Name:…… Index No. …….

Signature:…..……

P525/1
Chemistry
Paper 1
June/July 2016

Uganda Advanced Certificate of Education

CHEMISTRY

Paper 1

TIME: 2 ¾ HOURS

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of two sections **A** and **B***
- *Section **A** is compulsory.*
- *Attempt **only six** questions in section **B***
- *Answers must be written in the spaces provided **only***

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

SECTION A: (46 MARKS)

Answer all questions in this section

1. (a) Write the equation of reaction between sodium hydroxide and
   (i) Lead (IV) oxide (1 ½ marks)

   $PbO_2(s) + 2OH^-(aq) \rightarrow PbO_3^{2-}(aq) + H_2O(l)$

   (ii) Chromium (III) oxide (1 ½ marks)
   $Cr_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Cr(OH)_4^-(aq)$

   (b) Concentrated nitric acid was added to a solution of manganese (II) sulphate followed by lead (IV) oxide
   (i) State what was observed (½ marks)
   Solution turns purple

   (ii) Write equation for the reaction (1 ½ marks)
   $2Mn^{2+}(aq) + 5PbO_2(s) + 4H^+(aq) \rightarrow 2MnO_4^-(a) + 2H_2O(l)$

2. (a) The emission spectrum of the element hydrogen contains several series of lines.
   (i) Give a general expression for the energy of the lines in a hydrogen line spectrum. (01 mark)
   E = hf (E = energy, h = Planks constant, f = frequency)

   (ii) What do the different lines in a given series have in common (01 marks)

   They quantum number to which electrons return

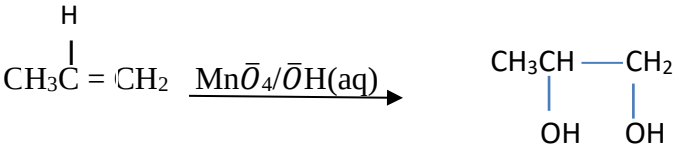
   (b) The frequency of hydrogen at the point of ionization is 32.8×10^{14} Hz. Calculate the ionization energy of hydrogen in $kJmol^{-1}$ (03 marks)
   (Planks constant = 6.6×10^{-34} Js)

   $E = 6.6 \times 10^{-34} \times 32.8 \times 10^{14} \times 6.02 \times 10^{23} = 1303 kJmol^{-1}$

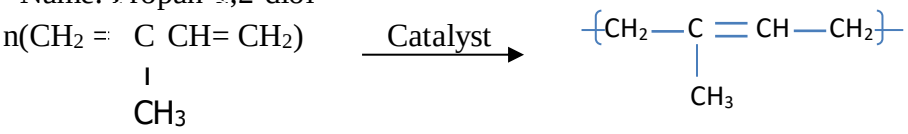
3. Complete the following organic equations and in each case name the main organic product

   (a) $CH_3\ \underset{\underset{O}{\|}}{C}\ CH_3 \xrightarrow[(ii)\ H^+]{(i)\ CH_3MgI} (CH_3)_3COH$

   Name : 2-methylpropan-2-ol (01mark)

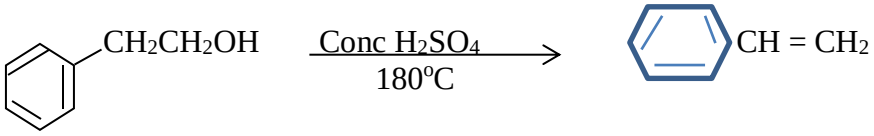
(b) 

Name: Propan-1,2-diol

(c) 

Poly(2-methylbut-1,3-diene)

Name …… (01mark)

(d) 

Name: phenylethene (01 mark)

(e) $(CH_3COO)_2Ca \xrightarrow{heat} CH_4$

Name: methane (01 mark)

4. Silver chromate is sparingly soluble in water.

(a) Write

(i) Equation for the solubility of silver chromate in water (01mark)

$Ag_2CrO_4(aq) \rightarrow 2Ag^+(aq) + CrO_4^{2-}(aq)$

(ii) The expression for the solubility product of silver chromate (01mark)

$K_{sp} = [Ag^+]2[CrO_4^{2-}]$

(b) Calculate the solubility of silver chromate in the presence of 0.005M potassium chromate (VI) solution ($K_{sp} = 9 \times 10^{-12}$ mol^3dm^{-9}) (03marks)

