→P

FIITJEE JEE (Advanced Paper)

(PAPER-1)

ANSWER KEY

MATHEMATICS

1.	**2.35 or 2.36**	2.	**0.5**	3.	**0.80**	4.	**0.50**
5.	**4**	6.	**18900**	7.	**569**	8.	**0.83 or 0.84**
9.	**C, D**	10.	**B, C**	11.	**A, B, D**	12.	**A, B, C**
13.	**B, C, D**	14.	**A, C**	15.	**B**	16.	**A**
17.	**B**	18.	**C**				

PHYSICS

1.	**2.30**	2.	**2.32**	3.	**8.00**	4.	**6.00**
5.	**0.52**	6.	**2.85**	7.	**4.00**	8.	**0.95**
9.	**B**	10.	**A, B, C, D**	11.	**B**	12.	**A, B**
13.	**A, B, C**	14.	**A, B, D**	15.	**None**	16.	**C**
17.	**C**	18.	**A**				

CHEMISTRY

1.	**90.39**	2.	**0.77**	3.	**10.02**	4.	**0.32**
5.	**2.38**	6.	**1.50**	7.	**1.31**	8.	**136.00**
9.	**A, D**	10.	**A, D**	11.	**B, C, D**	12.	**A, D**
13.	**B, C, D**	14.	**A,B,C**	15.	**A**	16.	**D**
17.	**A**	18.	**D**				

HINTS AND SOLUTIONS

MATHEMATICS

1. **2.35 or 2.36**

Let $\tan\theta = \frac{\pi}{\sqrt{2}} \Rightarrow \frac{\pi}{4} \le \theta \le \frac{\pi}{2} \Rightarrow \pi = \sqrt{2}\tan\theta$

$$\frac{3}{2}\cos^{-1}\sqrt{\frac{2}{2+2\tan^2\theta}} + \frac{1}{4}\sin^{-1}\left(\frac{2\sqrt{2}\sqrt{2}\tan\theta}{2+2\tan^2\theta}\right) + \tan^{-1}\left(\frac{\sqrt{2}}{\sqrt{2}\tan\theta}\right)$$

$$= \frac{3}{2}\cos^{-1}(\cos\theta) + \frac{1}{4}\sin^{-1}(\sin 2\theta) + \tan^{-1}(\cot\theta)$$

$$\frac{3}{2}\theta + \frac{1}{4}(\pi - 2\theta) + \frac{\pi}{2} - \theta = \frac{\pi}{4} + \frac{\pi}{2} = \frac{3\pi}{4}$$

2. **0.5**

$$\lim_{x\to\alpha^+} f(g(x)) = f\left(\lim_{x\to\alpha^+} g(x)\right)$$

Now $\lim_{x\to\alpha^+} g(x) = \lim_{x\to\alpha^+} \frac{2\ln\left(\sqrt{x}-\sqrt{\alpha}\right)}{\ln\left(e^{\sqrt{x}}-e^{\sqrt{\alpha}}\right)} \quad \left(\frac{-\infty}{-\infty}\right)$

Apply D'L Hospital

$$\lim_{x\to\alpha^+} \frac{2\cdot\frac{1}{\sqrt{x-\sqrt{\alpha}}}\cdot\frac{1}{2\sqrt{x}}}{\frac{1}{e^{\sqrt{x}}-e^{\sqrt{\alpha}}}\cdot e^{\sqrt{x}}\cdot\frac{1}{2\sqrt{x}}}$$

$$\lim_{x\to\alpha^+} \frac{2\left(e^{\sqrt{x}}-e^{\sqrt{\alpha}}\right)}{e^{\sqrt{x}}\left(\sqrt{x}-\sqrt{\alpha}\right)}$$

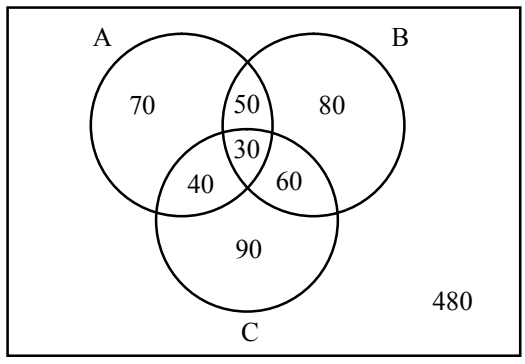
$$\lim_{x\to\alpha^+} \frac{2e^{\sqrt{\alpha}}\left(e^{\sqrt{x}-\sqrt{\alpha}}-1\right)}{e^{\sqrt{x}}\left(\sqrt{x}-\sqrt{\alpha}\right)} = 2$$

Now $f(x) = \sin\frac{\pi x}{12}$ given

$f(2) = \sin\frac{\pi(2)}{12} = \sin\frac{\pi}{6} = \frac{1}{2} = 0.5$

3. **0.80**

Let A denote the persons having symptoms of fever.
B denote the persons having symptoms of cough
C denote the persons having symptoms of breathing problem
Given that
$n(A) = 190 \quad n(B) = 220 \quad n(C) = 220$
$n(A \cap B \cap C) = 30$
$n(A \cup B) = 330 \quad n(B \cup C) = 350 \quad n(C \cup A) = 340$
$n(A \cup B) = n(A) + b(B) - n(A \cap B)$
$\Rightarrow 330 = 190 + 220 - n(A \cap B) \Rightarrow n(A \cap B) = 80$
Similarly $n(B \cap C) = 90$ and $n(C \cap A) = 70$
If we make the Venn diagram



$n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(B \cap C) - n(C \cap A) + n(A \cap B \cap C)$
$= 190 + 220 + 220 - 80 - 90 - 70 + 30 = 420$
$\therefore$ Number of person having atmost one symptom
$= 480 + 70 + 80 + 90 = 720$
$\therefore$ Probability $= \frac{720}{900} = \frac{4}{5} = 0.80$

4. **0.50**

$\frac{2+3z+4z^2}{2-3z+4z^2}$ is a real number

$\Rightarrow 1+\frac{6}{\frac{2}{z}-3+4z} \in R \Rightarrow 2z+\frac{1}{z} \in R \Rightarrow 2z+\frac{1}{z} = 2\overline{z}+\frac{1}{\overline{z}}$

$\Rightarrow \left(2\overline{z}z-1\right)\left(z-\overline{z}\right) = 0$

$\Rightarrow |z|^2 = \frac{1}{2} = 0.50$

5. **4**

Let $z = x + iy$
$x - iy - x^2 + y^2 - 2ixy = i(x - iy + x^2 - y^2 + 2ixy)$
$(x - x^2 + y^2) - i(y + 2xy) = (y - 2xy) + i(x + x^2 - y^2)$
$\Rightarrow \quad x - x^2 + y^2 = y - 2xy \qquad \ldots(1)$
$\quad x + x^2 - y^2 = -y - 2xy \qquad \ldots(2)$
$(1) + (2) \qquad 2x = -4xy$

$\Rightarrow x = -2xy \Rightarrow x(1 + 2y) = 0 \Rightarrow x = 0$ or $y = -\frac{1}{2}$

Put $x = 0$ in (1) or (2) we get
$y^2 = y \Rightarrow y = 0, 1$
$\therefore$ 2 complex numbers are possible $0 + 0i$ and $0 + i$
put $y = -\frac{1}{2}$ in (1) or (2) $\quad x - x^2 + \frac{1}{4} = -\frac{1}{2} + x$

$\Rightarrow x^2 = \frac{3}{4} \Rightarrow x = \pm \frac{\sqrt{3}}{2}$

$\therefore \frac{\sqrt{3}}{2} - \frac{i}{2}$ and $-\frac{\sqrt{3}}{2} - \frac{i}{2}$ are possible
$\therefore$ 4 solutions are possible.

