

MODEL QUESTION PAPER SET- 1 : 2021 - 22


MM : 70

CHEMISTRY THEORY
SOLUTIONS

Time : 3 Hrs

Entire Syllabus

SECTION A

Q.1	Select & Write the correct Answer	10M
i.	c) phenol + iodomethane	
ii.	c) Na_2SO_4	1M
iii.	b) 5	
iv.	a) 7.4	1M
v.	c) + 4	
vi.	 d)	1M
vii.	d) If half reaction is multiplied by a numerical factor, the corresponding E° value is also multiplied by the same factor.	1M
viii.	b) Pentan-1-ol	1M
ix.	b) 1	1M
x.	a) Iodoform test	1M
Q.2	Short Answers (1 Mark Each)	8M
i.	examples of nonideal solutions Ethanol + acetone, Carbon disulphide + acetone,	1M
ii.	Co-ordination no. of atoms in scc is 6	1M
iii.	The process by which a network of cross-links is introduced into an elastomer is called vulcanization.	1M
iv.	Ribose, five carbon sugar found in RNA.	1M
v.	2-Bromo-3-methylpent-3-ene	1M
vi.	The value of $\frac{2.303RT}{F} = 0.0591$	1M
vii.	In complex $[\text{Pt}(\text{NH}_3)\text{Cl}_5]$, the coordination number of the metal ion is 6, and the oxidation state of the metal ion is +4.	1M
viii.	$\Delta U = q + W$ $\Delta U = -2 + 6 = 4 \text{ kJ}$	1M

SECTION B

Attempt Any Eight Questions **16M****Q.3** **Given:** **2M**

$$[A]_0 = 20 \text{ mmol dm}^{-3}, [A]_t = 8 \text{ mmol dm}^{-3}, t = 38 \text{ min}$$

To find:Half life of reaction $t_{1/2}$ **Formulae:**

$$\text{i. } k = \frac{2.303}{t} \log_{10} \frac{[A]_0}{[A]_t}$$

$$\text{ii. } t_{1/2} = \frac{0.693}{k}$$

Calculation:

Substituting given value in

$$k = \frac{2.303}{t} \log_{10} \frac{[A]_0}{[A]_t}$$

$$k = \frac{2.303}{38 \text{ min}} \log_{10} \frac{20}{8}$$

$$= \frac{2.303}{38 \text{ min}} \log_{10}(2.5)$$

$$= \frac{2.303}{38 \text{ min}} \times 0.3979 = 0.0241 \text{ min}^{-1}$$

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{0.0241} = 28.7 \text{ min}$$

The half life of reaction is 28.7 min.

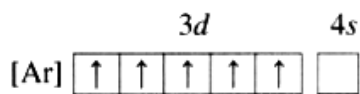
Q.4 Structure of sulphurous acid $\text{HO}-\overset{\text{O}}{\parallel}{\text{S}}-\text{OH}$, **2M**

Uses of helium

- (i) inert atmosphere welding of metal
- (ii) rocket propulsion

Q.5 For element with atomic number 25. **2M**

electronic configuration of its divalent cation will be : $[\text{Ar}] 3d^5$.

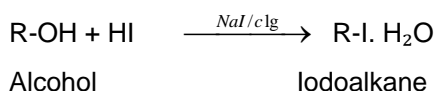


There are 5 unpaired electrons.

$$\therefore n = 5.$$

$$\therefore \mu = \sqrt{5(5+2)} = 5.92 \text{ B.M.}$$

Q.6 Good yield of alkyl iodides may be obtained by heating alcohols with sodium or potassium iodide in 95 % phosphoric acid. Here HI is generated in situ. **2M**