Let solubility of silver chromate be x

$[CrO_4^{2-}] = x + 0.005 \cong 0.005$ moles

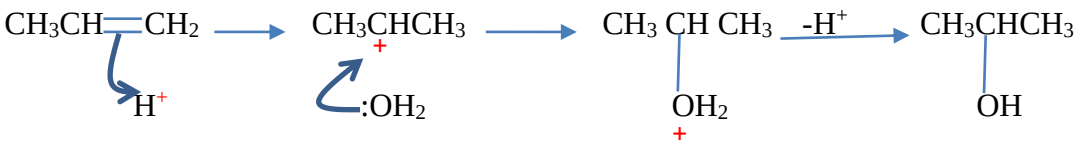
$[Ag^+] = 2x$

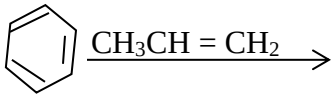
$K_{sp} = 9 \times 10^{-12} = [2x]^2 \times 0.005$

$x = 2.12 \times 10^{-5} moldm^{-3}$

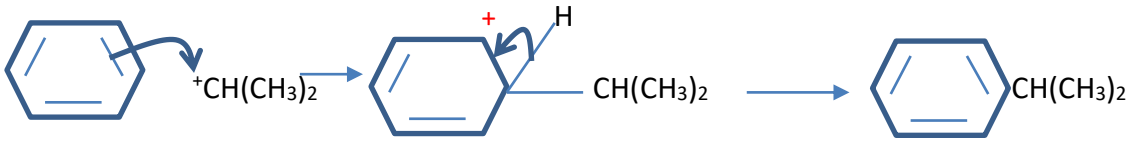
5. Complete the following equations and in each case outline the mechanism for the reaction

(a) $CH_3CH = CH_2 \xrightarrow[\text{Heat}]{H^+|H_2O} CH_3CHCH_3$ (02 marks)



(b)  $CH_3CH = CH_2$  $CH(CH_3)_2$

$CH3CH=CH_2 + H^+$ $^+CH(CH_3)_2$



6. State what is observed and write equations for the reactions that would take place when sodium hydroxide solution is added to;

(a) Iron (II) sulphate solution

Observation (1 ½ marks)

Green precipitate insoluble in excess

Equation (1 ½ marks)

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

(b) Chromium (III) sulphate solution

Observation (1 ½ marks)

A green precipitate soluble in excess to give green solution

Equation (1 ½ marks)

$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s) + OH^-(aq) \rightarrow Cr(OH)_4^-(aq)$

7. (a) State Raoult's law (01 mark)

States that the partial vapor pressure of a component in a mixture is a product of its mole fraction and vapor pressure of pure component

(b)A solution contains 1 mole of trichloromethane and 4 moles of propanone has a vapour pressure of 0.4 atmospheres at 25°C. At this temperature the vapour pressures of pure trichloromethane and propanone are 0.359 and 0.453 atmospheres respectively.

(i) Calculate the vapor pressure of the solution. State your assumption(s)

Assumption: the mixture obeys Raoult's law

From $P_t = X_A P^0_A + X_B P^0_B$

$= \frac{1}{5} x\ 0.359 + \frac{4}{5} x\ 0.453 = 0.4342$ atmospheres

(ii) State whether trichloromethane and propanone form a minimum or maximum boiling azeotrope. Give a reason.

Forms maximum boiling point azeotrope because it deviates negatively from Raoult's law or its vapour pressure is less than expected

8. (a) A chloride of chromium X contains 19.512% chromium, 39.96% chlorine and the rest water of crystallization.

Determine:

(i) The empirical formula of X (1 ½ marks)

Percentage of water of crystallization = 100 – (19.512 + 39.96) = 40.528

Components	Cr	Cl	H_2O
Percentage	19.512	39.96	40.522
RFM	52	35.4	18
moles	0.375	1.129	2.251
Mole ratio	1	3	6
Empirical formula	$CrCl_3.6H_2O$		

(ii) The molecular formula of X (Vapour density of X is 133.25) (1 mark)

Molecular mass = 133.25 x 2 = 266.6

$(CrCl_3.6H_2O)n = 266.5$

n = 1

Molecular formula = $CrCl_3.6H_2O$

(c) An aqueous solution of X was treated with excess sodium hydroxide solution followed by hydrogen peroxide.

