CHEMISTRY

SECTION 1 (Maximum Marks: 24)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER ranging from 0 TO 9, BOTH INCLUSIVE.**
- For each question, enter the correct integer corresponding to the answer using the using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 If **ONLY** the correct integer is entered;
  Zero Marks : 0 If the question is unanswered;
  Negative Marks : –1 In all other cases.

*Q. 1 Concentration of H_2SO_4 and Na_2SO_4 in a solution is 1 M and 1.8×10^{-2} M, respectively. Molar solubility of $PbSO_4$ in the same solution is $X\times10^{-Y}$ M (expressed in scientific notation). The value of Y is________.
[Given : Solubility product of $PbSO_4\left(K_{sp}\right)=1.6\times10^{-8}$. For H_2SO_4, K_{a_1} is very large and $K_{a_2}=1.2\times10^{-2}$]

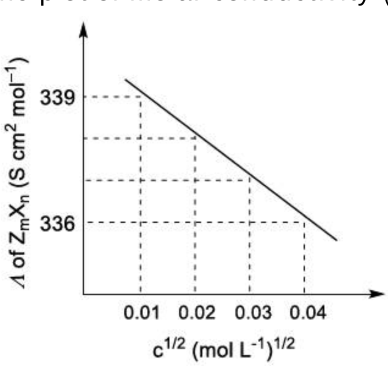
Q. 2 An aqueous solution is prepared by dissolving 0.1 mol of an ionic salt in 1.8 kg of water at 35^oC. The salt remains 90% dissociated in the solution. The vapour pressure of the solution is 59.724 mm of Hg. Vapor pressure of water at 35^oC is 60.000 mm of Hg. The number of ions present per formula unit of the ionic salt is______.

Q. 3 Consider the strong electrolytes Z_mX_n, U_mY_p and V_mX_n. Limiting molar conductivity $\left(\Lambda^0\right)$ of U_mY_p and V_mX_n are 250 and 440 S cm^2 mol^{-1}, respectively. The value of (m + n + p) is__________.
Given:

Ion	Z^{n+}	U^{p+}	V^{n+}	X^{m-}	Y^{m-}
$\lambda^0\left(S\ cm^2\ mol^{-1}\right)$	50.0	25.0	100.0	80.0	100.0

λ^0 is the limiting molar conductivity of ions.

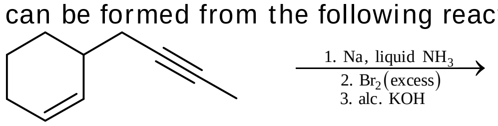
The plot of molar conductivity (Λ) of Z_mX_n vs $c^{1/2}$ is given below.



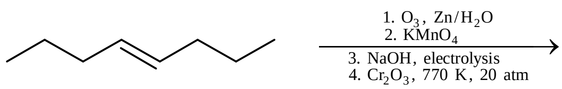
Q. 4 The reaction of Xe and O_2F_2 gives a Xe compound **P.** The number of moles of HF produced by the complete hydrolysis of 1 mol of **P** is________.

*Q. 5 Thermal decomposition of $AgNO_3$ produces two paramagnetic gases. The total number of electrons present in the antibonding molecular orbitals of the gas that has the higher number of unpaired electrons is_______.

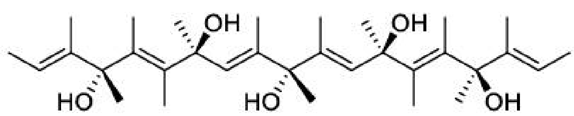
*Q. 6 The number of isomeric tetraenes (**NOT** containing *sp*-hybridized carbon atoms) that can be formed from the following reaction sequence is________.



*Q. 7 The of $-CH_2-$ (methylene) groups in the product formed from the following reaction sequence is______.



*Q. 8 The total number of chiral molecules formed from one molecule of **P** on complete ozonolysis $(O_3, Zn/H_2O)$ is__________.



P

SECTION 2 (Maximum Marks: 24)

This section contains **SIX (06)** questions.

- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE 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 according to the following marking scheme:

Full Marks : +4 **ONLY** if (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.

*Q.9. To check the principle of multiple proportions, a series of pure binary compounds (P_mQ_n) were analyzed and their composition is tabulated below. The correct option(s) is(are)

Compound	Weight % of P	Weight % of Q
1	50	50
2	44.4	55.6
3	40	60

(A) If empirical formula of compound **3** is P_3Q_4, then the empirical formula of compound **2** is P_3Q_5.

(B) If empirical formula of compound **3** is P_3Q_2, and atomic weight of element P is 20, then the atomic weight of Q is 45.

(C) If empirical formula of compound **2** is PQ, then the empirical formula of compound **1** is P_5Q_4.

(D) If atomic weight of P and Q are 70 and 35, respectively, then the empirical formula of compound **1** is P_2Q.

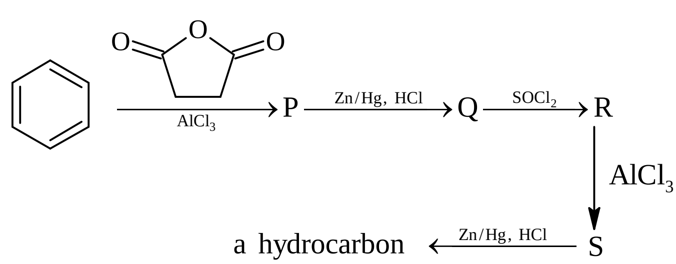
Q. 10 The correct option(s) about entropy (S) is(are)
[R = gas constant, F = Faraday constant, T = Temperature]

(A) For the reaction, $M(s) + 2H^+(aq) \longrightarrow H_2(g) + M^{2+}(aq)$, if $\frac{dE_{cell}}{dT} = \frac{R}{F}$, then the entropy change of the reaction is R (assume that entropy and internal energy changes are temperature independent).
(B) The cell reaction, $Pt(s) | H_2(g, 1\,bar) | H^+(aq, 0.01\ M) || H^+(aq, 0.1\ M) | H_2(g, 1\ bar) | Pt(s)$, is an entropy driven process.
(C) For racemisation of an optically active compound, $\Delta S > 0$.
(D) $\Delta S > 0$, for $[Ni(H_2O)_6]^{2+} + 3\ en \longrightarrow [Ni(en)_3]^{2+} + 6H_2O$ (where en = ethylenediamine).

*Q. 11 The compound(s) which react(s) with NH_3 to give boron nitride (BN) is(are)
(A) B
(B) B_2H_6
(C) B_2O_3
(D) HBF_4

Q. 12 The correct option(s) related to the extraction of iron from its ore in the blast furnace operating in the temperature range 900 – 1500 K is(are)
(A) Limestone is used to remove silicate impurity.
(B) Pig iron obtained from blast furnace contains about 4% carbon.
(C) Coke (C) converts CO_2 to CO.
(D) Exhaust gases consist of NO_2 and CO.

*Q. 13 Considering the following reaction sequence, the correct statement(s) is(are)



(A) Compound **P** and **Q** are carboxylic acids.
(B) Compound **S** decolorizes bromine water.
(C) Compounds **P** and **S** react with hydroxylamine to give the corresponding oximes.
(D) Compound **R** reacts with dialkylcadmium to give the corresponding tertiary alcohol.

Q. 14 Among the following, the correct statement(s) about polymers is(are)
(A) The polymerization of chloroprene gives natural rubber.
(B) Teflon is prepared from tetrafluoroethene by heating it with persulphate catalyst at high pressures.
(C) PVC are thermoplastic polymers.
(D) Ethene at 350 – 570 K temperature and 1000-2000 atm pressure in the presence of a peroxide initiator yields high density polythene.