Q.7 Given : $W_1 = 50 \text{ g}$ acetic acid **2M**

$$\Delta T_b = 1.76 \text{ K}$$

$$K_b = 3.07 \text{ K kg mol}^{-1}$$

$$M = ?$$

$$\Delta T_b = K_b \times m$$

$$\therefore m = \frac{\Delta T_b}{K_b}$$

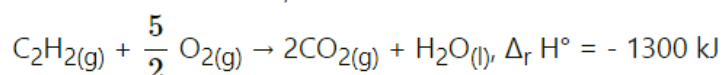
$$= \frac{1.76}{3.07}$$

$$= 0.5733 \text{ m}$$

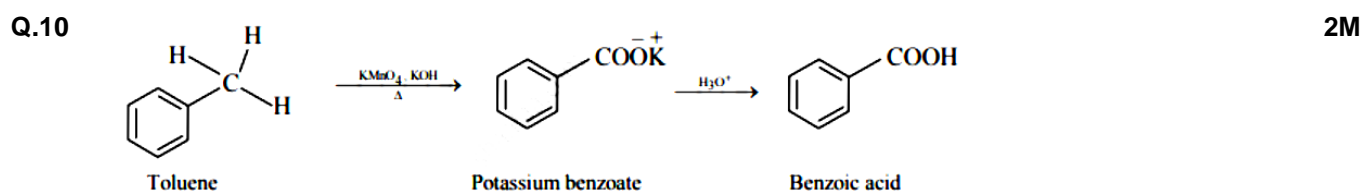
Q.8 Bidentate ligands are which have two donor atom **2M**
e.g. Ethylene diamine $\text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{NH}_2$

Q.9 1. The standard enthalpy of combustion of a substance is the standard enthalpy change **2M**
accompanying a reaction in which one mole of the substance in its standard state is completely oxidised.

2. Consider the reaction,



In the above reaction, the standard enthalpy change of the oxidation reaction, -1300 kJ is the standard enthalpy of combustion of $\text{C}_2\text{H}_2(\text{g})$.



Q.11 The ionic product of water, K_w is given by, **2M**

$$K_w = [\text{H}_3\text{O}^+] \times [\text{OH}^-]$$

$$\text{At } 298 \text{ K, } K_w = 1 \times 10^{-14}$$

$$\therefore \text{p}K_w = -\log_{10} K_w = -\log_{10} 1 \times 10^{-14} = 14$$

$$\therefore [\text{H}_3\text{O}^+] \times [\text{OH}^-] = 1 \times 10^{-14}$$

Taking logarithm to base 10 of both sides,

$$\log_{10}[\text{H}_3\text{O}^+] + \log_{10}[\text{OH}^-] = \log_{10} 1 \times 10^{-14}$$

Multiplying both the sides by -1 ,

$$-\log_{10}[\text{H}_3\text{O}^+] - \log_{10}[\text{OH}^-] = -\log_{10} 1 \times 10^{-14}$$

$$\therefore \text{pH} = -\log_{10}[\text{H}_3\text{O}^+]; \text{pOH} = -\log_{10}[\text{OH}^-];$$

$$\text{p}K_w = -\log_{10} K_w$$

$$\therefore \text{pH} + \text{pOH} = \text{p}K_w$$

$$\text{OR } \text{pH} + \text{pOH} = 14$$

Q.12 i. At the boiling point of a liquid, its vapour pressure is equal to 1 atm.

2M

ii. In order to reach boiling point, the solution and solvent must be heated to a temperature at which their respective vapour pressures attain 1 atm.

iii. At any given temperature the vapour pressure of a solution is lower than that of pure solvent. Hence, the vapour pressure of solution needs a higher temperature to reach 1 atm than that of needed for vapour pressure of solvent.

Therefore, vapour pressure lowering causes a rise in the boiling point of a solution.

Q.13 Molar mass of urea (NH_2CONH_2) = $14 + 2 + 12 + 16 + 14 + 2 = 60 \text{ g mol}^{-1}$

2M

Molar mass of water = 18 g mol^{-1}

Now, using formula,

$$\frac{P_1^0 - P_1}{P_1^0} = \frac{W_2 M_1}{M_2 W_1}$$

$$\frac{17 \text{ mm Hg} - P_1}{17 \text{ mm Hg}} = \frac{2.8 \text{ g} \times 18 \text{ g mol}^{-1}}{50 \text{ g} \times 60 \text{ g mol}^{-1}}$$

