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UGANDA NATIONAL EXAMINATIONS BOARD
UGANDA ADVANCED CERTIFICATE OF EDUCATION
NOVEMBER - DECEMBER, 2020

DO NOT WRITE YOUR SCHOOL/CENTRE NAME OR NUMBER ANYWHERE IN THIS BOOKLET

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READ THE INSTRUCTIONS BELOW CAREFULLY BEFORE USING THE ANSWER BOOKLET.

1. Use a blue or black ink ball pen. Work in pencil, other than graphs, maps and drawings, will **not** be marked.
2. List the question numbers, in the order attempted, in the left-hand column of the boxes opposite. Do **not** list the multiple choice questions.
3. Write your answers on both sides of each sheet.
4. Do your rough work in this answer booklet. Cross through any work you do not want marked.
5. Do **not** fold, dismantle or tear any part of the answer booklet. Do **not** accept an answer booklet with missing pages. Folding, dismantling or tearing of the answer booklet is a malpractice and shall lead to cancellation of results. All work must be handed in.
6. Check that you have written your name, signature, random number and personal number on each page of the answer booklet(s) used. Tie all the booklets used together.
7. Do **not** share your work with another candidate or expose your work such that another candidate can copy from it. Sharing or exposing your work may lead to cancellation of results.
8. Answer only the number of questions as instructed on the question paper. Answers to extra questions will **not** be marked.

Question number attempted	For Examiners' use only	
	Mark	Examiners' initials
Total		

Write here the number of answer booklets you have used.	

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Qn1 a (i) pH is the negative logarithm to base ten of hydrogen ion concentration in $moldm^{-3}$ in a solution.

OR $pH = -\log_{10}[H^+] = \log\frac{1}{[H^+]}$

OR Is the measure of degree of acidity and alkalinity of the solution. (2mks only)

(ii) A buffer solution is a solution that resists change in pH when a small amount of acid or alkali is added to it. It consists of a weak acid and its salt from a strong base or a weak base and its salt from a strong acid.

Reject strong salt

b) - Fermentation.

- Maintain pH of body fluid.
- Making cultured medium in microbiology.
- Manufacture of medicines/drugs.

Reject For hair Champoo.
Accept cosmetics.

c) (i) $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

$Ka = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$, Assumptions: $[H^+] = [CH_3COO^-]$, $[CH_3COOH] = 0.1M$ }

Reject $[CH_3COOH] = c$

$Ka = \frac{[H^+]^2}{0.1}$, $[H^+] = \sqrt{1.75\times10^{-5}\times0.1} = 1.325\times10^{-3}\ moldm^{-3}$. (with units)

$pH = -\log 1.325\times10^{-3} = 2.88$

$\alpha << 1$

OR $Ka = \alpha^2 C$, $\alpha = \sqrt{\frac{1.75\times10^{-5}}{0.1}} = 0.0132$

$[H^+] = \alpha C = 0.0132\times0.1 = 1.32\times10^{-3}\ moldm^{-3}$ (with units)

$pH = -\log 1.32\times10^{-3} = 2.88.$

(ii) $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$

$Ka = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$,

Assumption: $[CH_3COO^-] = [Salt]$
$[CH_3COOH] = [Acid]$.

$[H^+] = \frac{Ka[Acid]}{[Salt]}$

RFM of $CH_3COONa = (12\times2)+(1\times3)+(16\times2)+(23\times1) = 82$

$[Salt] = \frac{16.4}{82} = 0.2M.$

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O.1M Sodium hydroxide

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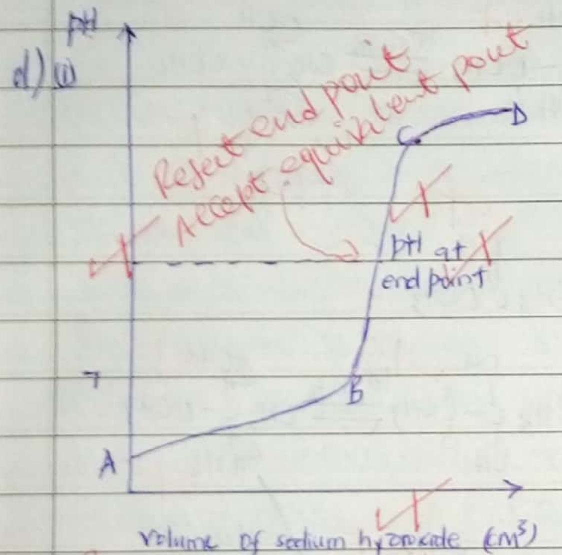
$[H^+] = \frac{1.25\times10^{-5}\times0.1}{0.2} = 8.75\times10^{-6}\ moldm^{-3}$