Section 3 (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:
  Full Marks : +3 If **ONLY** the correct option 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.

Q. 15 Atom X occupies the fcc lattice sites as well as alternate tetrahedral voids of the same lattice. The packing efficiency (in %) of the resultant solid is closed to

(A) 25 (B) 35
(C) 55 (D) 75

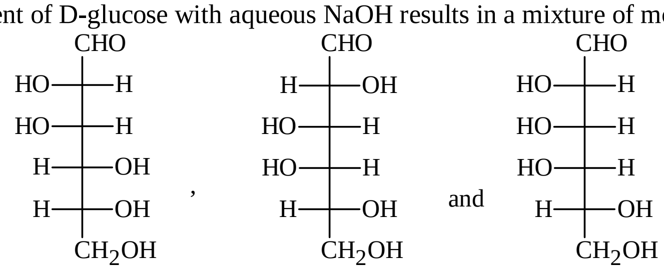
Q. 16 The reaction of $HClO_3$ with HCl gives a paramagnetic gas, which upon reaction with O_3 produces

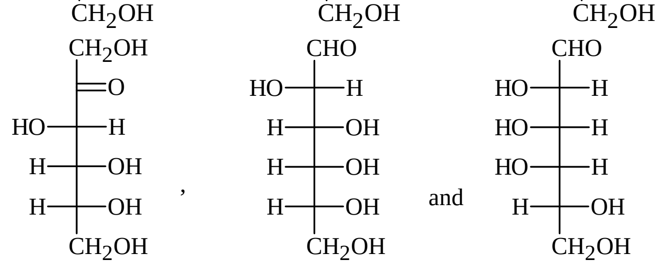
(A) Cl_2O (B) ClO_2
(C) Cl_2O_6 (D) Cl_2O_7

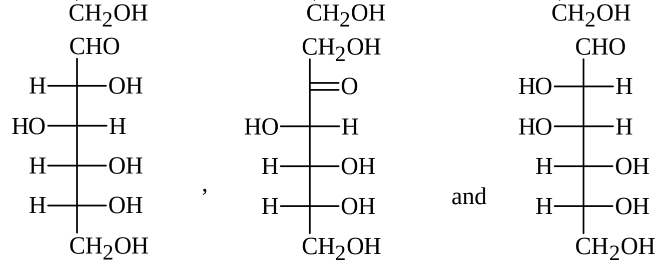
Q. 17 The reaction of $Pb(NO_3)_2$ and NaCl in water produces a precipitate that dissolves upon the addition of HCl of appropriate concentration. The dissolution of the precipitate is due to the formation of

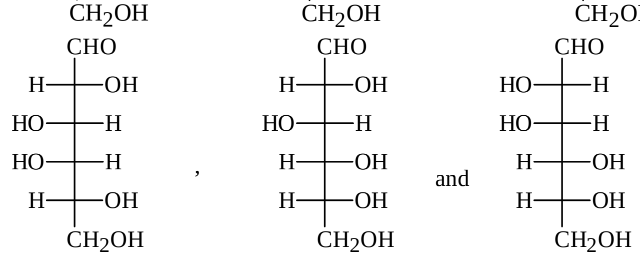
(A) $PbCl_2$ (B) $PbCl_4$
(C) $[PbCl_4]^{2-}$ (D) $[PbCl_6]^{2-}$

Q. 18 Treatment of D-glucose with aqueous NaOH results in a mixture of monosaccharides, which are

(A)


(B)


(C)


(D)


FIITJEE JEE (Advanced Paper)-2022

(PAPER-2)

ANSWER KEY

MATHEMATICS

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

PHYSICS

1.	**3**	2.	**2**	3.	**5**	4.	**4**
5.	**4**	6.	**3**	7.	**6**	8.	**3**
9.	**B**	10.	**A, B, C**	11.	**C, D**	12.	**A, C, D**
13.	**A, B**	14.	**B, C, D**	15.	**B**	16.	**A**
17	**NONE**	18.	**C**				

CHEMISTRY

1.	**6**	2.	**5**	3.	**7**	4.	**2**
5.	**6**	6.	**2**	7.	**0**	8.	**2**
9.	**B, C**	10.	**B, C, D**	11.	**B, C**	12.	**A, B, C**
13.	**A, C**	14.	**B, C**	15.	**B**	16.	**C**
17.	**C**	18.	**C**				

HINTS AND SOLUTIONS

MATHEMATICS

1. $$\frac{\sin\alpha}{\cos\beta}+\frac{\cos\alpha}{\sin\beta}+\frac{\cos\beta}{\sin\alpha}+\frac{\sin\beta}{\cos\alpha} \Rightarrow \frac{\cos(\alpha-\beta)}{\sin\beta\cos\beta}+\frac{\cos(\alpha-\beta)}{\sin\alpha\cos\alpha}$$
$$= 2\cos(\alpha-\beta)\left[\frac{1}{\sin((\alpha+\beta)-(\alpha-\beta))}+\frac{1}{\sin((\alpha+\beta)+(\alpha-\beta))}\right]$$
$$\left[\frac{2\times\frac{2}{3}}{\frac{1}{3}\times\frac{2}{3}-\frac{2\sqrt{2}}{3}\cdot\frac{\sqrt{5}}{3}}+\frac{2\times\frac{2}{3}}{\frac{1}{3}\times\frac{2}{3}+\frac{2\sqrt{2}}{3}\cdot\frac{\sqrt{5}}{3}}\right] = \frac{2\times\frac{2}{3}\times\frac{4}{9}}{\frac{4-40}{81}}$$
$$= \frac{48}{-36}=-\frac{4}{3} \Rightarrow \text{Required answer is 1}$$

2. $$y=\frac{4}{1+x^4} \Rightarrow 10\text{y}\left(\sqrt{2}\right)=8$$

3. $$\int_1^2 \log_2\left(x^3+1\right)dx+\int_1^{\log_2 9}\left(2^x-1\right)^{\frac{1}{3}}dx = 2\log_2 9-1 = \log_2\left(\frac{81}{2}\right)$$
GIF of $\log_2\left(\frac{81}{2}\right)=5$

4. $$\left(16\left(\log_5 x\right)^3-68\log_5 x\right)\left(\log_5 x\right)=-16$$
$$\log_5 x=t \Rightarrow 4t^4-17t^2+4=0$$
$$t^2=\frac{17\pm\sqrt{17^2-8^2}}{2\cdot 4}=\frac{17\pm 15}{8}=4, \frac{1}{4}$$
$$\Rightarrow \log_5 x=\pm 2, \pm\frac{1}{2} \Rightarrow x=25, \frac{1}{25}, \sqrt{5}, \frac{1}{\sqrt{5}}$$
Product = 1

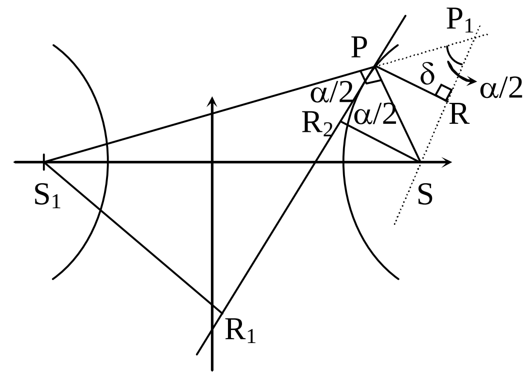
5. $$\beta=\lim_{x\to 0}\frac{1+x^3-\left(1-\frac{x^3}{3}\right)+\left(1-\frac{x^2}{2}-1\right)x}{x^3} = \frac{5}{6} \Rightarrow 6\beta = 5$$