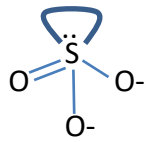
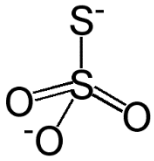
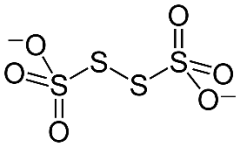
(i) State what was observed. (1 mark)

A green precipitate soluble in excess turned yellow with hydrogen peroxide

(ii) Write equation for the reaction which took place. (1 mark)

$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$
$Cr(OH)_3(s) + OH^-(aq) \rightarrow Cr(OH)_4^-(aq)$
$2Cr(OH)_4^-(aq) + 3H_2O_2(aq) + 2OH^-(aq) \rightarrow 2CrO_4^{2-}(aq) +$
8Type equation here.$H_2O(l)$

9. (a) Draw the structure and name the shape of the following oxyanions of sulphur

Oxyanion	Structure	Shape
SO_3^{2-}		Trigonal pyramidal
$S_2O_3^{2-}$		tetrahedral
$S_4O_6^{2-}$		

(02 marks)

(c) Write the equation of reaction between

(i) $S_2O_3^{2-}$ and Iodine solution (1 ½ marks)

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

(ii) $S_2O_8^{2-}$ and potassium iodide (1 ½ marks)

$S_2O_8^{2-}(aq) + I_2(aq) \rightarrow 2SO_4^{2-}(aq) + 2I^-(aq)$

SECTION B (54marks)

Attempt only six questions in this section

10. Elements tin and lead belong to group (IV) of the periodic table. Describe the reactions of the elements with;

(a) Water

Tin does not react with water

Lead reacts with soft water (water that contains oxygen) to form lead II hydroxide.

$Pb(s) + 2H_2O(g) + O_2(g) \rightarrow Pb(OH)_2(s)$ (03 marks)

(b) Concentrated sulphuric acid (03 marks)

Sn and Pb reacts hot concentrated sulphuric acid liberating sulphur dioxide.

$Pb(s) + 2H_2SO_4(aq) \rightarrow PbSO_4(s) + SO_2(g) + 2H_2O(l)$

$Sn(s) + 2H_2SO_4(aq) \rightarrow SnSO_4(s) + SO_2(g) + 2H_2O(l)$

(c) Alkalis (03 marks)

Sn react liberating hydrogen and stannates (IV)

$Sn(s) + 2NaOH(aq) + H_2O(l) \rightarrow Na_2SnO_3(aq) + 2H_2(l)$

Lead reacts to form plumbates (II).

$Pb(s) + 2NaOH(aq) \rightarrow Na_2PbO_2(aq) + 2H_2(g)$

11. (a) Define the terms

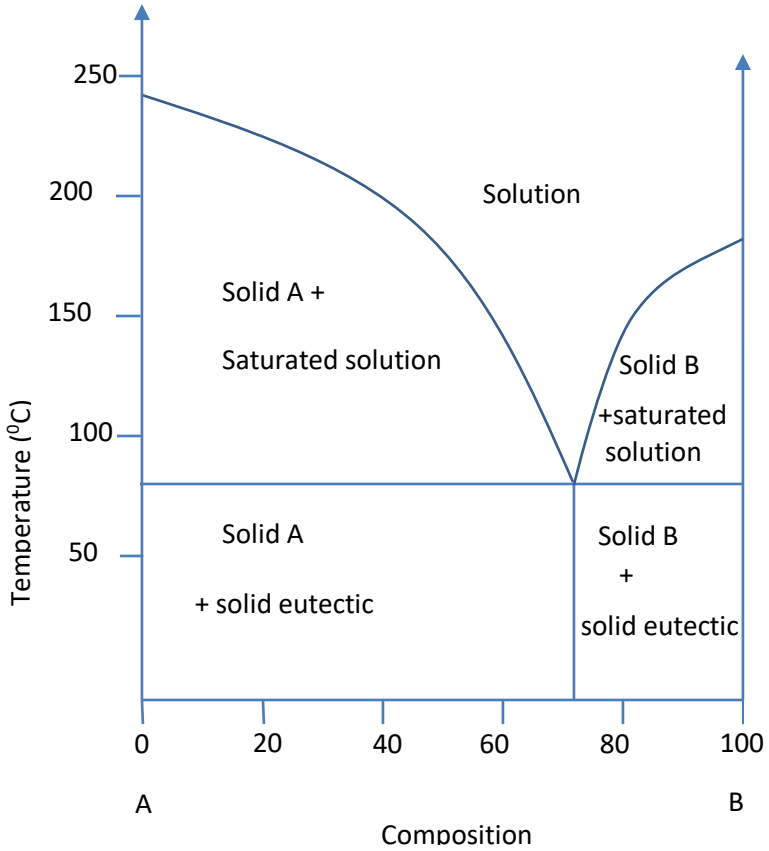
(i) Eutectic point (2 marks)