$pH = -\log 8.75\times10^{-6} = 5.06$

OR $pH = pKa + \log\frac{[Salt]}{[Acid]}$

$pH = -\log 1.25\times10^{-5} + \log\left(\frac{0.2}{0.1}\right) = 5.06$

d) (i)



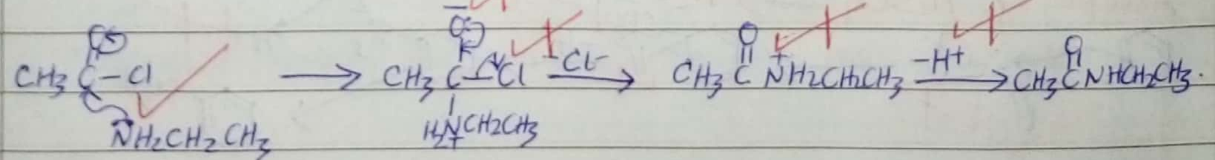
(ii) At A the pH is fairly low because ethanoic acid is a weak. Accept partially ionised for weak. Along AB the pH gradually increases due to neutralization of the acid but the acid is still in excess and a buffer solution is formed.

Accept B is the end point

At B there is complete neutralization, there is a big (rapid) change in pH along BC due to excess strong base added. The pH at the end point is greater than 7 because the salt formed undergoes hydrolysis to form an alkaline solution.

The pH gradually increases along CD due to excess strong base added after the end point. Reject without strong base.

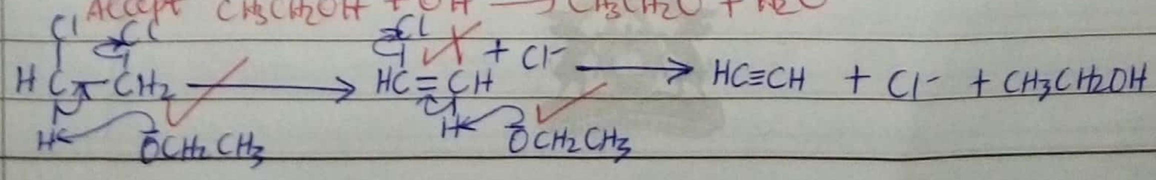
Qn2 a) $CH_3COCl + CH_3CH_2NH_2 \longrightarrow CH_3CONHCH_2CH_3 + (HCl)$



b) $CH_2ClCH_2Cl \xrightarrow[Heat]{KOH(aq)/CH_3CH_2OH} HC{\equiv}CH + (2H_2O + 2KCl)$

