Digital Teachers

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525/1

S6 CHEMISTRY

Exam 19

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions to candidates;

- *Answer **all questions in Section A** and **any six in Section B**.*
- *All questions must be answered in spaces provided.*
- *Illustrate your answers with equations where applicable.*
- *Molar gas constant, R=8.314Jk^{-1}mol^{-1}*
- *Molar volume for a gas at s.t.p is 22400cm^3*
- *Standard temperature =273k*
- *Standard pressure =101325 Nm^{-2}*

SECTION A

Answer all questions from this section.

1. State the condition(s) and write equation for the reaction of aluminium and;
i) water (2marks)

Aluminium reacts with hot water to produce aluminium hydroxide and hydrogen

$2Al(s) + 6H_2O(l) \rightarrow Al(OH)_3(s) + 3H_2(g)$

ii) Iron (III) oxide (2marks)

Iron (III) oxide does not react with water

2. a) State what is meant by the term ebullioscopic constant. (1mark)

Ebullioscopic constant is elevation of boiling point caused by 1mole of solute in 1000g of solvent.

b) 0.40g of camphor when dissolved in 33.5g of trichloromethane produces a solution boiling at 0.30^0C above the boiling point of pure solvent. Calculate the ebullioscopic constant of trichloromethane. (Molar mass of camphor = 155).
(3marks)

Mass of camphor in 1000g of trichloromethane

33.5g of trichloromethane contain 0.40g

1000g of trichloromethane contain $\frac{0.4\ x\ 1000}{33.5}$ 11.94g

Ebulioscopic constant, K_b

11.94 g produce 0.30^0C

155g produce K_b

$K_b = \frac{0.30\ x\ 155}{11.94} = 3.90 Kmol^{-1}kg^{-1}$

3. a) State what is observed and write equation for the reaction when;

i) Ethanal is mixed with a saturated solution of sodium bisulphite. (2marks)

Observation:

White crystals

Equation

$CH_3CHO + NaHSO_3 \rightarrow CH3\underset{OH}{C}HSO_3Na$

ii) Neutral iron(III) chloride solution is added to aqueous solution of hydroxybenzene. (2marks)

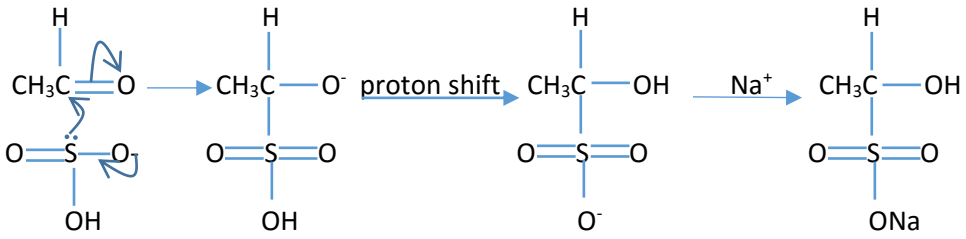
Observation;

Purple solution

Equation;

$3C_6H_5OH(aq) + Fe^{3+}(aq) \rightarrow (C_6H_5O)_3Fe$

b) Write the mechanism for the reaction in a (i). (2½ marks)



4. a) State what is meant by the term electrode potential. (1mark)

This is the potential difference developed when an electrode of an element is placed in a solution containing ions of that element

b) The electrode potential of some half cells are given below.

(ECV)

$S_2O_8^{2-}(aq) + 2e^- \longrightarrow 2SO_4^{2-}(aq)$ $+2.01$

$I_2(aq) + 2e^- \longrightarrow 2I(aq)$ $+0.54$

Write;

i) The cell notation of cell formed when the half cells are combined.

