KIBUGO DENNIS

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P525/1
CHEMISTRY
Paper 1
August 2022
2¾ hrs

Kib

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UNNASE MOCK EXAMINATIONS

Uganda Advanced Certificate of Education

CHEMISTRY

PAPER 1

2 HOURS 45 MINUTES

INSTRUCTIONS TO CANDIDATES

- *Answer **all** questions in Section A and **six** questions in Section B.*
- *All questions must be answered in the spaces provided.*
- *The periodic table, with relative atomic masses, is attached at the end of the paper.*
- *Where necessary, use the following*
  - *Molar gas constant, $R = 8.31JK^{-1}mol^{-1}$.*
  - *Molar volume of a gas at s.t.p is 22.4 litres.*
  - *Standard temperature = 273K.*
  - *Standard pressure = $101325NM^{-2}$.*

For Examiner's 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 from this Section.*

1. Uranium undergoes nuclear decay according to the following equation

$$^{238}_{92}U \xrightarrow{\alpha} X \xrightarrow{\beta} Y \xrightarrow{\beta} Z$$

(03 marks)

a) Identify the species X, Y and Z

X. $^{234}_{90}Th$ ✓ 01

Y. $^{234}_{91}Pa$ ✓ 01

Z. $^{232}_{92}U$ ✓ 01 Reject; $^{234}_{92}U$

b) 10g of Uranium was left to decay. Calculate the mass of Uranium that remained after 2.5×10^9 years. (The half-life of Uranium 238 is 4.5×10^9 years) *(03 marks)*

$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ ✓

$\lambda = \frac{\ln 2}{4.5 \times 10^9}$ ✓

$\lambda = 1.54 \times 10^{-10}\ year^{-1}$ ✓

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

$\ln\left(\frac{10}{N_t}\right) = 1.54 \times 10^{-10}$ ✓

$\ln N_t = e^{1.91750333}$

$N_t = 6.804\,g$ ✓

03

2. Complete the equations and write the accepted mechanism in each case.

a) $CH_3CH_2\underset{\underset{OH}{|}}{C}HCH_3 \xrightarrow[180^oC]{Conc.H_2SO_4} CH_3CH{=}CHCH_3 + H_2O$ *(2½ marks)*

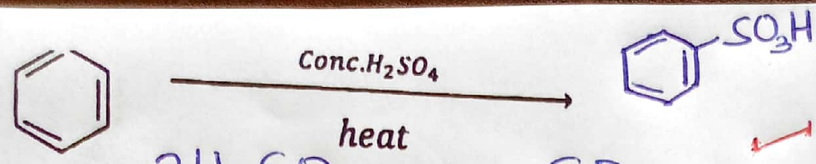
$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$ ✓ 02½

$CH_3CH_2CHCH_3 \longrightarrow CH_3CH_2\overset{+}{C}HCH_3 \rightleftharpoons CH_3CH_2CH(\overset{+}{O}H_2)CH_3$ ✓

$HO: \rightarrow H^+$ ✓

$CH_3CH(\overset{+}{O}H_2)CHCH_3 \longrightarrow CH_3CH{=}CHCH_3$ ✓

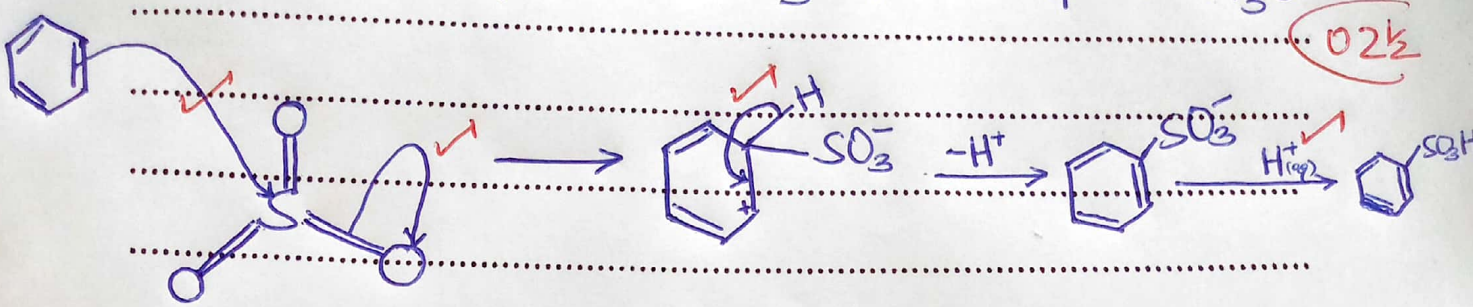
H ✓ OSO$_3$H

b) 