$KOH + CH_3CH_2OH \longrightarrow CH_3CH_2O^-K^+ + H_2O$

Accept $CH_3CH_2OH + \bar{O}H \longrightarrow CH_3CH_2\bar{O} + H_2O$



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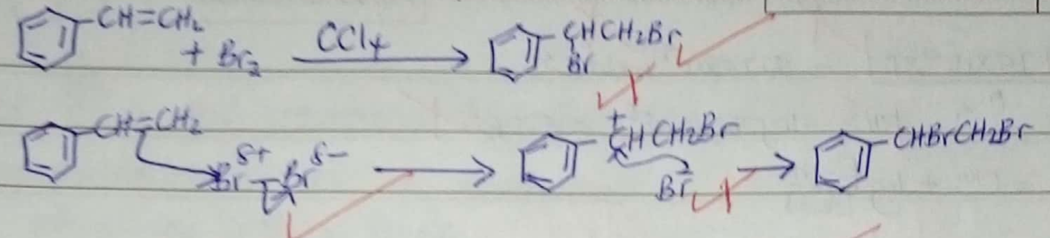
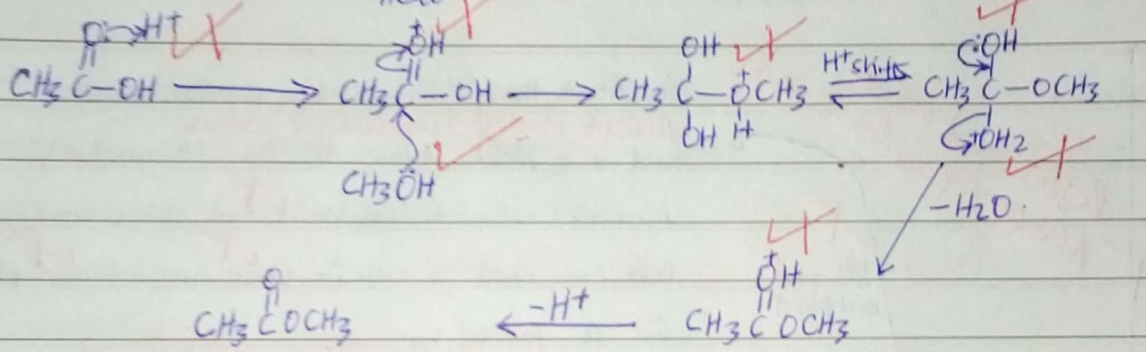
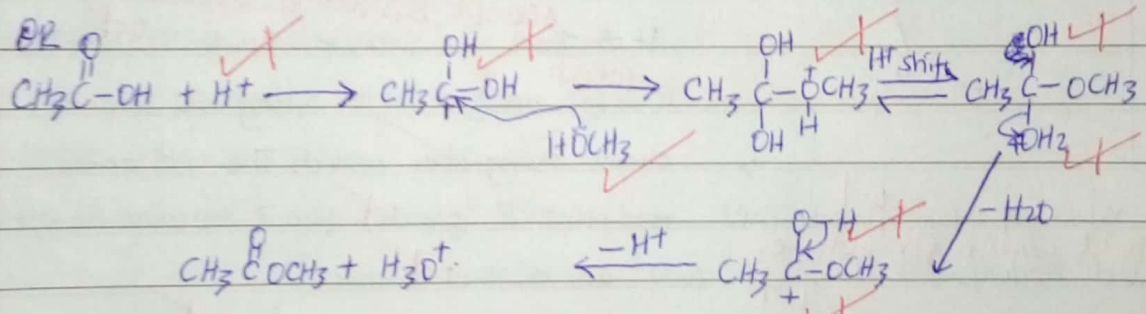
c)



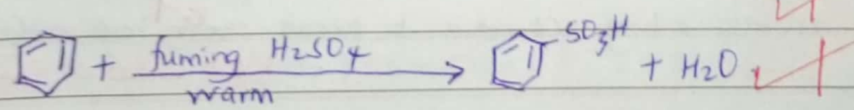
d) $CH_3COOH + CH_3OH \xrightarrow[Heat]{Conc.\ H_2SO_4} CH_3COOCH_3 + H_2O$



OR

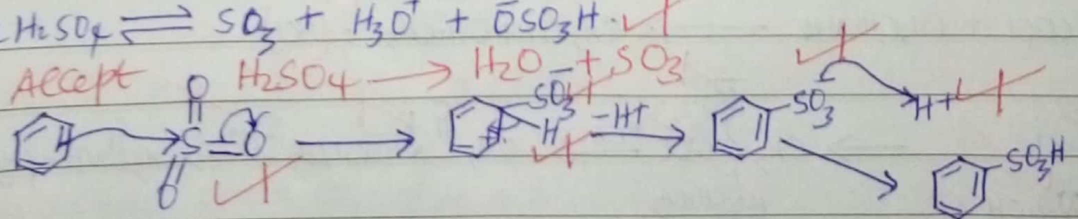


e)



$2H_2SO_4 \rightleftharpoons SO_3 + H_3O^+ + \bar{O}SO_3H$

Accept $H_2SO_4 \rightarrow H_2O + SO_3$



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Qn 3. a) (i) CH_4, SiH_4, SnH_4, PbH_4 Accept any hydrocarbon for C hydride
OR XH_4 where X - C, Si, Sn, Pb

(ii) Carbon undergoes catenation or forms long chains or rings or forms stable multiple bonds with itself and hydrogen. Down the group atomic radius increases, X-H bond becomes longer and less stable.