(1mark)

$Pt/2I^-(aq), I_2(aq) // S_2O_8^{2-}(aq), 2SO_4^{2-}(aq)/Pt$

ii) equation for the overall cell reaction. (1½ marks)

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

iii) Calculate the e.m.f of cell. (1mark)

$E_{cell} = E_{LHE} - E_{RHE} = 2.01 - 0.54 = 1.47V$

iv) State whether the cell reaction is feasible or not. Give a reason for your answer. (1mark)

it is feasible because emf is positive

5. a) State two properties in which beryllium shows diagonal relationship with aluminum. (2marks)

Reacts with nitrogen to give a nitride

React with oxygen to give normal oxide

React with carbon to give carbide

b) Write equations to illustrate the properties stated in (a) (3marks)

$6Li(s) + N_2(g) \rightarrow 2Li_3N\ (s)$

$4Li\ (s) + O_2\ (g) \rightarrow 2Li_2O\ (s)$

$2Li(s) + 2C(s) \rightarrow Li_2C_2(s)$

6. State what would be observed and write equation for the reaction that takes place when

a) Chlorine gas is passed through a solution of potassium manganate(VI) (2 ½ marks)

A green solution turns purple

$2MnO_4^{2-}(aq) + Cl_2\ (g) \rightarrow MnO_4^{-}(aq) + 2Cl^{-}(aq)$

b) A few drops of hydrogen peroxide solution is added to acidified potassium dichromate(VI) solution. (2 ½ marks)

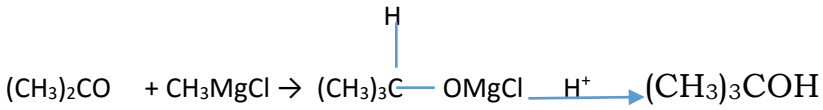
Purple solution

$Cr_2O_7^{2-}\ (aq) + 2H^{+}(aq) + 4H_2O_2(aq) \rightarrow 2CrO(O_2)_2\ (aq) + 5H_2O(l)$

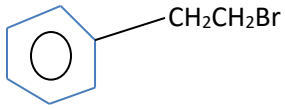
7. Write equations to show how the following conversions can be effected.

(2½ marks)

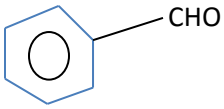
a) $(CH_3)_2CO$ to $(CH_3)_3COH$

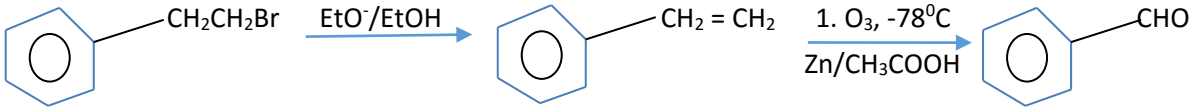


b)



to





8. $30cm^3$ of a hydrocarbon Q was exploded with $200cm^3$ of oxygen in excess. The volume of the residual gas on cooling to room temperature was found to be $155cm^3$. When the residual gas was treated with concentrated potassium hydroxide solution, the volume reduced to $35cm^3$.

a) Calculate the molecular formula of Q. (3marks)

volume of carbon dioxide = 155 – 35 = 120 cm^3

volume of oxygen that reacted = 200 – 35 = $165cm^3$

$$CxHy + (x + \frac{y}{4})O_2 \rightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$$

Volumes	30	165	120
Volume ratio	1	5.5	4

x = 4

$x + \frac{y}{4} = 5.5$

y = 6

molecular formula of Q = C_4H_6

b) Write the structures of all possible open chain isomers of Q. (1mark)

$CH_3CH_2C{\equiv}CH$ but-1-yne

$CH_3C{\equiv}CCH_3$ but-2-yne

c) Q reacts with ammoniacal copper(I) chloride solution.

i) State what is observed. (1mark)

red precipitate

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

$CH_3CH_2C{\equiv}CH + Cu^+(aq) \xrightarrow{NH_3(aq)} CH_3CH_2C{\equiv}CH$

9. The molar conductivity of a 0.093M solution of ethanoic acid at 25^0C is 5.34×10^{-4} sm^2mol^{-1}. The molar conductivity at infinite dilution of H^+ and CH_3COO^- ions are 3.51×10^{-2} and $0.4 \times 10^{-2} Sm^2mol^{-1}$ respectively. Calculate the;

i) molar conductivity of ethanoic acid at infinite dilution. (1 ½ marks)

$\Lambda_0 CH_3COOH = \lambda_0 CH_3COO^- + \lambda_0 H^+$

$= 0.4 \times 10^{-2} + 3.51 \times 10^{-2}$

$= 3.91 Sm^2mol^{-1}$

ii) degree of dissociation , α of ethanoic acid. (1 ½ marks)