6. **18900**

$A_{51} - A_{50} = 1000$
$l_{51}w_{51} - l_{50}w_{50} = 100$
$(l_1 + 50d_1)(w_1 + 50d_2) - (l_1 + 49d_1)(w_1 + 49d_2) = 1000$
$l_1w_1 + 50l_1d_2 + 50d_1w_1 + 2500d_1d_2 - l_1w_1 - 49l_1d_2 - 49d_1w_1 - 240d_1d_2 = 1000$
$\Rightarrow l_1d_2 + d_1w_1 + 99d_1d_2 = 1000$
$\Rightarrow l_1d_2 + d_1w_1 = 10$
$A_{100} - A_{90} = (l_{100}w_{100}) - (l_{90}w_{90})$
$= (l_1 + 99d_1)(w_1 + 99d_2) - (l_1 + 89d_1)(w_1 + 89d_2)$
$= 10d_1w_1 + 10l_1d_2 + 1880d_1d_2$
$= 10 \times 10 + 18800 = 18900$

7. **569**

Number of numbers whose digits are

2	0		
—	—	—	—
	$6 \times 6 - 7 = 209$		
2			
—	—	—	—
	$5 \times 6 \times 6 = 180$		
3	—	—	—
	$6 \times 6 \times 6 = 216$		
4	—	—	—
	$4 \times 6 \times 6 = 144$		

Total number are $(36 - 7) + (5 \times 6 \times 6) + (6 \times 6 \times 6) + 4 \times 6 \times 6 = 569$

8. **0.83 or 0.84**

Let A be (0, 0), B(1, 0) and C(0, 3)

$\therefore$ AB lies on x-axis and AC lies on y-axis

$\therefore$ equation of circle touching both x and y-axis is of the form

$(x - h)^2 + (y - h)^2 = h^2$ $(\because h = k = r)$

It touches the circle $\left(x - \frac{1}{2}\right)^2 + \left(y - \frac{3}{2}\right)^2 = \frac{5}{2}$

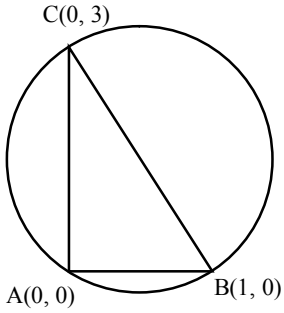
$\therefore c_1c_2 = |r_1 - r_2|$

$$\sqrt{\left(h - \frac{1}{2}\right)^2 + \left(h - \frac{3}{2}\right)^2} = \left|h - \frac{\sqrt{5}}{\sqrt{2}}\right|$$

$$\Rightarrow h^2 + \frac{1}{4} - h + h^2 + \frac{9}{4} - 3h = h^2 + \frac{5}{2} - \sqrt{10}h$$

$$\Rightarrow h^2 + \left(\sqrt{10} - 4\right)h = 0 \Rightarrow h = 4 - \sqrt{10}$$

$\therefore r = 4 - \sqrt{10} = 0.8377$



9. **C, D**

$$\int_1^e \frac{(\ln x)^{1/2}}{x\left(a - (\ln x)^{3/2}\right)^2} dx = 1$$

$a - (\ln x)^{3/2} = t$

$$-\frac{3}{2}(\ln x)^{1/2} \times \frac{1}{x} dx = dt$$

$$\int_a^{a-1} -\frac{\frac{2}{3}dt}{t^2} = 1$$

$$\left[-\frac{2}{3} \times -\frac{1}{t}\right]_a^{a-1} = 1$$

$$\frac{2}{3}\left[\frac{1}{a-1} - \frac{1}{a}\right] = 1$$

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

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

$3a^2 - 3a - 2 = 0$

$$a = \frac{3 \pm \sqrt{9 + 24}}{6} = \frac{3 \pm \sqrt{33}}{6}$$

10. **B, C**

$$\sum_{n=1}^{n}\left(T_{n+1}-T_n\right)=\sum a_n$$

$$\Rightarrow T_{n+1}-T_1=\sum a_n=\frac{n}{2}\left[2\times 7+(n-1)8\right]$$

$T_{n+1} = n(4n + 3) + T_1$

$T_{n+1} = 4n^2 + 3n + 3$

(A) $T_{20} = 4 \times 19^2 + 3 \times 9 + 3$

$= 1444 + 27 + 3 = 1474$

(B) $\sum_{k=0}^{19} T_{n+1} = \sum_{k=0}^{19} k(4k+3)+3$

$$= \sum_{k=0}^{19}\left(4k^2+3k+3\right)=10510$$

(C) $T_{30} = 29(4 \times 29 + 3) + 3 = 3454$

(D) $\sum_{k=1}^{30} T_k = \sum_{n=0}^{29} T_{n+1} = \sum_{n=0}^{29} n(4n+3)+3$

$$= 4\times\left(\frac{29\times 30\times 59}{6}\right)+\frac{3(29\times 30)}{2}+90=35615$$

11. **A, B, D**

The line should be either coincident on P_1 or on P_2 or intersect on P_1 and P_2 on different points.

(D) $\frac{x}{1}=\frac{y-4}{-2}=\frac{z}{3}=\lambda$

$\Rightarrow (\lambda, -2\lambda + 4, 3\lambda)$ lie on P_2

(A) $\frac{x-1}{0}=\frac{y-1}{0}=\frac{z-1}{5}$ intersects P_1 and P_2 on different points.

(B) $\frac{x-6}{5}=\frac{y}{2}=\frac{z}{3}$ also intersects P_1 and P_2 on different points.

12. **A, B, C**

Clearly plane is given by $x + y + z = 1$

using mirror image formula

$$\Rightarrow \frac{\alpha-10}{1}=\frac{\beta-15}{1}=\frac{\gamma-20}{1}=\frac{-2(10+15+20-1)}{1^2+1^2+1^2}=-\frac{88}{3}$$

$$\Rightarrow \alpha=-\frac{58}{3};\beta=-\frac{43}{3} \text{ and } \gamma=-\frac{28}{3}$$

13. **B, C, D**

Let P_1 and P_2 be $\left(t_1^2, 2t_1\right)$ and $\left(t_2^2, 2t_2\right)$

$\Rightarrow P \equiv (t_1t_2, t_1 + t_2) \equiv (-2, 1)$

$\Rightarrow t_1 = 2, t_2 = -1$ or $t_1 = -1, t_2 = 2$

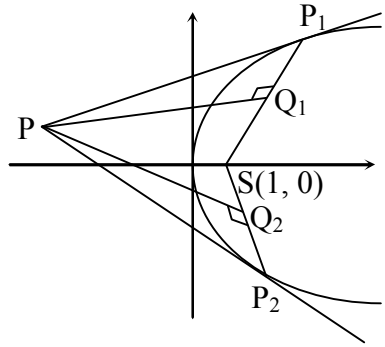
$\Rightarrow P_1(4, 4)$ and $P_2(1, -2)$

Slope of $SP_1 = \frac{4}{3}$ slope of $SP_2 = \infty$

Equation of SP_1

$$y - 0 = \frac{4}{3}(x - 1) \Rightarrow 4x - 3y - 4 = 0$$

Equation of PQ_1



$y - 1 = -\frac{4}{3}(x + 2) \Rightarrow 3x + 4y + 2 = 0 \ \therefore \ Q_1\left(\frac{2}{5}, -\frac{4}{5}\right)$

