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P525/1
CHEMISTRY
Paper 1
Feb./March. 2024
2 ¾ hours.

MARKING GUIDE.

25/04/2024. S.6

THE CHEMISTRY DEPARTMENT

TEST ONE- 2024

CHEMISTRY

Paper 1

2 hours 45 minutes

INSTRUCTIONS:

*Answer **all** questions in this section **A** and **six** questions in section **B**.*
All answers must be written in the spaces provided.
The Periodic Table, with relative atomic masses, is attached at the end of the paper.
Mathematical tables (3-figure tables) are adequate or non-programmable scientific electronic calculators may be used.
Illustrate your answers, with equations where applicable.
Where necessary, use the following;

Molar gas constant, $R=8.31\ JK^{-1}mol^{-1}$.
Molar volume of a gas at s.t.p is 22.4 litres.
Standard temperature = 273K.
Standard pressure = $101325Nm^{-2}$

For Teachers' Use Only																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total

SECTION A (46 MARKS)

Answer **all** *questions in this section*

1. (a) Aluminium chloride is covalent and rapidly undergoes hydrolysis in moist air.

(i) State **three** other properties to show that aluminium chloride is covalent. *(1 ½ marks)*

- Aluminium chloride has a lower melting point than NaCl ✓
- It dimerises in vapour form to form Al_2Cl_6 ✓ (1½)
- Aluminium chloride dissolves in methylbenzene ✓ (It is soluble in non polar solvents like methylbenzene)

Accept any other correct alternative.

(ii) Write an equation for the hydrolysis of aluminium chloride in moist air. *(01 mark)*

$AlCl_{3(s)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3HCl_{(g)}$ ✓ (01)

(b) (i) State how anhydrous aluminium chloride can be prepared in the laboratory. *(01 mark)*

By passing dry chlorine or dry hydrogen chloride over heated aluminium ✓ (01)

(ii) Write equation for the reaction in b(i) above. *(01 mark)*

$2Al_{(s)} + 3Cl_{2(g)} \longrightarrow 2AlCl_{3(s)}$ ✓

OR / or $2Al_{(s)} + 6HCl_{(g)} \longrightarrow 2AlCl_{3(s)} + 3H_{2(g)}$ (01)

2. (a) Complete the following nuclear reactions;

(i) $^{9}_{4}Be + \gamma \longrightarrow {}^{8}_{4}Be + \ldots {}^{1}_{0}n \ldots$ ✓ *(01 mark)*

(ii) $^{19}_{9}F + {}^{1}_{0}n \longrightarrow \ldots {}^{16}_{7}N \ldots + {}^{4}_{2}He$ ✓ *(01 mark)*

(b) It takes 5 days for 0.025g of Bismuth-214 to disintegrate into 0.0125mg of Bismuth-210. Calculate the time required for 0.016mg of Bismuth-214 to change into 0.001mg of Bismuth-210. *(03 marks)*

$\ln\left(\frac{N_o}{N_t}\right) = \lambda t$ ✓✓

$\ln\left(\frac{0.025}{0.0125}\right) = \lambda \times 5$ ✓

$\lambda = 0.13863$ ✓

when $N_o = 0.016$, $t = ?$, $N_t = 0.001$

$\ln\left(\frac{0.016}{0.001}\right) = 0.13863\, t$ ✓

$t = 19.99$

$t \simeq 20$ days ✓✓

from: $2.303 \log\left(\frac{N_o}{N_t}\right) = \lambda t$.

Alternatively

$2.303 \log\left(\frac{0.025}{0.0125}\right) = \lambda \times 5$.

$\lambda = 0.1386$

$2.303 \log\left(\frac{0.016}{0.001}\right) = 0.1386 \times t$.

Alternatively. 03

$t = 20$ days.

3. Complete the following equations and in each case outline the mechanism for the reaction.

(a) $CH_3CH_2CH_2OH \xrightarrow[\text{heat } 180^\circ]{Conc.\ H_2SO_4} CH_3CH=CH_2 + H_2O$ (02 marks)

$H_2SO_4 \longrightarrow H^+ + HSO_4^-$

$CH_3CH_2CH_2\ddot{O}H + H^+ \longrightarrow CH_3CH_2CH_2\overset{+}{O}H_2$ 02

$CH_3\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{+}{O}H_2 \xrightarrow{-H_2O} CH_3CH=CH_2$

$\ddot{O}SO_3H$ $\quad HSO_4^- + H^+ \longrightarrow H_2SO_4$.

reject with hanging arrows.

(b) $CH_3CH=CH_2 \xrightarrow{Br_2/H_2O} CH_3\underset{OH}{CH}CH_2Br + HBr$ (03 marks)

$Br_2 + H_2O \rightleftharpoons HOBr + HBr$. ✓

$CH_3CH=CH_2 \longrightarrow CH_3\overset{+}{C}HCH_2Br$

$\overset{\delta+}{Br}-\overset{\delta-}{O}H$ 03

reject hanging arrows.

reject hanging bonds.