b (i) The hydrides do not react with dilute hydrochloric acid
(ii) Silane reacts with sodium hydroxide solution to form sodium silicate and hydrogen gas.
$SiH_{4(g)} + 2\bar{O}H_{(aq)} + H_2O_{(l)} \longrightarrow SiO_3^{2-}{}_{(aq)} + 4H_{2(g)}$
The hydrides of carbon, tin and lead do not react with sodium hydroxide
(iii) Silane reacts poorly with water to form hydrogen gas and silicic acid or silicon(IV) hydroxide or hydrated silicon(IV) oxide.
$SiH_{4(g)} + 3H_2O_{(l)} \longrightarrow H_2SiO_{3(s)} + 4H_{2(g)}$
OR $SiH_{4(g)} + 4H_2O_{(l)} \longrightarrow Si(OH)_{4(s)} + 4H_{2(g)}$.
OR $SiH_{4(g)} + 4H_2O_{(l)} \longrightarrow SiO_2 \cdot 2H_2O_{(s)} + 4H_{2(g)}$
OR
Silane reacts with water in the presence of a trace of alkali to form a silicate and hydrogen gas
$SiH_{4(g)} + H_2O_{(l)} + 2\bar{O}H_{(aq)} \longrightarrow SiO_3^{2-}{}_{(aq)} + 4H_{2(g)}$
Hydrides of Carbon, tin and lead do not react with water.

c (i) Tin is oxidized by chlorine when heated to form tin(IV) chloride
$Sn_{(s)} + 2Cl_{2(g)} \longrightarrow SnCl_{4(l)}$
Lead is oxidized by dry chlorine when heated to form lead(II) chloride
$Pb_{(s)} + Cl_{2(g)} \longrightarrow PbCl_{2(s)}$

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(ii) Carbon is oxidized by (hot concentrated) nitric acid to carbondioxide gas, nitrogen dioxide gas and water.

$C_{(s)} + 4HNO_{3(aq)} \rightarrow CO_{2(g)} + 4H_2O_{(l)} + 2H_2O_{(l)}$

Lead is oxidized by hot or warm concentrated nitric acid to form lead(II) nitrate, nitrogen dioxide gas and water.

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

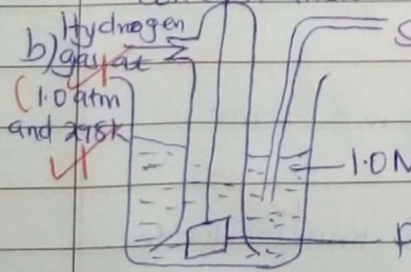
OR lead reacts with warm or hot moderately concentrated nitric acid to form lead(II) nitrate, nitrogen monoxide gas and water.

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

Qn 4 a) i) This is the electromotive force of a cell in which the electrode or half cell is on the right hand side while the standard hydrogen electrode/half cell is on the left hand side under standard conditions.
OR This is the reduction potential of an electrode or half cell measured against or using a standard hydrogen electrode under standard conditions.

(ii) - Temperature
- Ionization energy.
- Atomization energy
- Hydration energy of the ions.
- Concentration of the ions (or pressure for gases).

Any 3

b) 

W/A

(Accept platinum black) w platinum.

Hydrogen gas at 1.0 atmospheres is bubbled over platinised platinum dipped in a 1.0M solution of hydrogen ions at 298K. Platinum provides ~~the~~ surface for the reaction and conducts current from and to the external circuit. Equilibrium is set up between

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hydrogen gas and hydrogen ions or hydrogen gas is oxidized to hydrogen ions.

$H_2(g) \rightleftharpoons 2H^+(aq) + 2e$

The standard hydrogen electrode (on the left) is connected ~~to~~ another electrode placed on the right hand side using a salt bridge; The electromotive force of the half cell is measured using a voltemeter potentiometer. Since the electrode potential of the standard hydrogen electrode is taken as 0.00V, the reading of the voltameter is the reduction potential of the right hand side half cell.

c) (i) $X(s)|X^{2+}(aq)||Fe^{2+}(aq)|Fe(s)$

or $X(s)|X^{2+}(aq)\,\vdots\vdots\,Fe^{2+}(aq)|Fe(s)$

Deny if state symbols are missing

(ii) $X(s) + Fe^{2+}(aq) \longrightarrow X^{2+}(aq) + Fe(s)$

d) $E_{cell} = E_{RHE} - E_{LHE}$

$= -0.41 - -0.76 = +0.35V$. The reaction is feasible

Depend on Part (a)(i)

e) $Fe^{2+}(aq) + 2e \longrightarrow Fe(s)$

56g of iron is deposited by 2x96500C

15g of iron is deposited by $\frac{2 \times 96500}{5}$ C = 51696.42857C

From $Q = It$.