Equation of SP_2 $\quad x = 1$

Equation of PQ_2 $\quad y = 1 \ \therefore \ Q_2(1, 1)$

$\therefore \ SQ_1 = 1, Q_1Q_2 = \frac{3\sqrt{10}}{5}$

$PQ_1 = \sqrt{\left(-2-\frac{2}{5}\right)^2 + \left(1+\frac{4}{5}\right)^2} = \sqrt{\frac{144}{25} + \frac{81}{25}} = 3$

and $SQ_2 = \sqrt{(1-1)^2 + (1-0)^2} = 1$

14. **A, C**

$$f(\theta) = \frac{1}{2}\begin{vmatrix} 0 & 0 & 2 \\ -\sin\theta & 1 & \sin\theta \\ -1 & -\sin\theta & 1 \end{vmatrix} + \begin{vmatrix} \sin\pi & \cos\left(\theta+\frac{\pi}{4}\right) & \tan\left(\theta-\frac{\pi}{4}\right) \\ \sin\left(\theta-\frac{\pi}{4}\right) & -\cos\frac{\pi}{2} & \log_e\left(\frac{4}{\pi}\right) \\ \cot\left(\theta+\frac{\pi}{4}\right) & \log_e\left(\frac{\pi}{4}\right) & \tan\pi \end{vmatrix}$$

As second determinant is skew symmetric $\therefore$ its value is 0.

$\Rightarrow f(\theta) = (1 + \sin^2\theta)$

$\Rightarrow g(\theta) = |\sin\theta| + |\cos\theta| \in \left[1, \sqrt{2}\right]$

$\Rightarrow p(x) = a(x - 1)\left(x - \sqrt{2}\right)$ as $p(2) = 2 - \sqrt{2} \Rightarrow a = 1$

$\Rightarrow p(x) = (x - 1)\left(x - \sqrt{2}\right)$

and hence $p\left(\frac{3+\sqrt{2}}{4}\right) < 0$ and $p\left(\frac{5\sqrt{2}-1}{4}\right) > 0$

15. **B**

(I) $\cos x + \sin x = 1$

$\Rightarrow \sqrt{2}\cos\left(x - \frac{\pi}{4}\right) = 1$

$\Rightarrow \cos\left(x - \frac{\pi}{4}\right) = \frac{1}{\sqrt{2}}$

$\Rightarrow x - \frac{\pi}{4} = 2n\pi \pm \frac{\pi}{4}$

for $n = 0, x = \frac{\pi}{2}, 0$

for $n = 1, 2, 3, \ldots$ no solution in $\left[-\frac{2\pi}{3}, \frac{2\pi}{3}\right] \ \therefore \ I \to P$

(II) $\tan 3x = \frac{1}{\sqrt{3}} \Rightarrow 3x = n\pi + \frac{\pi}{6} \Rightarrow x = \frac{n\pi}{3} + \frac{\pi}{18}$

for $n = 0 \quad x = \frac{\pi}{18}$ for $n = -1, x = -\frac{5\pi}{18}$

for $n = 1, 2, 3, \ldots$ no solution $\therefore$ II $\to$ P

(III) $\cos 2x = \frac{\sqrt{3}}{2} \Rightarrow 2x = 2n\pi \pm \frac{\pi}{6} \Rightarrow x = n\pi \pm \frac{\pi}{12}$

for $n = -1$ $\quad x = -\frac{13\pi}{12}, -\frac{11\pi}{12}$ $\quad \therefore$ III $\rightarrow$ T

(IV) $\cos\left(\frac{\pi}{4} + x\right) = -\frac{1}{\sqrt{2}} \Rightarrow x + \frac{\pi}{4} = 2n\pi \pm \frac{3\pi}{4}$

for $n = 0$ $\quad x = \frac{\pi}{2}, -\pi$

for $n = 1$ $\quad x = \pi$ $\qquad$ for $n = -1$ $\qquad x = -\frac{3\pi}{2}$ $\qquad \therefore$ IV $\rightarrow$ R

16. **A**

Let A_1 ; P_1 won the round $\Rightarrow P(A_1) = \frac{{}^6C_2}{6^2} = \frac{6 \times 5}{2 \times 6 \times 6}$

$P(A_1) = \frac{5}{12}$

A_2 ; P_2 won the round $\Rightarrow P(A_2) = \frac{5}{12}$

D ; round ends in draw $\Rightarrow P(D) = \frac{6}{6^2} = \frac{1}{6}$

(i) $P(X_2 \geq Y_2) = P(A_1 \cap A_1) + 2P(A_1 \cap A_1) + P(D \cap D) + 2P(A_1 \cap D)$

$= \frac{5}{12} \cdot \frac{5}{12} + 2 \cdot \frac{5}{12} \cdot \frac{5}{12} + \frac{1}{6} \cdot \frac{1}{6} + 2 \cdot \frac{5}{12} \cdot \frac{1}{6} = \frac{11}{16}$

$\Rightarrow$ (1) $\rightarrow$ (Q)

(ii) $P(X_2 > Y_2) = P(A_1 \cap A_1) + 2P(A_1 \cap D)$

$= \frac{5 \times 5}{12 \times 12} + 2 \cdot \frac{5}{12} \cdot \frac{1}{6} = \frac{25}{144} + \frac{5}{36} = \frac{45}{144} = \frac{5}{16}$

$\Rightarrow$ (ii) $\rightarrow$ R

(iii) $P(X_3 = Y_3) = 3P(A_1 \cap D \cap A_2) + P(D \cap D \cap D)$

$= 6 \times \frac{5}{12} \times \frac{5}{12} \times \frac{1}{6} + \frac{1}{6} \times \frac{1}{6} \times \frac{1}{6}$

$= \frac{25}{144} + \frac{1}{216} = \frac{75 + 2}{432} = \frac{77}{432}$

$\Rightarrow$ (iii) $\rightarrow$ T

(iv) $P(X_3 > Y_3) = P(A_1 \cap A_1 \cap A_1) + 3P(A_1 \cap A_1 \cap A_2) + 3P((A_1 \cap A_1 \cap D) + 3P(A_1 \cap D \cap D)$

$= \frac{5}{12} \times \frac{5}{12} \times \frac{5}{12} + 3 \times \frac{5}{12} \times \frac{5}{12} \times \frac{5}{12} + 3 \times \frac{5}{12} \times \frac{5}{12} \times \frac{1}{6} + 3 \times \frac{5}{12} \times \frac{1}{6} \times \frac{1}{6}$

$= \frac{710}{12^3} = \frac{355}{144 \times 6} = \frac{355}{864}$

$\therefore$ IV $\rightarrow$ S

17. **B**

$x + y + z = 1$ ..... (1)

$10x + 100y + 1000z = 0$ ..... (2)

$\frac{x}{p} + \frac{y}{q} + \frac{z}{r} = 0$ ..... (3)

$\frac{1}{p} = A + 9d \; ; \; \frac{1}{q} = A + 99d \; ; \; \frac{1}{r} = A + 999d$

$\Rightarrow$ From equation (2) and (3), we get $(A-d)x + (A-d)y + (A-d)z = 0$

$\Rightarrow$ If $A \neq d$, then no solution

If $A = d \Rightarrow \frac{p}{q} = 10, \frac{q}{r} = 10, \frac{p}{r} = 100$ then the equations have infinite solutions