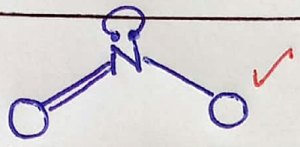
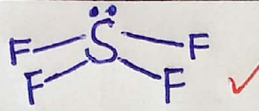
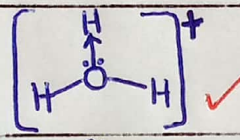
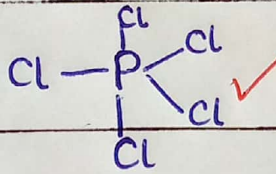
(2½ marks)

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

02½



3. Draw the structure and name the shape of the following species. *(04 marks)*

Species	Structure	Shape
NO_2^-	 ✓	Bent ✓ Accept; V-shape Reject; V-shaped.
SF_4	 ✓	Irregular tetrahedral ✓
H_3O^+	 ✓	Trigonal pyramidal. ✓
PCl_5	 ✓	Trigonal bipyramidal. ✓

4. Write equation for the reaction between aqueous sodium hydroxide and

a) Beryllium oxide *(1½ marks)*

$BeO_{(s)} + 2\bar{O}H_{(aq)} + H_2O_{(l)} \rightarrow Be(OH)_4^{2-}{}_{(aq)}$ ✓✓

Accept other correct versions.

b) Chromium (III) oxide *(1½ marks)*

$Cr_2O_{3(s)} + 2\bar{O}H_{(aq)} + 3H_2O_{(l)} \rightarrow 2Cr(OH)_4^-{}_{(aq)}$ ✓✓

Accept other correct versions.

c) Sulphur (IV) oxide *(1½ marks)*

$SO_{2(g)} + \bar{O}H_{(aq)} \rightarrow HSO_3^-{}_{(aq)}$ ✓✓

Accept; $SO_{2(g)} + \bar{O}H_{(aq)} \rightarrow SO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

5. a) State

i) Raoults law *(01 mark)*

For an ideal solution, the partial vapour pressure of a volatile component is equal to the product of its vapour pressure and its mole fraction at constant temperature. (01)

Accept other correct alternative.

ii) two conditions under which the law is valid. *(01 mark)*

Temperature must be kept Constant ✓

Solution must be dilute ✓ (01)

b) The vapour pressures of heptane and octane are 473.2Pa and 139.8Pa respectively at 20°C.
Calculate:

i) the vapour pressure of a mixture containing 0.5 moles of heptane and 0.25 moles of octane at 20°C. (Assume that the two liquids form an ideal solution). *(02 marks)*

Total moles $= (0.5 + 0.25) = 0.75$ moles ✓

$P_{Total} = P_{heptane} + P_{octane}$ ✓

$= P^{o}_{heptane} X_{heptane} + P^{o}_{octane} X_{octane}$ (02)

$= \left(473.2 \times \frac{0.5}{0.75}\right) + \left(139.8 \times \frac{0.25}{0.75}\right)$ ✓

$= 362.0667$ Pa ✓

∴ Vapour pressure is 362.1Pa of mixture *(02 marks)*

ii) the composition of the vapour.

Composition of heptane $= \left(\frac{\frac{0.5}{0.75} \times 473.2}{362.1}\right) \times 100$ ✓ $= 87.13\%$ ✓

Composition of octane $= (100 - 87.13) = 12.87\%$ ✓ (02)

6. Compound Q is a green solid. P dissolves in water to give a pale green solution. The solution of Q formed a red precipitate when reacted with butanedionedioxime and a redish brown solution when a few drops of Iron (III) chloride were added to it.

When Q was heated propanone was formed.

a) Identify Q. *(01 mark)*

$Ni(CH_3COO)_2$ ✓ (01)

b) Write equation for the reaction that took place when Q was heated.