It is temperature and composition at which a liquid of a liquid mixture freezes to give a solid of the same composition.

(ii) Eutectic mixture (2 marks)

It a mixture that freezes at constant temperature to give a solid of constant composition.

(b) Two metals A and B form a eutectic mixture with a eutectic point of 80°C and 72% B. Draw a well labeled phase diagram for the two metals. (Melting points of A and B are 242 °C and 185 °C) (04marks)



(c) State two similarities between eutectic mixture and a metal (1 mark)

- have constant composition in liquid and solid
- freeze at constant temperature

12. The molecular formula of an organic compound Q is C_4H_8O. Compound Q forms a yellow precipitate with Brady's reagent

(a) Write the structural formulae and names of all the possible isomers of A (2 marks)

$CH_3CH_2CH_2CHO$ butanal

$CH_3CH_2COCH_3$ butanone

(b) Q reacted with iodine in an aqueous solution of sodium hydroxide to form a yellow precipitate

(i) Identify Q (01 mark)

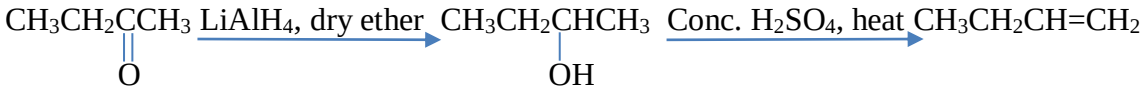
butanone

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

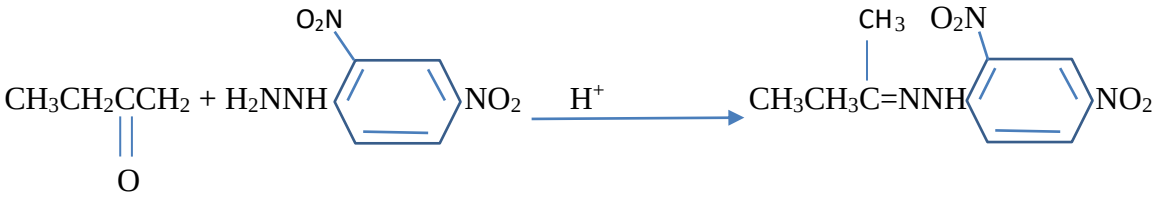
$CH_3CH_2COCH_3 + I_2 + OH^- \rightarrow CHI_3 + CH_3CH_2COO^-$

(c) Write;

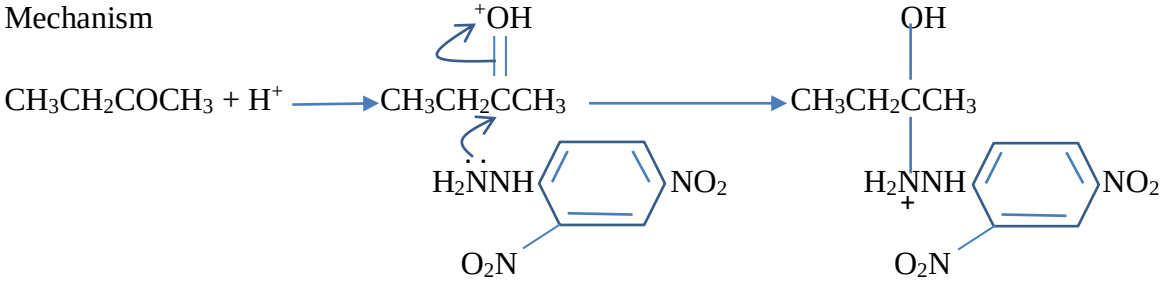
(i) equations indicating conditions to show how Q can be converted to an alkene (2 marks)