$51696.42857 = 12t$

$t = \frac{51696.42857}{12} = 4308$ Seconds. OR $\frac{4308}{60} = 71.80$ minutes

(Forfeit answer without units)

OR $= \frac{71.80}{60} = 1.2$ hours.

Method 2

$x = \frac{Mr \times I \times t}{nF}$

$15 = \frac{56 \times 12 \times t}{2 \times 96500}$, $t = 4308$ Seconds.

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Method 3

No. of moles of Iron = $\frac{15}{56}$ moles.

$Fe^{2+}_{(aq)} + 2e \longrightarrow Fe_{(s)}$

Moles of electrons = $\frac{2 \times 15}{56}$

1mole of electrons equals 96500C

$\frac{30}{56}$ moles of electrons equals to $\frac{96500 \times 30}{56} = 51696.4C$

From $Q = It$, $t = \frac{Q}{I} = \frac{516964}{12} = 4308$ seconds.

f) – Manufacture of sodium hydroxide and chlorine by electrolysis of brine.
– Extraction of metals such as sodium, aluminium, magnesium.
– Purification of metals such as copper, silver etc.

Qn6 a) (i) Lattice energy is the heat/energy required to convert one mole of a solid ionic compound ~~to~~ into its gaseous ions.

Reject substance

OR Is the heat/energy evolved when one mole of an ionic crystal lattice is formed from its gaseous ions.

(ii) Hydration energy is the heat evolved when one mole of gaseous ions dissolves in water to form an infinite dilute solution.

OR Is the heat evolved when one mole of gaseous ions is completely surrounded by water molecules or completely hydrated to form an infinite dilute solution without change in pH.

(iii) Enthalpy of solution is the heat change that takes place when one mole of a compound or a substance dissolves in water/solvent to form an infinite dilute solution.

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OR Is the heat change that occurs when one mole of a compound/substance dissolves in a specific amount of water/solvent to form infinite dilute solution.

b) A known volume ($V cm^3$) of water is placed into insulated caloameter and its temperature measured measured, T_1°C. A known mass of calcium iodide, Xg is added to water in insulated calorimeter and the mixture stirred and final steady temperature (highest or lowest) is recorded T_2°C

Constant.

Assumption.

Density of solution = Density of water = $1 g cm^{-3}$.

SHC of the solution = that of water = $4.2 J g^{-1} °C^{-1}$

Reject C for S.H.C

Heat capacity of calorimeter is negligible.

Temperature change = ΔT°C = $(T_2 - T_1)$ or $(T_1 - T_2)$

Mass of solution = $(V + x)$

Heat change = $(V+x) \times 4.2 \times \Delta T$ Joules

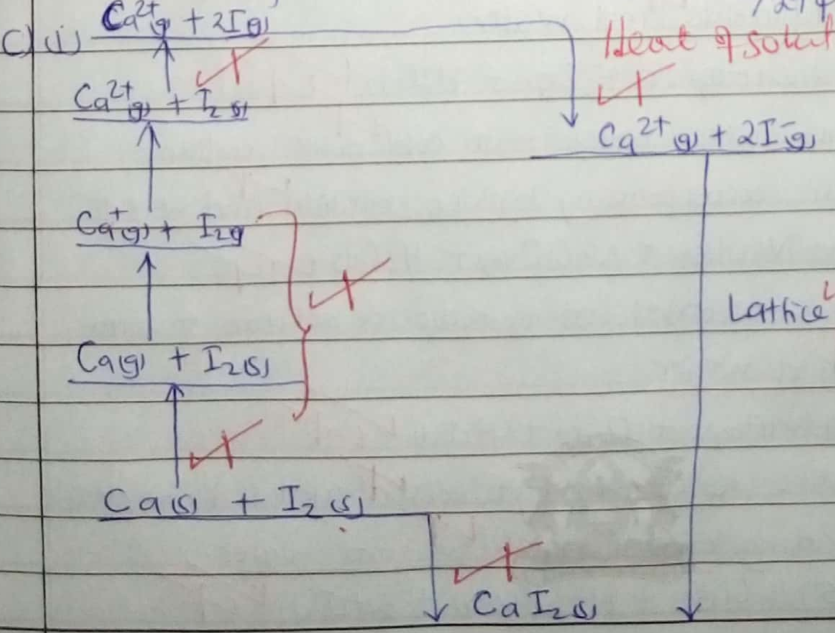
Moles of CaI_2 = $\frac{x}{294}$

$\frac{x}{294}$ moles of CaI_2 produce $(V+x) \times 4.2 \times \Delta T$ Joules

1 mole of CaI_2 produce $\left(\frac{(V+x) \times 4.2 \times \Delta T}{x/294}\right)$ Joules mol^{-1}