(1½ marks)

$Ni(CH_3COO)_2(s) \longrightarrow NiCO_3(s) + CH_3COCH_3(g)$ ½ ½

Accept; $Ni(CH_3COO)_2(s) \longrightarrow NiO(s) + CO_2(g) + CH_3COCH_3(g)$ 01½

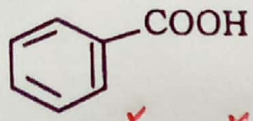
c) Write equation(s) for the reaction(s) that would take place when excess ammonia solution is added to a solution of Q.

(02 marks)

$Ni^{2+}(aq) + 2\bar{O}H(aq) \longrightarrow Ni(OH)_2(s)$ ✓✓ 02

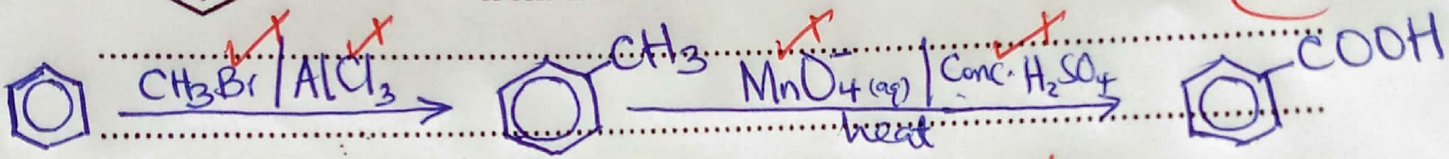
$Ni(OH)_2(s) + 6NH_3(aq) \longrightarrow Ni(NH_3)_6^{3+}(aq) + 2\bar{O}H(aq)$ ✓✓

7. Write the equation in each case to show how the following conversions can be effected.

a) 

from benzene

02



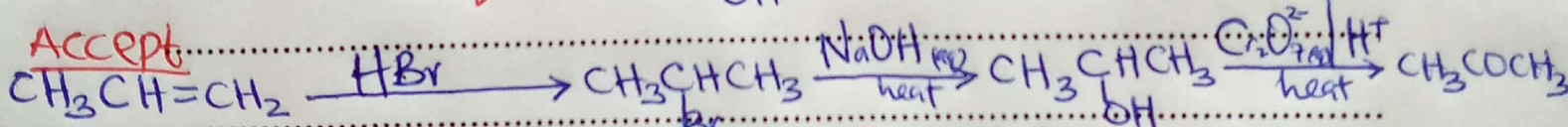
Allow other correct routes

b) 

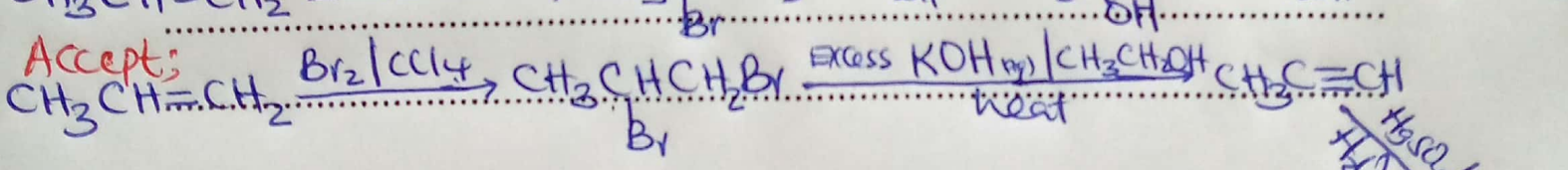
CH_3CCH_3 from Prop – I – ene

(03 marks) 03

Accept



Accept;



8. State what would be observed and write an equation that takes place when

a) Excess concentrated hydrochloric acid is added to aqueous copper (II) sulphate solution

(2½ marks)

Observation

Blue solution turns into a yellow solution ✓ ✓

02½

Equation

$Cu^{2+}(aq) + 4Cl^-(aq) \longrightarrow CuCl_4^{2-}(aq)$ ✓✓

b) Solid sodiumiodide is heated with concentrated sulphuric acid . *(02 marks)*

Observation

Purple vapour ✓ 02

Equation

$2NaI_{(s)} + 2H_2SO_{4(l)} \longrightarrow SO_{2(g)} + I_{2(g)} + Na_2SO_{4(aq)} + 2H_2O_{(l)}$ ✓✓