6. $$|A|^5\left|A^2-(\beta-1)A-\beta\right|=0$$
$$|A|\neq 0 \Rightarrow \left|A^2-(\beta-1)A-\beta\right|=0 \Rightarrow |A+1|\,|A-\beta|=0$$
$$|A+1|\neq 0 \Rightarrow |A-\beta|=0 \Rightarrow \beta=\frac{1}{3} \Rightarrow 9\beta = 3$$

7. $PR = SR_2 = \delta$

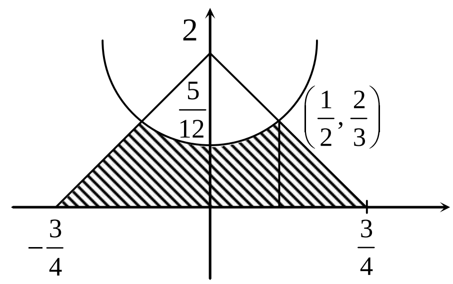
$$S_1R_1 = S_1P\sin\frac{\alpha}{2} = \beta\sin\frac{\alpha}{2}$$

$$\frac{\beta\delta}{9}\sin\left(\frac{\alpha}{2}\right) = \frac{SR_2 \cdot S_1R_1}{9} = \frac{b^2}{9} = 7$$



8. $$9\alpha = 9\cdot 2\left[\int_0^{\frac{1}{2}}\left(x^2+\frac{5}{12}\right)dx + \frac{1}{2}\cdot\frac{2}{3}\cdot\frac{1}{4}\right]$$

$$= 18\left(\frac{1}{24}+\frac{5}{24}+\frac{2}{24}\right) = 6$$



9. In ΔPQR $\frac{\alpha}{\sin 30^\circ} = \frac{1}{\sin\theta^\circ} \Rightarrow \alpha = \frac{1}{2\cos 10^\circ}$ … (i)

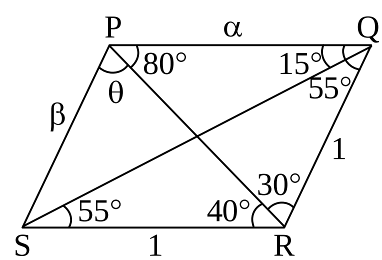
In ΔPSR $\frac{\beta}{\sin 40^\circ} = \frac{1}{\sin\theta^\circ} \Rightarrow \beta\sin\theta^\circ = \sin 40^\circ$ … (ii)

From equation (i) and (ii)

$$\alpha\beta\sin\theta = \frac{\sin 40^\circ}{2\cos 10^\circ}$$

$$4\alpha\beta\sin\theta = \frac{2\sin 40^\circ}{\sin 80^\circ} = \frac{2\sin 40^\circ}{2\sin 40^\circ\cos 40^\circ} = \sec 40^\circ$$

$$\frac{2}{\sqrt{3}} < \sec 40^\circ < \sqrt{2}$$



10. So $\alpha = \sum_{k=1}^{\infty}\left(\frac{1}{2}\right)^{2k} = \frac{\frac{1}{4}}{1-\frac{1}{4}} = \frac{1}{3}$

$$g(x) = 2^{7/3} + 2^{\frac{1-x}{3}}$$

$$\frac{2^{\frac{x}{3}} + 2^{\frac{1-x}{3}}}{2} \ge \left(2^{\frac{x}{3}+\frac{1-x}{3}}\right)^{\frac{1}{2}} \Rightarrow g(x) \ge 2^{\frac{7}{6}}$$

Also $g(x) \le 1 + 2^{1/3}$ at x = 0, 1

11. Let $\omega = I_1 + iI_2 = (\bar{z})^2 + \frac{1}{z^2}$, $I_1, I_2 \in$ Integers

$$\Rightarrow \quad |\omega| = \sqrt{I_1^2 + I_2^2} = |z|^2 + \frac{1}{|z|^2}$$

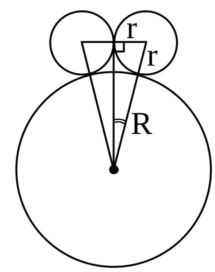
$$\Rightarrow \quad |z|^4 + \frac{1}{|z|^4} = I_1^2 + I_2^2 - 2$$

$$\Rightarrow \quad |z|^8 - \left(I_1^2 + I_2^2 - 2\right)|z|^4 + 1 = 0$$

$$\Rightarrow \quad |z|^4 = \frac{\left(I_1^2 + I_2^2 - 2\right) \pm \sqrt{\left(I_1^2 + I_2^2 - 2\right)^2 - 4}}{2}$$

$$\Rightarrow \quad |z| = \left(\frac{43 \pm 3\sqrt{205}}{2}\right)^{1/4} \text{ where } I_1 = 6,\ I_2 = 3.$$

12. $\sin\left(\frac{2\pi}{2n}\right) = \frac{r}{R+r} \Rightarrow \frac{R+r}{r} = \frac{1}{\sin\left(\frac{\pi}{n}\right)}$



$\frac{R}{r} + 1 = \operatorname{cosec}\frac{\pi}{n} \Rightarrow \frac{R}{r} = \left(\operatorname{cosec}\frac{\pi}{n} - 1\right)$

For n = 4, $\frac{R}{r} = \left(\sqrt{2} - 1\right) \Rightarrow R = r\left(\sqrt{2} - 1\right)$

For n = 8, $\frac{R}{r} > \left(\sqrt{2} - 1\right) \Rightarrow R > \left(\sqrt{2} - 1\right)r$

For n = 5, $\frac{R}{r} = \left(\operatorname{cosec} 36^\circ - 1\right) < 1 \Rightarrow R < r$

For n = 12, $\frac{R}{r} = \left(\operatorname{cosec} 15^\circ - 1\right) \Rightarrow \frac{R}{r} = \left(\sqrt{2}\left(\sqrt{3}+1\right) - 1\right) < \sqrt{2}\left(\sqrt{3}+1\right) \Rightarrow R < \sqrt{2}\left(\sqrt{3}+1\right)r$

13. $\vec{a} \cdot \vec{b} = 0$

$\Rightarrow \quad 3 + b_2 - b_3 = 0$

$\Rightarrow \quad |\vec{b}| = \sqrt{1 + b_2^2 + b_3^2}$

$\Rightarrow \quad |\vec{b}| = \sqrt{2b_2^2 + 6b_2 + 10} = \sqrt{2(b_2)(b_2 + 3) + 10}$

$\Rightarrow \quad |\vec{b}| = \sqrt{2b_2 b_3 + 10}$

$\Rightarrow \quad |\vec{b}| > 10 \qquad (\because b_2 b_3 > 0)$

Also, $\vec{c} \times \vec{b} = \vec{a} - \vec{c}$

$\Rightarrow \quad \vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{c} = 0$

Also, $\vec{a} \cdot \vec{c} = |\vec{c}|^2 \le |\vec{a}||\vec{c}|$

$\Rightarrow \quad |\vec{c}| \le |\vec{a}| \Rightarrow |\vec{c}| \le \sqrt{11}$

If $\vec{a} \cdot \vec{c} = 0 \Rightarrow |\vec{c}| = 0 \Rightarrow \vec{c} = 0 \Rightarrow \vec{a} = 0$ (which is not possible)

