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525/1

## **S6 CHEMISTRY**

**Exam 12**

### ***PAPER 1***

**DURATION: 2 HOUR 45 MINUTES**

**For Marking guide contact and consultations: Dr. Bbosa Science 0776 802709,**

**Instructions to candidates;**

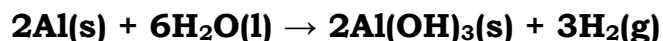
- Answer **all questions in Section A** and **any six in Section B**.
- All questions must be answered in spaces provided.
- Illustrate your answers with equations where applicable.
- Molar gas constant,  $R=8.314\text{jk}^{-1}\text{mol}^{-1}$
- Molar volume for a gas at s.t.p is  $22400\text{cm}^3$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

## SECTION A

*Answer all questions from this section.*

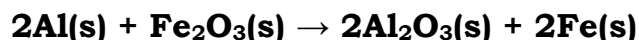
1. State the condition(s) and write equation for the reaction of aluminium and;  
i) water (2marks)

Condition: **heat**



- ii) Iron (III) oxide (2marks)

Condition: **heat**



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

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

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

(3marks)

Boiling point elevation = 0.30°C

Mass of camphor in 1000g of trichloromethane

33.5g of trichloromethane contain 0.4g of camphor

1000g of trichloromethane contain  $(0.4 \times 1000)/33.5 = 11.94\text{g}$

Ebullioscopic point constant  $K_b$

11.94g of camphor causes boiling point elevation of 0.30g

155g of camphor causes boiling point elevation of  $(0.30 \times 155)/11.94$

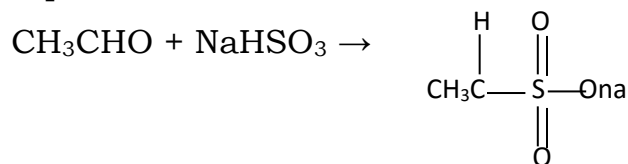
$$= 3.9^\circ\text{Cmol}^{-1}\text{kg}^{-1}$$

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:

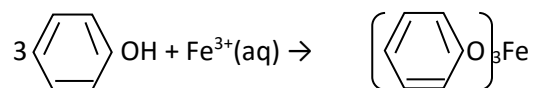


ii) Neutral iron (III) chloride solution is added to aqueous solution of hydroxybenzene. (2marks)

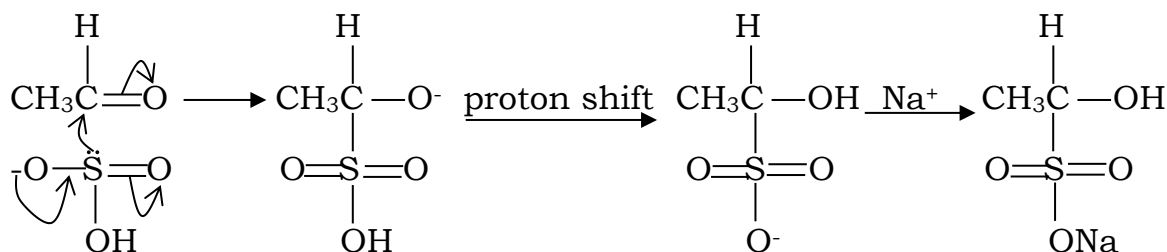
Observation;

**Purple solution**

Equation;



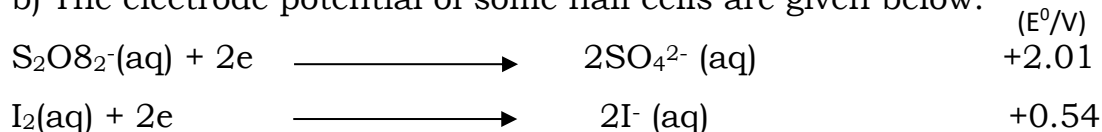
b) Write the mechanism for the reaction in a (i). (2 ½ marks)



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

It is a potential difference set between a metal and a solution of metal ions

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



Write;

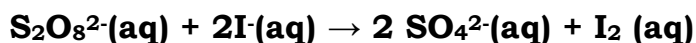
i) The cell notation of cell formed when the half cells are combined.

