Solution

CHEMISTRY

Class 12 - Chemistry

Section A

1. Select and write the correct answer:

(i) **(a)** A_3B

Explanation: {

As 'A' ions are present at the face centres of the 6 faces of the cube, the number of ions of 'A' in the unit cell $= \frac{1}{2} \times 6 = 3$

As 'B' is present at the 8 corners of the cube, number of ions of B in the unit cell $= \frac{1}{8} \times 8 = 1$

$\therefore$ Ratio of atoms $A : B = 3 : 1$.

The formula of the compound is A_3B.

(ii) **(c)** 3

Explanation: {

$pH = -\log_{10}\left[H_3O^+\right]$

$= -\log_{10}\left[1 \times 10^{-3}\right] = 3$

(iii) **(b)** $2NH_{3(\,g)} \xrightarrow{Pt} N_{2(\,g)} + 3H_{2(\,g)}$

Explanation: {

Decomposition of ammonia in the presence of Pt catalyst is an example of zero order reaction.

(iv) **(d)** CO

Explanation: {

Fe_2O_3 is reduced to spongy iron by CO.

$Fe_2O_3 + 3CO \xrightarrow{900\ K} 2Fe + 3CO_2$

(v) **(b)** potassium hexacyanoferrate

Explanation: {

potassium hexacyanoferrate

(vi) **(d)** alkyl halide

Explanation: {

alkyl halide

(vii) **(c)** $CH_3 - CH = CH - CH_2 - CH_2 - OH$

Explanation: {

$CH_3 - CH = CH - CH_2 - CH_2 - OH$

(viii) **(a)** 10

Explanation: {

Each of five hydroxyl groups are bonded to five different carbon atoms in glucose molecule reacts with acetic anhydride. So, 1 mole of glucose requires 5 moles of acetic anhydride.

Hence, 2 moles of glucose (2 moles $= 2M$, assuming volume is 1 L) requires 10 moles of acetic anhydride.

(ix) **(c)** silver

Explanation: {

silver

(x) **(d)** acid anhydrides

Explanation: {

acid anhydrides

2. Answer the following:

(i) Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales where properties differ significantly from those at a larger scale.

(ii) Hinsberg's reagent is: $C_6H_5SO_2Cl$

(iii) The product formed when alkyl halide $(R - X)$ reacts with silver nitrite $(AgNO_2)$ is nitroalkane $(R - NO_2)$.

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(iv) Selenium reacts with magnesium metal to form magnesium selenide.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Selenium}}{Se} \rightarrow \underset{\text{Magnesium selenide}}{MgSe}$$

(v) The complex $[Cu(NH_3)_4]\,[PtCl_4]$ and $[Pt(NH_3)_4]\,[CuCl_4]$ exhibit coordination isomerism.

(vi) The freezing point of a liquid is the temperature at which liquid and solid are in equilibrium and the two phases have the same vapour pressure.

(vii) A property which depends on the amount of matter present in a system is called an **extensive property**.

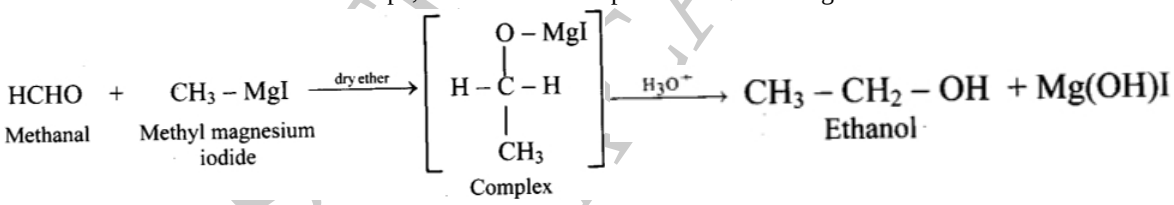
(viii) Net cell reaction during discharge:

$$Pb_{(s)} + PbO_{2(s)} + 4H^+_{(aq)} + 2SO^{2-}_{4(aq)} \longrightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$$

OR

$$Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \longrightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$$

