MARKING GUIDE                Coordinated copy.

P525/1 CHEMISTRY PAPER 1 2023

1 (a)(i) $Pt_{(s)} | V^{3+}_{(aq)}, H_2O_{(l)}, VO^{2+}_{(aq)}, H^+_{(aq)} // MnO_{2(s)} | H^+_{(aq)}, Mn^{2+}_{(aq)} | Pt_{(s)}$ (1½)

(Accept $Pt_{(s)} | V^{3+}_{(aq)}, H_2O_{(l)}, VO^{2+}_{(aq)}, H^+_{(aq)} // MnO_{2(s)} | H^+_{(aq)}, Mn^{2+}_{(aq)}, H_2O_{(l)} | Pt_{(s)}$)

(ii) $MnO_{2(s)} + 2V^{3+}_{(aq)} + \cancel{2H^+_{(aq)}} \longrightarrow Mn^{2+}_{(aq)} + \cancel{2H_2O_{(l)}} + 2VO^{2+}_{(aq)}$ (1½)

$MnO_{2(s)} + 2V^{3+}_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + 2VO^{2+}_{(aq)}$

(b)(i) $E^\theta_{cell} = E^\theta_{right} - E^\theta_{left}$

$= (+1.23 - 0.34)V$   (1½)

$= +0.89V$   deny if sign is missing.

(ii) ~~Its~~ feasible because the ~~e.m.f~~ e.m.f of the cell has a positive value or has a positive sign (1)   deny if sign is missing in b(i) above

5½

(2) (a) (i) A greenish-yellow gas is formed. (½)

(ii) $MnO_{2(s)} + 2Cl^-_{(s)} + 4H^+_{(aq)} \longrightarrow Mn^{2+}_{(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$ (1½)

−½ mark for wrong or missing state symbols; deny if equation is not balanced; symbol is wrong

(b) (i) A yellow solid is formed which dissolves forming colourless solution. (1)   wrong for us

Allow: $MnO_{2(s)} + 4NaCl_{(s)} + 4H_2SO_{4(l)} \longrightarrow 4NaHSO_{4(aq)} + MnCl_{2(s)} + Cl_{2(g)} + 2H_2O$

(ii) $4Cl_{2(g)} + S_2O_3^{2-}{}_{(aq)} + 5H_2O_{(l)} \longrightarrow 2SO_4^{2-}{}_{(aq)} + 8Cl^-_{(aq)} + 10H^+_{(aq)}$ (1½)

reject if not balanced; wrong formula's wrong symbols.

4½

(3) (a) Reagent: Neutral iron(III) chloride solution

observation (3)

 —OH — purple or violet colouration

 —CH(OH)CH$_3$ — No observable change

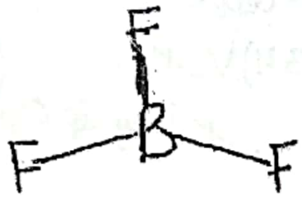
(iii) $CH_3CH_2CHO$

(b) Reagent: Ammoniacal silver nitrate Solution and warm (or heat)

$CH_3CH_2CHO$ – silver mirror (3)

$CH_3COCH_2CH_3$ – No observable change. $\boxed{6}$

(4) (a)



(1)

Name: Trigonal planar shape. ($\frac{1}{2}$)

Accept triangular.

(b) Boron trifluoride is non polar. Fluorine is more electronegative than boron. The fluorine atom strongly attracts the bonding pair of electrons more towards itself resulting into dipole moment towards the fluorine atom. Since the fluorine atoms are symmetrically arranged on the boron atom the dipole moments cancel out or add up to zero ($2\frac{1}{2}$)

(c) $NH_{3(g)} + BF_{3(g)} \longrightarrow H_3N:BF_{3(g)}$ (1) Accept $H_3N \rightarrow BF_3$ $\boxed{4}$ (Ignore if state symbol is wrong.)

(5) a(i) Vegetable oil is the oil which is exists naturally in seeds of plants (1)

(ii) Groundnuts, simsim, cotton seeds; ($\frac{1}{2}$)

(iii) The

The vegetable oil is heated together with concentrated sodium hydroxide solution for sometime until the solution becomes saturated. Concentrated sodium chloride (or brine) is added in order to precipitate out soap. ~~The~~ The liquid mixture is stirred and later left to cool. The soap is filtered off and processed into bars. (2)

(ii) 
$$\begin{matrix} H_2C-O-COR \\ HC-O-COR \\ H_2C-O-COR \end{matrix} + 3NaOH_{(aq)} \rightarrow 3RCOONa + \underset{OH}{CH_2}\underset{OH}{CH}CH_2OH$$ (1)

$\boxed{4\frac{1}{2}}$

6(a) The sum of the powers to which molar concentrations of the reactants are raised in an experimentally determined rate equation.