$CH_3\overset{+}{C}HCH_2Br + \ddot{O}H \longrightarrow CH_3\underset{OH}{CH}CH_2Br$

Alternatively,

$CH_3CH=CH_2 \longrightarrow CH_3\overset{+}{C}HCH_2Br + Br^-$

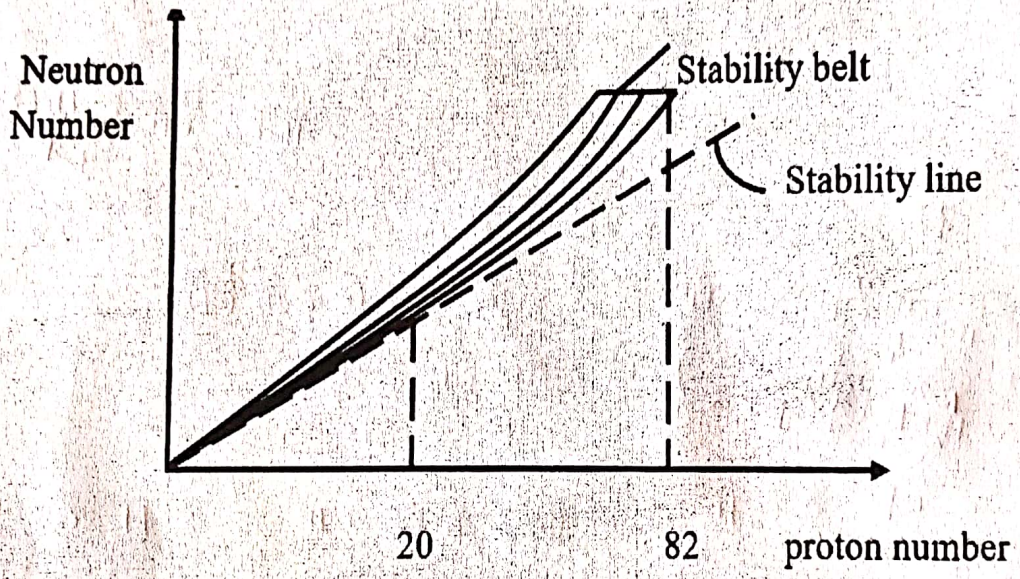
$CH_3\overset{+}{C}HCH_2Br \longrightarrow CH_3\underset{+OH_2}{CH}CH_2Br \xrightarrow{-H^+} CH_3\underset{OH}{CH}CH_2Br$

$H^+ + Br^- \longrightarrow HBr$.

4. (a) Define the term **nuclear stability**. (01 mark)

Nuclear stability is the ability of the nucleus of an atom to resist spontaneous decay that would result into formation of other nuclei and emission of radiation.

(b) (i) The graph below shows the variation of number of neutrons in an atom with proton numbers.



Explain why the band of nuclear stability (stability belt) deviates from $^{n}/_{p} = 1$ (stability line) after atomic number 20. (02 marks)

This is because as atomic number increases (number of protons increases), there is a strong repulsive force that develops in the nucleus. More neutrons are needed to counterbalance the repulsive forces. This increases the neutron-proton ratio.

(01 mark)

(ii) Determine the number of alpha and beta particles that must be emitted for $^{232}_{90}Th$ to transform to $^{208}_{82}Pb$ (02 marks)

$^{232}_{90}Th \longrightarrow {}^{208}_{82}Pb + 6{}^{4}_{2}He + 4{}^{0}_{-1}e$ ✓

∴ 6 alpha particles. ✓

4 beta particles. ✓

reject poorly written symbols of the elements

5. (a) Lead(IV) oxide reacts with hydrochloric acid according to the redox reaction below:

$$PbO_2(s) + 4HCl(aq) \longrightarrow PbCl_2(aq) + Cl_2(g) + 2H_2O(l)$$

(i) State the condition(s) for the above reaction. (01 mark)

Concentrated hydrochloric acid. ✓

Heat ✓ Allow: Hot concentrated hydrochloric acid.

(ii) Write the half reduction and oxidation reactions from the overall redox reaction above. (02 marks)

Reduction half equation: $PbO_2 + 4H^+_{(aq)} + 2e \longrightarrow Pb^{2+}_{(aq)} + 2H_2O_{(l)}$ ✓

Oxidation half equation: $2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e$ ✓

(b) Lead(IV) oxide was added to an acidified solution of potassium iodide and the mixture heated.