Section B

3. i. When small atoms like hydrogen, carbon or nitrogen are trapped in the interstitial spaces within the crystal lattice, the compounds formed are called **interstitial compounds**.
   Steel and cast iron are examples of interstitial compounds of carbon and iron.
   ii. Alloys are classified as ferrous and nonferrous alloys.
      a. Ferrous alloys have atoms of other elements distributed randomly in atoms of iron in the mixture. As percentage of iron is more, they are termed ferrous alloys.
      e.g. Nickel steel, chromium steel, stainless steel etc. All steels have 2% carbon.
      b. Nonferrous alloys are formed by mixing atoms of transition metal other than iron with a non-transition element.
      e.g. Brass, which is an alloy of copper and zinc.
4. i. **van't Hoff factor** (i) is defined as the ratio of colligative property of a solution of electrolyte divided by the colligative property of nonelectrolyte solution of the same concentration.
   ii. The van't Hoff factor is related to degree of ionization as follows:
   $i = 1 + \alpha(n-1)$
   or $\alpha = \frac{i-1}{n-1}$
   where, $\alpha =$ Degree of ionization/dissociation
   $i =$ van't Hoff factor
   $n =$ Moles of ions obtained from ionization of 1 mole of electrolyte.
5. Nanochemistry is the combination of chemistry and nanoscience which deals with designing and synthesis of materials of nanoscale with different size and shape, structure and composition and their organization into functional architectures.
6. 

7. Conversion of 2-bromobutane into unsaturated hydrocarbon by using alcoholic KOH:

$$\underset{2-Bromobutane}{H_3C - \underset{\underset{Br}{|}}{CH} - CH_2 - CH_3} \xrightarrow[\triangle,\ -HBr]{alc.KOH} \underset{But-2-ene\ (80\%)}{H_3C - CH = CH - CH_3} + \underset{But-1-ene\ (20\%)}{CH_3 - CH_2 - CH = CH_2}$$

8. **Limitations of Arrhenius theory:**
   i. Arrhenius theory accounts for properties of different acids and bases but is applicable only to aqueous solutions.
   ii. It does not account for the basicity of compounds such as NH_3 and Na_2CO_3 which do not have OH group.
9. Nitroethane on reduction in presence of Sn/HCl or $LiAlH_4$ in ether yields ethanamine (or ethylamine).

$$\underset{\text{Nitroethane}}{CH_3 - CH_2 - NO_2} \xrightarrow{LiAlH_4/\text{ether}} \underset{\text{Ethanamine}}{CH_3 - CH_2 - NH_2}$$

10. Calculation:
    i. $\Delta G = \Delta H - T\Delta S$
    $\Delta H = -110\ kJ$
    $\Delta S = +40 JK^{-1} = 40 \times 10^{-3}\ kJ\ K^{-1}$
    $T = 400\ K$
    $\therefore \Delta G = -110\ kJ - \left(400\ K \times 40 \times 10^{-3}\ kJ\ K^{-1}\right) = -110\ kJ - 16\ kJ$

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$= -126\ kJ$

As ΔG is negative, the reaction is **spontaneous**.

As ΔH is negative, the reaction is **exothermic**.

11. i. The optical isomers differ from each other in terms of a measurable property called optical activity.

    ii. Glucose contains 4 chiral carbon atoms. Hence, the number of optical isomers is $2^n = 2^4 = 16$.

12. i. a. **Extensive property:** A property which depends on the amount of matter present in a system is called an **extensive property**.

    b. **Intensive property:** A property which is independent of the amount of matter in a system is called **intensive property.**

    ii. a. **Isobaric process** is a process in which pressure remains constant during the transformation.

    b. **Adiabatic process** is a process in which there is no exchange of heat between system and surroundings.

13. $$\underset{\text{Tetrafluoroethylene}}{n\ CF_2 = CF_2} \xrightarrow[\text{Peroxide}]{\text{Polymerization}} \underset{\text{Teflon}}{\left[CF_2 - CF_2\right]_n}$$

14. i. **Magnetic property:** Oxygen is paramagnetic while others are diamagnetic.

    ii. **Oxidation state:** Oxygen shows $-2, -1$, and +2 oxidation states while other elements show -2, $+2, +4, +6$ oxidation states. Oxygen cannot exhibit higher oxidation state due to absence of vacant d orbitals.

    iii. **Hydrides:** Hydride of oxygen (H_2O) is liquid at room temperature while hydrides of other members of the group are gases.