(b)(i) Using experiments 3 and 4 keeping the concentrations of B and C constants and multiplying ~~the~~ concentrations of A by 2 ~~the~~ rate doubles. Its first order with respect to A.

(ii) Using experiments 1 and 2, keeping the concentrations of A and B constant and reducing ~~the~~ concentration of B ~~by~~ four times (or multiplying by aquarter) the rate reduces four ~~times~~. Its first order with respect to B.

(iii) Using experiments 1 and 3 (or 2 and 3 or 2 and 4)

$$\frac{8.0\times10^{-5}}{1.0\times10^{-5}} = \frac{\cancel{k}(0.1)(0.2)(0.2)^x}{\cancel{k}(0.05)(0.1)(0.1)^x}$$ $1\frac{1}{2}$

$$8 = 4(2)^x$$

$$x = 1$$

-4-

~~Rate~~ The reaction is first order with respect to C.

Using results from experiment 1.

$8.0 \times 10^{-5} = K(0.1)(0.2)(0.2)$ (1)

$K = \frac{8.0 \times 10^{-5} \text{ mol } l^{-3} s^{-1}}{4 \times 10^{-3} \text{ mol}^3 l^{-3}} = 2.0 \times 10^{-2} \text{ mol}^{-2} s^{-1}$

Rate Constant $= 2.0 \times 10^{-2} \text{ mol}^{-2} s^{-1}$ (6½)

(Ignore units)

7 (a) This is the amount of energy which is required to remove one mole of electrons from one mole of free gaseous atoms in order to form one mole of positively charged gaseous ions.

(b) There is gradual increase from first, second and third but there is sharp increase (or very big difference) between ~~the~~ third and fourth ionisation energies. (Accept there is general increase from first to ~~the~~ fourth ionisation energy however there is sharp increase from ~~the~~ third to ~~the~~ fourth ionisation energy) (2½)

The general or gradual increase is because as ~~the~~ electrons are removed ~~the~~ nuclear charge per electron increases. Accept proton to electron ratio (or ~~the~~ few remaining electrons become attracted more strongly by ~~the~~ constant nuclear charge). Therefore

increasing amount of heat energy must be supplied to remove more electrons.
The sharp increase is because the fourth electron is being removed from a different energy level which is completely full and stable. Therefore a lot of heat energy will be required to remove ~~the~~ fourth electron. Allow thermodynamically stable shell or subshell

(c) (i) Covalent

Simple molecular structure. (1)

(ii) Element M forms cation with highest charge density and therefore polarises the chloride ion making the bond covalent. (1) [5½]

(8) (a) Both lithium and magnesium form cations with almost similar charge density and similar polarising power. (1½)
Both elements have similar electronegativity and almost similar standard electrode (or electrode) potential.
· Both elements have small atomic radius.
· Both elements have low electropositivity. (1)

(b) $Li_2C_{2(s)} + 2H_2O_{(l)} \longrightarrow 2LiOH_{(aq)} + C_2H_{2(g)}$

$CH \equiv CH_{(g)}$

$Mg_2C_{3(s)} + 5H_2O_{(l)} \longrightarrow 2Mg(OH)_{2(s)} + CH_3C \equiv CH_{(g)}$ [3½]

Reject if symbol or formula is wrong; if the equation is not balanced.

$Mg_2C_{3(s)} + 4H_2O_{(l)} \longrightarrow 2Mg(OH)_{2(s)} + CH_3-C\equiv CH_{(g)}$.

(9) (a) (i) The rate of diffusion of a gas at constant temperature and pressure is inversely proportional to ~~the~~ square root of its molecular mass (or density) (1)

(1½)

(ii) $\frac{R_{O_2}}{R_T} = \sqrt{\frac{M_T}{M_{O_2}}}$ ✓ R.f.m of $O_2$ ; $16 \times 2 = 32$.