14. $\frac{dy}{dx} + 12y = \cos\left(\frac{\pi x}{12}\right)$, y(0) = 0

$$ye^{12x} = \int \cos\left(\frac{\pi x}{12}\right) e^{12x}\, dx$$

$$ye^{12x} = \frac{e^{12x}}{12^2 + \frac{\pi^2}{12^2}}\left[12\cos\left(\frac{\pi x}{12}\right) + \frac{\pi}{12}\sin\left(\frac{\pi x}{12}\right)\right] + c$$

$$\Rightarrow \quad y = \frac{1}{12^2 + \frac{\pi^2}{12^2}} \left[12\cos\left(\frac{\pi x}{12}\right) + \frac{\pi}{12}\sin\left(\frac{\pi x}{12}\right) - 12e^{-12x} \right]$$

15. Required number of ways

= coefficient of x^2 + coefficient of xy + coefficient of y^2 in $(3x + 3x^2 + x^3)^4\,(2y + y^2)^4$

$\Rightarrow$ Required number of ways = $(6 . 3^4) + 4 . 3^3) \times 2^4 + 3^4 \times 6 \times 4 + 3^4 \times 4 \times 8 \times 4$

= 21816

16. $$M = \begin{bmatrix} \frac{5}{2} & \frac{3}{2} \\ -\frac{3}{2} & -\frac{1}{2} \end{bmatrix} = I + \frac{3}{2}\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

$$A^2 = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}, \text{ where } A = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

$$\Rightarrow \quad M^{2022} = \left(I + \frac{3}{2}A\right)^{2022} = I + \frac{3}{2} \times 2022A$$

$$= \begin{bmatrix} 3034 & 3033 \\ -3033 & -3032 \end{bmatrix}$$

17. $$P\left(\frac{W_1}{G_{12}}\right) = \frac{P\left(\frac{W}{G}\right)}{P(G)}$$

$$= \frac{\frac{5}{16}\cdot\frac{6}{32}}{\frac{5}{16}\cdot 1 + \frac{8}{16}\cdot\frac{15}{48} + \frac{3}{16}\cdot\frac{12}{16}} = \frac{15}{80+40+36} = \frac{5}{52}$$

18. $$f(n) = n + \sum_{r=1}^{n} \frac{16r + 9n - 4nr - 3n^2}{4nr + 3n^2}$$

$$= \sum_{r=1}^{n} \frac{16r + 9n}{4nr + 3n^2}$$

$$\lim_{n\to\infty} f(x) = \int_0^1 \frac{16x+9}{4x+3}\,dx$$

$$= \int_0^1 4 - \frac{3}{4x+3}\,dx$$

$$= 4 - \frac{3}{4}\ln\left(\frac{7}{3}\right).$$

PHYSICS

1. **3**

$\vec{F}$ is passing through origin, so torque of $\vec{F}$ is zero.

So $\vec{L}$ of the particle about O is conserved.

So $\overrightarrow{L_O} = \left(\frac{1}{\sqrt{2}}\hat{i} + \sqrt{2}\,\hat{j}\right)\times(1)\left(-\sqrt{2}\,\hat{i} + \sqrt{2}\,\hat{j} + \frac{2}{\pi}\hat{k}\right)$

$$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{1}{\sqrt{2}} & \sqrt{2} & 0 \\ -\sqrt{2} & \sqrt{2} & \frac{2}{\pi} \end{vmatrix}$$

$$= \hat{i}\left(\frac{2\sqrt{2}}{\pi}\right) - \hat{j}\left(\frac{2}{\pi\sqrt{2}}\right) + \hat{k}(1+2)\ \text{kg m}^2\ \text{s}^{-1}$$

$\vec{L}$ at any $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ having velocity $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$

$$\vec{L} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ x & y & z \\ v_x & v_y & v_z \end{vmatrix}$$

$$= \hat{i}\left(yv_z - zv_y\right) - \hat{j}\left(xv_z - zv_x\right) + \hat{k}\left(xv_y - yv_x\right)$$

so $\quad xy_y - yv_x = 3$

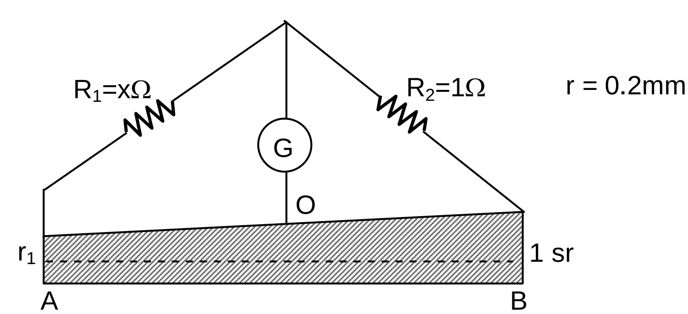
2. **2**

${}^{230}_{90}\text{Th} \rightarrow {}^{214}_{84}\text{P}_0 + 4\,{}^{4}_{2}\text{He} + 2\beta^-$

(from consv. Of mass no and charge)

So $\frac{n_\alpha}{n_\beta} = \frac{4}{2} = 2.$

3. **5**



$$R_{AO} = \int_0^{1/2} \frac{\rho}{\pi}\frac{dx}{(r+4rx)^2} = \frac{2\rho}{3\pi r^2}$$

$$R_{OB} = \int_{1/2}^{1} \frac{\rho}{\pi}\frac{dx}{(r+4r\pi)^2} = \frac{2\rho}{15\pi r^2}$$

$$(x)\frac{2\rho}{15\pi r^2} = (1)\frac{2\rho}{3\pi r^2} \Rightarrow x = 5$$

4. **4**

$[B] = [e]^\alpha [M_e]^\beta [h]^\gamma [K]^\delta$

$[B] = MT^{-2}I^{-1}$

$[e] = I^T$

$[h] = ML^2\,T^{-1}$

$[K] = ML^3\,T^{-4}\,I^{-2}$

$$MT^{-2}I^{-1} = [IT]^{\alpha}[M]^{\beta}[ML^2T^{-1}]^{\gamma}[ML^3T^{-4}I^{-2}]^{\delta}$$

$1 = \beta + \gamma + \delta$ (1)

$-2 = \alpha - \gamma - 4\delta$ (2)

$-1 = \alpha - 2\delta$ (3)

$0 = 2\gamma + 3\delta$ (4)

On solving equation (1), (2), (3) and (4), we get

$\alpha = 3$

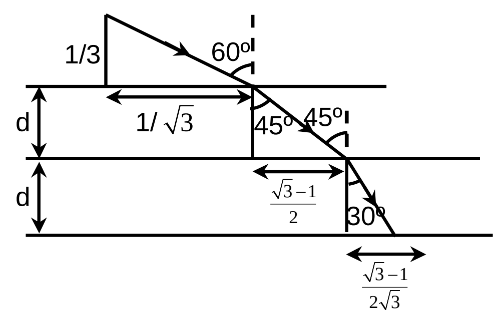
$\gamma = -3$

$\delta = 2$

$\beta = 2$

$\alpha + \beta + \gamma + \delta = 4$

5. **4**



$$1\sin 60^\circ = \frac{\sqrt{3}}{2}r$$

$r = 45^\circ$

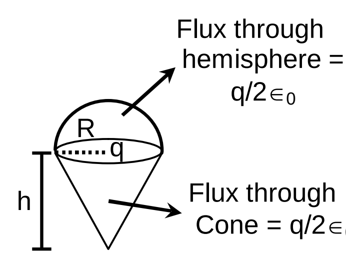
$$\frac{\sqrt{3}}{2}\sin 45^\circ = \sqrt{3}\sin r_2$$

$r_2 = 30^\circ$

$$\left(\frac{1}{\sqrt{3}} + \frac{(\sqrt{3}-1)}{2} + \frac{(\sqrt{3}-1)}{2\sqrt{3}}\right)\times n = \frac{8}{\sqrt{3}}$$

$n = 4$.