Section C

15. i. The boiling point elevation is directly proportional to the molality of the solution. Thus,

    $\Delta T_b = K_b m$ ...(1)

    ii. Suppose we prepare a solution by dissolving $W_2\ g$ of solute in $W_1 g$ of solvent.

    Moles of solute in $W_1\ g$ of solvent $= \frac{W_2}{M_2}$

    where, M_2 is the molar mass of solute.

    Mass of solvent $= W_1\ g = \frac{W_1\ g}{1000\ g/kg} = \frac{W_1}{1000}\ kg$

    iii. The molality is expressed as,

    $$m = \frac{\text{Moles of solute}}{\text{Mass of solvent in } kg}$$

    $$m = \frac{W_2/M_2\ mol}{W_1/1000\ kg}$$

    $$m = \frac{1000\ W_2}{M_2\ W_1}\ mol\ kg^{-1} \quad ...(2)$$

    iv. Substituting equation (2) in equation (1), we get,

    $$\Delta T_b = \frac{1000\ K_b W_2}{M_2\ W_1}$$

    Hence, $M_2 = \frac{1000\ K_b W_2}{\Delta\ T_b W_1}$

16. i. A face-centred cubic (fcc) unit cell has particles (atoms) at the eight corners plus particles (atoms) at the centre of its six faces.

    ii. Each particle present at the corner of a given unit cell is shared with seven other neighbouring unit cells. As a result, its contribution to the given unit cell is only $\frac{1}{8}$.

    Thus, the number of atoms present at corners per unit cell $= 8$ corner atoms $\times \frac{1}{8}$ atom per unit cell $= 1$

    iii. Each particle at the centre of the six faces is shared with one neighbouring cube. Thus, $\frac{1}{2}$ of each face particle belongs to the given unit cell.

    Thus, the number of atoms present at faces per unit cell = 6 atoms at the faces $\times \frac{1}{2}$ atom per unit cell = 3

    Therefore, the total number of atoms per unit cell $= 1 + 3 = 4$

    Thus, fcc unit cell has total of 4 atoms per unit cell.

17. Given: Current $(I) = 5\ A, t = 6000$ seconds, Molar mass of $Cu = 63.5\ g\ mol^{-1}$

    To find: Mass o fCu metal produced at cathode (W)

    i. Mole ratio $= \frac{\text{Moles of product formed in half reaction}}{\text{Moles of electrons required in half reaction}}$

    ii. $W = \frac{I(A) \times t(s)}{96500(C/mole^-)} \times$ mole ratio $\times$molar mass

    Calculation:

    i. Stoichiometry for the formation of Cu is $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$

    Hence,

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Mole ratio $= \frac{1\,mol}{2\,mole^-}$

ii. Mass of Cu formed,

$W = \frac{I(\,A) \times t(\,s)}{96500(C/mole^-)} \times$ mole ratio $\times$ molar mass of Cu

$= \frac{5\,A \times 6000\,s}{96500(C/mole^-)} \times \frac{1\text{ mol}}{2\text{ mol }e^-} \times 63.5\,g = 9.87\,g$

Mass of copper deposited at cathode is 9.87 g.

18. i. $\underset{\text{Ethyl bromide}}{CH_3 - CH_2 - Br} + \underset{\text{Silver nitrite}}{Ag - O - N = O} \rightarrow \underset{\text{Nitroethane}}{CH_3 - CH_2 - NO_2} + AgBr\downarrow$

ii. Ethyl bromide yields ethyl magnesium bromide on treatment with magnesium metal in dry ether.

$\underset{\text{Ethyl bromide}}{CH_3CH_2 - Br} + Mg \xrightarrow{\text{dry ether}} \underset{\text{Ethyl magnesium bromide}}{CH_3CH_2 - Mg - Br}$

iii. $\underset{\text{Ethyl bromide}}{CH_3 - CH_2Br} + \underset{\text{(alc.)}}{NaOH} \xrightarrow{\Delta} CH_2 = CH_2 + NaBr + H_2O$

19. Given: $\Delta_r H^\circ = -104\,kJ, \Delta H^\circ(C-H) = 414\,kJ\,mol^{-1}$

$\Delta H^\circ(Cl-Cl) = 243\,kJ\,mol^{-1}, \Delta H^\circ(H-Cl) = 431\,kJ\,mol^{-1}$