Heat of solution for CaI_2 = $\pm \frac{(V+x) \times 4.2 \times \Delta T}{\frac{x}{294} \times 1000}$

c)(i)



Reject the cycle if states are missing

Reject Born haber cycle.

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$-533.5 = 178.2 + 590 + 1145 + 2(106.8) + 2(-295.4) + LE$

$LE = -2069.5 \ KJmol^{-1}$

(ii) Hydration energy of $CaI_2 = -1562 + 2(-307)$

$= -2176 \ KJmol^{-1}$

Heat of solution = Lattice energy + Hydration energy

$= +2069.5 - 2176 = -106.5 \ KJmol^{-1}$

(iii) Calcium iodide is soluble in water because its enthalpy of solution is negative / exothermic.

d) Lattice energy decreases from potassium fluoride to potassium iodide. Reject lattice decreases down the group.
This is because from fluoride ions to iodide ions, the ionic radius increases, the strength of the ionic bonds reduce.

Qn5 a) (i) see graph Plot axes Shape

(ii) Boiling points increase with increase in atomic number (or down the group) or from fluorine and iodine. As the atomic number increases down the group their molecular masses also increases leading to increase in the strength of the van der Waals forces.

b) Fluorine reacts with cold dilute sodium hydroxide solution to form sodium fluoride, Oxygen difluoride and water.

$2F_{2(g)} + 2NaOH_{(aq)} \longrightarrow 2NaF_{(aq)} + F_2O_{(g)} + H_2O_{(l)}$

Chlorine, bromine and iodine react with cold dilute sodium hydroxide solution to form corresponding halides, halate(I) and water

eg $2NaOH_{(aq)} + Cl_{2(g)} \longrightarrow NaCl_{(aq)} + NaClO_{(aq)} + H_2O_{(l)}$

Fluorine reacts with hot concentrated sodium hydroxide solution to form sodium fluoride, oxygen and water.

$4NaOH_{(aq)} + 2F_{2(g)} \rightarrow 4NaF_{(aq)} + O_{2(g)} + 2H_2O_{(l)}$

Chlorine, bromine and iodine react with hot concentrated sodium hydroxide solution to form corresponding halides, halates(V) and water.

$6NaOH_{(aq)} + 3Cl_{2(g)} \longrightarrow 5NaCl_{(aq)} + NaClO_{3(aq)} + 3H_2O_{(l)}$

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c) To a solution of each of the halides, silver nitrate solution is added.
Chloride ions form insoluble white precipitate of silver chloride.
Bromide ions form insoluble pale yellow precipitate (or cream) of silver of silver bromide.
Iodide ions form insoluble pale yellow / yellow precipitate of silver iodide.

~~X~~ $Ag^+_{(aq)} + X^-_{(aq)} \longrightarrow AgX_{(s)}$ where X - Cl, Br, I.

Qn 7. a) Ethanol is heated with excess concentrated sulphuric acid at 180°C to form ethene. Ethene is reacted with ozone in the presence of carbon tetrachloride to form an ozonide which is hydrolyzed with zinc and ethanoic acid to form methanal.

OR

Ethanol is heated with acidified potassium manganate (VII) or acidified potassium dichromate (VI) to form ethanoic acid. Ethanoic acid is reacted with phosphorous pentachloride to form ethanoyl chloride. Ethanoyl chloride is reacted with concentrated ammonia to form ethanamide. Ethanamide is warmed with bromine concentrated sodium hydroxide and bromine to form methylamine. Methylamine is reacted with sodium nitrite and concentrated hydrochloric acid to form methanol which is heated with acidified potassium dichromate (VI) to form methanal.

OR

Ethanol is heated with acidified potassium permanganate (VII) to form ethanoic acid. Ethanoic acid is reacted with ammonium carbonate to form ammonium carbonate which is heated to form ethanamide. Ethanamide is warmed with bromine and concentrated sodium hydroxide to form methylamine. Methylamine is reacted with sodium nitrite and concentrated hydrochloric acid to form methanol which is heated with acidified potassium dichromate (VI) to form methanal.