(i) State what was observed. (01 mark)

Dark brown solid dissolves to form a colourless solution and purple vapours. ✓

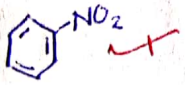
(ii) Write equation for the reaction that took place. (1 ½ marks)

$PbO_{2(s)} + 2I^-_{(aq)} + 4H^+_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + I_{2(g)} + 2H_2O_{(l)}$ ✓ ✓

6. Complete each of the following equations and name the main organic product.

(i) $(CH_3)_2C = CH_2 \xrightarrow{KMnO_4/\bar{O}H} CH_3\overset{CH_3}{\underset{OH}{C}}CH_2OH$ ✓ ✓ (1 ½ marks)

Name of main product: 2-methylpropane-1,2-diol ✓

(ii)  $\xrightarrow[Conc.H_2SO_4, 55-60°C]{Conc.HNO_3}$  (1 ½ marks)

Name of main product; Nitrobenzene

(iii) $CH_3CH=CH_2 \xrightarrow[heat]{H^+/H_2O} CH_3\overset{OH}{C}HCH_3$ (1 ½ marks) (14)

Name of main product; Propan-2-ol

7. (a) Potassium manganate (VII) is a commonly used reagent in volumetric analysis and yet it is not a primary standard.

(i) What is meant by the term **'primary standard'**? (01 mark)

A primary standard is a substance that is analytically pure and chemically stable such that a known mass of it when weighed is the exact mass that dissolves in water to form a standard solution (01)

(ii) State **two** reasons why potassium manganate (VII) is not a primary standard (01 mark)

- It is never obtained free from manganese(IV) oxide impurity
- It is easily reduced by even weak reducing agents since it is a strong oxidising agent (01)

(b) Explain why hydrochloric acid is not used to acidify a solution of potassium manganate(VII) solution in volumetric analysis. (03 marks)

It oxidises hydrochloric acid to chlorine as it is reduced to manganese(II) ions (03)

$2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq) \longrightarrow 2Mn^{2+}(aq) + 5Cl_2(g) + 8H_2O(l)$

OR $2KMnO_4(s) + 16HCl(aq) \longrightarrow 2KCl(aq) + 2MnCl_2(aq) + 8H_2O(l) + 5Cl_2(g)$.

8. State what would be observed and write equation(s) for the reaction(s) that take place when:

(i) hydrogen sulphide is bubbled through an aqueous solution of acidified potassium dichromate(VI).

Observation *(1 ½ marks)*

Orange solution turns green and a yellow solid deposited. ✓✓

Equation *(1 ½ marks)*

$Cr_2O_7^{2-}(aq) + 8H^+(aq) + 3H_2S(g) \longrightarrow 2Cr^{3+}(aq) + 3S(s) + 7H_2O(l)$ ✓✓

(ii) An aqueous solution of sodium thiosulphate is left standing in air.

Observation *(1 ½ marks)*

A yellow solid is deposited and bubbles of a colourless gas. ✓✓

Equation *(1 ½ marks)*

$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow S(s) + SO_2(g) + H_2O(l)$ ✓✓

9. Write equation(s) to show how the following conversions can be effected. In each case indicate the necessary reagents and conditions.

(a) $CH_3CH_2C \equiv CH$ to $CH_3CH_2\underset{Cl}{C}HCH_3$ *(02 marks)*

$CH_3CH_2C\equiv CH$ to $CH_3CH_2\underset{Cl}{C}HCH_3$

Reagents: H_2 / Ni cat. (Lindlars cat) ✓; $HCl(aq)$ ✓

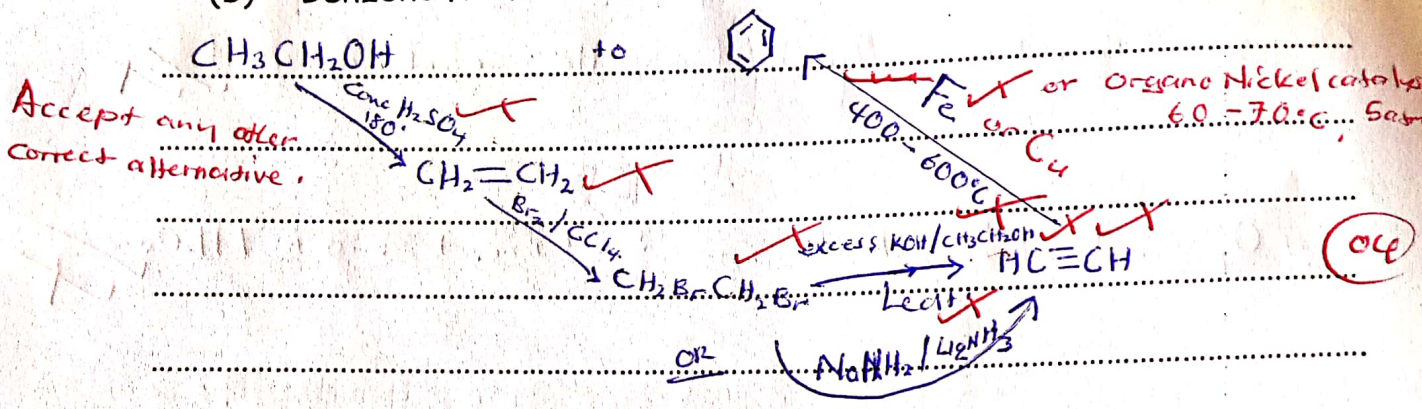
$CH_3CH_2CH=CH_2$ ✓

(02)

Reject Nickel Catalyst.