To find: $C-Cl$ bond enthalpy, $\Delta H^\circ(C-Cl)$

Formula: $\Delta_r H^\circ = \Sigma\Delta H^\circ$ (reactant bonds) $-\Sigma\Delta H^\circ$ (product bonds)

Calculation: $\Delta_r H^\circ = \Sigma\Delta H^\circ$ (reactant bonds) $-\Sigma\Delta H^\circ$ (product bonds)

$= [3\Delta H^\circ(C-H) + \Delta H^\circ(C-Cl) + \Delta H^\circ(Cl-Cl)] - 2\Delta H^\circ(C-H) + 2\Delta H^\circ(C-Cl) + \Delta H^\circ(H-Cl)]$

$= \Delta H^\circ(C-H) + \Delta H^\circ(Cl-Cl) - \Delta H^\circ(C-Cl) - \Delta H^\circ(H-Cl)$

$\therefore -104\,kJ = 1\,mol \times \left(414\,kJ\,mol^{-1}\right) + 1\,mol \times \left(243\,kJ\,mol^{-1}\right) - \Delta H^\circ(C-Cl) - 1\,mol \times \left(431\,kJ\,mol^{-1}\right)$

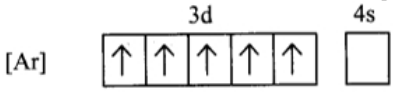
$\therefore -104\,kJ = 226\,kJ - \Delta H^\circ(C-Cl)$

$\therefore \Delta H^\circ(C-Cl) = 2266\,kJ + 104\,kJ$

$\therefore \Delta H^\circ(C-Cl) = 330kJ\,mol^1$

$C-Cl$ bond enthalpy is $330kJ\,mol^{-1}$.

20. i. For element with atomic number 25, the condensed electronic configuration for its divalent cation will be



There are 5 unpaired electrons, so $n = 5$.

$\therefore \mu = \sqrt{5(5+2)} = 5.92$ **BM**

$\therefore$ Spin only magnetic moment of the given ion is **5.92 BM**.

ii. a. Condensed electronic configurations of Ti^{4+} is: $[Ar]3\,d^0$

b. Ti^{4+} ion has completely empty d-orbitals i.e., no unpaired electrons are present. Thus, salts of Ti^{4+} are colourless, as d-d transitions are not possible.

21. Given: pH of solution $= 3.12$

To find: Concentration of H_3O^+ion

Formula: $pH = -\log_{10}\left[H_3O^+\right]$

Calculation: From formula,

$pH = -\log_{10}[H_3O^+]$

$\log_{10}\left[H_3O^+\right] = -pH$

$= -3.12$

$= -3 - 0.12 + 1 - 1$

$= (-3-1) + 1 - 0.12$

$= -4 + 0.88$

$= -4.88$

Thus,

$\left[H_3O^+\right] =$ Antilog $_{10}[\bar{-}.88]$

$= 7.586 \times 10^{-4}M$

The concentration of $H_3O^+$is $7.586 \times 10^{-4}M$.

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22. **Monodentate ligands:** A monodentate ligand is the one where a single donor atom shares an electron pair to form a coordinate bond with the central metal ion.
e.g. Cl^-, OH^-, CN, etc.
Ambidentate ligands: The ligands which have two donor atoms and use the electron pair of either donor atoms to form a coordinate bond with the metal ion are called ambidentate ligands.
e.g. SCN^- has two donor atoms nitrogen and sulphur either of which links to metal $M \leftarrow SCN^-$ or $M \leftarrow NCS^-$

23. i. The integrated rate law for the first order reaction is $k = \frac{2.303}{t}\log_{10}\frac{[A]_0}{[A]_t}$
where, $[A]_0$ is the initial concentration of reactant at $t = 0$. It falls to $[A]_t$ at time t after the start of the reaction.
ii. The time required for $[A]_0$ to become $\frac{[A]_0}{2}$ is denoted as $t_{\frac{1}{2}}$ or $[A]_t = \frac{[A]_0}{2}$ at $t = t_{\frac{1}{2}}$
Putting this condition in the integrated rate law we write
$k = \frac{2.303}{t_{\frac{1}{2}}}\log_{10}\frac{[A]_t}{[A]_0/2} = \frac{2.303}{t_{\frac{1}{2}}}\log_{10} 2$
Substituting value of $\log_{10} 2$,
$k = \frac{2.303}{t_{\frac{1}{2}}} \times 0.3010$
$\therefore k = \frac{0.693}{t_{\frac{1}{2}}}$
$\therefore t_{\frac{1}{2}} = \frac{0.693}{k}$
Thus, the half life of the first order reaction is independent of initial reactant concentration.