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b) Calcium carbide reacts with water or dil hydrochloric acid to form ethyne ~~to f~~ which is reacted with water in the presence of sulphuric acid and mercury (II) sulphate at 60°C to form ethanal. Ethanal is reacted lithium aluminium hydride to form ethanol which is heated with concentrated sulphuric acid at 180°C to form ethene. Ethene is reacted with acidified or alkaline potassium manganate (VII) to form ethane-1,2-diol.

OR ~~eh~~ Ethene is reacted with chlorine or bromide in the presence of carbon tetrachloride to form 1,2-dibromoethane which is reacted with hot excess sodium hydroxide solution to form ~~1,2-dibromoethane~~ ethane-1,2-diol.

OR Ethyne is reacted with hydrogen in the presence of Lindler's catalyst to form ethene which is reacted with bromine in carbon tetrachloride to form 1,2-dibromoethane which is heated with excess sodium hydroxide solution to form ethane-1,2-diol.

c) Ethanol is heated with acidified potassium manganate(VII) solution to form ethanoic acid which is heated with sodalime to form methane

OR

Ethanol is heated with excess concentrated sulphuric acid at 180°C to form ethene. Ethene is reacted with ozone in the presence of carbon tetrachloride to form ozonide which is hydrolyzed with water in the presence of zinc and ethanoic acid to form methanal. Methanal is reacted with zinc amalgam in the presence of concentrated hydrochloric acid to form methane.

d) Propanoic acid is reacted with lithium aluminium hydride in dry ether to form propan-1-ol which is then heated with concentrated sulphuric acid at 180°C to form propene. Propene is reacted with concentrated sulphuric acid to form 2-propylhydrogensulphate which is warmed with water to form propan-2-ol.

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OR Propene is reacted with hydrogen chloride to form 2-chloropropane which is heated with sodium hydroxide solution to form propan-2-ol.

Qn 8 a) Propan-1-ol molecules are held by hydrogen bonds. This is because propan-1-ol has an O-H bond which is polar since oxygen has a high electronegativity. Butane molecules are non-polar. They are held Van der Waals forces which are weaker than hydrogen bonds.

b) Concentrated sulphuric acid oxidises hydrogen bromide to bromine

$2HBr_{(aq)} + H_2SO_{4(l)} \longrightarrow Br_{2(aq)} + SO_{2(g)} + H_2O_{(l)}$

OR

$2NaBr_{(s)} + 3H_2SO_{4(l)} \longrightarrow 2NaHSO_{4(aq)} + Br_{2(l)} + SO_{2(g)} + 2H_2O_{(l)}$

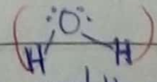
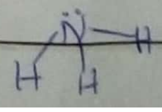
OR

$2NaBr_{(s)} + 2H_2SO_{4(l)} \longrightarrow Na_2SO_{4(aq)} + Br_{2(aq)} + SO_{2(g)} + 2H_2O_{(l)}$

c) Down the group ionic radius increases, lattice energy and hydration energy reduce but lattice energy reduces more than hydration energy. The enthalpy of solution becomes more negative

d) Phenol is sparingly soluble in water because it has a benzene ring which is hydrophobic or which has a higher molecular mass. Since it's acidic, it reacts with sodium hydroxide solution to form sodium phenoxide which is soluble

$C_6H_5OH_{(s)} + NaOH_{(aq)} \longrightarrow C_6H_5O^-Na^+_{(aq)} + H_2O_{(l)}$

e) In water, the oxygen atom has two lone pairs of electrons and two bonds. It has a ~~trigonal pyramidal~~ V-shape. OR 
In ammonia, the nitrogen atom has one lone pair and three bonds. It has a trigonal pyramidal shape. OR 

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The two lone pairs cause a greater repulsion of bonds than one lone pair hence reducing the bond angle.

f) Mg: $1s^2 2s^2 2p^6 3s^2$
AL: $1s^2 2s^2 2p^6 3s^2 3p^1$.

Magnesium has a 3s sub-energy level which is full and stable. Aluminium has an outermost 3p sub-energy level which is not full or half full. Therefore it requires more energy to remove an electron from a stable sub-energy level.

Reject $3s^2$

Reject partially filled

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