Accept any other correct alternative.

(b) Benzene from ethanol. (04 marks)



SECTION B: (54 MARKS)

Answer any **six** *questions from this section.*

10. (a) (i) Define the term **enthalpy of a reaction.** (01 mark)

This is the enthalpy change which occurs when quantities of reactants as stated in their equation react to form products. 01

(ii) State **four** factors affecting the quantity of an enthalpy change of a reaction. (02 marks)

- Temperature at which the reaction is carried out.
- Pressure of gaseous reactants or products 02
- Amount of reactants used
- Physical state of reactants and products
- Allotropic modifications – ie the enthalpy change involved in conversion of one allotrope to another.

(b) The standard heat of formation of ethanol, carbon dioxide and water are -227.0, -393.5 and -285.5 kJmol^{-1} respectively.

(i) Calculate the standard heat of combustion of ethanol using the information above. (3 ½ marks)

$CH_3CH_2OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

$\Delta H_{reaction} = \sum \Delta H^{\ominus}_{f,products} - \sum \Delta H^{\ominus}_{f,reactants}$

$= 2\times(-393.5) + 3\times(-285.5) - (-227.0)$

$= -1416.5\ Kmol^{-1}$

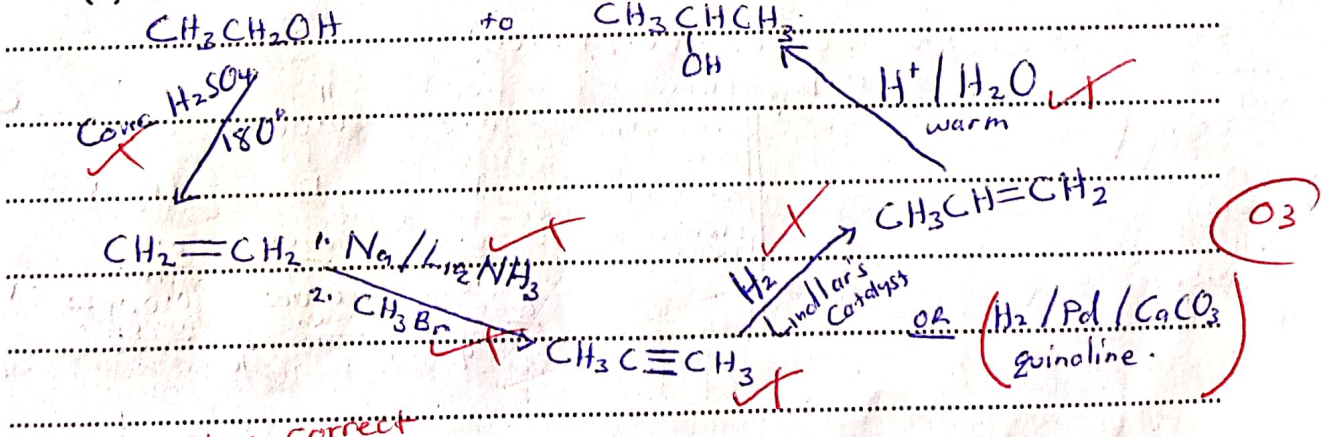
(ii) From your calculation in above and energy changes in b(i) above, what can be the ideal use of ethanol in chemistry? Give a reason for your answer. (1 ½ marks)

Can Ethanol can be used as fuel.

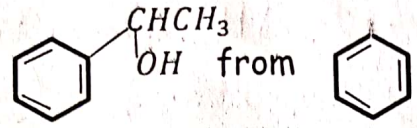
This is because it undergoes combustion to produce alot of heat.

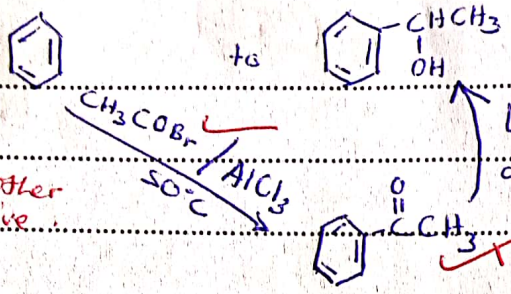
11. Show how the following conversions can be effected. In each case, indicate the reagents and conditions for the reaction

(a) Ethanol to propan-2-ol (03 marks)



Accept any other correct alternative route.