$R_T = \frac{V}{46}$ $R_{O_2} = \frac{V}{19.90}$

$\therefore \frac{V}{19.90} \times \frac{46}{V} = \sqrt{\frac{M_T}{32}}$

$\left(\frac{46}{19.90}\right)^2 = \frac{M_T}{32}$ ✓

✓ $M_T = \frac{(46)^2 \times 32}{(19.90)^2} = 170.99$ ✓ Accept 171 (3)

(iii) R.f.m of $Ni(CO)_x = 170.99$

$58.7 + (12+16)x = 170.99$

$28x = 170.99 - 58.7$

$28x = 112.29$

$x = 4$ ✓

Molecular formula of T is $Ni(CO)_4$ ✓

(b) Tetracarbonylnickel ✓

Cordination number is 4 ✓ (1)

$\boxed{5}$

SECTION B

(10) (a) This is ~~the~~ the method or technique of separating or purifying a volatile ~~component~~ substance which is immiscible with water from ~~the~~ the non volatile components using steam at a temperature below the boiling point of water. (1)

(ii) mass of Carbon; $\frac{12}{44} \times 5.28 = 1.44g$

mass of nitrogen; $\frac{224}{22400} \times 28 = 0.28g$

mass of Hydrogen; $1.86 - (1.44 + 0.28) = 0.14g$

Accept:
22400 cm³ contain 1 mol $N_2$ 28g
224 cm³ contain $\frac{224 \times 1}{22400}$ = 0.01 mol
mass of $N_2$ = 0.01 × 28 = 0.28

| C | H | N |
|---|---|---|
| $\frac{1.44}{12}$ | $\frac{0.14}{1}$ | $\frac{0.28}{14}$ |
| 0.12 | 0.14 | 0.02 |
| $\frac{0.12}{0.02}$ | $\frac{0.14}{0.02}$ | $\frac{0.02}{0.02}$ |
| 6 | 7 | 1 |

(3)

Empirical formula of Y is $C_6H_7N$

(b)(i) $\frac{V.P_w \times R.f.M_w}{V.P_o \times R.f.M_o} = \frac{\text{mass of water in distillate}}{\text{mass of organic in distillate}}$

$V.P_o = 760 - 722 = 38$

% of organic compound; $100 - 78.61 = 21.39$

if all substractions shown

(2)

$\frac{722 \times 18}{38 \times R.f.M_o} = \frac{78.61}{21.39}$

$R.f.M_o = \frac{722 \times 18 \times 21.39}{38 \times 78.61} = 93$

(ii) $(C_6H_7N)_n = 93$

(1)

$((6\times12) + 7 + 14)n = 93$

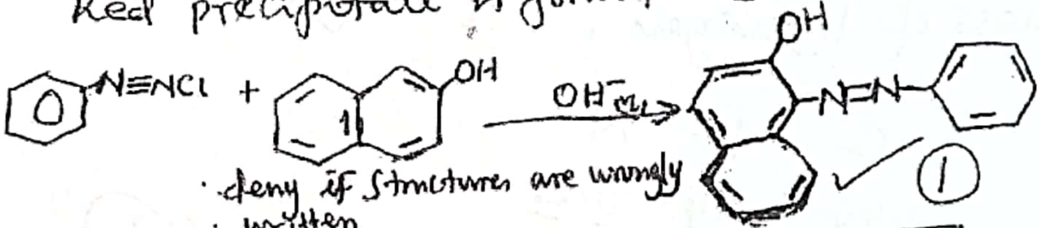
$93n = 93$

$n = 1$

molecular formula of Y is $C_6H_7N$

c(i) Y is  (or phenylamine) (½)

(ii) Red precipitate is formed (½)



deny if structures are wrongly written (1)

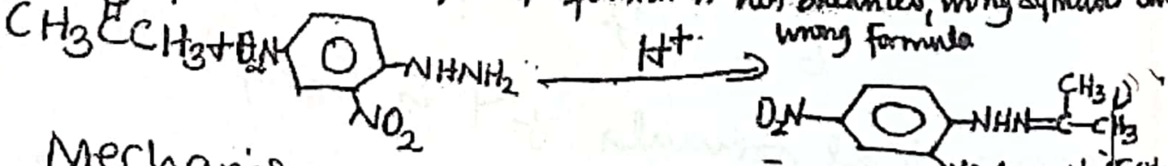
**09**

(11) (a)(i) The blue solid turns black. (1)

(ii) $(CH_3COO)_2Cu_{(s)} \longrightarrow CuO_{(s)} + CH_3COCH_{3(g)} + CO_{2(g)}$ (½)