6. **3**



Flux through cone = $\dfrac{q}{2\epsilon_0} = \dfrac{nq}{6\epsilon_0}$

$n = 3$

7. **6**

For $\ell > \ell_0$, it oscillates with frequency $\dfrac{1}{2\pi}\sqrt{\dfrac{k_1}{m}}$

And for $\ell < \ell_0$, it oscillates with frequency $\dfrac{1}{2\pi}\sqrt{\dfrac{k_2}{m}}$

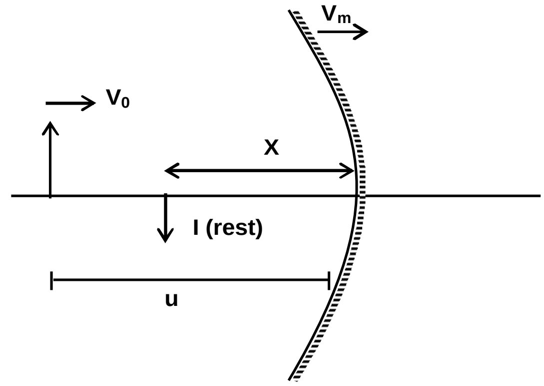
Therefore $T = \pi\sqrt{\dfrac{m}{k_1}} + \pi\sqrt{\dfrac{m}{k_2}}$

$$= \pi\left[\sqrt{\frac{0.1}{0.009}} + \sqrt{\frac{0.1}{0.016}}\right] = \frac{70}{12}\pi \approx 6\pi$$

$6\pi = n\pi$

$n = 6$

8. $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$



$$\frac{1}{-x}+\frac{1}{-30}=\frac{1}{-10}$$

x = 15 cm

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{-x}+\frac{1}{(-u)}=\frac{1}{f}$$

$$\frac{1}{x^2}\frac{dx}{dt}+\frac{1}{u^2}\frac{du}{dt}=0$$

$$\frac{dx}{dt}=-\left(\frac{x}{u}\right)^2\frac{du}{dt}$$

$$(v_m-0)=-\left(\frac{15}{30}\right)^2[v_m-v_0]$$

$$v_m=-\frac{1}{4}[v_m-15]$$

$$4v_m+v_m=15$$

$$v_m=3\text{ cm/s}.$$

9. for $r\in[0,1]$; $\rho=kr$

for $r\in[1, r_B]$; $\rho=\frac{2k}{r}$

total charge of the configuration is q

$$q=\int_0^1(kr)4\pi r^2\ dr+\int_1^{r_B}\frac{2k}{r}4\pi r^2\ dr$$

$$q=k\pi+4k\pi\left(r_B^2-1\right)$$

For $r_B=\sqrt{\frac{3}{2}}$; $q=k\pi+2k\pi=3k\pi$

Electric field just outside B is $E=\frac{1}{4\pi\in_0}\frac{(3\pi k)}{r_B^2}=\frac{k}{2\in_0}$

For $r_B=\frac{3}{2}$; $q=k\pi+5\pi k=6k\pi$

Potential just outside B is $v=\frac{(6\pi k)}{4\pi\in_0\left(\frac{3}{2}\right)}=\frac{k}{\in_0}$

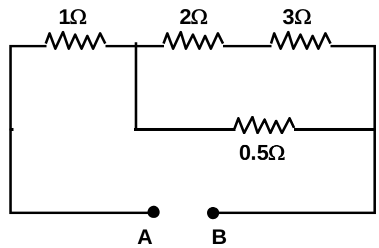
For $r_B=2$; $q=k\pi+12k\pi=13k\pi$

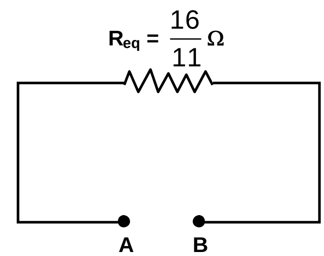
For $r_B=\frac{5}{2}$; $q=k\pi+21k\pi=22\pi k$

Mag. of E just outside B is $\frac{1}{4\pi\in_0}\frac{(22\pi k)}{\left(\frac{25}{4}\right)}=\frac{22}{25}\frac{k}{\in_0}$.

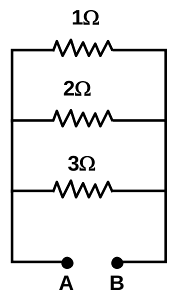
10. **A, B, C**

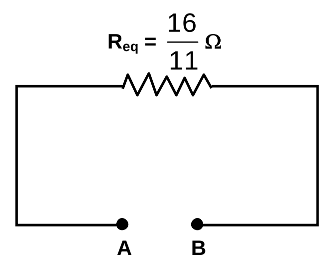
(1)





(2)





If 6_V voltage source connected to both circuit

$P \propto \frac{1}{R}$ voltage constant

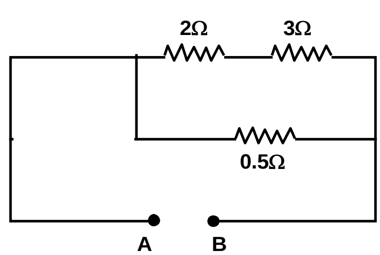
$R_1 > R_2$ $\quad P_1 < P_2$

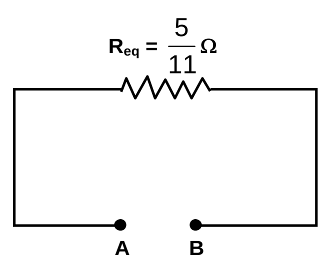
If 2 Amp current source connected

$P \propto R$

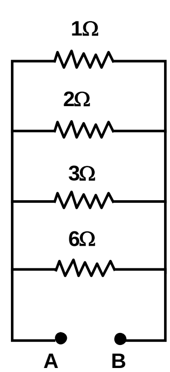
$P_1 > P_2$

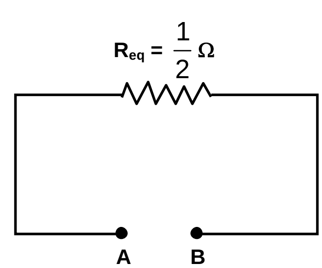
(1)





(2)





$$P_1 = \frac{6^2}{\left(\frac{16}{11}\right)} \qquad Q_1 = \frac{6^2}{\left(\frac{5}{11}\right)}$$

$Q_1 > P_1$

$P = i^2R \quad R_2 > R_1 \quad \therefore \quad Q_2 > Q_1$

11. **C, D**

(Conducting)

Isothermal process T = constant

PV = constant

$P_1V_1 = P_2V_2$

$$\left(P_1 + \frac{4T}{R_1}\right)\frac{4}{3}\pi R_1^3 = \left(P_2 + \frac{4T}{R_2}\right)\frac{4}{3}\pi R_2^3$$

$$\left(\frac{R_1}{R_2}\right)^3 = \frac{P_2 + \frac{4T}{R_2}}{P_1 + \frac{4T}{R_1}}$$

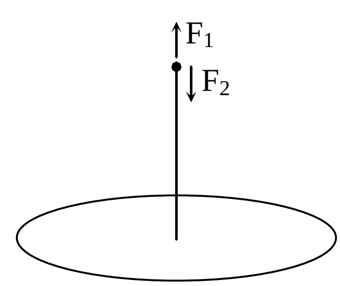
adiabatic process PV^r = constant $PT^{-5/2}$ = const.