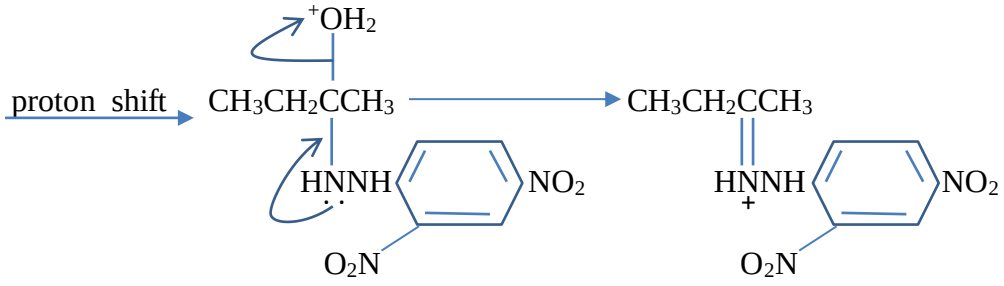


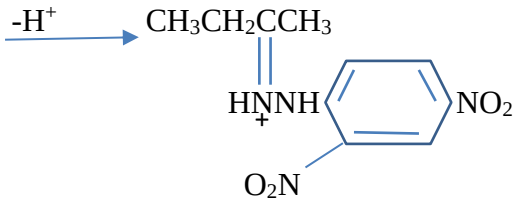
(ii) equation and outline the mechanism for the reaction between Q and Brady's reagent (2 ½ marks)



Mechanism



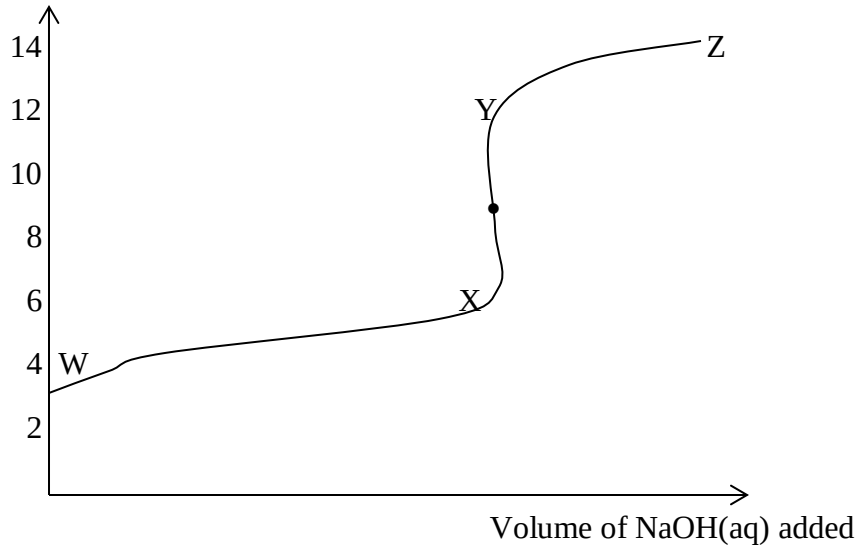




13. (a) Explain the term buffer solution (02marks)

A buffer is a solution which resist changes in pH when small amount of acid or base are added.

(b) The graph below shows the changes in P^H during the titration of a weak acid (ethanoic acid) with a strong alkali (sodium hydroxide)



(i) Explain the shape of the graph (5 ½ marks)

Initially at W the pH is relatively high due to partial ionization of the acid, between W and X pH increases due to removal of H^+ by OH^-.XY the end point occurs at a pH above 7 because ethanoate ions hydrolyses to produce hydroxyl ions

$CH_3COO^-(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + OH^-(aq)$

YZ pH increases due to excess hydroxyl ions

(ii) Calculate the P^H at mid-point of titration (Ka CH_3COOH) = 1.8×10^{-5} moldm^{-3}) (1 ½ marks)

$pH = pKa + \text{Log } \frac{salt}{acid}$

at half neutralization [salt] = [acid]

$pH = pKa = -\log 1.8 \times 10^{-5} = 4.74$

14. (a) Outline the industrial preparation of sulphuric acid from zinc sulphide (*use equations only*) (06 marks)

$2ZnS\ (s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$H_2SO_4(aq) + SO_3(g) \rightarrow H_2S_2O_7(l)$