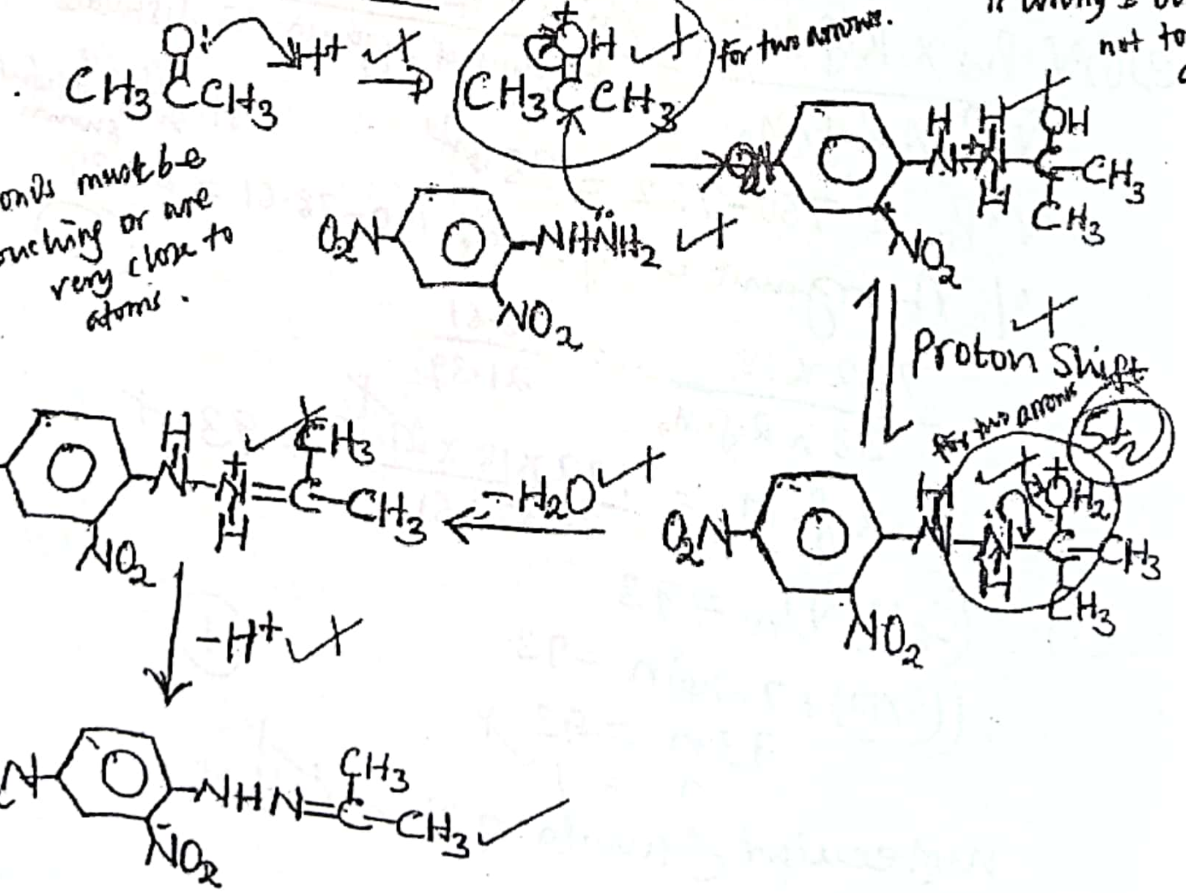
-½ for wrong or missing state symbol.

reject if equation is not balanced, wrong symbols and wrong formula

(b) 

reject if struct is wrong & bonds are not touching atom.

Mechanism



for two arrows.

bonds must be touching or are very close to atoms.

Proton Shift

for two arrows

(5½)

(f) $CH_3COOH \xrightarrow{CaCO_3} (CH_3COO)_2Ca \xrightarrow{Heat} CH_3COCH_3$ (1)

$CH_3COOH \xrightarrow[\text{dry ether}]{LiAlH_4} CH_3CHO \xrightarrow[2.\ H^+/H_2O]{1.\ CH_3MgBr} CH_3\underset{OH}{C}HCH_3 \xrightarrow[\text{heat}]{H^+/Cr_2O_7^{2-}} CH_3COCH_3$

[07]

(12) (a)(i) $SrF_{2(s)} + aq \rightleftharpoons Sr^{2+}_{(aq)} + 2F^-_{(aq)}$ (1) ignore if state symbol is wrong.

- deny if symbol is wrong.

(ii) $K_{sp} = [Sr^{2+}][F^-]^2$ (1) if formula is wrong

reject if equation is wrong

(b) R.f.m of $SrF_2 = 87.6 + (19 \times 2) = 125.6$

$[SrF_2] = \frac{0.109}{125.6} = 8.678 \times 10^{-4}\ mol\ dm^{-3}$

$[Sr^{2+}] = 8.678 \times 10^{-4}\ mol\ dm^{-3}$ (2½)

$[F^-] = 2 \times 8.678 \times 10^{-4} = 1.736 \times 10^{-3}$

$K_{sp} = (8.678 \times 10^{-4})(1.736 \times 10^{-3})^2\ mol^3\ dm^{-9}$

$= 2.615 \times 10^{-9}\ mol^3\ dm^{-9}$. ignore units

(c) $[Sr^{2+}]$ is fixed by the more soluble salt of strontium nitrate $= 0.1$ $[Sr^{2+}] = 0.1$