Now, equation (2) and (3) both are same

So, (1) and (2) both equation are satisfying $x = 0, \; y = \frac{10}{9}, \; z = \frac{-1}{9}$

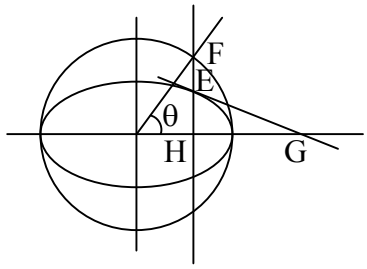
18. **C**

Equation of auxiliary circle $x^2 + y^2 = 4$

$\therefore$ Let F be (2 cos θ, 2 sin θ)

$\therefore$ E is $\left(2\cos\theta, \sqrt{3}\sin\theta\right)$

Equation of tangent at E, $\frac{x\cos\theta}{2} + \frac{y\sin\theta}{\sqrt{3}} = 1$



It cuts x-axis at (2 sec θ, 0)

$\therefore$ G is (2 sec θ, 0)

H is (2 cos θ, 0) and F(2 cos θ, 2 sin θ)

$\therefore$ Area of ΔFGH is $\frac{1}{2} \times 2\sin\theta(2\sec\theta - 2\cos\theta)$

= 2 sin θ(sec θ – cos θ)

If $\theta = \frac{\pi}{4}$, area = $2 \times \frac{1}{\sqrt{2}}\left(\sqrt{2} - \frac{1}{\sqrt{2}}\right) = 1$

If $\theta = \frac{\pi}{3}$, area = $2 \times \frac{\sqrt{3}}{2}\left(2 - \frac{1}{2}\right) = \frac{3\sqrt{3}}{2}$

If $\theta = \frac{\pi}{6}$, area = $2 \times \frac{1}{2}\left(\frac{2}{\sqrt{3}} - \frac{\sqrt{3}}{2}\right) = \frac{1}{2\sqrt{3}}$

If $\theta = \frac{\pi}{12}$, area = $2 \times \frac{\sqrt{3}-1}{2\sqrt{2}}\left(\frac{2\sqrt{2}}{\sqrt{3}+1} - \frac{\sqrt{3}+1}{2\sqrt{2}}\right) = \left(\frac{\sqrt{3}-1}{8}\right)^4$.

PHYSICS

1. **2.30**

$M_B = 2M_A \quad \Rightarrow \quad \rho_B = 2\rho_A$

Now after the mass transfer,

$M'_A = \rho_A \frac{4}{3} \times \frac{R^3}{8}$ and $M'_B = G\frac{4}{3}\pi\left(2\rho_A R^3 + \frac{7}{8}\rho_A R^3\right)$

and outer radius R' = $= \frac{(15)^{1/3}}{2} R$

So, $v_A = \sqrt{\frac{2GM'_A}{R}} = \sqrt{\frac{2}{3} G\rho_A \pi R^2}$

$$v_B = \sqrt{\frac{2G(4/3)\pi(2\rho_A R^3 + \frac{7}{8}\rho_A R^3)}{R'}}$$

$$\frac{v_B}{v_A} = \sqrt{\frac{23}{(15)^{1/3}}} = \sqrt{\frac{(2.3)(10)}{(15)^{1/3}}}$$

So, n = 2.30

2. **2.32**

$${}^{14}_{7}N + {}^{4}_{2}He \rightarrow {}^{1}_{1}H + {}^{19}_{8}O$$

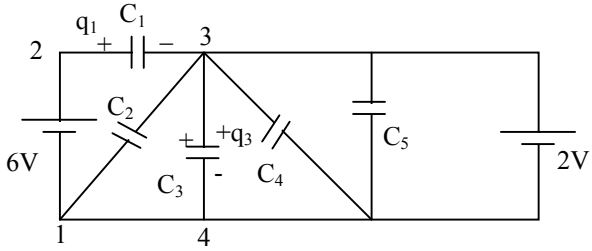
Q = [16.006 + 4.003 – 1.008 – 19.003] × 930
= - 1.86 MeV

$$E_{th} = \left(1+\frac{m}{M}\right)|Q| \approx \left(1+\frac{4}{16}\right)(1.86) = 2.32 MeV$$

3. **8.00**

In the loop 1234, $+6 - \frac{48}{12} - \frac{q_3}{4} = 0$, $q_1 = 12\,(6-2) = 48\ \mu C$

$q_3 = 8\ \mu C$



4. **6.00**

$$u_1 = -\frac{40}{3}$$

f = 10

$$\frac{1}{V_1} + \frac{1\times 3}{40} = \frac{1}{10}$$

$V_1 = 40$

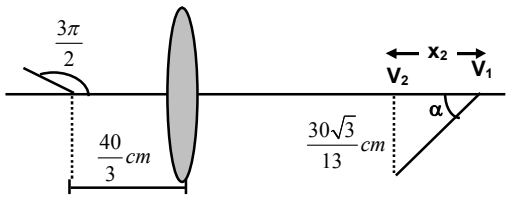
$$u_2 = -\frac{43}{3}$$

$$\frac{1}{V_2} = \frac{1}{10} - \frac{3}{43} = \frac{43-30}{430}$$

$$V_2 = \frac{430}{13}$$

$$x_2 = V_1 - V_2 = 40 - \frac{430}{13} = \frac{90}{13}$$

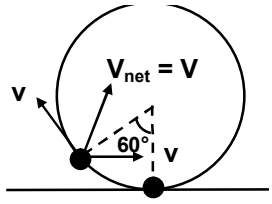
$$\tan\alpha = \frac{30\sqrt{3}}{13\times x} = \frac{30\sqrt{3}\times 13}{13\times 90} = \frac{1}{\sqrt{3}}$$



$\alpha = \frac{\pi}{6} = \frac{\pi}{n}$

n = 6

5. **0.52**



$\theta = \frac{1}{2}\alpha t^2$

$= \frac{1}{2} \times \frac{2}{3}\pi = \frac{\pi}{3} = 60°$

$v_{cm} = \alpha t$

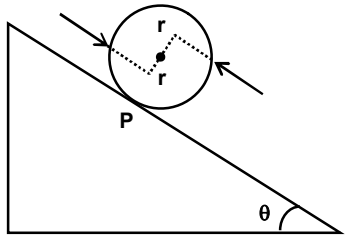
Net velocity of point P is V = αt at an angle 60° with horizontal

$u_y = \alpha t \sin 60°$

$y_{max} = \frac{1}{2} + \frac{u_y^2}{2g} = \frac{1}{2} + \frac{\alpha^2 t^2}{20}\frac{3}{4} = \frac{1}{2} + \frac{\pi}{60}$

x = 0.52

6. **2.85**



$mg \sin\theta \times R + 1 \times \frac{R}{2} - 1 \times \frac{3R}{2} = I_P \alpha$

$\frac{10}{2} \times 1 + \frac{1}{2} - \frac{3}{2} = \frac{7}{5} \times mR^2\alpha$

$5 - 1 = \frac{7}{3}\alpha$

$\frac{20}{7} = \alpha$

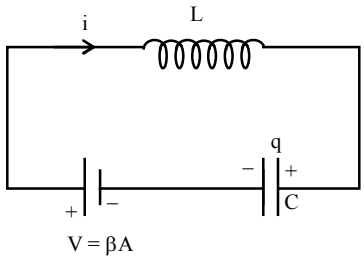
$a_{cm} = R\alpha = \frac{20}{7}$

7. **4.00**

$\phi = (B_0 + \beta t)A$

$|\varepsilon_{ind}| = \frac{d\phi}{dt} = \beta A$

Applying kVL in the equivalent circuit diagram of the loop.