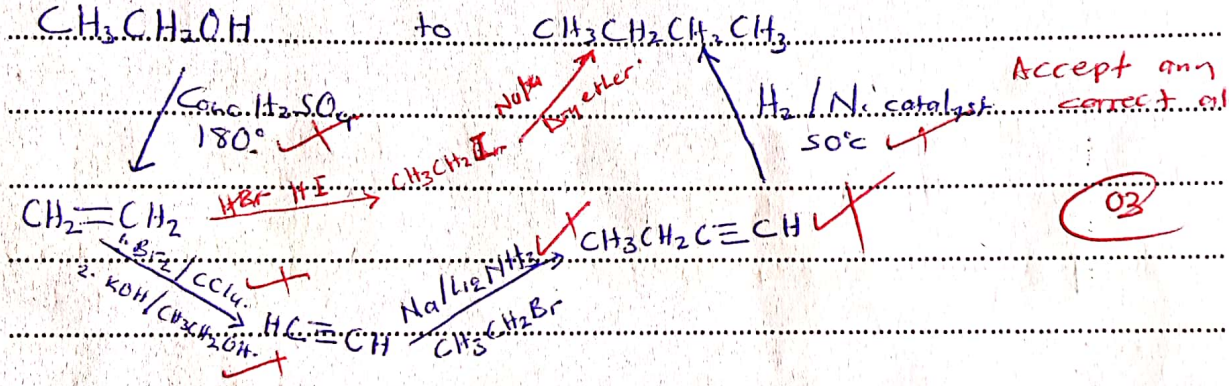
(b)  from (03 marks)



03

Accept any other correct alternative.

(c) Butane from CH_3CH_2OH (03 marks)



Accept any other correct alternative.

03

12. (a) A compound **R** contains carbon, hydrogen and oxygen only. 0.463g of **R** on combustion gave 1.1g of carbon dioxide and 0.563g of water. Determine the empirical formula of **R**. (03 marks)

RMM of CO_2: $12+16\times2 = 44$

Mass of C: $\frac{12}{44}\times1.1 = 0.3g$

RMM of H_2O: $1\times2+16 = 18$

Mass of H: $\frac{2}{18}\times0.563 = 0.063g$

Mass of O $= 0.463-(0.3+0.063)$

$= 0.1g$

Element	C	H	O
Composition by mass	0.3	0.063	0.1
Atomic mass	12	1	16
Number of moles	$\frac{0.3}{12}$ = 0.025	$\frac{0.063}{1}$ = 0.063	$\frac{0.1}{16}$ = 0.00625
Mole ratio	$\frac{0.025}{0.00625}$ = 4	$\frac{0.063}{0.00625}$ = 10	$\frac{0.00625}{0.00625}$ = 1

$C_4H_{10}O$

03

(b) When 0.1g of **R** was vapourised at 208°C and 98.3kPa, it occupied a volume of 54.5cm^3. Determine the molecular formula of **R**.

3 marks)

$n = 0.1g$

$T = (208 + 273)$
$= 481\ k.$

Accept correct calculation using another value of molar gas constant R.

$R = 8.314\ J mol^{-1} k^{-1}$

(02 marks)

$P = (98.3 \times 1000)$
$= 98300\ Pa.$

from $PV = \frac{m}{Mr} RT$ ✓

$V = 54.5\ cm^3 = 5.45 \times 10^{-5}$.

$Mr = \frac{mRT}{PV}$

$Mr = \frac{0.1 \times 8.314 \times 481}{98300 \times 5.45 \times 10^{-5}}$ ✓ (02)

$(C_4H_{10}O)_n = 74.65$

$12 \times 4n + 1 \times 10n + 1 \times 16n = 74.65$

$\frac{74n}{74} = \frac{74.65}{74}$ $= 74.65_g$.

$n = 1$ ✓ ∴ Molecular formula is $C_4H_{10}O$ ✓

(c) **R** reacts with sodium metal with evolution of a gas. Write the structural formulae of all possible isomers of **R**.

(02 marks)

reject IUPAC name of isomer alone.

$CH_3CH_2CH_2CH_2OH$ ✓

$CH_3CHCH_2CH_3$ (OH) ✓

CH_3CHCH_2OH (CH_3) ✓

$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-OH$ ✓ (02)

~~$CH_3CH_2OCH_2CH_3$~~

(d) **R** reacts with anhydrous zinc chloride and concentrated hydrochloric acid to form a cloudy solution in about 5 minutes.

(i) Identify **R** (01 mark)

$CH_3CHCH_2CH_3$ (OH) ✓ (01)

(ii) Write equation(s) to show how can be synthesized from but-2-ene (01 mark)

$CH_3CH=CHCH_3 \xrightarrow[\text{warm}]{H^+/H_2O} CH_3CHCH_2CH_3$ (OH) ✓ (01)

13. Explain the following observations.

(a) When refluxed with aqueous potassium hydroxide followed by acidified silver nitrate solution. Chloroethane forms a white precipitate while chlorobenzene gives no observable change. (03 marks)

In chloroethane, the chlorine atom is more electronegative than the carbon atom. This makes the carbon atom gain a partial negative charge and the carbon atom gains a partial positive charge. Therefore the carbon-chlorine bond is polar. The partial positive carbon atom is easily attacked by the hydroxyl ion and substituted releasing chloride ions in solution. The chloride ions react with silver ions to form insoluble silver chloride. Chloroethane reacts with silver ions to form silver chloride which is insoluble in the acid.