9. a) Synthetic rubber, neoprene, is made by polymerisation of 2–chlorobuta–1,3–diene, $CH_2 = C(Cl) - CH = CH_2$ according to the following equation

$$nH_2C = C(Cl) - CH = CH_2 \longrightarrow \{CH_2 - C(Cl) = CHCH_2\}_n$$

i) State the conditions for the reaction *(01 mark)*

Presence of potassium persulphate solution Catalyst ✓

Heating is required. ✓ 01

ii) Name the type of polymerisation leading to the formation of polyneoprene *(0½ mark)*

Addition polymerisation ✓ 0½ Reject Additional

b) A solution containing 2.8% of polyneoprene was found to have an osmotic pressure of 7.0×10^{-4} atmospheres at 25°C. Calculate the;

i) Molar mass of polyneoprene *(02 marks)*

$\pi V = nRT$ ✓ $T = 273 + 25 = 298K$

$\pi V = \frac{m}{M_r} RT$

$(7.0 \times 10^{-4} \times 101325) \times 100 \times 10^{-6} = \frac{2.8}{M_r} \times 8.31 \times 298$ ✓ 02

$M_r = 977,598.816\ g.$ ✓

ii) Value of n *(1½ marks)*

$(C_4H_5Cl)_n = 977,598.816$ ✓

$(12 \times 4)n + (1 \times 5)n + 35.5n = 977,598.816$ ✓ 01½

$n = 11,046$ Units ✓

SECTION B (54 MARKS)

*Answer **six** questions from this Section.*

*Any additional question(s) answered will **not** be marked.*

Accept any other correct differences

10. a) Differentiate between order of a reaction and molecularity. *(02 marks)*

Order of reaction is the sum of the powers to which the concentration terms of the reactants are raised in an experimentally determined rate equation (01)

Molecularity is the number of species required to form an activated complex in a given reaction. (01)

Accept; Molecularity is the number of reacting species taking part in the rate determining step in a given chemical reactions.

b) The data in the table below was obtained for the reaction

3C → Products

Time (minutes)	0	60	120	180	240	320
$Log_{10}[A]$	-0.62	-0.80	-1.00	-1.14	-1.34	-1.47

Plot a graph of $log_{10}[C]$ against time. *(03 marks)*

c) From the graph determine the order of the reaction. *(01 mark)*

First order. (01)

Neglect the reason.

d) Calculate

i) the rate constant for the reaction *(02 marks)*

Slope $= \frac{-K}{2.303}$ But slope $= \frac{-1.7 - -0.7}{325 - 25}$

$\frac{-K}{2.303} = -0.0033$ $= -0.0033 min^{-1}$

$K = 0.007689 min^{-1}$ (01½)

ii) the half-life of the reaction. *(01 mark)*

$t_{½} = \frac{ln2}{K} = \frac{0.693}{0.007689} = 90.13$ minutes. (01½)

11. Name one reagent that can be used to distinguish between the following pairs of compounds. In each case, State what would be observed if each member of the pair is separately treated with the reagent you have named.

a) $CH_3C(CH_3)_2OH$ and $CH_3CH_2CH_2CH_2OH$ *(03 marks)*

Anhydrous Zinc chloride in presence of Concentrated hydrochloric acid.

With $CH_3C(CH_3)_2OH$, Immediate cloudy solution (03)

With $CH_3CH_2CH_2CH_2OH$, No observable change at room temperature

b) CH_3CH_2CHO and $CH_3CH_2COCH_2CH_3$ *(03 marks)*

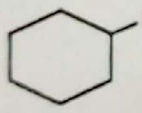
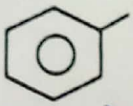
Fehling's solution

With CH_3CH_2CHO, A red precipitate (03)

With $CH_3CH_2COCH_2CH_3$, No observable change.