$\beta A - \frac{Ldi}{dt} - \frac{q}{C} = 0$ … (i)

Also, $i = \frac{dq}{dt}$ . . . (ii)

From (i) and (ii) $L\frac{d^2i}{dt^2} = -\frac{i}{c}$

$i = i_m \sin \omega t$ $\omega = \frac{1}{\sqrt{LC}}$

$\int_0^q dq = i_m \int_0^t \sin(\omega t) dt$

$q = \frac{i_m}{\omega}(1 - \cos \omega t)$

when $i = i_m \Rightarrow \sin \omega t = 1 \Rightarrow \cos\omega t = 0$

$q = \frac{i_m}{\omega} = \beta AC$

$I_m = \omega\beta AC = \beta A\sqrt{\frac{C}{L}} = 4mA$

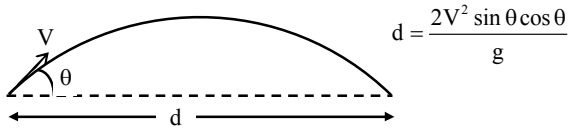
8. **0.95**

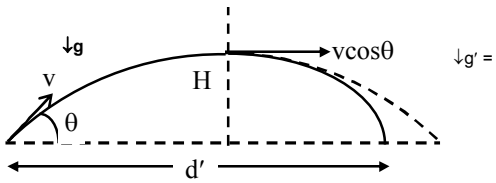
$d' = \frac{d}{2} + \sqrt{\frac{2H}{g'}} v\cos\theta = \frac{d}{2} + \sqrt{\frac{2}{g'}\frac{v^2\sin^2\theta}{2g}} v\cos\theta$

$d' = \frac{d}{2} + \frac{V^2\sin\theta\cos\theta}{\sqrt{g\frac{g}{0.81}}} = \frac{d}{2} + \frac{d}{2}\left(\frac{9}{10}\right) = \frac{19d}{20}$

$d' = 0.95d$

$n = 0.95$



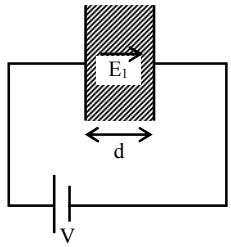


9. **B**

Refer to figure (a)

$V = E_1 d$

$C_1 = \frac{k\varepsilon_0 A}{d}$



Figure(a)

Refer to figure (b)

$V = E_3\frac{d}{2} + E_2\frac{d}{2} + E_3\frac{d}{2}$

Also $E_3 = E_2K$

$V = E_2d + KE_2d$

$V = (K + 1)E_2d$

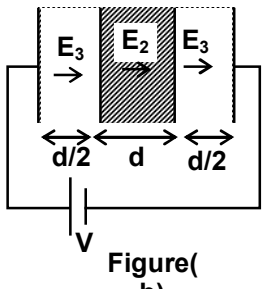
$C_2 = \frac{\varepsilon_0 A}{d + \frac{d}{K}} = \frac{K}{K+1}\frac{\varepsilon_0 A}{d}$

Now $\frac{E_1}{E_2} = K + 1$

$\frac{C_1}{C_2} = (K+1)$

$W_{ext} + W_{battery} = \Delta U$

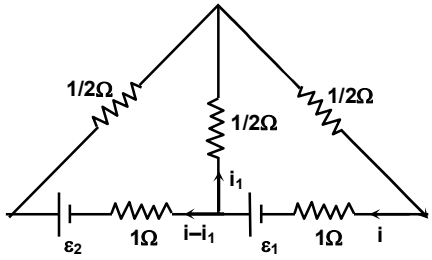
$W_{ext} + (C_2 - C_1)V^2 = (C_2 - C_1)\frac{V^2}{2}$



Figure(

$$W_{ext} = \left(C_1 - C_2\right)\frac{V^2}{2} = \frac{K\varepsilon_0 A}{d}\left(1 - \frac{1}{K+1}\right)\frac{V^2}{2} = \frac{K^2\varepsilon_0 A V^2}{2d\left(K+1\right)}$$

10. **A, B, C, D**



$$-\left(i - i_1\right) + 6 - \frac{1}{2}\left(i - i_1\right) + \frac{1}{2}i_1 = 0$$

$$-\frac{3}{2}\left(i - i_1\right) + \frac{i_1}{2} + 6 = 0$$

$$-\frac{3}{2}i + \frac{3}{2}i_1 + \frac{i_2}{2} + 6 = 0$$

$$-\frac{3}{2}i + 2i_1 + 6 = 0$$

$$-\frac{i_1}{2} - \frac{i}{2} - i + 12 = 0$$

$$-\frac{i_1}{2} - \frac{3}{2}i + 12 = 0$$

$$\frac{5}{2}i_1 - 6 = 0$$

$$i_1 = \frac{6\times 2}{5} = \frac{12}{5} = 2.4$$

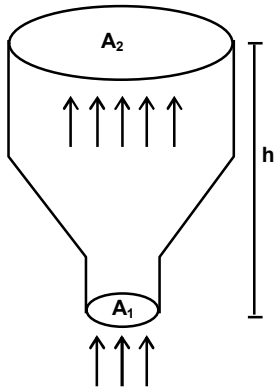
$$-1.2 - 1.5i + 12 = 0$$

$$1.5i = 10.8$$

$$i = \frac{10.8}{1.5}$$

$$i = 7.2$$

11. **B**



$P^{1-\gamma}T^{\gamma}$ = Const.

$P_2 = 150$ Pa …(1)

$$\frac{dm}{dt} = \rho_1 A_1 v_1$$

$v_1 = 40$ m/s …(2)

$$\rho = \frac{PM}{RT}$$

$\rho_2 = 0.1$ Kg/m^3 …(3)

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$v_2 = 20$ m/s …(4)

From work energy theorem,

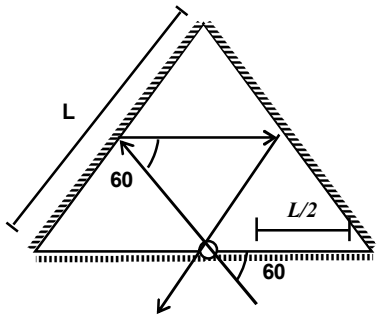
$P_1\ A_1\ v_1\ dt - \rho_2\ A_2\ v_2\ dt + \rho_1\ A_1 v_1 dt\ g(0) - \rho_2 A_2 v_2 dt\ g(h)$

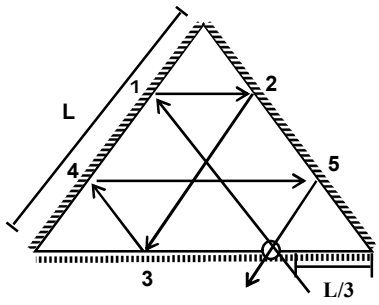
$$= \frac{1}{2}\rho_2 A_2 v_2 dt\ v_2^2 - \frac{1}{2}\rho_1 A_1 v_1 dt\ v_1^2 + \frac{1}{\gamma - 1}\left[P_2 A_2 v_2 dt - P_1 A_1 v_1 dt\right]$$

$h = 360$ m.

12. **A, B**

For option 'A' there will be normal incidence and ray retrace its path. For option 'B'





13. **A, B, C**

When x = q, electric field at O is zero.