(1mark)

**Pt, 2I<sup>-</sup>(aq)/I<sub>2</sub>(aq)//S<sub>2</sub>O<sub>8</sub><sup>2-</sup>(aq)/SO<sub>4</sub><sup>2-</sup>(aq), Pt**

ii) Equation for the overall cell reaction.

(1½ marks)



iii) Calculate the e.m.f of cell.

(1mark)

$$\begin{aligned} E_{\text{cell}} &= E_{\text{RHE}} - E_{\text{LHE}} \\ &= 2.01 - 0.54 \\ &= 1.47\text{V} \end{aligned}$$

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

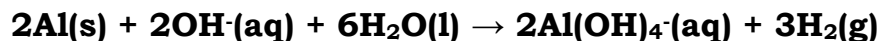
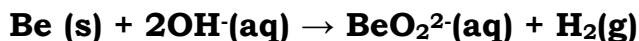
(1mark)

It is feasible because emf is positive

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

(2marks)

- the react with sodium hydroxide

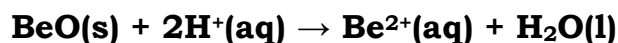
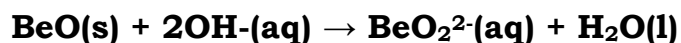
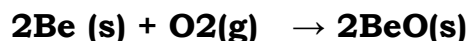
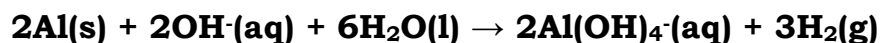
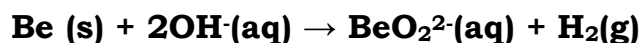


- do not react with nitric acid

- React with oxygen to form amphoteric oxides

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

(3marks)

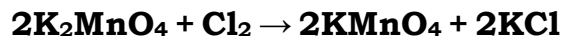


6. State what would be observed and write equation for the reaction that takes place when

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

(2 ½ marks)

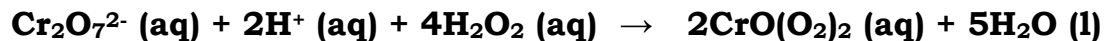
**A green solution turns purple**



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

(2 ½ marks)

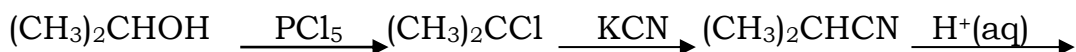
**Blue solution formed**



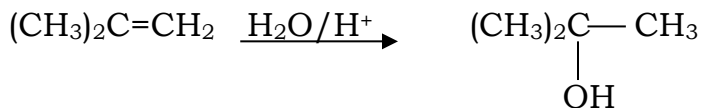
7. Write equations to show how the following conversions can be effected.

(2½ marks)

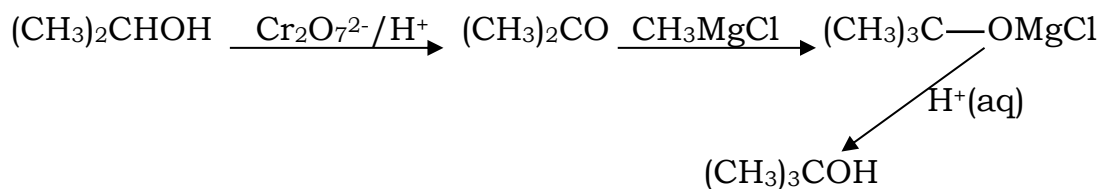
a)  $(\text{CH}_3)_2\text{CHOH}$  to  $(\text{CH}_3)_3\text{COH}$