$\therefore\ 2.615 \times 10^{-9} = \cancel{[Sr^{2+}](0.1)^2}\ (0.1)[F^-]^2$ (2½)

$[F^-] = \sqrt{\frac{2.615 \times 10^{-9}}{(0.1)}} = 1.617 \times 10^{-4}\ mol\ dm^{-3}$

Solubility of $SrF_2 = \frac{[F^-]}{2} = \frac{(1.617 \times 10^{-4})}{2} = 8.085 \times 10^{-5}$

Solubility of strontium fluoride $= [Sr^{2+}]$

$= \cancel{2.615 \times 10^{-8}\ mol\ dm^{-3}}$

$= 8.085 \times 10^{-5}\ mol\ dm^{-3}$ ignore units

(d) Potassium fluoride increases on the concentration of fluoride ions in the solution. The strontium ions react with fluoride ions forming the insoluble strontium fluoride which is precipitated out of the solution. The solubility of strontium fluoride will reduce. (1½)

deny if there is a wrong spelling

Allow: Potassium fluoride is a strong electrolyte so provides high concentration of fluoride ions. Due to the common ion effect of the fluoride ions, the fluoride ions react with strontium ions shifting the equilibrium position to the left thus precipitating more strontium fluoride so solubility of strontium fluoride reduces.

(e) - It is used in precipitation of sparingly soluble salts

deny. Any one mark if more than one is given.

- Used in precipitation of soap.
- Used to identify cations in qualitative analysis
- Used in fractional crystallisation.

09

(13) (a) % of oxygen; $100 - 90.66 = 9.34$

only if subtraction is shown.

$$Pb : O$$

$$\frac{90.66}{207} : \frac{9.34}{16}$$

$$0.438 \quad 0.58375$$

$$\frac{0.438}{0.438} \quad \frac{0.58375}{0.438}$$

$$(1 \quad 1.33)3$$

$$3 \quad 4$$

$$Pb_3O_4$$

2

(ii) $(Pb_3O_4)_n = 684.9$

$$((207 \times 3) + (16 \times 4))n = 684.9$$

$$685n = 684.9$$

$$n = 1$$

1

Molecular formula of R is $Pb_3O_4$.

(b) $Pb_3O_{4(s)} + 4HNO_{3(aq)} \longrightarrow 2Pb(NO_3)_{2(aq)} + PbO_{2(s)} + 2H_2O_{(l)}$ 1½

reject if: - equation is not balanced
- wrong symbol; & formula

-½ for missing or wrong states

(c) Purple solution was formed ½

$5PbO_{2(s)} + 2Mn^{2+}_{(aq)} + 4H^+_{(aq)} \longrightarrow 5Pb^{2+}_{(aq)} + 2MnO^-_{4(aq)} + 2H_2O_{(l)}$ 1

Ignore state symbols

i) Yellow precipitate that dissolves to form ~~Colourless~~ yellow solution (1)

$Pb^{2+}_{(aq)} + CrO_{4(aq)}^{2-} \longrightarrow PbCrO_{4(s)}$ (1)

Reject if symbol or formula is wrong.

$PbCrO_{4(s)} + 4OH^{-}_{(aq)} \longrightarrow Pb(OH)_{4(aq)}^{2-} + CrO_{4(aq)}^{2-}$ (1)

Ignore state symbols. [04]

(14) (a) (i) This the enthalpy change that occurs when one mole of a compound is formed from its elements in their standard states (1)

(ii) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ $-394$ --- (i) kJmol$^{-1}$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$ $-286$ --- (ii)

$CH_3COOH_{(l)} + 2O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O_{(l)}$ $-878$ - (iii)

Required equation:

$2C_{(s)} + O_{2(g)} + 2H_{2(g)} \longrightarrow CH_3COOH_{(l)}$

(2 x eqn (i)) + (2 x eqn ii) + Reversing eqn (iii)

$2C_{(s)} + 2O_{2(g)} \longrightarrow 2CO_{2(g)}$ (2 x -394)

$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$ (2 x -286) (3½)

$2CO_{2(g)} + 2H_2O_{(l)} \longrightarrow CH_3COOH_{(l)} + 2O_{2(g)}$ +878

$2C_{(s)} + 2H_{2(g)} + O_{2(g)} \longrightarrow CH_3COOH_{(l)}$ $-482$ kJmol$^{-1}$

Accept: $\Delta H_f$ $2C_{(s)} + O_{2(g)} + 2H_{2(g)} \longrightarrow CH_3COOH_{(l)}$