When x = –q, electric field at O is,

$$E = \frac{1}{4\pi\varepsilon_0}\frac{2q}{\left(\sqrt{3}a\right)^2} = \frac{q}{6\pi\varepsilon_0 a^2}$$

When x = 2q, potential at O is,

$$V = \frac{7q}{4\sqrt{3}\pi\varepsilon_0 a}$$

When x = – 3q, potential at O is,

$$V = \frac{2q}{4\sqrt{3}\pi\varepsilon_0 a}$$

14. **A, B, D**

15. **None**

The magnitude of $\hat{n}$ mentioned in List-I of the question is not 1, it is $\frac{1}{\sqrt{2}}$

16. **C**

ω is same, therefore angle between velocity vectors remain same.

$$V_{rel} = \sqrt{1^2 + 1^2} = \sqrt{2}\ m/s$$

$$\Rightarrow \quad \vec{v}_1 = \frac{5\pi}{2}\hat{i} + \frac{5\pi}{3}\hat{j}$$

$$\vec{v}_1 = -\frac{5\pi}{2}\hat{i} + \left(\frac{5\pi}{3} + 1\right)\hat{j}$$

$v_{rel} = |\,|\vec{v}_2 - \vec{v}_1\,| = \sqrt{25\pi^2 + 1}$

17. **C**

$W = P\Delta V = 0.1$ kJ

$Q = mL = 2.25$ kJ

$\Delta U = Q - W = 2.15$ kJ

$$\Rightarrow \quad \frac{V}{500} = \frac{3V}{T} \quad \Rightarrow \ T = 1500$$

$\Delta U = nC_v \Delta T = 4$kJ

$$\Rightarrow \quad W = \frac{PV - (32P)(V/8)}{1 - 5/3} = 3 \qquad [PV = P'(V/8)^{\gamma};\ P' = 32\,P\,]$$

$$\Rightarrow \quad \frac{\Delta U}{\Delta Q} = \frac{nC_v\Delta T}{nC_P\Delta T} = \frac{1}{v} \qquad (\ f = 6 - \text{vibration included}\ )$$

$\Delta U = 9 \times (3/4) \approx 7$

18. **A**

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} \quad (concave\,lens)$$

$\Rightarrow \quad v = -10$

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} \quad (convex\,lens)$$

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{-15}$$

$\Rightarrow \quad v = +30$

CHEMISTRY

1. $\Delta T = 312.8 - 298 = 14.8$

Molar heat capacity of calorimeter = 20 kJ K^{-1}

Heat released by combustion of 2 moles of Hg(g)

$= -20 \times 14.8$

$= -296$ kJ

$$\Delta U_{combustion} = -\frac{296}{2} = -148 \text{ kJ mol}^{-1}$$

$$Hg(g) + \frac{1}{2}O_2(g) \longrightarrow HgO(s)$$

$$\Delta n_g = 0 - \left(1 + \frac{1}{2}\right) = -\frac{3}{2}$$

$$\Delta H_{combustion} = \Delta U_{combustion} + \Delta n_g RT$$

$$= -148 + \left(-\frac{3}{2}\right) \times 8.3 \times 10^{-3} \times 298$$

$= -148 - 3.710$

$= -151.710$ kJ mol^{-1}

$$Hg(\ell)+\frac{1}{2}O_2(g)\longrightarrow HgO(s)$$

$$\Delta H^\circ_{combustion}=\Delta H^\circ_f(HgO)-\Delta H^\circ_{Hg(\ell)\longrightarrow Hg(g)}+\frac{1}{2}\Delta H^\circ_f O_2$$

$-151.710 = \Delta H_f^\circ\ (HgO) - 61.32 + 0$

$\Delta H_f^\circ\ (HgO) = -151.710 + 61.32 = 90.39$

ΔH_f° = **90.39**

2. (i) $MnO_4^-(aq)+8H^++7e^-\longrightarrow Mn(s)+4H_2O(\ell);\ \Delta G_1^\circ=-7\times F\times E_1^\circ$

(ii) $MnO_4^-+4H^++3e^-\longrightarrow MnO_2(s)+2H_2O(\ell);\ \Delta G_2^\circ=-3\times F\times 1.68$

(iii) $MnO_2(s)+4H^++2e^-\longrightarrow Mn^{2+}(aq)+2H_2O(\ell);\ \Delta G_3^\circ=-2\times F\times 1.21$

(iv) $Mn^{2+}(aq)+2e^-\longrightarrow Mn(s);\ \Delta G_4^\circ=-2\times F\times(-1.03)$

Now,

(i) = (ii) + (iii) + (iv)

$$\Delta G_1^\circ=\Delta G_2^\circ+\Delta G_3^\circ+\Delta G_4^\circ$$

$$-7\times F\times E_1^\circ=-3\times F\times 1.68--2\times F\times 1.21+2\times F\times 1.03$$

$$-7E_1^\circ=3\times 1.68+2\times 1.21-2\times 1.03$$

$$E_1^\circ=\frac{3\times 1.68+2\times 1.21-2\times 1.03}{7}$$

$$E_1^\circ=\frac{5.04+2.42-2.06}{7}$$

$= 0.7714$

$=$ **0.77 V**

3.

	H_2CO_3	+ $NaOH\longrightarrow$	$NaHCO_3$	+ H_2O
Initial mol	0.01	0.01	0.01	
After neutralization	0	0	$0.01+0.01$ $=0.02$	

Now, mixture contains 0.01 mole Na_2CO_3 and 0.02 mol of $NaHCO_3$ so it is a buffer.

$$pH=pK_{a_2}+\log\frac{\left[CO_3^{2-}\right]}{\left[HCO_3^-\right]}$$

$$pH=10.32+\log\frac{0.01}{0.02}$$

$$=10.32+\log\frac{1}{2}$$

$= 10.32 - 0.30$

$= 10.02$

4. $2Cu(NO_3)_2+4KI\longrightarrow 2CuI\downarrow+I_2+4KNO_3$

$I_2+KI\longrightarrow KI_3$

$2Cu(NO_3)_2+5KI\longrightarrow 2CuI\downarrow+KI_3+4KNO_3$

$$\text{Mole}=\frac{3.74}{187}=0.02 \qquad \frac{0.02}{2}=0.01$$

$$KI_3 + H_2S \longrightarrow S\downarrow + 2HI + KI$$

0.01 mol 0.01 mol

(X)

Mass of 'S' = 0.01 × 32= 0.32

5. Mole of $P_4 = \frac{1.24}{124} = 0.01$

$$P_4 + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + \underset{(Q)}{PH_3}$$

mole 0.01 0.01

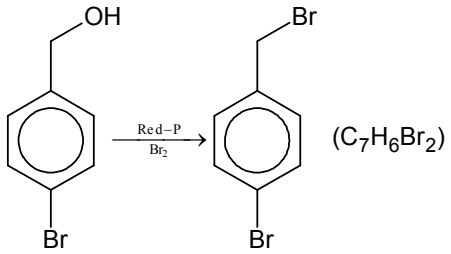
$$\underset{(Q)}{2PH_3} + 3CuSO_4 \longrightarrow Cu_3P_2 + 3H_2SO_4$$

mole 0.01 $\frac{3}{2}\times 0.01$

$\therefore$ Mole of $CuSO_4$ required = $0.01\times\frac{3}{2}$

Weight of $CuSO_4$ = $0.01\times\frac{3}{2}\times 159 = 2.385$ g

6.