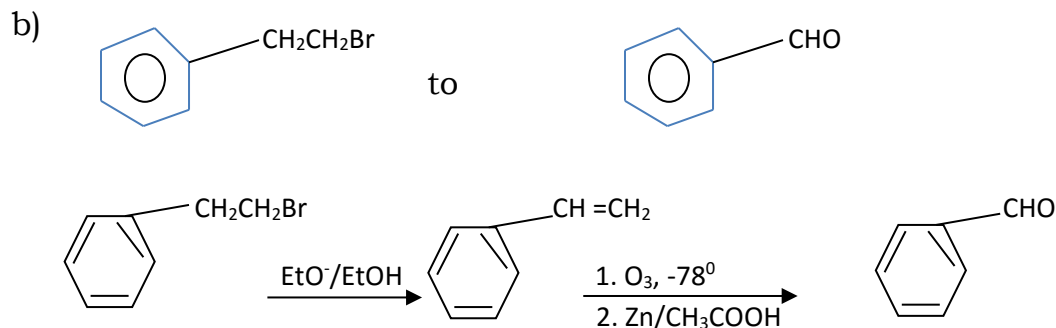


then



Or





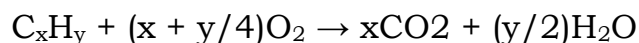
8.  $30\text{cm}^3$  of a hydrocarbon Q was exploded with  $200\text{cm}^3$  of oxygen in excess. The volume of the residual gas on cooling to room temperature was found to be  $155\text{cm}^3$ . When the residual gas was treated with concentrated potassium hydroxide solution, the volume reduced to 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

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

$$\text{volume of carbon dioxide produced} = 155 - 35 = 120\text{cm}^3$$

$$\text{Volume of oxygen used } 200 - 35 = 165$$

Equation



Volume	30	165	120
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Volume ratio	1	5.5	4
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$$x = 4$$

$$(x + y/4) = 5.5$$

$$y = 6$$

Molecular formula of Q =  $\text{C}_4\text{H}_6$

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

**$\text{CH}_3\text{CH}_2\text{C}\equiv\text{CH}$  but-1-yne**

**$\text{CH}_3\text{C}\equiv\text{CCH}_3$  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)



9. The molar conductivity of a 0.093M solution of ethanoic acid at 25°C is  $5.34 \times 10^{-4} \text{ Sm}^2\text{mol}^{-1}$ . The molar conductivity at infinite dilution of  $\text{H}^+$  and  $\text{CH}_3\text{COO}^-$  ions are  $3.51 \times 10^{-2}$  and  $0.4 \times 10^{-2} \text{ Sm}^2\text{mol}^{-1}$  respectively. Calculate the;

i) molar conductivity of ethanoic acid at infinite dilution. (1½ marks)

$$\begin{aligned}\Lambda_0\text{CH}_3\text{COOH} &= \lambda_0\text{CH}_3\text{COO}^- + \lambda_0\text{H}^+ \\ &= 0.4 \times 10^{-2} + 3.51 \times 10^{-2} \\ &= 3.91 \times 10^{-2} \text{ Sm}^2\text{mol}^{-1}\end{aligned}$$

ii) degree of dissociation,  $\alpha$  of ethanoic acid. (1½ marks)

$$\begin{aligned}\alpha &= \Lambda_c / \Lambda_0 \\ &= 5.34 \times 10^{-4} / 3.91 \times 10^{-2} \\ &= 0.014\end{aligned}$$

iii) acid dissociation constant,  $K_a$  at 25°C (1½ marks)

$$\begin{aligned}K_a &= \alpha^2 C = 0.014^2 \times 0.093 \\ &= 1.8 \times 10^{-5} \text{ mol dm}^{-3}\end{aligned}$$

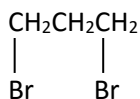
## SECTION B

Attempt only **six** questions from this Section

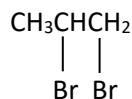
10. a) An organic compound Z has a molecular formula  $C_3H_6Br_2$ .

