

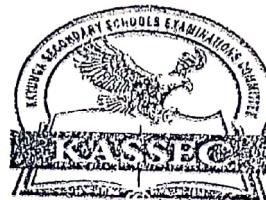
KIBUGO DENNIS

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P525/1  
Chemistry  
Paper 1  
July/August 2022  
2 3/4 hours



0750-732031

KAYUNGA SECONDARY SCHOOLS EXAMINATIONS COMMITTEE (KASSEC)  
JOINT MOCK EXAMINATIONS, 2022

*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 supplied.
- Mathematical tables(3 - figure tables) are adequate or non-programmable scientific electronic calculators may be used
- Illustrate your answers with equations where applicable.

Where necessary, use the following:

- Molar gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
- Molar volume of a gas at s.t.p is 22.4 litres,
- Standard temperature = 273 K
- Standard pressure =  $101325 \text{ N m}^{-2}$

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

Turn Over

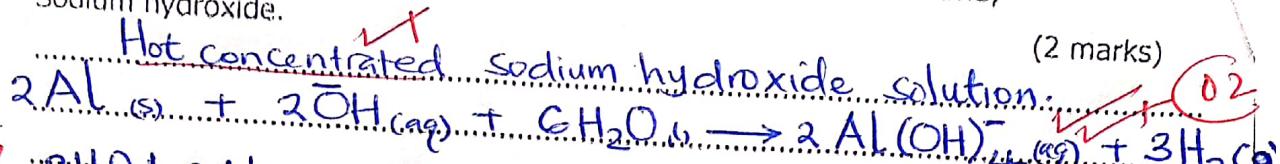
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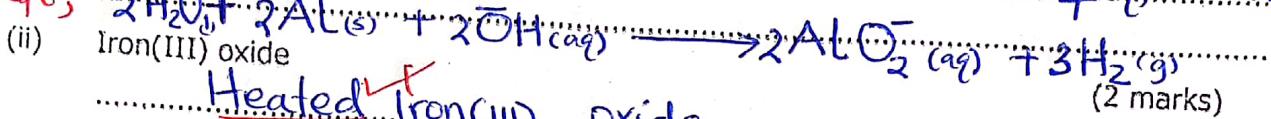
**SECTION A (46 MARKS)**

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

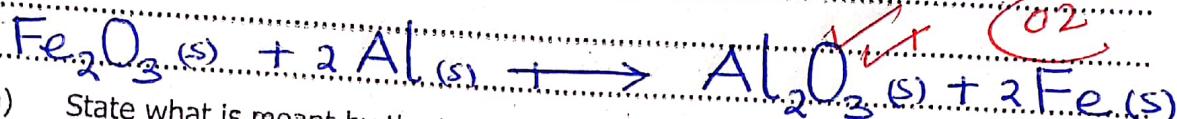
(i) Sodium hydroxide.



Accept;



Heated Iron(III) oxide



2.

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

The elevation in boiling point of a solvent caused when one mole of a non-volatile solute is dissolved in a thousand grams of a pure solvent

- (b) 0.40g of camphor when dissolved in 33.5g of trichloromethane produces a solution boiling at  $0.30^{\circ}\text{C}$  above the boiling point of pure solvent. Calculate the ebullioscopic constant of trichloromethane. (molar mass of camphor = 155)

33.5g of  $\text{CHCl}_3$  can dissolve 0.40g of Camphor. (3marks)

1000g of  $\text{CHCl}_3$  can dissolve  $\frac{(0.40 \times 1000)}{33.5}$  g of Camphor

$$= 11.94 \text{ g of Camphor.}$$

*Accept only first principles*  $0.30^{\circ}\text{C}$  is the elevation in boiling point caused by 11.94g of Camphor

$K_b$  is the elevation in boiling point caused by  $(K_b \times 11.94)$  g of Camphor

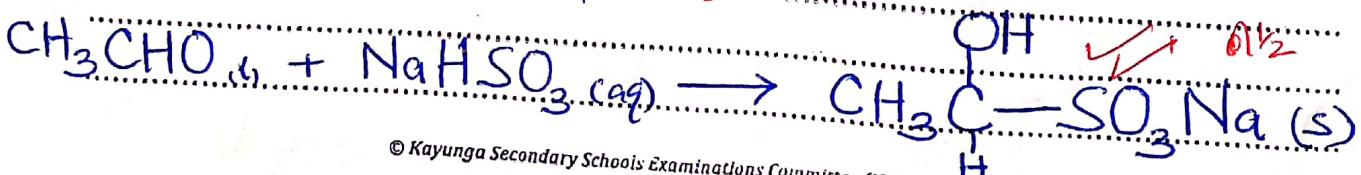
$$\therefore 155 = \frac{(K_b \times 11.94)}{0.30} \quad \text{Reject if no units or wrong units.}$$

3.