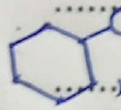
Accept; (1) Ammoniacal silver nitrate solution

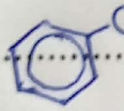
- With CH_3CH_2CHO, A silver mirror
- With $CH_3CH_2COCH_2CH_3$, No observable change

c)  and  *(03 marks)*

Hot Sodium hydroxide solution followed by dilute nitric acid and silver nitrate solution

Accept; Hot sodium hydroxide solution and silver nitrate solution

With  , white precipitate (03)

With  , No observable change

12. a) i) Write the electronic configuration of chromium atom. *(01 mark)*

~~$1s^2 2s^2 2p^6 3s^2 3p^6 3d$~~

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ (01)

Accept; $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

ii) State why chromium is classified as a transition element. (0½ mark)

It forms atleast one stable ion with partially filled 3d-orbital. ✓ 0½

b) Write the formula of all possible isomers of chromium (III) chloride – 6 – water $CrCl_3.6H_2O$. (03 marks)

$[Cr(H_2O)_6]Cl_3$ ✓

$[Cr(H_2O)_4Cl]Cl_2 \cdot H_2O$ ✓ 03

$[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$ ✓

c) To an aqueous solution of chromium (III) chloride was added concentrated ammonia solution dropwise until in excess.

i) State what was observed. (1½ marks)

A green precipitate soluble in excess forming a violet solution. ✓ 01½

ii) Write equation(s) for the reactions that took place. (03 marks)

$Cr^{3+}_{(aq)} + 3\bar{O}H_{(aq)} \longrightarrow Cr(OH)_{3(s)}$ ✓ 03

$Cr(OH)_{3(s)} + 6NH_{3(aq)} \longrightarrow Cr(NH_3)^{3+}_{6(aq)} + 3\bar{O}H_{(aq)}$ ✓

13. Compound Y consists of carbon 68.8%, hydrogen 4.92% and the rest being oxygen. The vapour density of the compound is 61.

a) Determine the:

i) empirical formula of Y. (2½ marks)

% of O = 100 − (4.92 + 68.8) = 26.28% ✓

Elements	C	H	O
Composition	68.8	4.92	26.28
Moles	$\frac{68.8}{12}$	$\frac{4.92}{1}$	$\frac{26.28}{16}$ ✓
	5.733	4.920	1.643
Mole ratio	$\frac{5.733}{1.643}$	$\frac{4.920}{1.643}$	$\frac{1.643}{1.643}$
	2 × (3.49	3	1) ✓
Simplest ratio	7 ✓	: 6	: 2

02½

∴ Empirical formula of Y is $C_7H_6O_2$ ✓

j) molecular formula of Y (1½ marks)

Molar mass = 2 × Vapour density

= 2 × 61

= 122 g

$(C_7H_6O_2)_n = 122$

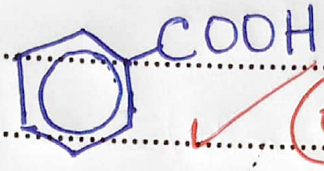
$(12\times7)n + (1\times6)n + (16\times2)n = 122$

$n = 1$

$(C_7H_6O_2)_1 = C_7H_6O_2$

∴ Molecular formula of Y is $C_7H_6O_2$ 01½

b) Compound Y burns with a sooty flame and the PH of its aqueous solution is less than 7. Write the structural formula of Y. (2½ marks)