Write down the structural formula and IUPAC names of all isomers of Z.

(3marks)



1,3-dibromopropane



1,2-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  $60^\circ\text{C}$  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.

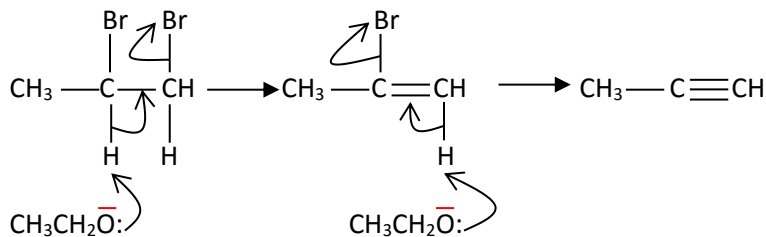
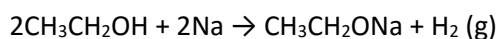
(1½ marks)

X -propanone

Y -propyne

Z - 1,2-dibromopropane

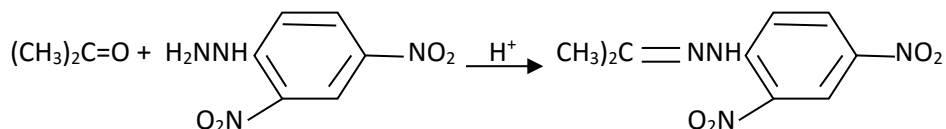
c) Write the equation and suggest the mechanism for the reaction between  
i) Z and sodium metal in ethanol.



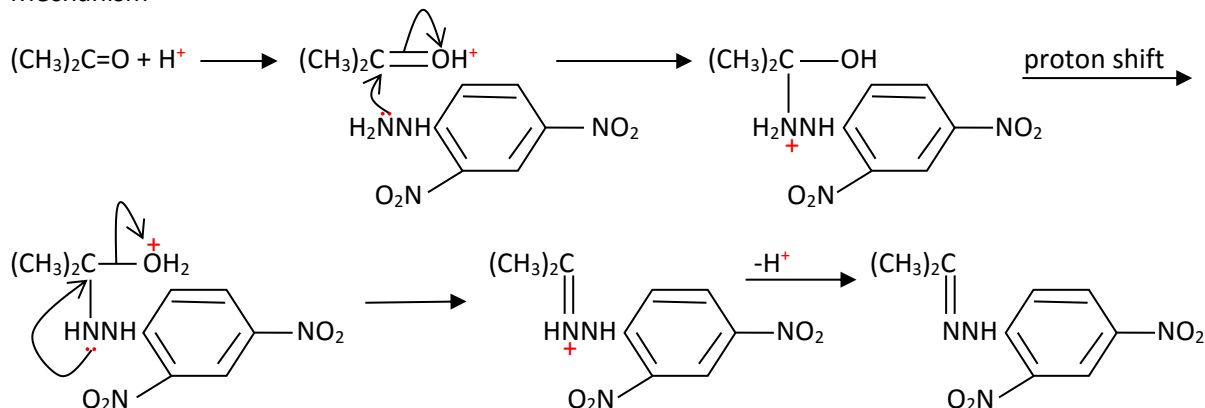


ii) X and Brady's reagent.