$CH_3CH_2Cl + Ag^+ \longrightarrow CH_3\overset{+}{C}H_2 + AgCl$

The chlorine atom in chloroethane is substituted by the hydroxide ion from sodium hydroxide. The chloride ion then reacts with the silver ions in solution to form a white precipitate of silver chloride. 03

In chlorobenzene, the lone pair of electrons on the chlorine atom interacts with the delocalised pi-electrons of the benzene ring. This makes the carbon-chlorine bond very strong and difficult to break.

(b) Iron(III) chloride and tin(II) chloride cannot exist together in aqueous solution. (03 marks)

This is because Iron(III) ions oxidise tin(II) ions to tin(IV) ions as they are themselves reduced to Iron(II) ions.

$2Fe^{3+}_{(aq)} + Sn^{2+}_{(aq)} \longrightarrow 2Fe^{2+}_{(aq)} + Sn^{4+}_{(aq)}$. 03

(c) The mass spectrum of dichloromethane(CH_2Cl_2) shows three peaks at mass to charge ratios of 84, 86 and 88 in a ratio 9:6:1. (03 marks)

Chlorine has two isotopes; Chlorine-35 and Chlorine-37.

The peak at 84 is due to the ion $[CH_2^{35}Cl^{35}Cl]^+$

The peak at 86 is due to the ion $[CH_2^{35}Cl^{37}Cl]^+$

The peak at 88 is due to the ion $[CH_2^{37}Cl^{37}Cl]^+$

The peak with mass to charge ratio 84 is longest because chlorine-35 is the most abundant isotope followed by the peak with mass to charge ratio 86 whose ion still has Chlorine-35 in it.

The peak with mass to charge ratio 88 is shortest because chlorine-37 is less abundant than Chlorine-35.

14.(a) Write (i) ... or ...

14.(a) Write equation for the reaction between water and the chloride of:

(i) Aluminium (1 ½ marks)

$AlCl_{3(s)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3HCl_{(aq)}$ ✓✓

or $Al(H_2O)_6^{3+}{}_{(aq)} + 3H_2O_{(l)} \longrightarrow Al(H_2O)_3(OH)_{3(s)} + 3H_3O^+_{(aq)}$

or $Al^{3+}_{(aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3H^+_{(aq)}$

(ii) Sulphur (1 ½ marks)

$2S_2Cl_{2(l)} + 3H_2O \longrightarrow 3S_{(s)} + H_2SO_{3(aq)} + 4HCl_{(g)}$ ✓+

(iii) Phosphorus (1 ½ marks)

$PCl_{3(l)} + 3H_2O_{(l)} \longrightarrow H_3PO_{3(aq)} + 3HCl_{(g)}$ ✓+

any $PCl_{5(s)} + H_2O_{(l)} \longrightarrow H_3PO_{4(aq)} + 5HCl_{(g)}$

(b) Write an equation for the reaction between concentrated sodium hydroxide and :

reject unbalanced equations.

(i) Aluminium (1 ½ marks)

$2Al_{(s)} + 2\bar{O}H_{(aq)} + 6H_2O_{(l)} \longrightarrow 2Al(OH)_4^-{}_{(aq)} + 3H_{2(g)}$ ✓+

or $2Al_{(s)} + 2\bar{O}H_{(aq)} + 2H_2O_{(l)} \longrightarrow 2AlO_2^-{}_{(aq)} + 3H_{2(g)}$

(ii) Chlorine (1 ½ marks)

Accept hot ionic

$3Cl_{2(g)} + 6\bar{O}H_{(aq)} \longrightarrow 5Cl^-_{(aq)} + ClO_3^-{}_{(aq)} + 3H_2O_{(l)}$ ✓+

(iii) Aluminium oxide (1 ½ marks)

$Al_2O_{3(s)} + 2\bar{O}H_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Al(OH)_4^-{}_{(aq)}$ ✓+

or $Al_2O_{3(s)} + 2\bar{O}H_{(aq)} \longrightarrow 2AlO_2^-{}_{(aq)} + H_2O_{(l)}$

15.(a) An organic compound X has a molecular formula C_4H_9Br

(i) Name the functional group in X. (01 mark)

Carbon-bromine bond. ✓ (01)

reject symbols.

(ii) Write the structural formulae and names of all possible isomers of X. (04 marks)

$CH_3CH_2CH_2CH_2Br$ 1-bromobutane

$CH_3C(CH_3)(Br)CH_3$ 2-bromo-2-methylpropane

$CH_3CH(CH_3)CH_2Br$ 1-bromo-2-methylpropane

$CH_3CH(Br)CH_2CH_3$ 2-bromobutane

04

(iii) Identify **two** isomers in a(ii) that when reacted with hot ethanolic potassium hydroxide solution give the same product. (01 mark)