- (a) State what is observed and write equation for the reaction when

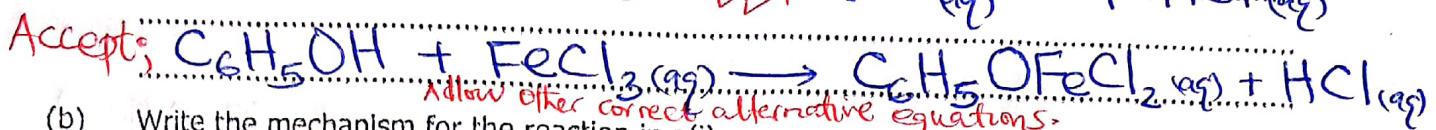
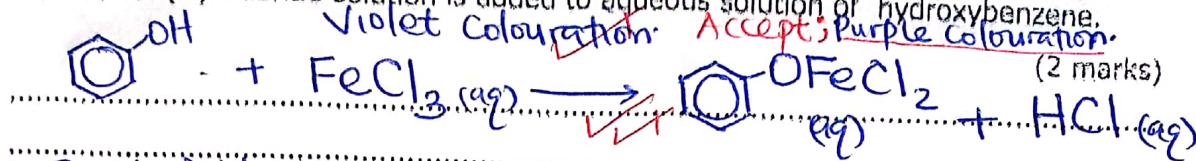
(i) Ethanal is mixed with a saturated solution of sodium bisulphite.

White precipitate. 0.5 (2marks)

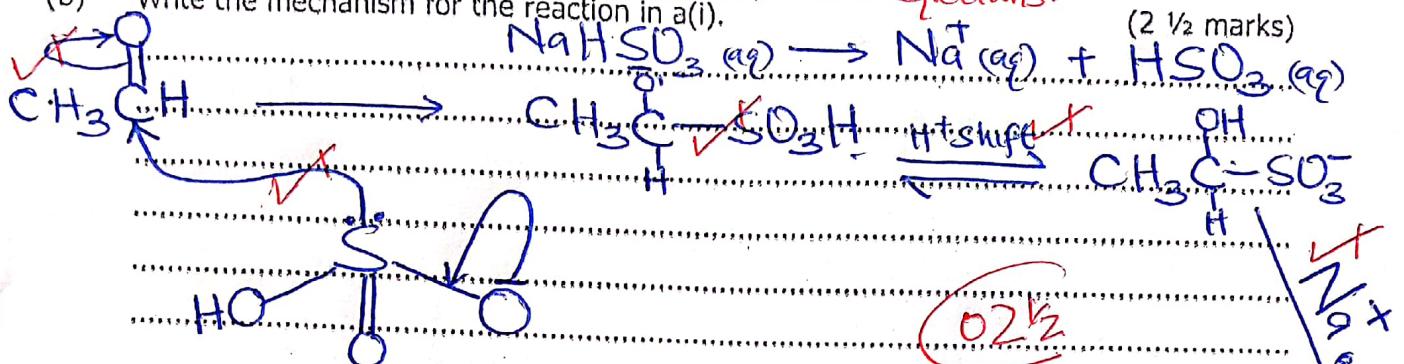


→

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



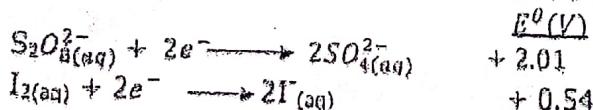
- (b) Write the mechanism for the reaction in a(i). (2 1/2 marks)



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

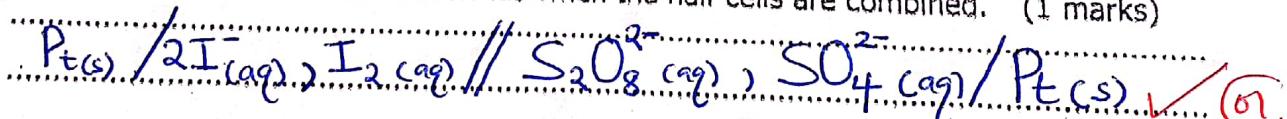
Is the potential difference developed between a metal electrode placed in contact with a solution of its ions. (1 mark)