( 2 ½ marks)



Mechanism

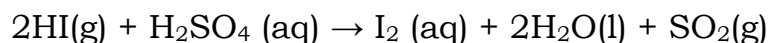


11. Explain each of the following observations (Your answer should include balanced equations if any). (3marks each)

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

### Solution

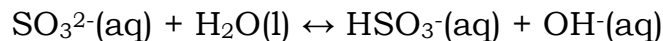
Iodide ion is a stronger reducing agent than chloride ion; it is oxidized by concentrated sulphuric acid to iodine



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

### Solution

Sulphate ions hydrolyze in water to produce hydroxide ions



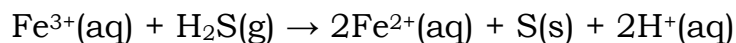
Whereas hydrogen sulphate ions hydrolyze in water to produce hydrogen ions



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

### Solution

Iron (III) ions oxidize hydrogen sulphide to Sulphur



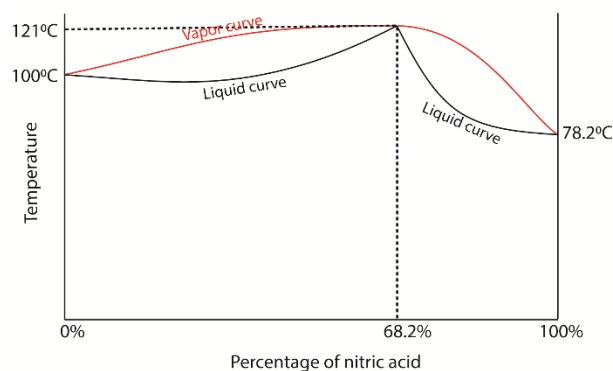
12. a) State Raoult's law as applied to binary liquid systems. (1mark)

**States that the partial vapor pressure of a component of an ideal solution is proportional to its concentration**

b) The mixture of water and nitric deviates negatively from Raoult's law. The mixture form an azeotropic mixture at 68.2% nitric and boiling point 121°C.

i) Sketch a labeled boiling point – composition diagram for the mixture above.

(Bpts of  $\text{HNO}_3$  and  $\text{H}_2\text{O}$  respectively are 78.2°C and 100°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 Raoult's 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.**

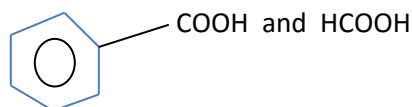
d) Name one method of obtaining pure nitric acid from the azeotropic mixture.

(1mark)

**Pure nitric acid is distilled a from azeotrope containing concentrated sulphuric acid is added.**

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)

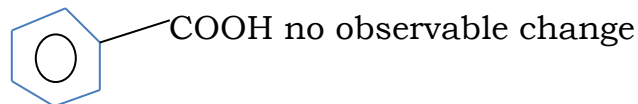
a)

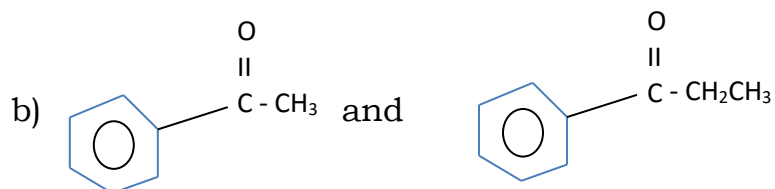


Reagent **Ammoniacal silver nitrate**

Observation

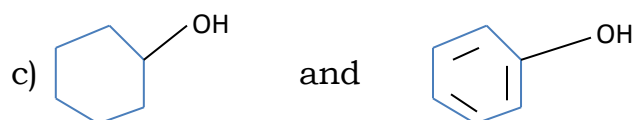
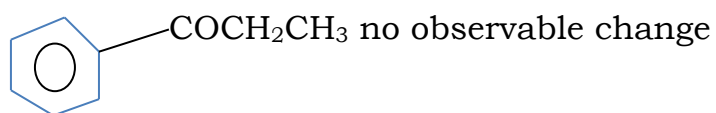
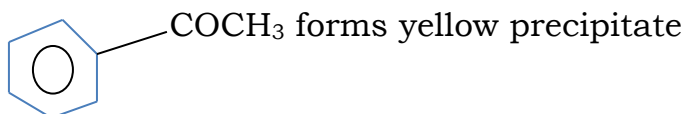
HCOOH forms silver mirror or black precipitate