$$\therefore \frac{17 \text{ mm Hg} - P_1}{17 \text{ mm Hg}} = 0.0168$$

$$\therefore 17 \text{ mm Hg} = 0.0168 \times 17 \text{ mm Hg}$$

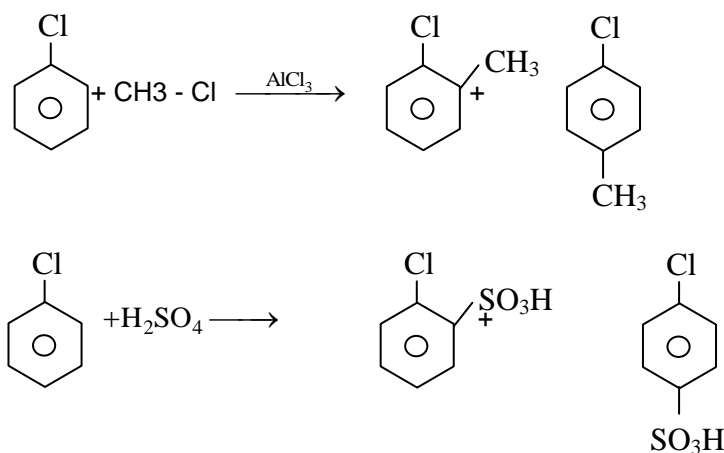
$$\therefore 17 \text{ mm Hg} - P_1 = 0.2856 \text{ mm Hg}$$

$$\therefore P_1 = 17 \text{ mm Hg} - 0.2856 \text{ mm Hg}$$

$$= 16.71 \text{ mm Hg}$$

Q.14

2M



SECTION C

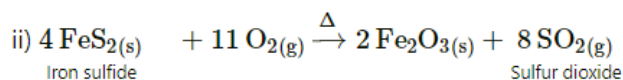
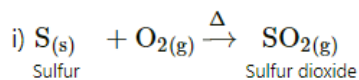
Attempt Any Eight Questions

24M

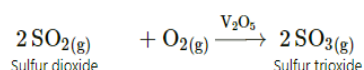
Q.15 Sulfuric acid is manufactured by the contact process, which involves the following three steps. **3M**

1) Roasting in air:

Sulfur or sulfide ore (iron pyrites) on burning or roasting in air produces sulfur dioxide.

**2) Catalytic oxidation of sulfur dioxide:**

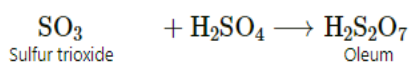
i) Sulfur dioxide is oxidised catalytically with oxygen to sulfur trioxide, in the presence of V_2O_5 catalyst.



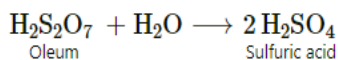
ii) The reaction is exothermic and reversible and the forward reaction leads to decrease in volume. Therefore, low temperature (720K) and high pressure (2 bar) are favourable conditions for maximum yield of SO_3 .

3) Absorption, followed by dilution of sulfur trioxide gas:

i) Sulfur trioxide gas (from the catalytic converter) is absorbed in concentrated H_2SO_4 to produce oleum.



ii) Dilution of oleum with water gives sulfuric acid of desired concentration.

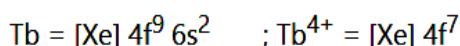
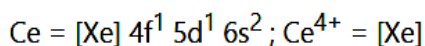


iii) The sulfuric acid obtained by contact process is 96-98 % pure.

Uses of sulfur dioxide.

- i) It is used in refining of petroleum and sugar
- ii) It is used in bleaching wool and silk

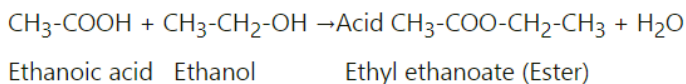
Q.16 **i.** Cerium (Ce) and Terbium (Tb) show +4 oxidation states. Their electronic configurations are given below: **3M**



ii. It is clear from the configuration of Ce that Ce^{4+} is favoured by its noble gas configuration. But it can be easily converted into stable Ce^{3+} by a gain of an electron. Due to this reason, Ce^{4+} is a good oxidizing agent.

iii. Similarly, Tb^{4+} ion is stabilized due to a half-filled f-subshell. It can be easily converted into stable Tb^{3+} by gain of an electron. Due to this reason, Tb^{4+} is a good oxidizing agent.

- Q.17** The reaction of carboxylic acid with alcohol forms an ester. For example, ethanol reacts with ethanoic acid in the presence of an acid catalyst to give sweet smelling substance, i.e. an ester which in this case will be ethylethanoate.



This reaction is known as **esterification reaction**.