$\alpha = \frac{\Lambda_C}{\Lambda_0} = \frac{5.34 \times 10^{-4}}{3.91 \times 10^{-2}} = 0.014$

iii) acid dissociation constant, Ka at 25^0C (1 ½ marks)

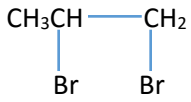
$Ka = \alpha^2 C = 0.014^2 \times 0.093 = 1.8 \times 10^{-5} moldm^{-3}$

SECTION B

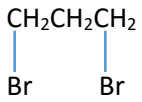
Attempt only **six** questions from this Section

10. a) An organic compound Z has a molecular formula $C_3H_6Br_2$.
Write down the structural formula and IUPAC names of all isomers of Z.

(3marks)



1,2-dibromopropane



1,3-dibromopropane

b) When Z was heated with sodium metal in ethanol a compound Y was formed. Y reacts with water in the presences of sulphuric acid and Mercurous sulphate at 60^0C to form a compound X. X does not react with Fehling's solution but forms an orange precipitate with Brady's reagent. Identify compound X, Y and Z.

(1½ marks)

X 1,2-dibromopropane

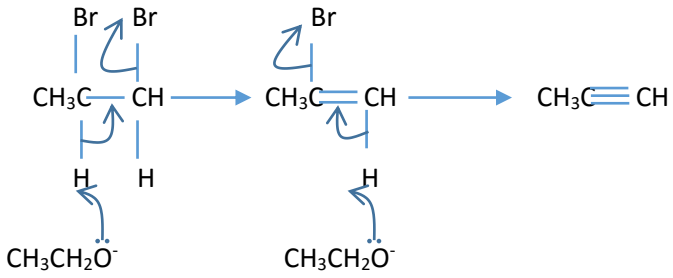
Y propyne

Z propanone

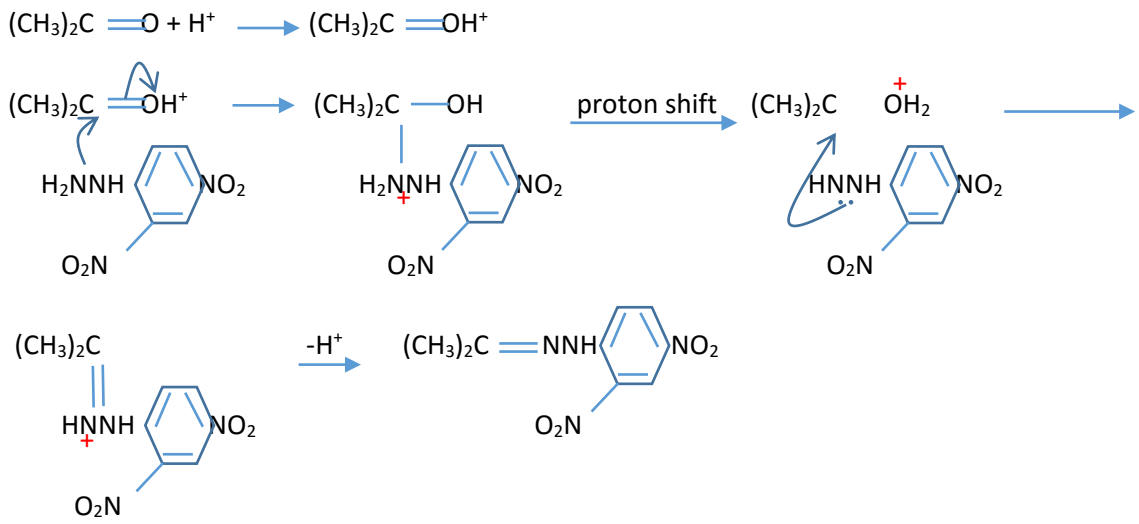
c) Write the equation and suggest the mechanism for the reaction between

i) Z and sodium metal in ethanol.

$2CH_3CH_2OH + 2Na \rightarrow CH_3CH_2O^-Na^+ + H_2(g)$



ii) X and Brady's reagent. (2 ½ marks)



11. Explain each of the following observations (Your answer should include balanced equations if any). (3marks each)

a) When hydrogen iodide is treated with concentrated sulphuric acid, iodine is liberated whereas when hydrogen chloride is similarly treated, chlorine is not evolved.