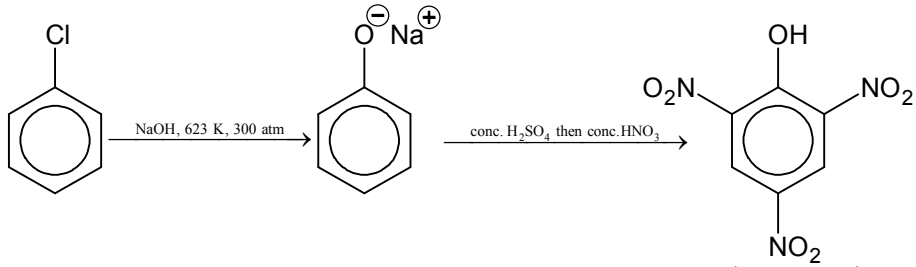
(R)

Molecular weight of (R) = 7 × 12 + 1 × 6 + 80 × 2= 250 g/mol

Mole of AgBr formed = 2 × mole of (R)

= $2\times\frac{1}{250}\times 188$ = $8\times 10^{-3}\times 188$ = **1.504 g**

7.



(Picric acid)

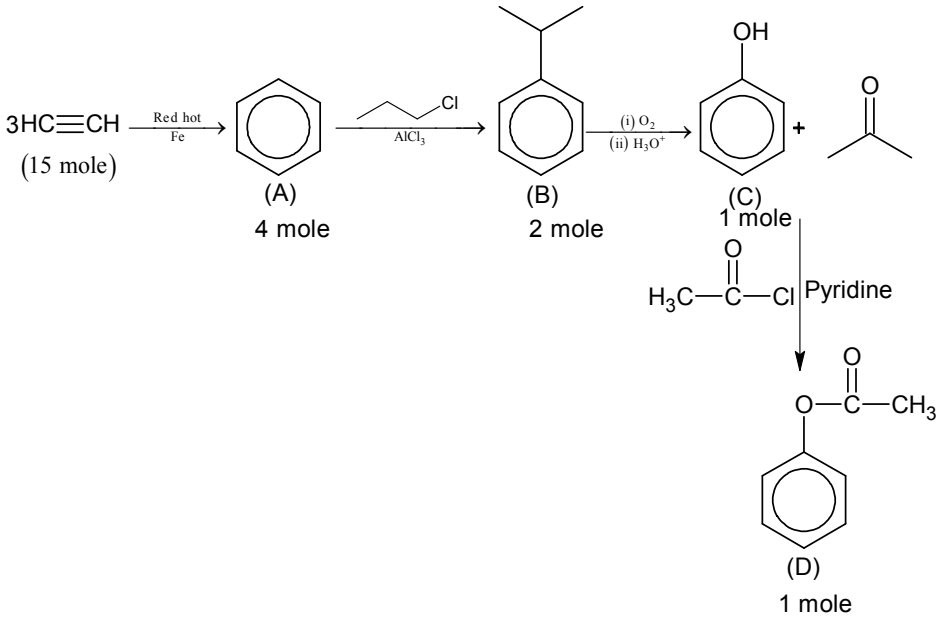
$C_6H_3O_7N_3$

Molecular weight = 12 × 6 + 1 × 3 + 16 × 7 + 14 × 3

= 72 + 3 + 112 + 42 = 229 gm/mole

$\therefore$ Weight percentage of H = $\frac{3}{229}\times 100 = 1.3100$ %

8.



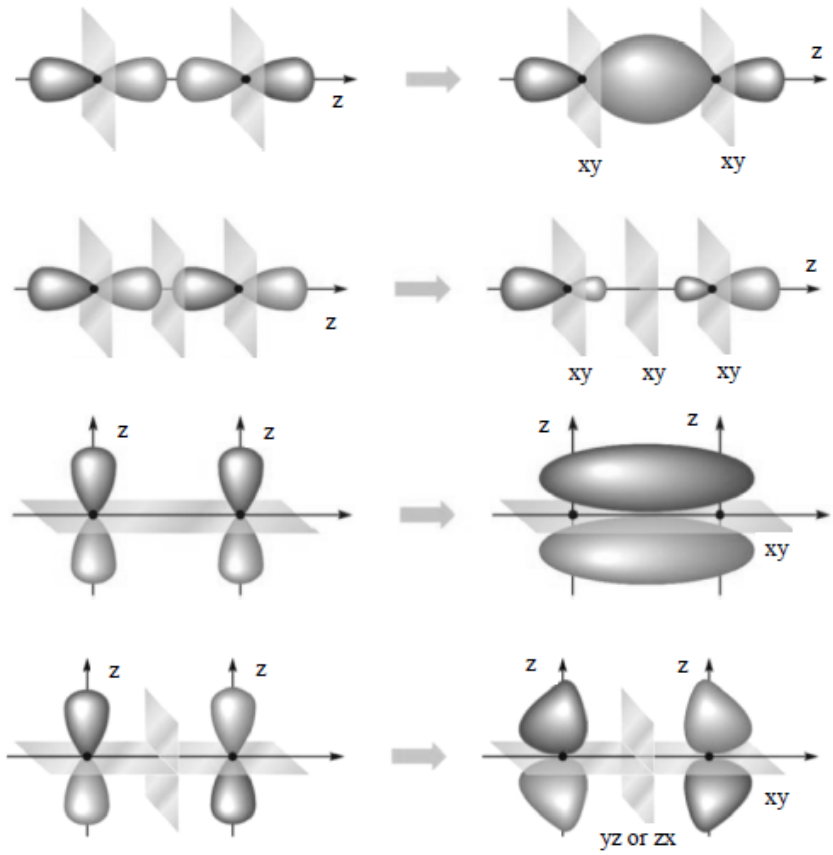
Molecular weight = $C_8H_8O_2$

$= 12 \times 8 + 1 \times 8 + 16 \times 2 = 96 + 8 + 32 = 136$

Moles of product (D) formed

$= \frac{15}{3} \times 0.8 \times 0.5 \times 0.5 = \frac{3}{3} = 1$ $\therefore$ Weight of product (D) = 1 × 136 = 136 g

9.



10. → Chemisorption is unimolecular layer and exothermic.
→ The enthalpy change in physiorption is 20 – 40 kJ/mol.
→ Physiorption decreases with increase of temperature.

11. $2NaAlO_2 + CO_2 + 3H_2O \longrightarrow 2Al(OH)_3 \downarrow + Na_2CO_3$

$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

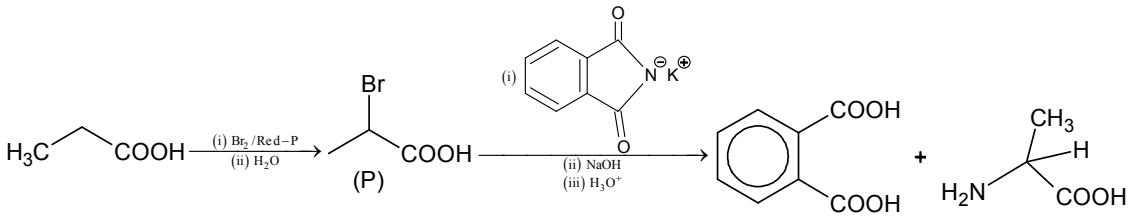
→ $Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

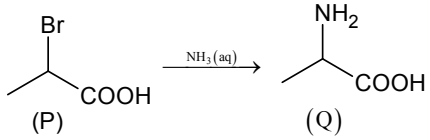
→ During electrolysis of alumina, cryolite (Na_3AlF_6) and fluorspar (CaF_2) are added to decrease the melting point of alumina.
→ Al metal is obtained at cathode while CO_2 releases at anode.