$CH_3C(CH_3)(Br)CH_3$ and $CH_3CH(CH_3)CH_2Br$

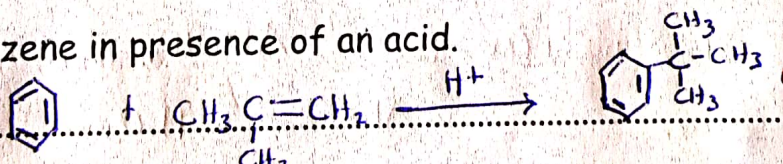
01

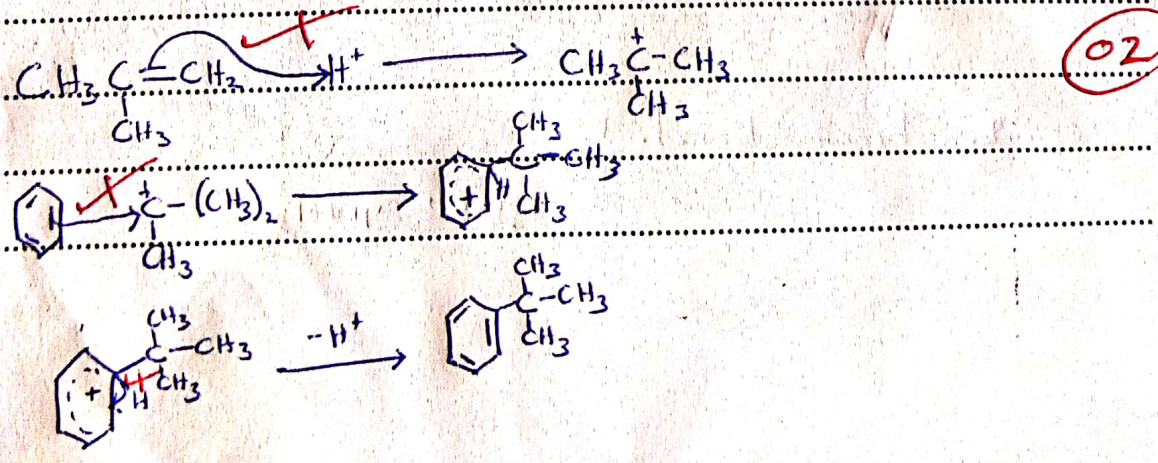
(iv) Write the structural formula and name of the product in a(iii) (01 mark)

$CH_3C(CH_3)=CH_2$ 2-methylpropene

01

(b) Outline the mechanism for the reaction between the product in a(iii) and benzene in presence of an acid. (02 marks)





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16.(a) Write an equation between water and the oxide of :

(i) Sodium (1 ½ marks)

$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$ ✓✓

(ii) Magnesium (1 ½ marks)

$MgO_{(s)} + H_2O_{(l)} \longrightarrow Mg(OH)_{2(s)}$ ✓✓

(iii) Phosphorus (1 ½ marks)

$P_4O_{6(s)} + 6H_2O_{(l)} \longrightarrow 4H_3PO_{3(aq)}$ ✓✓

or $P_4O_{10(s)} + 6H_2O_{(l)} \longrightarrow 4H_3PO_{4(aq)}$

(b)Write equation for the reaction between concentrated sulphuric acid and:

(i) magnesium (1 ½ marks)

$Mg_{(s)} + 2H_2SO_{4(aq)} \longrightarrow MgSO_{4(aq)} + SO_{2(g)} + 2H_2O_{(l)}$ ✓✓

(ii) aluminium (1 ½ marks)

$2Al_{(s)} + 6H_2SO_{4(aq)} \longrightarrow Al_2(SO_4)_{3(aq)} + SO_{2(g)} + 6H_2O_{(l)}$ ✓✓

(iii) phosphorus (1 ½ marks)

$P_{4(s)} + 10H_2SO_{4(aq)} \longrightarrow P_4O_{10(s)} + 10SO_{2(g)} + 10H_2O_{(l)}$ ✓✓

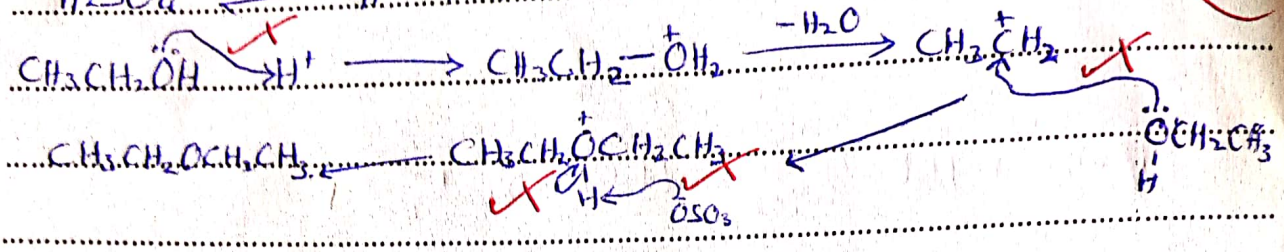
17.Write a mechanism for the reaction that occurs between a mixture of:

(a) ethanol and concentrated sulphuric acid at 140°C. (2 ½ marks)