Iodide ion is a strong reducing agent, it reduces sulphate ions and it is oxidized to iodine

$2I^-(aq) + SO_4^{2-}(aq) + 4H^+(aq) \rightarrow I_2(aq) + SO_2(g) + 2H_2O(l)$

Cl^- ion is not a reducing agent.

b) An aqueous solution of sodium sulphite has a pH greater than 7 whereas that of sodium hydrogen sulphite is less than 7.

Suphite ions hydrolyze in water to produce hydroxyl ion

$SO_3^{2-}(aq) + H_2O(l) \rightarrow HSO_3^-(aq) + OH^-(aq)$

Hydrogen sulphate ion hydrolyze in water to produce hydrogen ions

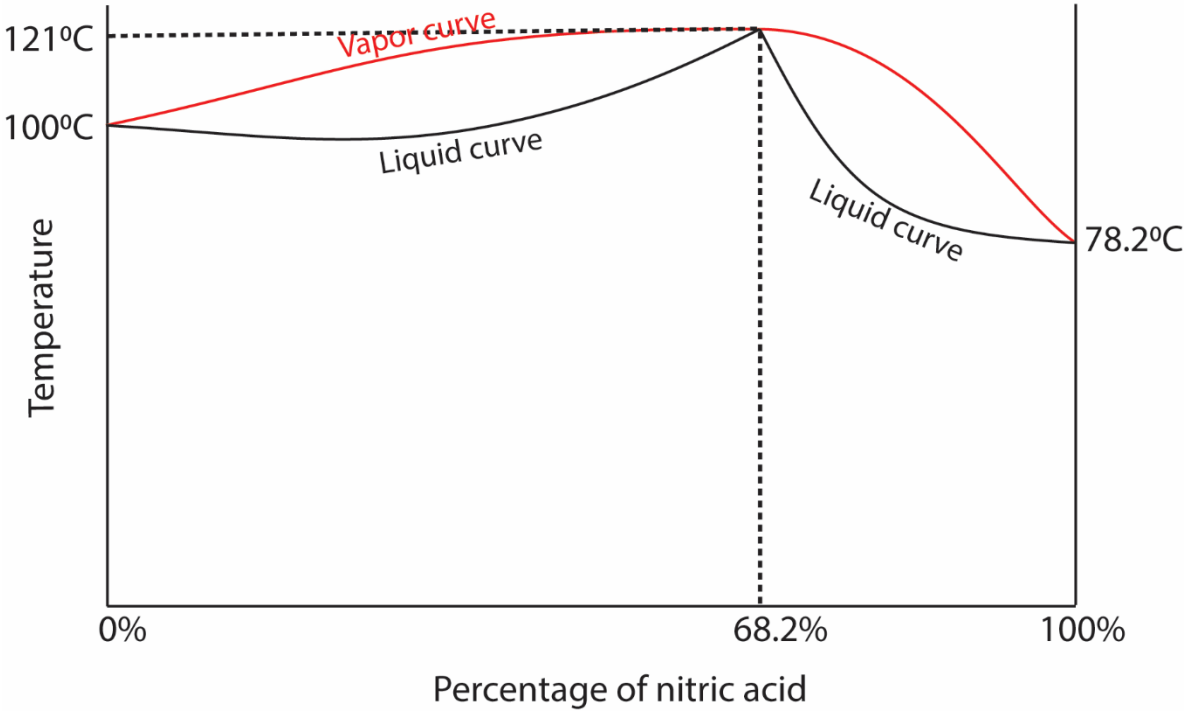
$HSO_3^-(aq) \leftrightarrow H^+(aq) + SO_3^{2-}(aq)$

c) When hydrogen sulphide is bubbled through an aqueous solution of iron(III) chloride a yellow precipitate is observed.
Iron (III) ions oxidize hydrogen sulphide to sulphur

$2Fe^{3+}(aq) + H_2S(g) \rightarrow 2Fe^{2+}(aq) + 2H^+(aq) + S(s)$

12. a) State Raoult's law as applied to binary liquid systems. (1mark)
It state that the partial pressure of a component in a mixture is a product of its mole fraction and vapor pressure.

b) The mixture of water and nitric deviates negatively from Raoults law. The mixture form an azeotropic mixture at 68.2% nitric and boiling point 121^{0}C.
i) Sketch a labeled boiling point – composition diagram for the mixture above. (Bpts of HNO_3 and H_2O respectively are 78.2^{0}C and 100^{0}C at 760mmHg pressure.) (3marks)



ii) Describe briefly what happens when a mixture containing 50% nitric acid is distilled. (2½ marks)

The distillate is water while the residue is azeotrope

c) Explain why the mixture deviates negatively from Raoults law.