24. There are four isomeric aldehydes having molecular formula $C_5H_{10}O$.

i. $CH_3 - CH_2 - CH_2 - CH_2 - CHO$
Pentanal
(n-valeraldehyde)

ii. $CH_3 - CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CHO$
2-Methylbutanal
(α-methyl butyraldehyde)

iii. $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CH_2 - CHO$
3-Methylbutanal
(β-methylbutyraldehyde)

iv. $CH_3 - \underset{\displaystyle CH_3}{\underset{|}{\overset{\displaystyle CH_3}{\overset{|}{C}}}} - CHO$
2,2-Dimethylpropanal
(α,α′-dimethylpropionaldehyde)

25. Ozone bleaches in absence of moisture.
$O_3 \longrightarrow [O] + O_2$
Coloured matter $+[O] \longrightarrow$ Colourless matter
So, bleaching action of ozone is also called dry bleach.

26. Answer the following:
(i) i. $HOOC - CH_2 - CH_2 - CH_2 - COOH$
Adipic acid
$(Hexane-1,6-dioic\ acid)$

ii. $CH_3 - CH_2 - \underset{\displaystyle CH_3}{\underset{|}{CH}} - CHO$
2-Methylbutanal
(α-methyl butyraldehyde)

(ii) **Ethanamine from methyl cyanide:**
Methyl cyanide on Mendius reduction gives ethanamine.

ACADEMY

$$\underset{\text{Methyl cyanide}}{CH_3 - C \equiv N} + 4[H] \xrightarrow{\text{Na/Ethanol}} \underset{\text{Ethanamine}}{CH_3 - CH_2 - NH_2}$$

Section D

27. Answer the following:

(i) The overall reaction is obtained by adding the two elementary steps of the mechanism.

Thus,

$NO_{2(g)} + F_{2(g)} \rightarrow NO_2F_{(g)} + F_{(g)}$

$F_{(g)} + NO_{2(g)} \rightarrow NO_2F_{(g)}$

Overall reaction: $2NO_{2(g)} + F_{2(g)} \rightarrow 2NO_2F$

$F_{(g)}$ is produced in step 1 and consumed in step 2. Hence, $F_{(g)}$ is the reaction intermediate.

(ii) Observed outer electronic configuration of copper is: $3d^{10}4s^1$

(iii) The reaction involved in sol-gel process during hydrolysis:

$$MOR + H_2O \rightarrow \underset{\text{Metal alkoxide}}{MOH} + ROH \text{ (Hydrolysis)}$$

28. Answer the following:

(i) **Statement:**

i. The total energy of a system and surroundings remains constant when the system changes from an initial state to final state.

ii. Energy of the universe remains constant.

iii. The total internal energy of an isolated system is constant.

iv. Energy is neither created nor destroyed and can only be converted from one form to another.

Mathematical expression:

The mathematical expression of first law of thermodynamics is:

$\Delta U = Q + W$

where, ΔU is the change in internal energy of the system, Q is the heat transferred and W is the work done.

(ii) The polymers which have only one type of repeating unit are called homopolymers.

e.g. Polythene, polypropene, Nylon 6, polyacrylonitrile, Nylon 6,6.

(iii) Peptide linkage is formed by combining the carboxyl group of one amino acid with the α-amino group of another amino acid.

29. Answer the following:

(i) Given: Density $(\rho) = 8.966\ g\ cm^{-3}$, Molar mass of copper $= 63.5\ g\ mol^{-1}$

To find: Volume of the unit cell

Formula: Density $(\rho) = \frac{M \times n}{a^3 N_A}$

Calculation: For fcc unit cell, $n = 4$.

From formula,

Volume of unit cell, $a^3 = \frac{M \times n}{\rho N_A}$

$$\therefore a^3 = \frac{63.5\ g\ mol^{-1} \times 4}{8.966\ g\ cm^{-3} \times 6.022 \times 10^{23}\ \text{atom}\ mol^{-1}} = 4.704 \times 10^{-23}\ cm^3$$

The volume of the unit cell is $4.704 \times 10^{-23}\ cm^3$.