(2 x -394) (2 x -286) -878

$2CO_{2(g)} + 2H_2O_{(l)}$ 03½

$\Delta H_f - 878 = 2 \times -394 + 2 \times -286$

$\Delta H_f = 2 \times -286 + 2 \times -394 + 878$

$= -482$ kJmol$^{-1}$

Accept: $CH_3COOH_{(l)} + 2O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O$

$\Delta H_f = x$ $\Delta H_f = 0$ $\Delta H_f = 2 \times -394$ 03½

$\Delta H_{rxn} = \sum \Delta H_{f(product)} - \sum \Delta H_{f(reactant)}$

$-878 = (2 \times -394) + (2 \times -286) - (x + 0)$

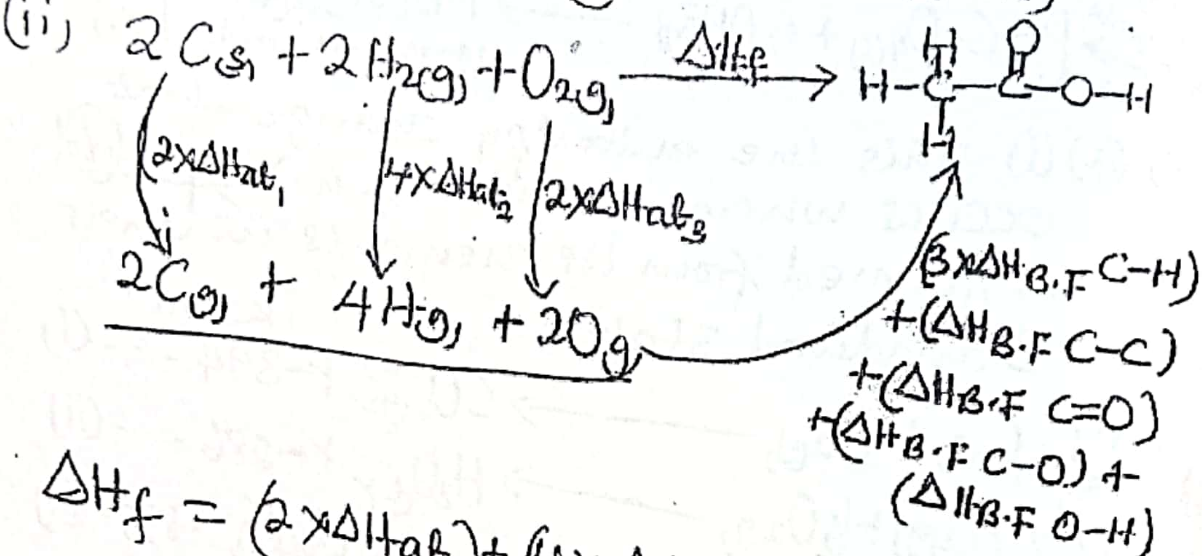
$\therefore x = -482$ kJmol$^{-1}$

(b) (i) Bond energy is the enthalpy change ~~that~~ occurs when one mole of covalent bonds are completely dissociated to form free gaseous atoms. (1)

(OR The enthalpy change ~~that~~ occurs

When one mole of Covalent bonds are formed from free gaseous atoms)

(ii)




$$\Delta H_f = (2\times\Delta H_{at_1}) + (4\times\Delta H_{at_2}) + 2\times\Delta H_{at_3} + (3\Delta H_{B.F}\ C-H) + (\Delta H_{B.F}\ C-C) + (\Delta H_{B.F}\ C-O) + (\Delta H_{B.F}\ C=O) + (\Delta H_{B.F}(O-H))$$

$$-482 = (2\times721) + (4\times218) + (2\times249) + 3\Delta H_{B-F}(C-H) + (-347) + (-743) + (-358) + (-463)\ \mathrm{kJmol^{-1}}$$

* Deny if structure is wrong.