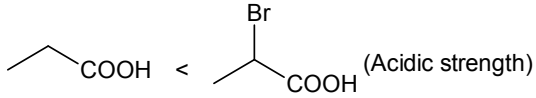
12. $3PbS + 8HNO_3 \longrightarrow 3Pb(NO_3)_2 + 3S + 2NO \uparrow + 4H_2O$

NO → paramagnetic, neutral oxide and colourless gas

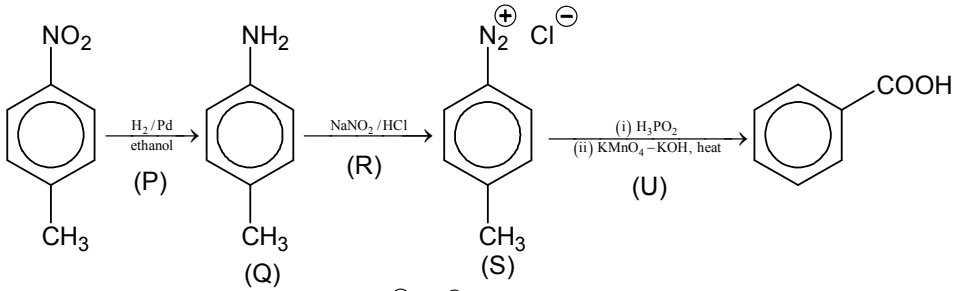
13.



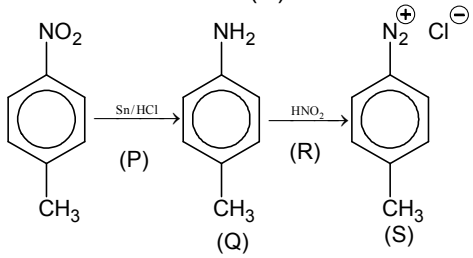




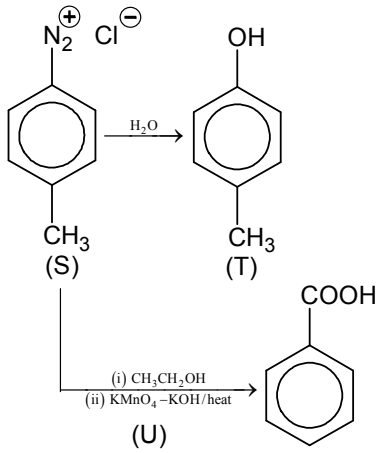
14. **(A)**



(B)

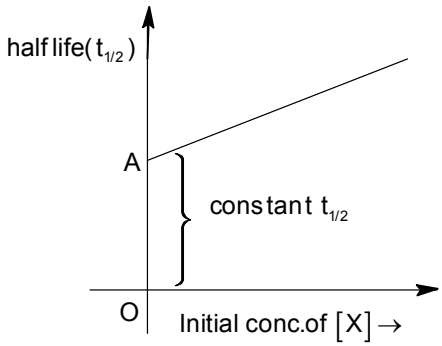


(C)



15. $I \rightarrow Rate = \dfrac{k[X]}{X_s + [X]}$

If [X] is low, then it follows first order kinetic ie. $t_{1/2}$ is constant (OA part in graph)
If [X] is high, then it follows zero order kinetics. So half life ($t_{1/2}$) varies linearly with [X] as shown in graph.



$I \rightarrow P$

$II \rightarrow Rate = \dfrac{k[X]}{X_s + [X]}$

If [X] is less than X_s, then reaction follows I^{st} order kinetics as shown by the graph Q and T
$II \rightarrow Q, T$

$III \rightarrow Rate = \dfrac{k[X]}{X_s + [X]}$

If [X] >> X_s, then reaction follows zero order kinetics, as show by the graph (S)
$III \rightarrow S$

$IV \rightarrow Rate = \dfrac{k[X]^2}{X_s + [X]}$

If [X] >> [X_s], then reaction follows first order kinetics, as show by the graph (Q), (T)
$IV \rightarrow Q, T$

16. $Mg(HCO_3)_2 + 2Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + 2CaCO_3 \downarrow + 2H_2O$

$BaO_2 + H_2SO_4 \longrightarrow BaSO_4 \downarrow + H_2O_2$

$Ca(OH)_2 + MgCl_2 \longrightarrow Mg(OH)_2 \downarrow + CaCl_2$

$BaO_2 + 2HCl \longrightarrow BaCl_2 + H_2O_2$

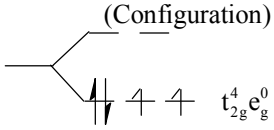
$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + H_2O$

I → Q,S; II → P,R; III → S; IV → P,T

17. $[Cr(CN)_6]^{4-}$ $Cr^{2+} \longrightarrow 4s^0 3d^4$

(Configuration)

I ⟶ P, T, R



$t_{2g}^4 e_g^0$

Low – spin

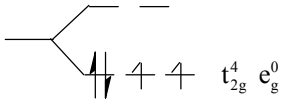
n = 2

$\mu = \sqrt{2(2+2)}$

$= \sqrt{8}$ B.M

$[RuCl_6]^{2-}$ $Ru^{4+} \longrightarrow 4s^0 3d^4$

II ⟶ P, R, S, T



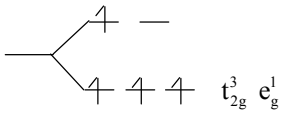
$t_{2g}^4\ e_g^0$

Low – spin

$\mu = \sqrt{8}$ B.M

$[Cr(H_2O)_6]^{2+}$ $Cr^{2+} \longrightarrow 4s^0 3d^4$

III ⟶ Q, T



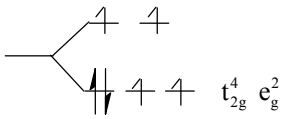
$t_{2g}^3\ e_g^1$

High – spin

$\mu = \sqrt{24}$ B.M

$[Fe(H_2O)_6]^{2+}$ $Cr^{2+} \longrightarrow 4s^0 3d^6$

IV ⟶ P, T

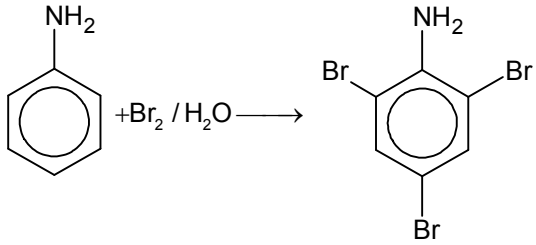


$t_{2g}^4\ e_g^2$

High – spin

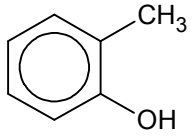
$\mu = \sqrt{4(4+2)} = \sqrt{24}$ B.M

18. (I) since aniline contains C and N so its sodium extract will give Prussian Blue colour with $FeSO_4$/Conc.H_2SO_4



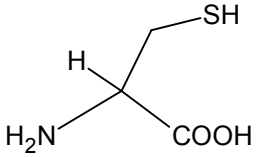
white ppt

(II) Produces violet colour with neutral $FeCl_3$



(III) It contains –COOH, so it give effervescence with $NaHCO_3$

It also contains C, N, S, so its Na-extract will give blood red colour with $FeCl_3/H_2SO_4$.



(IV) Caprolectum, it contains C and N, so its sodium extract will give Prussian blue colour