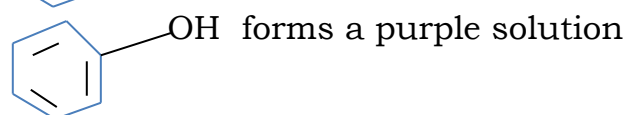
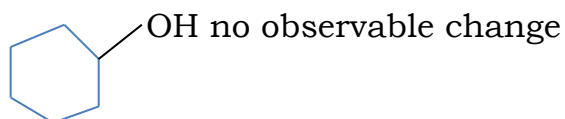
Reagent: solution of iodine in concentrated sodium hydroxide

Observations



Reagent: neutral iron (III) chloride solution

Observations



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

From  $\frac{PV}{T} = \text{constant}$

$$\frac{700 \times 48}{(273+20)} = \frac{760V}{273}$$

$$V = 41.2 \text{ cm}^3$$

Formula mass of R

41.2 cm<sup>3</sup> weight 0.111 g

22400 cm<sup>3</sup> weight RFM

$$\text{RFM} = \frac{0.111 \times 22400}{41.2} = 60$$

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

i) the empirical formula of R (2marks)

$$\text{Percentage of hydrogen} = 100 - (59.9 + 26.6) = 13.5$$

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 formula of R = C<sub>3</sub>H<sub>8</sub>O

ii) the molecular formula of R (1½ marks)

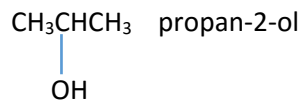
$$[\text{C}_3\text{H}_8\text{O}]_n = 60$$

$$n = 1$$

molecular formula = C<sub>3</sub>H<sub>8</sub>O

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

CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>OH propan-1-ol



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

- has variable oxidation states 2, 4, 7
- forms colored compounds MnO<sub>4</sub><sup>-</sup> is purple
- has catalytic activity e.g. MnO<sub>2</sub> is a catalyst in decomposition of H<sub>2</sub>O<sub>2</sub>.
- forms complexes e.g. MnO<sub>4</sub><sup>-</sup>

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

Mn 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>3d<sup>5</sup>4s<sup>2</sup>

ii) State the common oxidation states exhibited by manganese in its compounds. (1½ marks)

+2, +4, and +7.

c) i) Manganese (IV) oxide reacts with concentrated hydrochloric . Write the equation of reaction that takes place. (1½ marks)

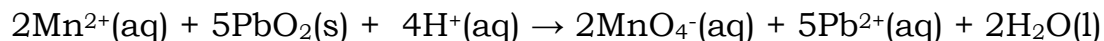


d) Lead(IV) oxide was added to an aqueous solution of manganese (II) chloride, followed by concentrated nitric acid. The mixture was then heated.

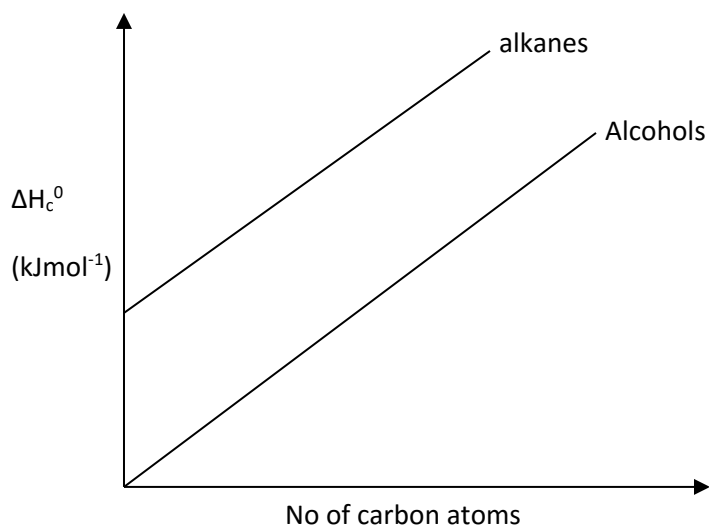
i) State what was observed. (1½ marks)