- (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. (1 marks)



Accept;  $2\text{SO}_4^{2-}$

(1 1/2 mark)

- (ii) Equation for the overall cell reaction

E



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

$$E_{\text{cell}}^{\theta} = E_{\text{right}}^{\theta} - E_{\text{left}}^{\theta}$$

$$= 2.01 - 0.54 \quad (01)$$

$$= +1.47 \text{ V} \quad \text{Neglect Units}$$

(1 mark)

~~Alkyl  
Acetyl~~ }  $E_{\text{cell}}^{\theta} = E_{\text{cathode}}^{\theta} - E_{\text{anode}}^{\theta}$   
OR  
 $E_{\text{cell}}^{\theta} = E_{\text{reducat}}^{\theta} - E_{\text{oxidat}}^{\theta}$

~~Reject if charge is missing~~

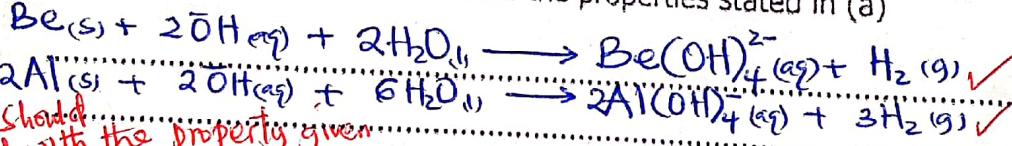
- (iv) State whether the cell reaction is feasible or not. Give a reason for your answer.

Feasible. This is because emf of the cell is positive. (01) (1 mark)

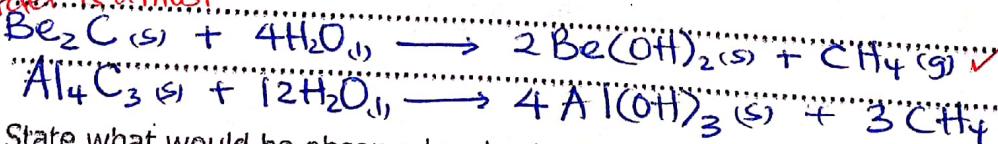
5. (a) State two properties in which beryllium shows diagonal relationship with aluminium.

- Both are rendered passive by concentrated nitric acid. (01) any 2 (1 mark)
- Both react with concentrated sodium hydroxide solution to form hydrogen gas and complexes.
- Both their oxides and hydroxides are amphoteric.
- Both their chlorides are covalent polymeric solids when anhydrous.
- Hydrolysis of their carbides in water produce methane gas.

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

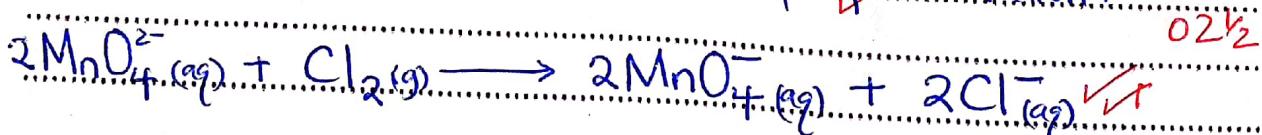


equations should correspond with the property given and the order is as thus



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

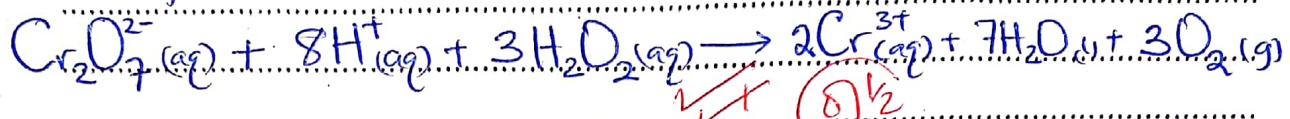
- (a) Chlorine gas is passed through a solution of potassium manganate (vi). (2 1/2 marks)
- The green solution turns to a purple solution.



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

(2 1/2 marks)

~~Orange~~ ✓ solution turns to ~~green~~ ✓ solution with bubbles of a colourless gas.