(Insulating)

$$\frac{P_1^1}{P_2^1} = \left(\frac{T_2}{T_1}\right)^{5/2}$$

$$\left(\frac{T_2}{T_1}\right)^{5/2} = \left(\frac{P_1 + \frac{4T}{R_1}}{P_2 + \frac{4T}{R_2}}\right)$$

12. **A, C, D**



$$\vec{F}_1 = \frac{q\sigma}{2\epsilon_0}\left(1 - \frac{Z}{\sqrt{R^2 + Z^2}}\right)\hat{k}$$

$$\vec{F}_2 = -c\hat{k}$$

$$\beta = \frac{1}{4} \quad \therefore \quad \frac{1}{4} = \frac{2c\varepsilon_0}{q\sigma} \text{ (Given)}$$

$$\frac{q\sigma}{2\varepsilon_0} = 4c \qquad \text{..... (1)}$$

For equilibrium at $z = Z_0$

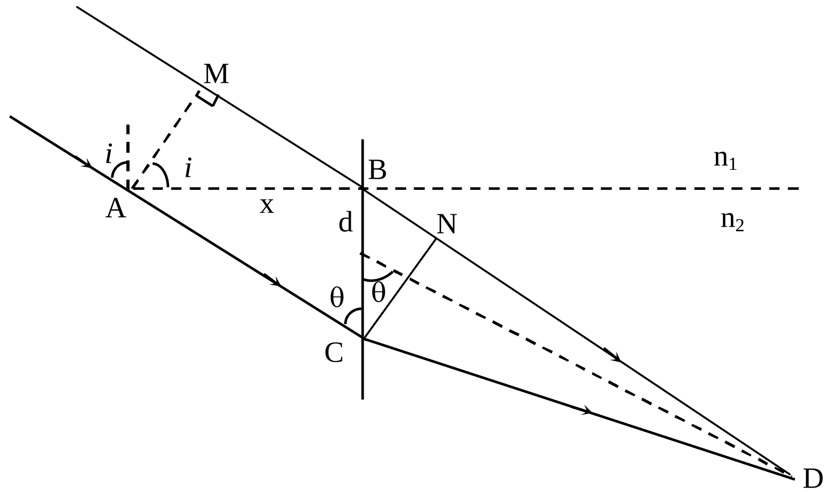
$$F_1 = F_2 \Rightarrow \frac{q\sigma}{2\varepsilon_0}\left(1 - \frac{Z}{\sqrt{R^2 + Z^2}}\right) = c \text{ from equation (1)}$$

$$\Rightarrow \left(1 - \frac{Z}{\sqrt{R^2 + Z^2}}\right) = \frac{1}{4} \Rightarrow \frac{Z}{\sqrt{R^2 + Z^2}} = \frac{3}{4} \Rightarrow Z = \sqrt{\frac{9}{7}R} \simeq 1.13R$$

$Z > 1.13R$; $F_2 > F_1$ Particle reaches origin

$Z < 1.13\ R$; $F_1 > F_2$ Particle reaches back to $z = Z_0$

13. **A, B**



Path difference

$\Delta r = (MB + BN) - AC$

$\Delta r = (n_1 x \sin i + n_2 d \cos\theta) - \frac{n_2 d}{\cos\theta}$

$\Delta r = n_1 (d \tan\theta)\frac{n_2}{n_1}\sin\theta + n_2 d\cos\theta - \frac{n_2 d}{\cos\theta}$ $(\because\ x = d\tan\theta\ ;\ n_1 \sin i = n_2 \sin\theta)$

$\Delta r = \frac{n_2 d \sin^2\theta}{\cos\theta} + n_2 d\cos\theta - \frac{n_2 d}{\cos\theta}$

$\Delta r = \frac{n_2 d\left[\sin^2\theta + \cos^2\theta - 1\right]}{\cos\theta} = 0$

14. **B, C, D**

Volume of gas at B is

$$V_B = \left(\frac{100}{300}\right)^{3/5}(0.8) = 0.4\ m^3$$

$W_{AB} = \frac{P_A V_A - P_B V_B}{\gamma - 1} = -60\ kJ$

$W_{BC} = P_B V_B \ln 2 = 84\ kJ$

$W_{CA} = 0$

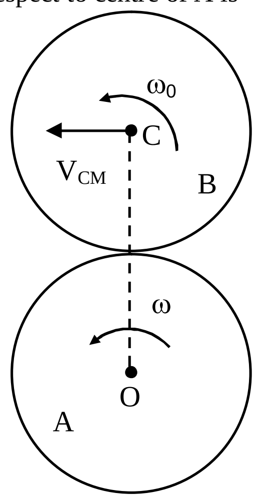
15. **B**

$V_{CM} = 2R\omega$

At point of contact

$V_{CM} = \omega_0 R \Rightarrow \omega_0 = 2\omega$

Angular momentum of disk B with respect to centre of A is



$$L = \left(\frac{MR^2}{2}\right)(\omega_0) + M(2R\omega)(2R)$$

$$= \left(\frac{MR^2}{2}\right)(2\omega) + 4MR^2\omega$$

$L = 5MR^2\omega \therefore n = 5.$

16. **A**

$$6e = \frac{hc}{\lambda} - \phi_0$$

$$0.6e = \frac{hc}{4\lambda} - \phi_0$$

Solving the above 2 equations, we get (A)

17. **None**

$$L.C. = \frac{0.5}{100} = .005\,\text{mm}$$

I $4 \times 0.25 + (20 - 4) \times .005 \rightarrow 1.08$ mm

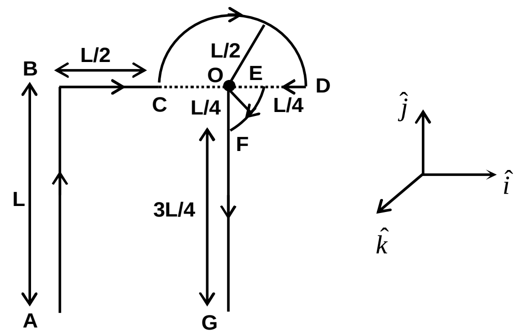
II $4 \times 0.25 + (16 - 4) \times .005 \rightarrow 1.06$ mm

$$d_m = \frac{1.06 + 1.08}{2} = 1.07$$

$$\Delta d_m = \frac{.01 + .01}{2} = .01$$

$d = (1.07 \pm .01)$ mm.