$$-482 = 3\Delta H_{B.F}\ C-H + 901$$

$$3\Delta H_{B.F}\ C-H = -482 - 901 = -1383$$

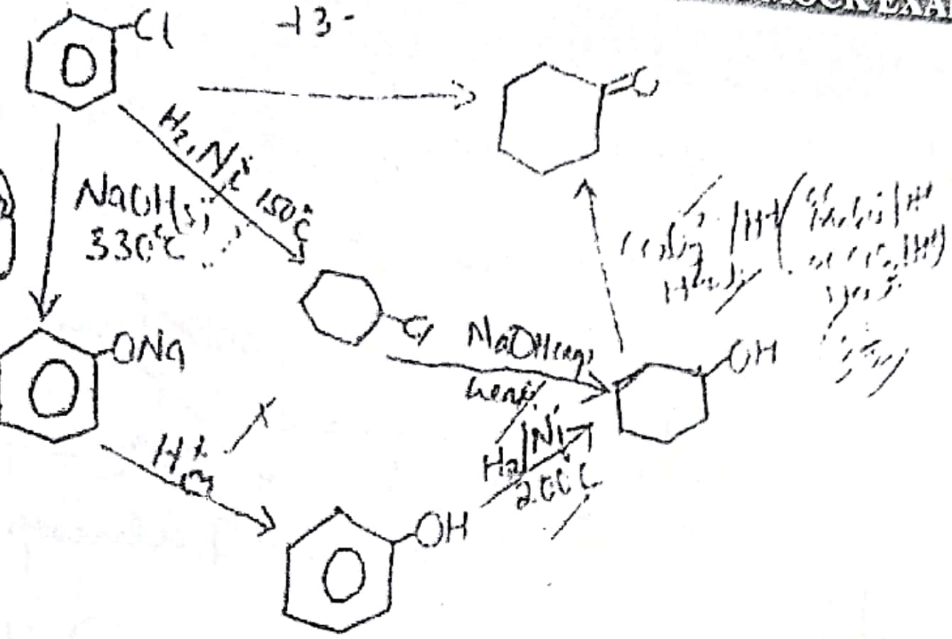
$$\Delta H_{B.F}(C-H) = \frac{-1383}{3} = -461$$

Enthalpy of bond formation of C–H $= -461\ \mathrm{KJmol^{-1}}$

3½

09

(15) (a)



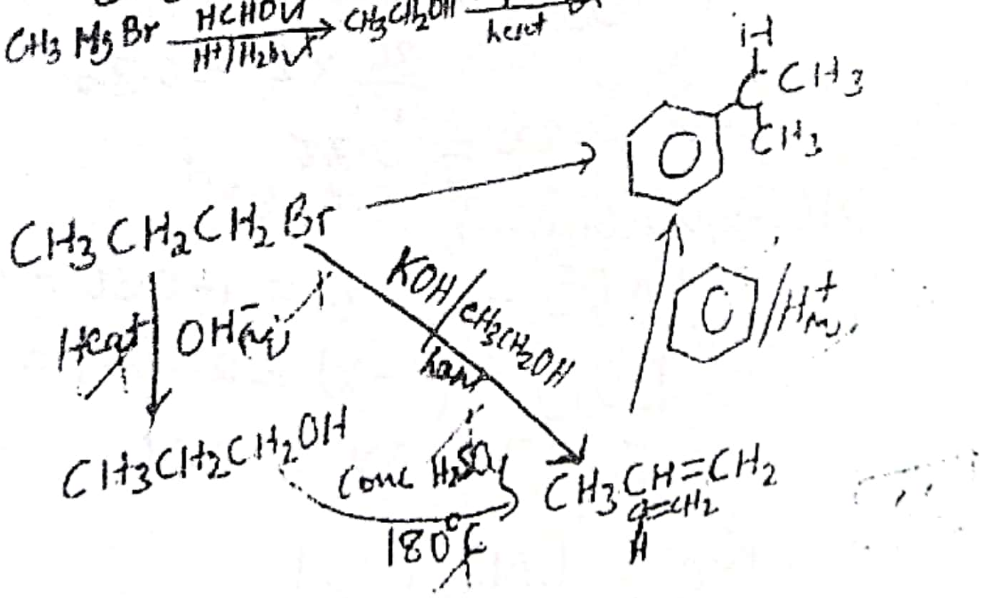

(b) $CH_3MgBr \longrightarrow CH_3COOCH_3$

$\downarrow CO_2$/dry ether

$CH_3COOMgBr \xrightarrow[\text{or } H^+/Cr_2O_7^{2-}]{H_2O/H^+} CH_3COOH \xrightarrow{CH_3OH/\text{conc } H_2SO_4} CH_3COOCH_3$

Accept: $CH_3MgBr \xrightarrow[H^+/H_2O]{HCHO} CH_3CH_2OH \xrightarrow[\text{heat}]{H^+/MnO_4^-} CH_3COOH$

(c)




For (a),(b) & (c) all routes must be continuous.

(16) (a) (i) $4NH_{3(g)} + 5O_{2(g)} \longrightarrow 4NO_{(g)} + 6H_2O_{(g)}$ (1½)

(ii) Platinum.