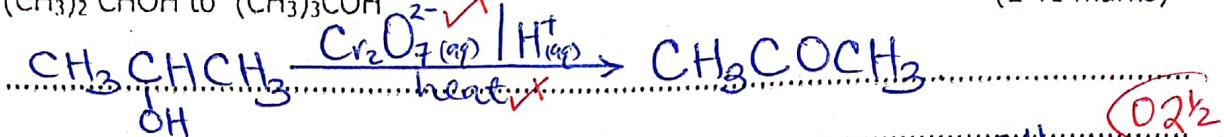


✓ (0 1/2)

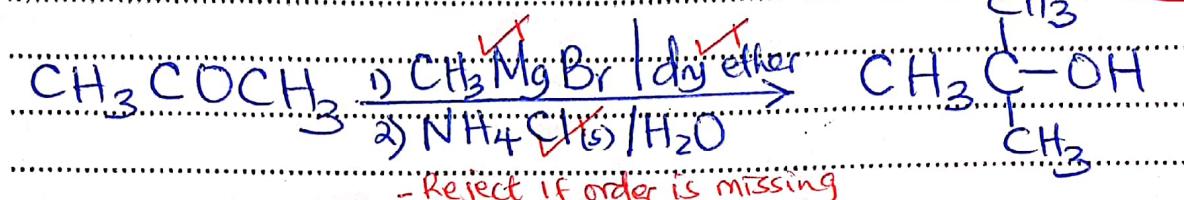
7. Write equations to show how the following conversions can be effected.

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

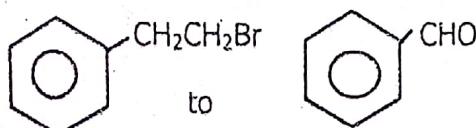
(2 1/2 marks)



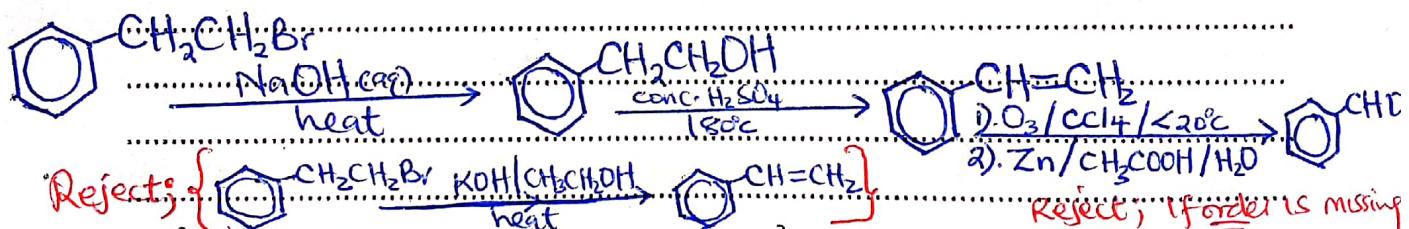
(0 1/2)



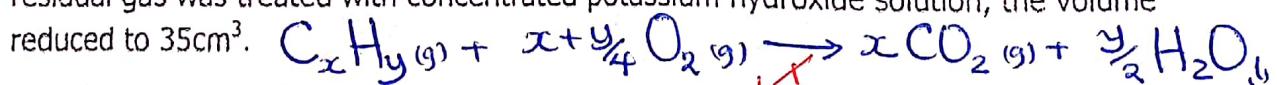
(b)



(2 1/2 marks)



8.  $30\text{cm}^3$  of 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.

(3 marks)

$$\text{Volume of CO}_2 = (155 - 35) = 120\text{cm}^3$$

$$\text{Volume of Unreacted O}_2 = (200 - 155) = 45\text{cm}^3$$

$$\text{Volume of reacted O}_2 = (200 - 35) = 165\text{cm}^3$$

(0 3)

For  $\text{CO}_2$

$$30\text{cm}^3 \text{ of C}_x\text{H}_y \text{ produce } 120\text{cm}^3 \text{ of CO}_2 \\ 1\text{cm}^3 \text{ of C}_x\text{H}_y \text{ produce } \frac{120}{30} = 4 \text{ cm}^3 \text{ of CO}_2$$

$$x = 4$$

For  $\text{O}_2$

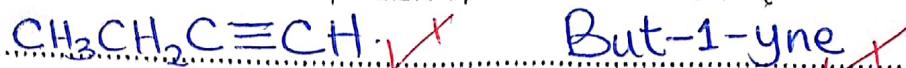
30cm<sup>3</sup> of C<sub>x</sub>H<sub>y</sub> react with 165cm<sup>3</sup> of O<sub>2</sub>