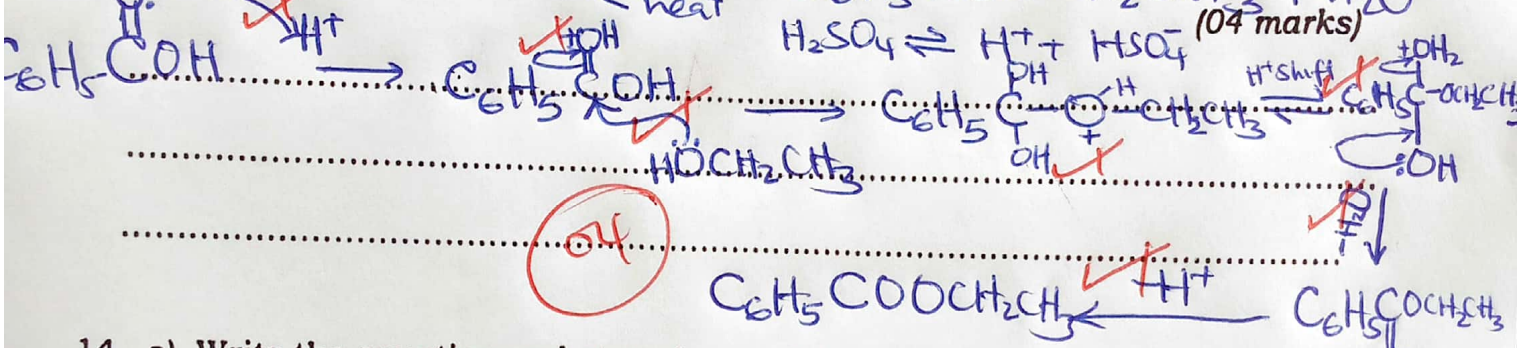
01

Reject: C_6H_5COOH

c) Write the equation and indicate the mechanism for the reaction between Y and ethanol in presence of concentrated sulphuric acid on heating. (04 marks)

$C_6H_5COOH + CH_3CH_2OH \underset{\text{heat}}{\overset{\text{Conc. } H_2SO_4}{\rightleftharpoons}} C_6H_5COOCH_2CH_3 + H_2O$

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



04

$C_6H_5COOCH_2CH_3 \xleftarrow{H^+} C_6H_5C(OH)(OH)OCH_2CH_3$

14. a) Write the equation and state the condition(s) for the reaction leading to the formation of:

i) Iron (II) chloride (2½ marks)

Equation

$Fe_{(s)} + 2HCl_{(g)} \longrightarrow FeCl_{2(s)} + H_{2(g)}$

Condition(s)

Heated Iron and excess dry hydrogen chloride gas

02½

ii) Iron (III) chloride (2½ marks)

Equation

$2Fe_{(s)} + 3Cl_{2(g)} \longrightarrow 2FeCl_{3(s)}$

02½

Condition(s)

Heated Iron and excess dry chlorine gas.

b) Write equation for the reaction that takes place when Iron (III) chloride is dissolved in water. *(1½ marks)*

$FeCl_3(s) + 3H_2O(l) \longrightarrow Fe(OH)_3(s) + 3HCl(aq)$

01½

Accept alternative hydrolysis equation

c) Magnesium ribbon was added to the solution in (b).

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

Grey solid dissolves with bubbles of a colourless gas forming a colourless solution. 01

ii) Write equation for the reaction that took place. *(1½ marks)*

$Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

01½

Accept; Molecular equation

15. The standard electrode potentials E^θ for some half-cell reactions are given below

	E^θ/V
$MnO_{4(aq)}^- + 8H_{(aq)}^+ + 5e \rightarrow Mn_{(aq)}^{2+} + 4H_2O_{(l)}$	+1.52
$SO_{4(aq)}^{2-} + 2H_{(aq)}^+ + 2e \rightarrow SO_{3(aq)}^{2-} + H_2O_{(l)}$	+0.20
$Br_{2(aq)} + 2e \rightarrow 2Br_{(aq)}^-$	+1.06
$Cl_{2(aq)} + 2e \rightarrow 2Cl_{(aq)}^-$	+1.36

a) Write the cell notation for the reaction between sulphite ions and acidified potassium manganate (VII) solution. *(1½ marks)*

$Pt(s)/SO_3^{2-}(aq), SO_4^{2-}(aq), H^+(aq) // MnO_4^-(aq), H^+(aq), Mn^{2+}(aq)/Pt(s)$

01½

b) Write the ionic equation for the overall cell reaction. *(1½ marks)*

$2MnO_4^-(aq) + 5SO_3^{2-}(aq) + 6H^+(aq) \longrightarrow 5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 3H_2O(l)$

01½

c) i) Calculate the e.m.f of the cell. *(1½ marks)*

$E^{\theta}_{cell} = E^{\theta}_{right} - E^{\theta}_{left}$

$= 1.52 - 0.20$

$= +1.32V$

01½

Accept: $E^{\theta} = E^{\theta}_{RHS} - E^{\theta}_{LHS}$ OR $= E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ OR $= E^{\theta}_{cathode} - E^{\theta}_{anode}$

-½ for missing charge on final answer
-neglect Units on final answer. value.