(ii) i. Conversion of carboxylic acids to esters:

$$R - COOH + R'OH \xrightarrow[\text{warm}]{H^+} \underset{\text{Ester}}{R - COOR'} + H_2O$$

ii. Conversion of carboxylic acids to acid amides:

$$\underset{\text{Carboxylic acid}}{R - \overset{O}{\overset{\|}{C}} - OH} + NH_3 \rightleftharpoons \underset{\text{Ammonium carboxylate}}{R - \overset{O}{\overset{\|}{C}} - O^- NH_4^+} \xrightarrow[-H_2O]{\Delta} \underset{\text{Acid amide}}{R - \overset{O}{\overset{\|}{C}} - NH_2}$$

OR

$$\underset{\text{Carboxylic acid}}{R - COOH} \xrightarrow[\Delta]{PCl_3/PCl_5/SOCl_2} \underset{\text{Acyl chloride}}{R - COCl} + NH_3 \longrightarrow \underset{\text{Acid amide}}{R - CONH_2} + HCl$$

30. Answer the following:

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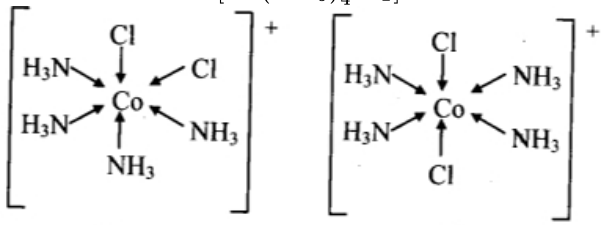
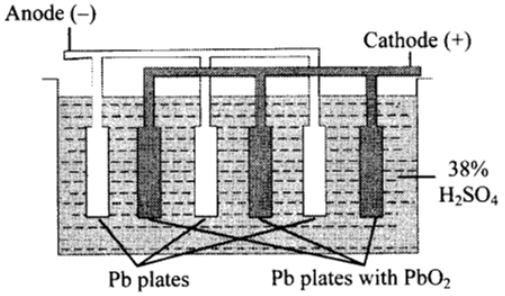
(i) Cis-trans isomers of $[Co(NH_3)_4Cl_2]^+$:



cis isomer trans isomer

(ii) **Lead storage battery:**

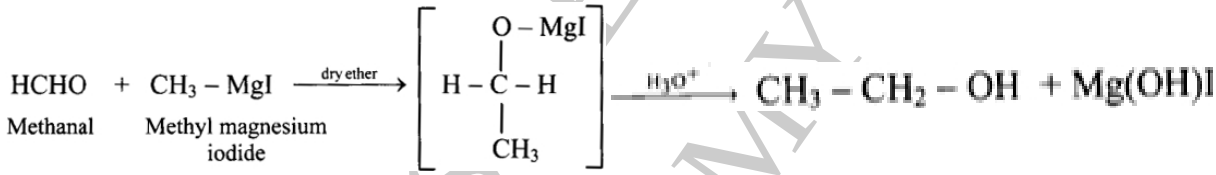


Lead storage battery

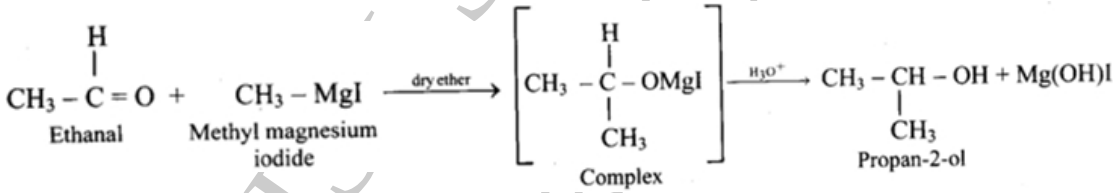
(iii) The radioactive element of group 16 is polonium.

31. Answer the following:

(i) i. Preparation of ethanol:



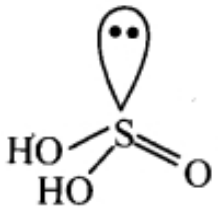
ii. Preparation of propan-2-ol:



(ii) Sulphurous acid:

Molecular formula: H_2SO_3

Structure:



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