1cm<sup>3</sup> of C<sub>x</sub>H<sub>y</sub> react with  $\frac{165}{30} = 5.5$  cm<sup>3</sup> of O<sub>2</sub>

$$\therefore x + \frac{y}{4} = \frac{165}{30} \\ 4 + \frac{y}{4} = \frac{165}{30}$$

∴ Formula of Q is C<sub>4</sub>H<sub>6</sub>

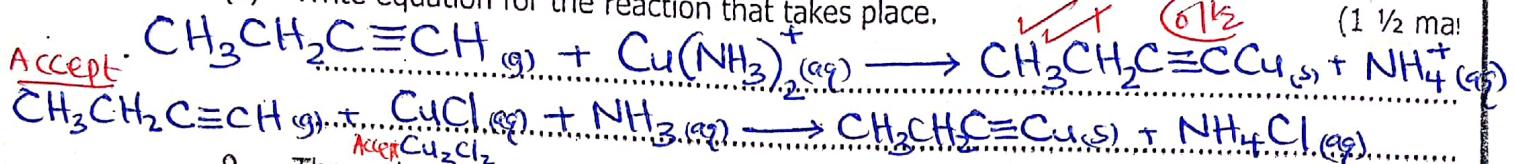
(b) Write the structures of all possible open chain isomers of Q.



(c) Q reacts with ammoniacal copper (I) chloride solution.  
 (i) State what is observed.

A red precipitate. ✓ (0.1) (1 mark)

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



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  $3.5 \times 10^{-2}$   $\text{sm}^2\text{mol}^{-1}$  and  $0.4 \times 10^{-2}$   $\text{sm}^2\text{mol}^{-1}$  respectively. Calculate the;

(i) Molar conductivity of ethanoic acid at infinite dilution.

From

$$\begin{aligned} \Lambda_0 \text{CH}_3\text{COOH} &= \Lambda_0 \text{CH}_3\text{COO}^- + \Lambda_0 \text{H}^+ \\ &= 3.5 \times 10^{-2} + 0.4 \times 10^{-2} \\ &= 0.039 \text{ Sm}^2 \text{ mol}^{-1} \end{aligned} \quad \begin{matrix} \text{reject if } \Lambda_0 \text{ or } \Lambda_0 \text{ missing} \\ \text{1/2 for missing units} \end{matrix} \quad (0.12)$$

(ii) Degree of dissociation,  $\alpha$  of ethanoic acid

$$\alpha = \frac{\Lambda_c}{\Lambda_0} = \frac{5.34 \times 10^{-4}}{0.039} \quad (0.12)$$

$$\alpha = 0.01369 \quad (0.12)$$

$$\alpha = 1.369\% \quad (0.12)$$

(iii) Acid dissociation constant,  $K_a$  at 25°C.

$$\begin{aligned} K_a &= C\alpha^2 \quad (0.12) \\ &= 0.093(0.01369)^2 \\ &= 1.74297 \times 10^{-5} \text{ mol dm}^{-3} \end{aligned}$$

Accept this alternative (1 1/2 marks)

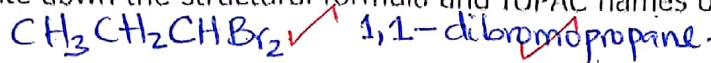
$$\begin{aligned} K_a &= \frac{C\alpha^2}{1-\alpha} \\ &= \frac{0.093(0.01369)^2}{1-0.01369} \\ &= 1.7692 \times 10^{-5} \text{ mol dm}^{-3} \end{aligned}$$

## SECTION B (54 marks)

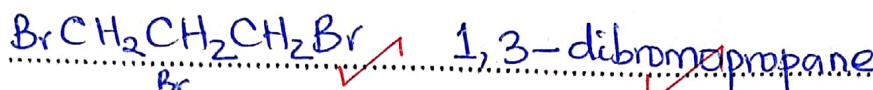
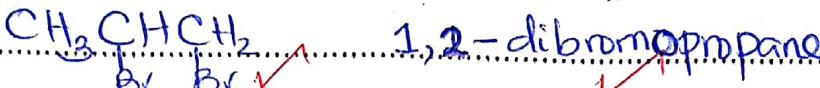
Attempt only six questions from this section.