The activity to show the formation of an ester is as follows:

1. Take 1 ml of ethanol (absolute alcohol) + 1 ml of glacial acetic acid in a boiling tube and mix the contents well.
2. Add few drops of concentrated H_2SO_4 to it.
3. Warm the contents on a water bath for a few minutes (at least 5 minutes).
4. Now pour the solution in a beaker containing 20-50 ml of water.
5. You will observe a sweet-fruity smell indicating the formation of an ester.

- Q.18** Consider first order reaction, $A \rightarrow B + C$

3M

The differential rate law is given by

$$\text{rate} = -\frac{d[A]}{dt} = k[A] \quad \dots(1)$$

where, $[A]$ is the concentration of reactant at time t .

Rearranging Eq. (1)

$$\frac{d[A]}{[A]} = -k dt \quad \dots(2)$$

Let $[A]_0$ be the initial concentration of the reactant A at time $t = 0$.

Suppose $[A]_t$ is the concentration of A at time = t

The equation (2) is integrated between limits $[A] = [A]_0$ at $t = 0$ and $[A] = [A]_t$ at $t = t$

$$\int_{[A]_0}^{[A]_t} \frac{d[A]}{[A]} = -k \int_0^t dt$$

On integration,

$$[\ln[A]]_{[A]_0}^{[A]_t} = -k(t)_0^t$$

Substitution of limits gives

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\text{or } \ln \frac{[A]_t}{[A]_0} = -kt \quad \dots(3)$$

$$\text{or } k = \frac{1}{t} \ln \frac{[A]_0}{[A]_t}$$

Converting \ln to \log_{10} , we write

$$k = \frac{2.303}{t} \log_{10} \frac{[A]_0}{[A]_t} \quad \dots(4)$$

Eq. (4) gives the integrated rate law for the first order reactions.

Q.19 $\Delta H = [4B.E_{N-H} + B.E_{N-N} + B.E_{H-H}] - [6B.E_{N-H}]$ **3M**

$$\Delta H = [4 \times 389 + 159 + 435] - [6 \times 389]$$

$$\Delta H = [1167 + 159 + 435] - [2334]$$

$$\Delta H = -573 \text{ kJ}$$

Q.20 1. What is meant by LDP and HDP? Mention the basic difference between the same with suitable examples. **3M**

2. LDP is a branched polymer of ethene with polymeric chains loosely held. Hence, even though it is tough, it is extremely flexible. Therefore, LDP is used in producing extruded films, sheets, mainly for packaging and household uses like in preparation of squeeze bottles, attractive containers, etc. where low tensile strength and flexibility are required.

On the other hand, HDP is a linear polymer of ethene with closely packed polymeric chains.

Hence, it is much stiffer- than LDP and has high tensile strength and hardness.

Therefore, HDP is used in the manufacture of toys and other household articles like buckets, dustbins, bottles, pipes, laboratory wares, and other objects where high tensile strength and stiffness are required.

Q.21 **i. Atom economy:** **3M**

a. Atom economy is a measure of the amount of atoms from the starting materials that are present in the useful products at the end of the chemical process.

b. Good atom economy means most of the atoms of the reactants are incorporated in the desired products and only small amounts of unwanted by-products are formed and hence lesser problems of waste disposal.

ii. Less hazardous chemical synthesis: According to this principle of green chemistry, designed chemical reactions and synthesis routes should be as safe as possible to avoid formation of hazardous waste from chemical processes.

iii. Designing safer chemicals: This principle of green chemistry aims at developing products that are less toxic or which require less toxic raw materials.

Q.22 Solution : pOH of the solution is given as : **3M**

$$\text{pOH} = 14 - \text{pH} = 14 - 11.2 = 2.8$$

$$\text{pOH} = -\log_{10}[\text{OH}^-]$$

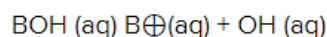
$$\log_{10}[\text{OH}^-] = -\text{pOH}$$

$$= -2.8 = -2 - 0.8 - 1 + 1$$

$$= -3 + 0.2 = 3.2$$

$$[\text{OH}^-] = \text{antilog } 3.2 = 1.585 \times 10^{-3} \text{ mol/dm}^3$$

For monoacidic base,



$$[\text{OH}^-] = \alpha c$$

$$\alpha = \frac{[\text{OH}^-]}{c}$$

$$= 1.585 \times 10^{-3}$$

$$0.02 = 0.07925$$

$$\text{Percent dissociation} = \alpha \times 100$$

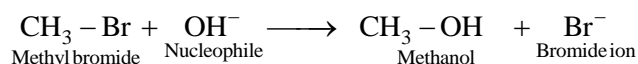
$$= 0.07925 \times 100$$

$$= 7.925 \%$$

Q.23 $\text{S}_{\text{N}}2$ mechanism:

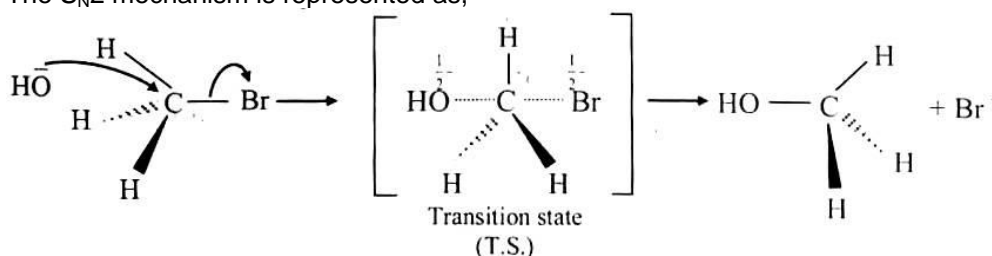
3M

- $\text{S}_{\text{N}}2$ mechanism is referred to as substitution nucleophilic bimolecular mechanism.
- For example, the reaction between methyl bromide and hydroxide ion to give methanol.



$$\text{Rate} = k [\text{CH}_3\text{Br}] [\text{OH}^-]$$

- The reaction follows a second order kinetics. That is, the rate of this reaction depends on concentration of two reacting species, namely, methyl bromide and hydroxide ion. Hence, it is called substitution nucleophilic bimolecular mechanism ($\text{S}_{\text{N}}2$).
- Rate of a chemical reaction is influenced by the chemical species taking part in the slowest step of its mechanism.
- In the above reaction, only two reactants are present and both are found to influence the rate of the reaction. This means that the reaction is a single step reaction which can also be called the slow step. This further implies that the two changes, namely, bond breaking and bond forming at the carbon take place simultaneously.
- The $\text{S}_{\text{N}}2$ mechanism is represented as,



Q.24

3M

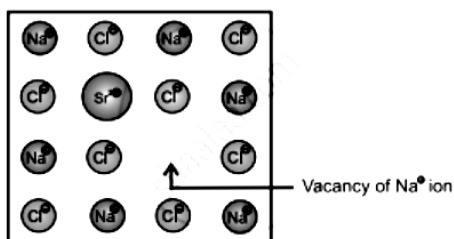
- Impurity defect arises when foreign atoms, that is, atoms different from the host atoms, are present in the crystal lattice.

ii. There are two kinds of impurity defects: Substitutional and interstitial impurity defects.

iii. Formation of vacancy through aliovalent impurity:

Vacancies are created by the addition of impurities of aliovalent ions (that is, ions with oxidation state different from that of host ions) to an ionic solid.

e.g. Consider a small amount of SrCl_2 impurity added to NaCl during its crystallization. The added Sr^{2+} ions (O.S. = +2) occupy some of the regular sites of Na^+ host ions (O.S. = +1). In order to maintain electrical neutrality, every Sr^{2+} ion removes two Na^+ ions. One of the vacant lattice sites created by the removal of two Na^+ ions is occupied by one Sr^{2+} ion. The other site of Na^+ ion remains vacant as shown in the figure.



Q.25 Cryoscopic constant is a rectro of depression in F.P to molality of solution. **3M**

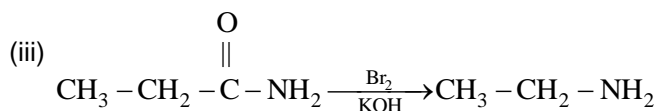
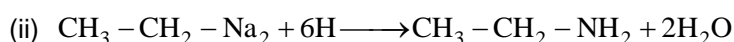
$$\Delta T_b \propto m \quad \Delta T_b = K_b m ,$$

where $m = \frac{n_2}{W_1(g)} \times 1000$

$$\Delta T_b = \frac{K_b n_2 \times 1000}{W_1(g)}$$

$$\Delta T_b = \frac{K_b W_2 \times 1000}{m_2 W_1(g)}$$

Q.26 (i) $\text{CH}_3 - \text{C} \equiv \text{N} + 4\text{H} \xrightarrow[\text{ethanol}]{\text{Na}} \text{CH}_3 - \text{CH}_2 - \text{NH}_2$ **3M**