ii) State whether the reaction is feasible or not and give a reason for your answer. *(01 mark)*

Feasible because emf of the cell is positive

01

d) Explain why hydrochloric acid is not used to acidify titrants in volumetric analysis involving potassium manganate (VII). *(2½ marks)*

Chloride ions in hydrochloric acid are strong reducing agents that are oxidised by Potassium manganate(VII) to Chlorine gas and ~~itself~~ to

02½

$2MnO^{-}_{4(aq)} + 16H^{+}_{(aq)} + 10Cl^{-}_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5Cl_{2(g)} + 8H_2O_{(l)}$

e) State which of bromine and chlorine in a stronger oxidising agent and give a reason for your answer. *(01 mark)*

Chlorine is a stronger oxidising agent than Bromine. 01

This is because chlorine has a more positive value of standard electrode potential than bromine.

16. State what would be observed and write equation for the reaction that would take place if

a) Propene is bubbled through bromine water *(02 marks)*

Observation

Reddish brown solution turns into a colourless solution

Equation

02

$CH_3CH=CH_{2(g)} + Br_{2(aq)} + H_2O_{(l)} \longrightarrow CH_3\underset{OH}{C}HCH_2Br_{(aq)} + HBr_{(aq)}$

Accept: $CH_3CH=CH_2 \xrightarrow{Br_2/H_2O} CH_3\underset{OH}{C}HCH_2Br$

b) A solution of iodine and sodium hydroxide is warmed with butanone *(02 marks)*

Observation

A yellow precipitate.

Equation

02

$CH_3COCH_2CH_{3(l)} + 6NaOH_{(aq)} + 4I_{2(aq)} \longrightarrow CHI_{3(s)} + CH_3CH_2COONa_{(aq)} + 5NaI_{(aq)} + H_2O$

c) Sulphur (IV) oxide is bubbled through acidified Potassium dichromate solution *(2½ marks)*

Observation

Orange solution turns to a green solution

Equation

02½

$Cr_2O_7^{2-}{}_{(aq)} + 3SO_{2(g)} + 3H^+_{(aq)} \longrightarrow 3SO_4^{2-}{}_{(aq)} + 2Cr^{3+}_{(aq)} + H_2O_{(l)}$

d) Chlorine gas is bubbled through potassium manganate (VI) solution. *(2½ marks)*

Observation

Green solution turns to a purple solution

Equation

02½

$2MnO_4^-{}_{(aq)} + Cl_{2(g)} \longrightarrow 2MnO_4^-{}_{(aq)} + 2Cl^-_{(aq)}$

17. a) Differentiate between soap and soapless detergents. *(02 marks)*

Soap is a potassium or sodium salt of a long chain carboxylic acid while

A soapless detergents is a potassium or sodium salt of a longchain sulphonic acid.

02

b) Write equations to show how a soapless detergent can be prepared from dodecanol $CH_3(CH_2)_{10}CH_2OH$. *(02 marks)*

$$CH_3(CH_2)_{10}CH_2OH \xrightarrow[0^oC]{Conc.\ H_2SO_4} CH_3(CH_2)_{10}CH_2SO_3H \xrightarrow{NaOH_{(aq)}} CH_3(CH_2)_{10}CH_2SO_3Na$$

02

c) Explain the cleansing action of soap. *(02 marks)*

Soap molecule consists of alkyl and carboxylate groups. The alkyl group is non-polar and hydrophobic hence dissolves in the dirt or greese. The Carboxylate group is polar and hydrophillic hence dissolves in water. This reduces the surface tension of water. On agitation, the dirt particles are removed/emulsified and suspended in water.

02

d) State the advantage and disadvantage of using a soapless detergent instead of soap in washing.

i) Advantage *(0½ mark)*

Don't form scum with hard water. 0½

ii) Disadvantage *(0½ mark)*

Non-biodegradable hence pollute environment 0½

e) Explain why aluminium utensils should not be washed with soap. *(02 marks)*

The excess hydroxide ions formed after hydrolysis of soap molecules in water, react with aluminium forming soluble aluminate ions. This makes the utensils to continuously dissolve hence wear out

02

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

END

THE DEAD ARE NOT DEAD — DISCUSS.