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**.



(3 marks)

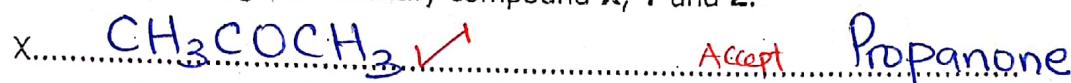


(03)

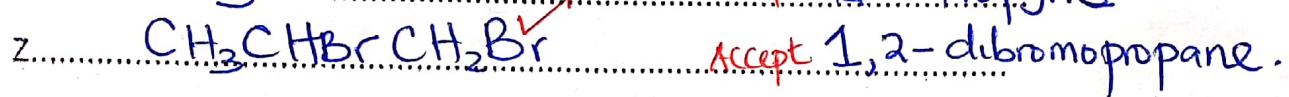


Accept any 3 correct  
isomers

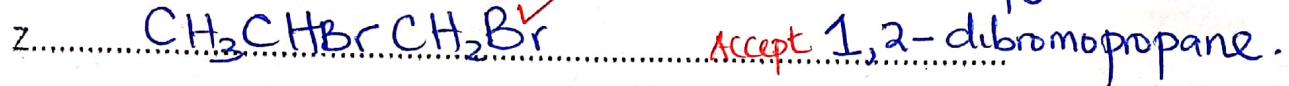
- (b) When **Z** was heated with sodium metal in ethanol, a compound **Y** was formed. **Y** reacts with water in the presence of sulphuric acid and Mercury sulphate at  $60^\circ C$  to form a compound **X**. **X** does not react with Fehling's solution but forms an orange precipitate with Brady's reagent. Identify compound **X**, **Y** and **Z**. (1 1/2 marks)



Accept B Propyne



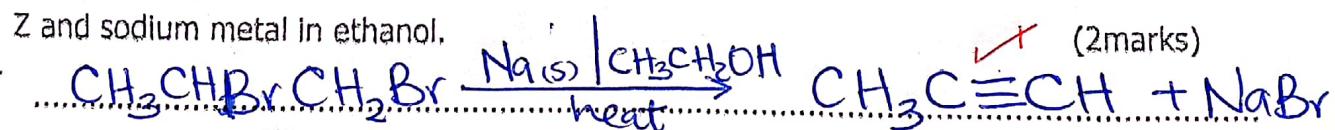
Accept B Propyne



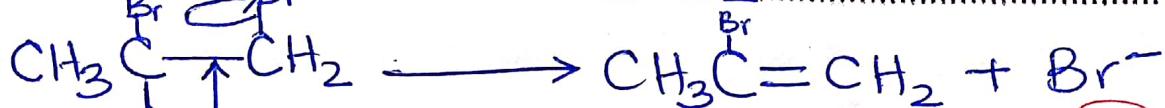
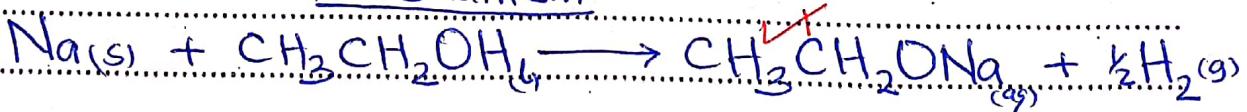
Accept 1,2-dibromopropane.

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

- (i) **Z** and sodium metal in ethanol.



Mechanism:



(02)