SECTION D

Attempt Any Three Questions **12M**

Q.27 Kohlrausch law of independent migration of ions: **4M**

i. Kohlrausch law state “at infinite dilution each ion migrates independent of co-ion and contributes to total molar conductivity of an electrolyte irrespective of the nature of other ion to which it is associated”

ii. Both cation and anion contribute to molar conductivity of the electrolyte at zero concentration and thus \wedge_0 is sum of molar conductivity of cation and that of the anion at zero concentration.

Thus, $\wedge_0 = n_+ \lambda_+^0 + n_- \lambda_-^0$

where λ_+ and λ_- are molar conductivities of cation and anion, respectively, and n_+ and n_- are the number of moles of cation and anion specified in the chemical formula of the electrolyte.

iii. Determination of molar conductivity of weak electrolyte at zero concentration:

The theory is particularly useful in calculating \wedge_0 values of weak electrolytes from those of strong electrolytes.

For example, \wedge_0 of acetic acid can be calculated by knowing those of HCl, NaCl and CH_3COONa as described below:

$$\wedge_0(\text{HCl}) + \wedge_0(\text{CH}_3\text{COONa}) - \wedge_0(\text{NaCl}) = \lambda_{\text{H}^+}^0 + \lambda_{\text{Cl}^-}^0 + \lambda_{\text{CH}_3\text{COO}^-}^0 + \lambda_{\text{Na}^+}^0 - \lambda_{\text{Cl}^-}^0$$

- Q.30** (i) A property which is independent of the amount of matter in a system is called intensive property. **4m**
- (ii) Enthalpy of sublimation is the enthalpy change for the conversion of one mole of solid directly into vapour at constant temperature and pressure.

Given : Amount of ideal gas = $n = 2$ mol
 Initial volume = $V_1 = 20$ L
 Final volume = $V_2 = 30$ L
 Gas constant = $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

To find: Work done (W_{\max})

Formula: $W_{\max} = -2.303 nRT \log_{10} \frac{V_2}{V_1}$

Calculation: From formula,

$$\begin{aligned} W_{\max} &= -2.303nRT \log_{10} \frac{V_2}{V_1} \\ &= -2.303 \times 2 \text{ mol} \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 300 \text{ K} \times \log_{10} \frac{30}{20} \\ &= -2.303 \times 2 \times 8.314 \text{ J} \times 300 \times \log_{10} 1.5 \\ &= -2.303 \times 2 \times 8.314 \text{ J} \times 300 \times 0.1761 \\ &= -2023 \text{ J} \\ &= \mathbf{-2023 \text{ kJ}} \end{aligned}$$

Ans: The maximum work done is **-2.023 kJ**.

- Q.31 (i)** **2M**

$$\text{Number of moles of O}_2 = \frac{\text{Mass of O}_2}{\text{Molar mass of O}_2}$$

$$= \frac{6 \text{ g}}{32 \text{ g mol}^{-1}}$$

$$= 0.1875 \text{ mol}$$

The enthalpy change when 0.1875 mol of O_2 react with ClF is 38.55 kJ.

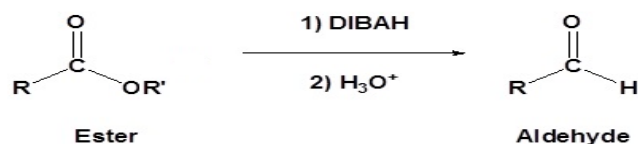
$$\therefore \text{Enthalpy change for 1 mole O}_2 = \frac{38.55}{0.1875}$$

$$= 205.6 \text{ kJ}$$

From the reaction, 2 moles of ClF react with 1 mole of O_2 .

So, the standard enthalpy of reaction is 205.6 kJ.

- (ii) Aliphatic or aromatic esters are reduced to aldehydes by using diisobutylaluminium hydride (DIBAL-H) or $\text{AlH}(\text{i-Bu})$. The reaction is usually carried out at 195 K to prevent further reduction of aldehyde produced. **2M**



Together we will make a difference