$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(aq)$

(b) Write equation of reaction between sulphuric acid and;

(i) Calcium phosphate (1½ marks)

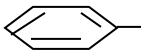
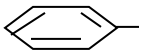
$Ca_3(PO_4)_2\ (s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + Ca(H_2PO_4)_2$

(ii) Propan – 2– ol (1 ½ marks)

$CH_3CHCH_3 \xrightarrow[\text{heat}]{\text{Conc. } H_2SO_4} CH_3CH{=}CH_2$

OH

15. Name a reagent(s) that can be used to distinguish between the following pairs of compounds. In each case state what would be observed if the reagent is treated separately with each member of a pair

(a)  $COCH_2CH_3$ and  $COCH_3$

Reagent: I_2/OH^- (01 mark)

Observations (02 marks)

 $COCH_2CH_3$ no observable change

 $COCH_3$ yellow ppt

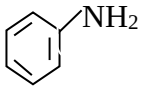
(b) $CH_3CH_2CH_2CH_2OH$ and $(CH_3)_3COH$

Reagent: anhydrous zinc chloride and concentrated hydrochloric acid (01 mark)

Observations (02 marks)

$CH_3CH_2CH_2CH_2OH$ no observable change

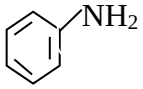
$(CH_3)_3COH$ immediate cloudiness

(c) $CH_3CH_2CH_2CH_2NH_2$ and 

Reagent: $NaNO_2/HCl < 5^0C$ (01mark)

Observations (02 marks)

$CH_3CH_2CH_2CH_2NH_2$ effervescence



No observable change

16. (a) (i) What is the chemical nature of soap (01mark)

Soap is sodium or potassium salt of long carboxylic acid

(ii) A fat has a molecular formula $C_{17}H_{35}COOR$. Write an equation for the reaction leading to the formation of soap from the fat. (2 marks)

$C_{17}H_{35}COOR + OH^-(aq) \rightarrow C_{17}H_{35}COO^- + ROH$

(soap)

(b) (i) Explain why soapless detergents are better cleansing agents than soaps. (3 marks)

They form soluble calcium salts and thus do not form scum with hard water

(ii) Starting from $CH_3(CH_2)_{10}CH_2OH$ show how a soapless detergent can be synthesized. (03 marks)

$CH_3(CH_2)_{10}CH_2OH + PCl^5 \rightarrow CH_3(CH_2)_{10}CH_2Cl$

$CH_3(CH_2)_{10}CH_2Cl +$  $\xrightarrow{AlCl_3}$  $CH_2(CH_2)_{10}CH_3$

 $CH_2(CH_2)_{10}CH_3$ $\xrightarrow{\text{Conc. } H_2SO_4, \text{ heat}}$ $CH_3(CH_2)_{10}CH_2$  SO_3H

$CH_3(CH_2)_{10}CH_2$  $SO_3H + OH^- \longrightarrow CH_3(CH_2)_{10}CH_2$  SO_3^-

17. Explain the following observations

(a) Hydrofluoric acid is a weaker acid than hydro bromic acid. (03 marks)

The H-F bond is stronger than H-Br bond and thus unlike to dissociate and produce H^+

The H-F bond is stronger because fluorine is more electronegative than bromine.

(b) The pH of a solution of chromium (III) chloride is less than 7. (03 marks)

Chromium (III) ions hydrolyze in solution to produce hydrogen ions

$Cr3+(aq) + 3H_2O(l)$ $Cr(OH)_3(s) + 3H^+(aq)$

(c) Ammonia is a weaker base than ethyl amine. (03 marks)

On ethylamine, the ethyl group donates electrons to a nitrogen atom; this increases electron density negative charge of lone pair of electrons; this increases the ability of alone pair electrons to attract a proton from water and produce more OH^- than ammonia.

THE PERIODIC TABLE

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

		57 La 139	58 Ce 140	59 Pr 141	60 Nd 144	61 Pm (145)	62 Sm 152	63 Sm 150	64 Eu 152	65 Tb 159	66 Dy 162	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
		89 Ac (227)	90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf 251	99 Es (254)	100 Fm (257)	101 Mv (256)	102 No (254)	103 Lw

1. $\frac{1}{H}$ - indicates Atomic number.

2. $\frac{H}{1.0}$ - indicates relative Atomic number.

END.