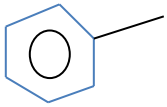
The adhesive forces between water and nitric acid molecules are stronger than the cohesive forces. This reduces the probability of molecules that escapes into vapour. The vapor pressure of the mixture lowers and the boiling point increase. The stronger adhesive forces are due to hydrogen bonds between water and nitric acid molecules.

d) Name one method of obtaining pure nitric acid from the azeotropic mixture. (1mark)

By distilling a mixture to which concentrated sulphuric acid is added. The distillate is concentrated nitric acid

13. Name the reagents that can be used to distinguish between the following pair of organic compounds. In each case state what is observed when the compounds are separately treated with the reagent. (3marks)

a)

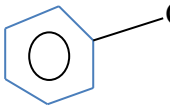


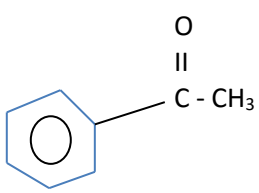
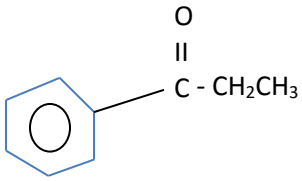
Reagent

Ammoniacal silver nitrate

Observation

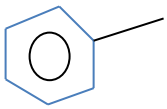
HCOOH silver mirror or black precipitate

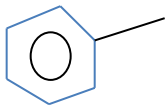


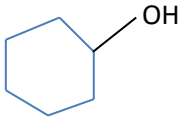
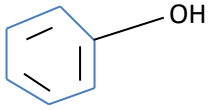
b)  and 

Reagent: iodine in sodium hydroxide solution

Observation

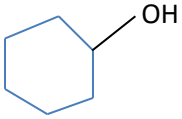
 $COCH_3$ yellow ppt

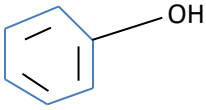
 $COCH_2CH_3$ no observable change

c)  and 

Reagent: neutral iron (III) chloride

Observations

 No observable change

 Purple solution

14. a) 0.111g of a vaporized sample of an organic compound R occupied $48.0cm^3$ at 20^0C and 700mmHg pressure. Calculate the relative molecular mass of R.

Volume (V) at stp

$$\frac{700\ x\ 48}{298} = \frac{760\ x\ V}{273}$$

$V = 40.5cm^3$

Formula mass

40.5cm^3 weigh 0.111g

22400cm^3 weigh 61

Formula mass = 61

b) R consists 59.9% carbon, 26.6% oxygen and the rest is hydrogen. Determine;

i) the empirical formula of R (2marks)

Percentage of hydrogen = 100-(59.9 + 26.6) = 13.5

Element	C	H	O
Percentage	59.9	13.5	26.6
RAM	12	1	16
Moles	5	13.5	1.6625
Mole ratio	3	8	1

Empirical formulaC_3H_8O

ii) the molecular formula of R (1½ marks)

$(C_3H_8O)n = 61$

$n = 1$

molecular formula = C_3H_8O

c) Write down the structural formulae and give the IUPAC names of all isomers of R. (3marks)

$CH_3CH_2CH_2OH$ propan-1 ol

$CH_3CH(OH)CH_3$ propan-2-ol

15. a) State two characteristic properties exhibited by manganese as a transition element.

Has variable oxidation state i.e. +2, +4, +7

b) i) Write the electronic configuration of manganese. (½ mark)

$1s^22s^22p^63s^23p^64s^23d^5$

ii) State the common oxidation states exhibited by manganese in its compounds. (1 ½ marks)

+2, +4, +7

c) i) Manganese (IV) oxide reacts with concentrated hydrochloric . Write the equation of reaction that takes place. (1 ½ marks)

$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + Cl_2(aq) + 2H_2O(l)$

d) Lead(V) oxide was added to an aqueous solution of manganese (II) chloride, followed by concentrated nitric acid. The mixture was then heated.