18. **C**



$$\vec{B}_{Net} = \vec{B}_{AB} + \vec{B}_{BC} + \vec{B}_{CD} + \vec{B}_{DE} + \vec{B}_{EF} + \vec{B}_{FG}$$

$$\vec{B}_{AB} = \vec{B}_{DE} = \vec{B}_{FG} = 0$$

$$\vec{B}_{AB} = \frac{\mu_0 I}{4\pi L}\sin 45°\left[-\hat{k}\right]$$

$$\vec{B}_{CD} = \frac{\mu_0 I}{4\left(\frac{L}{2}\right)}\left[-\hat{k}\right]$$

$$\vec{B}_{EF} = \frac{\mu_0 I}{8\left(\frac{L}{4}\right)}\left[-\hat{k}\right] \Rightarrow \text{(C)}$$

CHEMISTRY

1. $\underset{1}{H_2SO_4} \longrightarrow \underset{1}{H^+} + \underset{1}{HSO_4^-}$

$Na_2SO_4 \longrightarrow 2Na^+ + SO_4^{2-}$

$0 \quad\quad 0.036 \quad 0.018$

$HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$

$1 \quad\quad 1 \quad 0.018 \quad (Q > K_C$ so the reaction will go in backward direction$)$

$(1+a) \quad (1-a) \; (0.018-a)$

$\approx 1 \quad\quad \approx 1$

Now, $0.012 = \frac{1\times(0.018-a)}{1}$

$a = 0.006$

$[SO_4^{2-}] = 0.018 - 0.006 = 1.2\times10^{-2}$ M

$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$

$s \quad\quad (0.012+s) \approx 0.012$

$s = \frac{1.6\times10^{-8}}{0.012} = 1.33\times10^{-6}$

$\therefore y = 6$

2. $\frac{P^o - P_s}{P^o} = iX_B$

$\frac{60-59.724}{60} = i\times\frac{0.1}{0.1+100}$

$\frac{0.276}{60} = i\times\frac{0.1}{100.1} = i\times\frac{1}{1000}$

$i = \frac{276}{60} = 4.6$

$i = 1+(n-1)\alpha$

$4.6 = 1+(n-1)0.9$

$n = 5$

3. Let λ_m^0 the molar conductance by Z_mX_n

From the graph

$339 = \lambda_m^0 - b\sqrt{c}$

$339 = \lambda_m^0 - b\times0.01 \quad ...(1)$

$336 = \lambda_m^0 - b\times0.04 \quad ...(2)$

On solving, we get, $\lambda_m^0 = 340$

Now, $25m + 100p = 250 \quad ...(3)$

$100m + 80n = 440 \quad ...(4)$

$50m + 80n = 340 \quad ...(5)$

On solving (3), (4) and (5)

We get, m = 2, n =3, p = 2

4. $Xe + O_2F_2 \longrightarrow \underset{(P)}{XeF_2} + O_2$

$2\underset{(P)}{XeF_2} + 2H_2O \longrightarrow 2Xe + 4HF + O_2$

Per mol of P, 2 moles of HF will be formed.

5. $AgNO_3 \longrightarrow Ag + NO_2 \uparrow + \frac{1}{2}O_2 \uparrow$

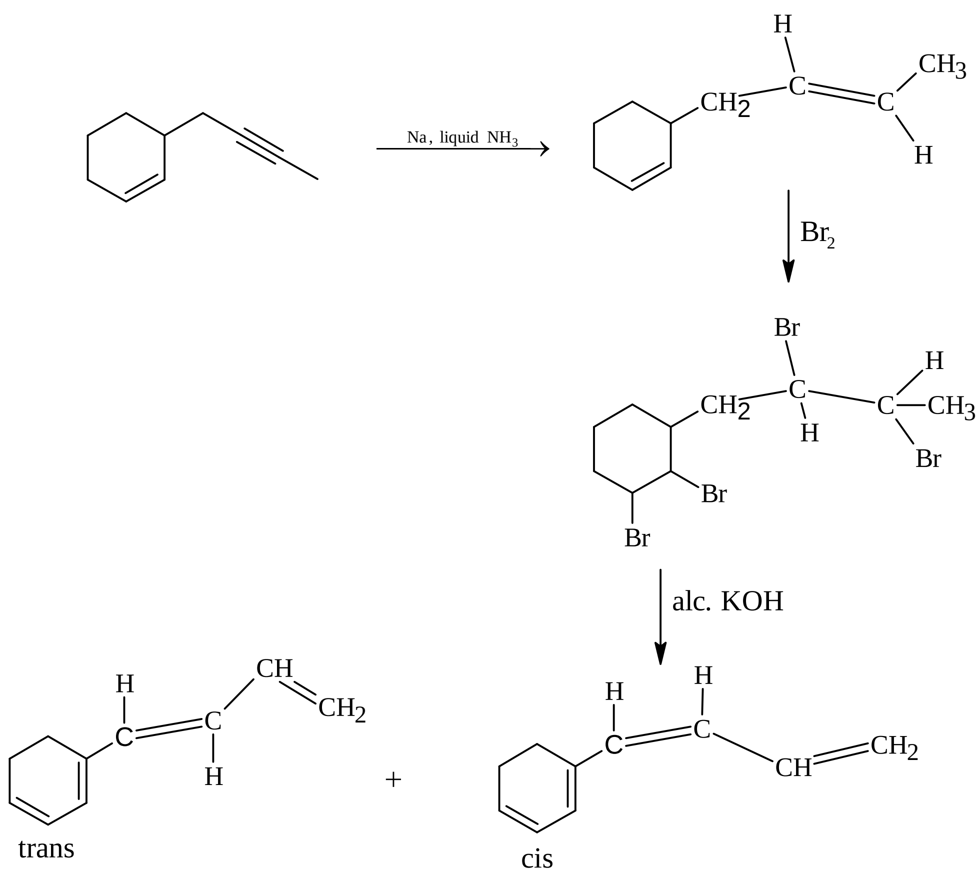
$NO_2 \longrightarrow$ One unpaired electron

$O_2 \longrightarrow$ Two unpaired electrons

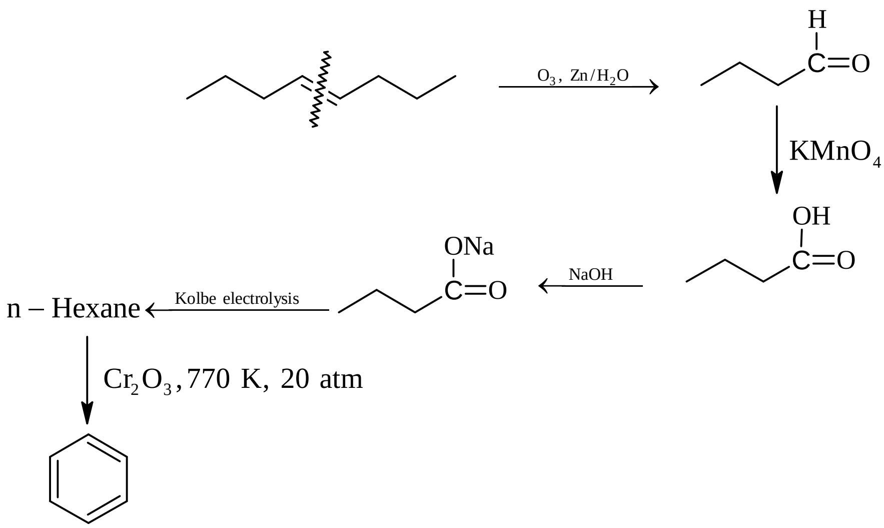
$\sigma 1s^2 < \sigma 1s^{*2} < \sigma 2s^2 < \sigma 2s^{*2} < \sigma 2p_z{}^2 < \pi 2p_x{}^2 = \pi 2p_y{}^2 < \pi 2p_x^{*1} = \pi 2p_y^{*1}$

Number of antibonding electron in $O_2 = 6$.