**Purple color is formed**

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



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)

Line graphs because compounds in the same homologous series differ from each other by a common group (CH<sub>2</sub>)

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

(1 ½ marks)

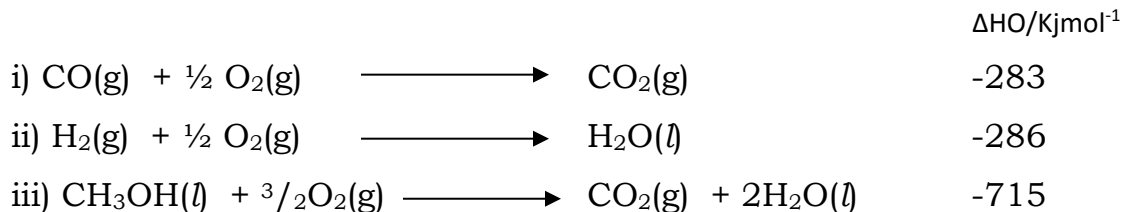
**Because alcohols are partially oxidized, therefore, their enthalpy of combustion is lower than that of alkanes**

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

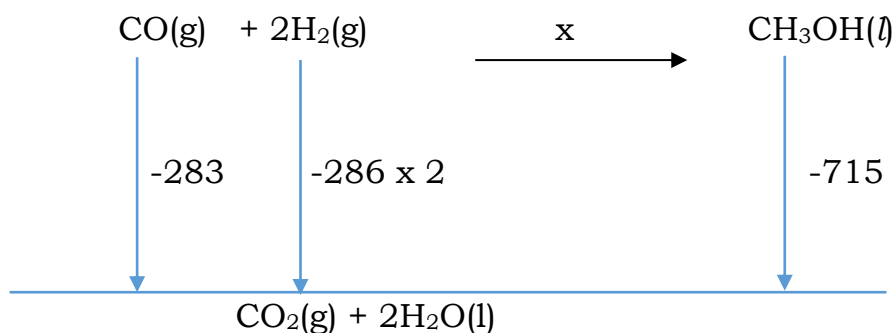
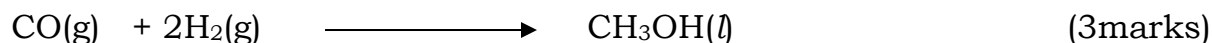
(1 ½ marks)

**The enthalpy of combustion of alkane is higher than that of alcohols that are partially oxidized**

b) Energy changes for some reactions are shown below;



Calculate the enthalpy change for the reactions



$$-283 - 286 \times 2 = x - 715 =$$

$$x = -140 \text{ kJmol}^{-1}$$

Therefore, enthalpy of combustion of  $\text{CH}_2\text{OH} = -140 \text{ kJmol}^{-1}$

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

**Complex ions are ions with a central metal ion bonded to one or more molecules or ions 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
$\text{CoCl}_4^{2-}$	4	+2
$\text{Fe(CN)}_6^{3-}$	6	+3
$\text{Ag(NH}_3)_2^+$	2	1



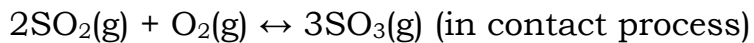
ii) Explain why transition metals form complex ions.

- **They have high charge density to attract lone pairs of electrons from ligands**
- **The have vacant orbitals to accommodate lone pairs of electrons to form dative bonds**

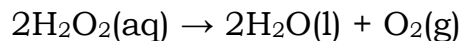
c) In each case write equation catalyzed by the following ions/species.

(1 ½ marks @)

i) Vanadium pentoxide



ii) Manganese II ions



**\*\*END \*\***