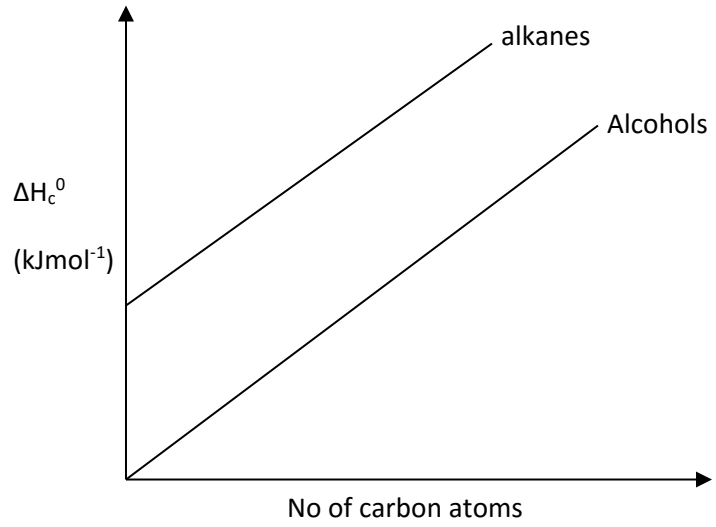
i) State what was observed. (1½ marks)

purple solution formed

ii) Write equation of reaction that takes place. (1½ marks)

$2Mn^{2+}(aq) + 5PbO_2(s) + H^+(aq) \rightarrow 2MnO_4^-(aq) + 5Pb^{2+}(aq) + H_2O(l)$

16. a) The standard enthalpies of combustion of some straight chain alkanes and alcohols against number of carbon atoms is shown below.



i) Explain the shape of the graph(s)

the graphs are linear and parallel because members in homologous series differ by constant common groups. That is methylene group (CH_2)

ii) The graph for alcohol passes through the origin. Explain why this is so. (1½ marks)

Alcohols are partially oxidised

iii) The graph for alkanes has an intercept. What is the significance of the intercept? (1 ½ marks)

the intercept is the enthalpy of partial oxidation of in alcohol

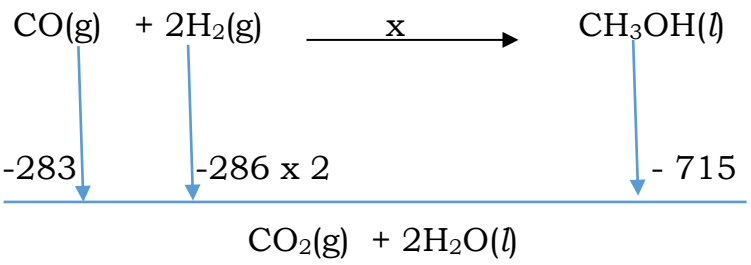
b) Energy changes for some reactions are shown below;

	ΔHO/Kjmol^{-1}
i) $CO(g) + ½\ O_2(g) \longrightarrow CO_2(g)$	-283
ii) $H_2(g) + ½\ O_2(g) \longrightarrow H_2O(l)$	-286
iii) $CH_3OH(l) + {}^3/_2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$	-715

Calculate the enthalpy change for the reactions

$CO(g) + 2H_2(g) \longrightarrow CH_3OH(l)$ (3marks)

Let enthalpy of reaction be x



x -715 = -283 -2 x 286 = -140kJmol^{-1}

x = -140kJmol^{-1}

17. a) Explain what is meant by the term complex ion. (1mark)

Complex ion is a metal ion bonded to small molecules called ligands through dative bonds

b) i) Some complex ions are given below. In each case state the coordination number and oxidation state of the central atom. (3marks)

Formulae of complex ion	**Coordination number**	**Oxidation state**
$CoCl_4^{2-}$	4	+2

$Fe(CN)_6^{3-}$	6	+3
$Ag(NH_3)_2^+$	2	+1

ii) Explain why transition metals form complex ions.

They have high charge density to attract lone pairs of electrons from ligands

They have vacant orbital to accommodate lone pairs of electrons

c) In each case write equation catalyzed by the following ions/species.

(1 ½ marks @)

i) Vanadium pentoxide

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

ii) Manganese II ions

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

END *