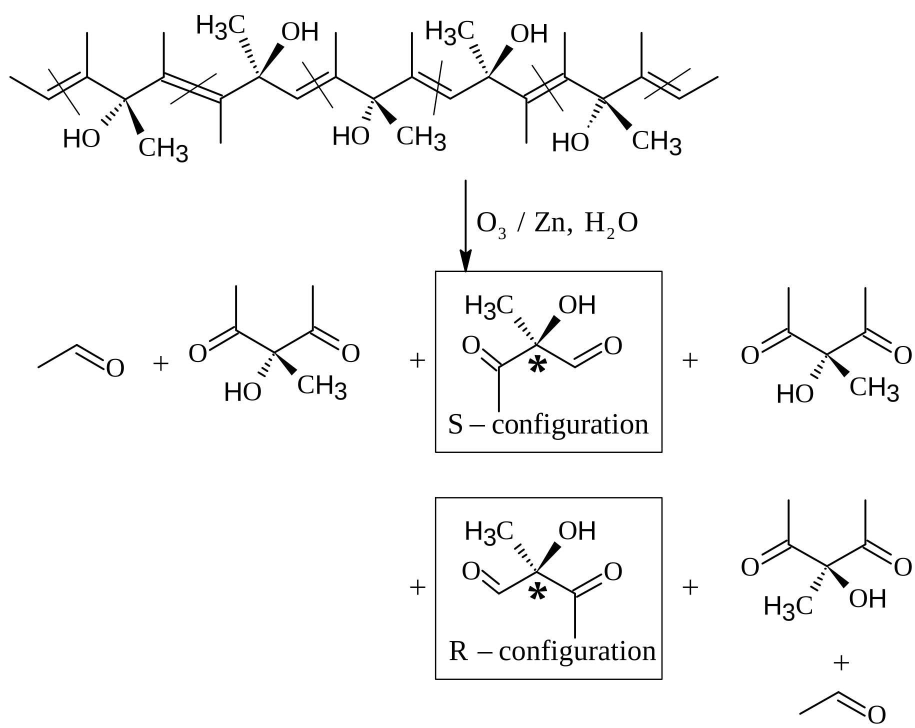
6.



7.



8.



Only 2-chiral molecules are formed.

9. As per the law of multiple proporation, if P and Q form two or more compounds, then the ratio of the masses of one of the element (P) that combines with fix mass of Q bear a simple whole number ratio.
Now

Compound	% of P	% of Q
1	50	50
2	44.4	55.6
3	40	60

OR

Compound	% of P	% of Q
1	50	50
2	40	50
3	33.33	50

(A) Given that formula of compound 3 is P_3Q_4 and that of compound 2 is P_3Q_5
Then compound 3 $\Rightarrow P_{15/4}\ Q_5$
Compound 2$\Rightarrow P_3\ Q_5$
So, ratio of masses of P in 3 and 2 which combines with fixed mass of
$Q = \frac{15}{4} : 3 = \frac{5}{4}$
But from table 2, ratio of masses of P in 3 and 2 $= \frac{33.33}{40} = \frac{5}{6}$
Since two ratio are not same, so option (A) is incorrect.

(B) Empirical formula of compound

P	$\frac{40}{20} = 2$	$\frac{3}{2}$
Q	$\frac{60}{45} = \frac{4}{3}$	1

So, empirical formula of compound 3 is P_3Q_2
(C) Compound 2$\Rightarrow$ PQ or P_4Q_4
Compound 3 $\Rightarrow P_5Q_4$
So, ratio of masses of P in 2 and 3 which combines with fix mass of Q is = 4 : 5 which resembles table 2.
(D) Empirical form of compound should be PQ_2 and not P_2Q

10. (A) $\Delta S = nF\left(\frac{\partial E_{cell}}{\partial T}\right)$

$= nF\times\frac{R}{F} = nR = 2R\ (\because n = 2)$

Incorrect statement.
(B) E_{cell} for the given cell is +ve.
$\therefore \Delta G = -ve$
Since, $\Delta S = nF\left(\frac{\partial E_{cell}}{\partial T}\right)$
$\therefore \Delta S = +ve$
Correct statement.
(C) Correct statement because racemisation involves formation of a racemic mixture.
(D) Correct statement because number of particles are increasing.

11. $\underset{}{B_2H_6} + \underset{(\text{excess})}{NH_3} \xrightarrow{\text{High temperature}} (BN)_x$

$B_2O_3 + NH_3 \xrightarrow{\Delta} B_2O_3.2NH_3 \xrightarrow{\Delta} (BN)_x + H_2O$

$2B + 2NH_3 \xrightarrow{\text{High temperature}} 2BN + 3H_2$

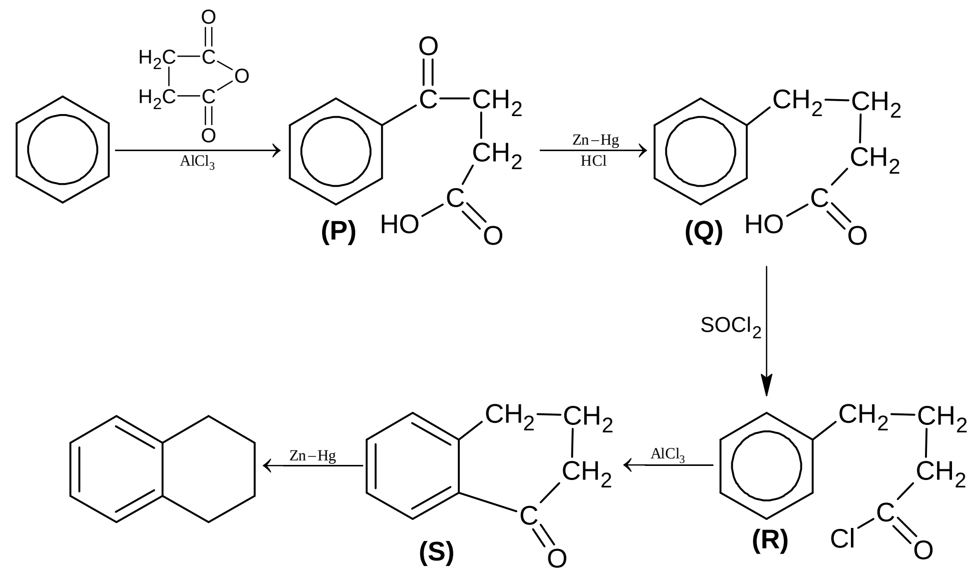
Since, Boron is not a compound, so option (A) is not correct.

12. (i) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2 \uparrow$

$\underset{\text{Gangue}}{SiO_2} + \underset{\text{Flux}}{CaO} \longrightarrow \underset{\text{Slag}}{CaSiO_3} \downarrow$

(ii) Pig iron contains 4% of carbon.
(iii) $C(s) + CO_2(g) \longrightarrow 2CO(g)$

13.



14. (i) Polymerization of chloroprene gives synthetic rubber.
(ii) PVC is thermoplastic polymer.
(iii) Ethene at 350 – 570 K temperature and 1000 – 2000 atm pressure in presence of peroxide initor yields low density polythene.

15. $X = 8\times\frac{1}{8} + 6\times\frac{1}{2} + \frac{1}{2}\times 8$

$= 1 + 3 + 4 = 8$

$2r = \frac{\sqrt{3}}{4}a;$

$r = \frac{\sqrt{3}}{8}a$

$$\text{Packing fraction } = \frac{\text{number of atoms} \times \text{volume of one atom}}{\text{volume of unit cell}} \times 100\%$$

$$= \frac{8\times\frac{4}{3}\times 3.14\times\left(\frac{\sqrt{3}}{8}a\right)^3}{a^3}\times 100\%$$

$= 35\%$

16. $ClO_3^- + Cl^- \longrightarrow ClO_2$

$2ClO_2 + 2O_3 \longrightarrow Cl_2O_6 + 2O_2$

17. $Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2 \downarrow$

$PbCl_2 + 2HCl \longrightarrow [PbCl_4]^{-2}$

18. Lobry-de-Bruyn-Van Ekenstin rearrangement]