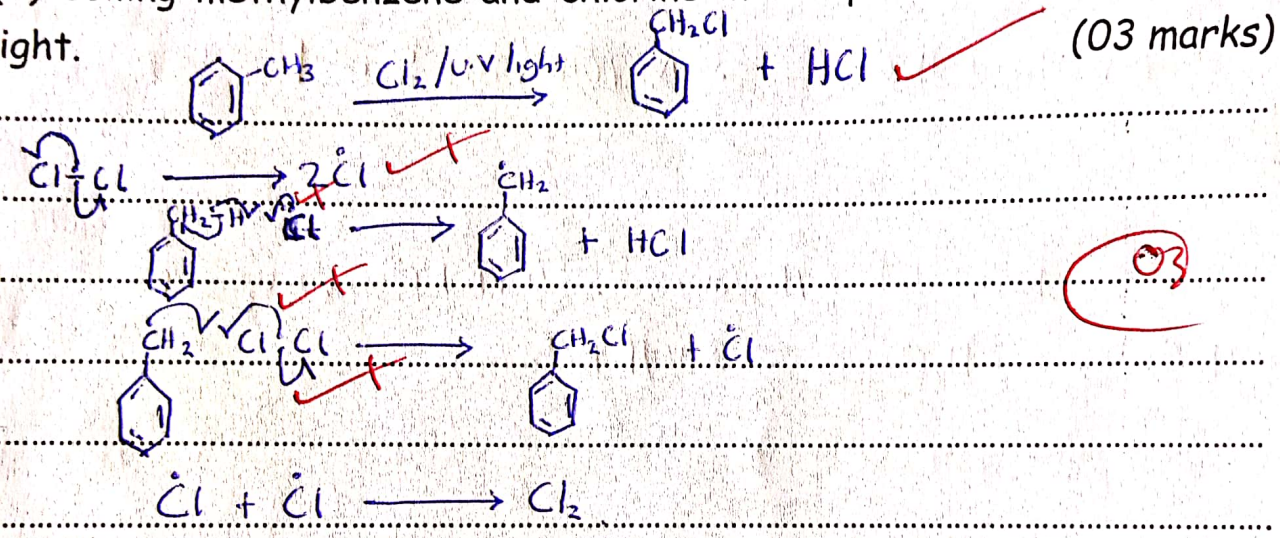
$CH_3CH_2OH \xrightarrow[+40^{o}C]{Conc\ H_2SO_4} CH_3CH_2OCH_2CH_3 + H_2O$

$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$

$2\frac{1}{2}$



(b) boiling methylbenzene and chlorine in the presence of ultraviolet light. (03 marks)

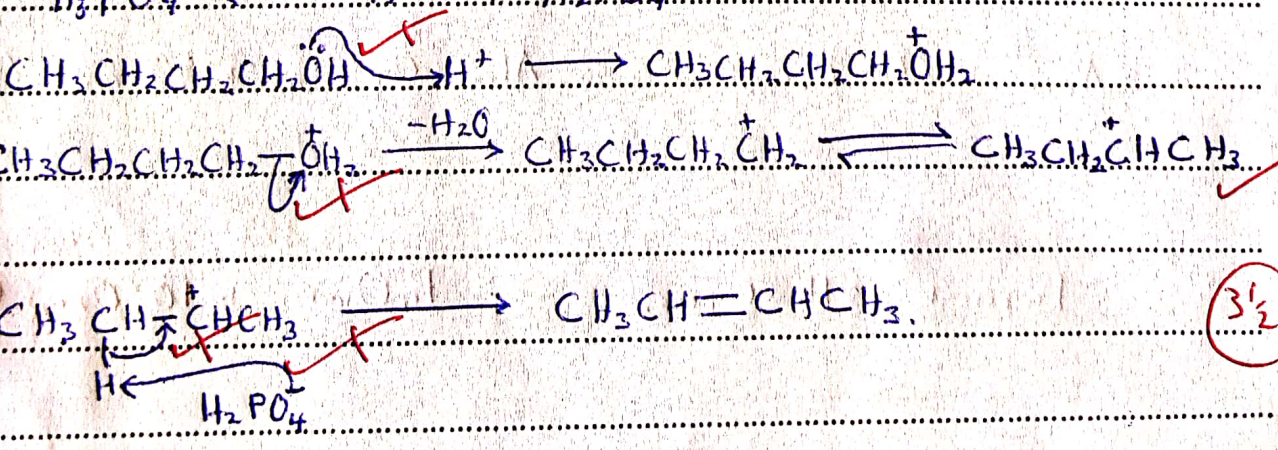


03

(c) butan-1-ol and hot concentrated orthophosphoric acid. ($3\frac{1}{2}$ marks)

$CH_3CH_2CH_2CH_2OH \xrightarrow[Heat]{Conc\ H_3PO_4} CH_3CH=CHCH_3 + H_2O$

$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$



$3\frac{1}{2}$

END

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 TI 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

		139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
		227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

END.