(iii) Temperature of 800°C and pressure of 8 atmospheres. (1)

(Accept temperature 800°C – 900°C pressure of 8 – 9 atmospheres)

(b)

$$2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$$

| | $2NO$ | $O_2$ | $2NO_2$ |
|---|---|---|---|
| Initially | 1 | 2 | — |
| Reacted | $2x$ | $x$ | $2x$ |
| At eqbm | $(1-2x)$ | $(2-x)$ | $2x$ |

~~Taking the volume of the~~ moles of ~~oxygen~~ nitrogen monoxide ~~that~~ reacted

$$\frac{36}{100} \times 1 = 0.36$$

$\therefore$ $2x = 0.36$

$\therefore$ $x = 0.18$

At equilibrium, (3)

$[NO] = (1-2x) = 1 - 0.36 = 0.64$

$[O_2] = (2-x) = 2 - 0.18 = 1.82$

$[NO_2] = 2x = 0.36$

$$K_c = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

$$= \frac{(0.36)^2}{(0.64)^2(1.82)} = 0.174\ mol^{-1}l$$

(ii) $3Pb_{(s)} + 8HNO_{3(aq)} \rightarrow 3Pb(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$

reject if: - symbols are wrong
- equation not balanced
- wrong symbols

-½ for wrong or missing state symbol

(iii) $Mg_{(s)} + 4HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

(17) (a) $(CH_3)_2CBrCH_2CH_3 \xrightarrow[heat]{OH^-(aq)} (CH_3)_2C(OH)CH_2CH_3$

Mechanism

$(CH_3)_2CBrCH_2CH_3 \underset{}{\overset{-Br}{\rightleftharpoons}} (CH_3)_2\overset{+}{C}CH_2CH_3 + Br^-$

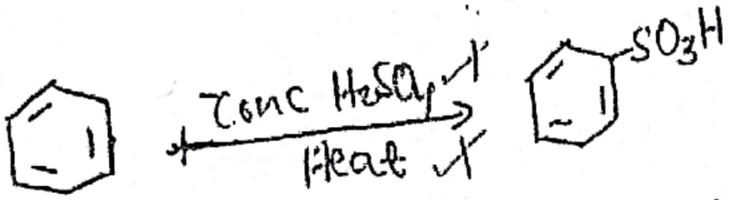
$OH^-$

$\downarrow$

$(CH_3)_2C(OH)CH_2CH_3$

(2½)

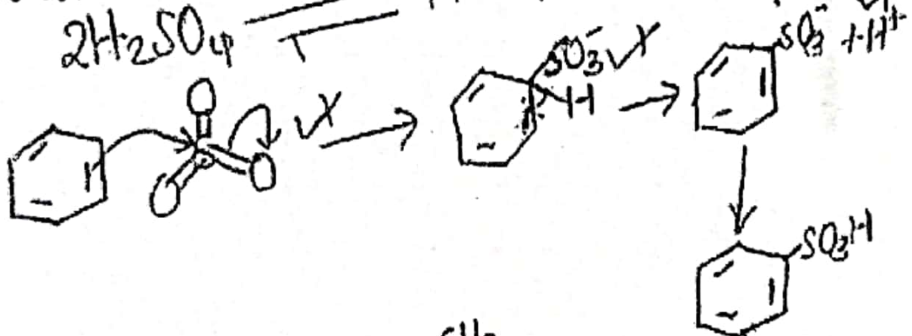
(b)



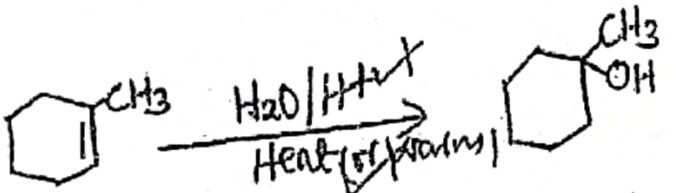

(3)

Mechanism:

$2H_2SO_4 \rightleftharpoons HSO_4^- + SO_3 + H_3O^+$

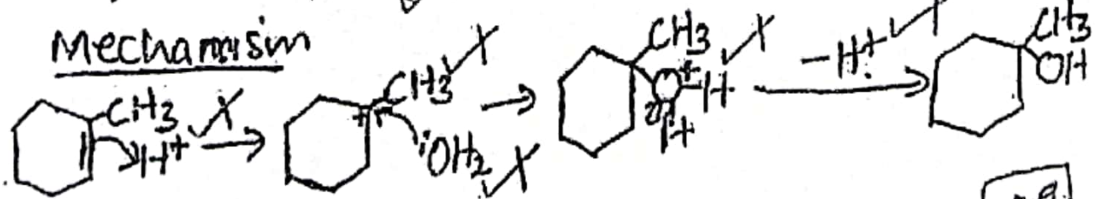


(c)




(3½)

Mechanism

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(d)

END.