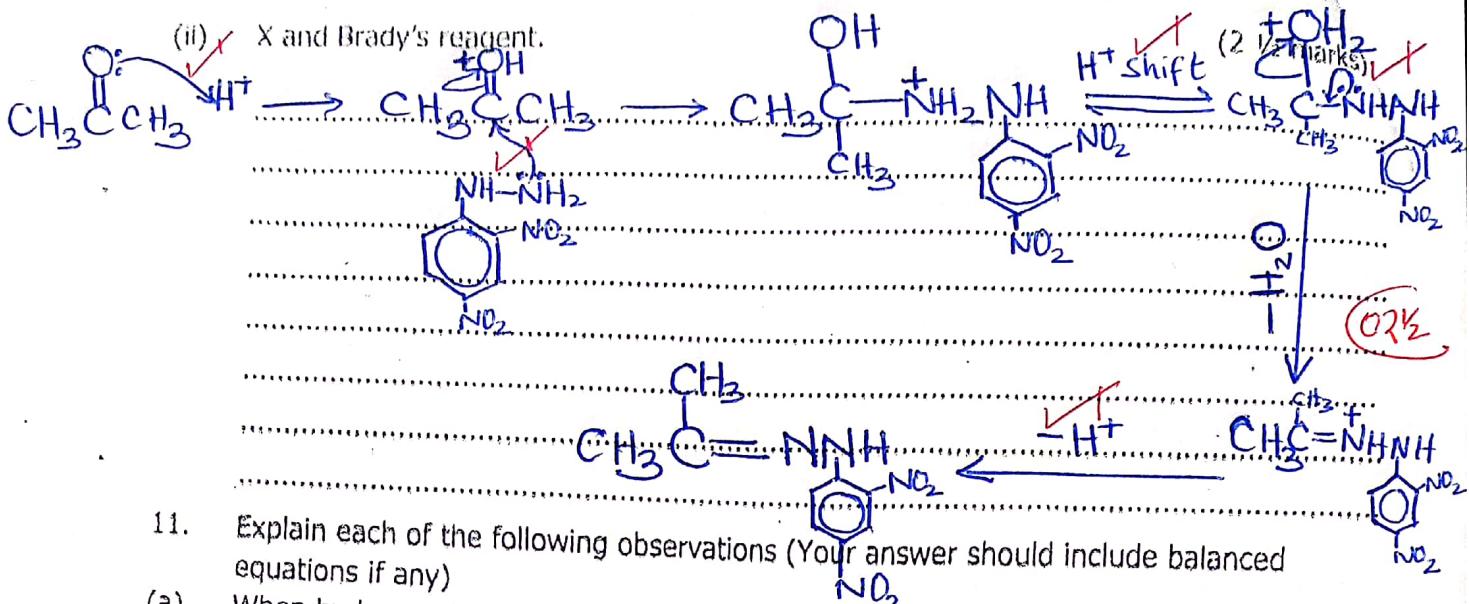


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11. Explain each of the following observations (Your answer should include balanced equations if any)

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

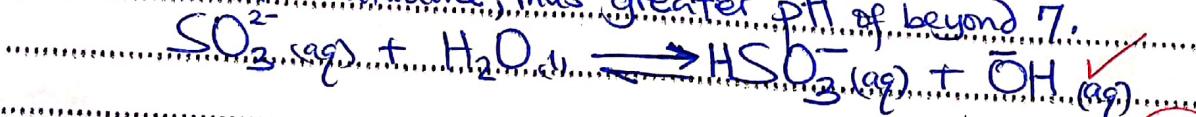
Concentrated sulphuric acid oxidises hydrogen iodide to iodine and itself reduced to sulphur dioxide and water.

$$2\text{HBr(g)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{SO}_2\text{(g)} + 2\text{H}_2\text{O(l)} + \text{I}_2\text{(g)}$$

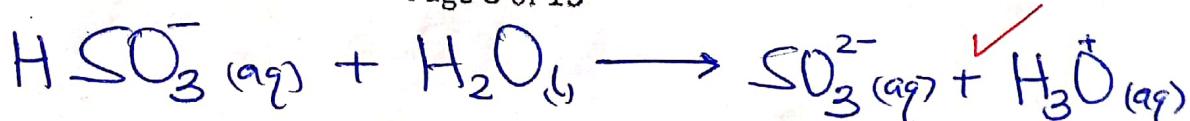
Hydrogen chloride on the other hand, is not a reducing agent thus can not be oxidised by the acid. hence no reaction.

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

Sulphite ions from sodium sulphite undergo hydrolysis in water forming hydrogensulphite ions, and hydroxide ions that make the resultant solution alkaline, thus greater pH of beyond 7.

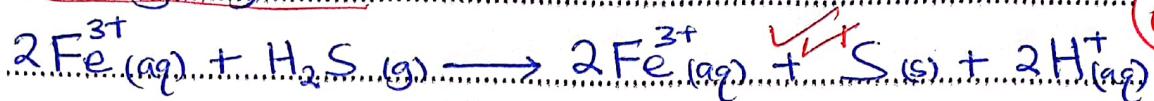


Hydrogensulphite ions from sodium hydrogensulphite undergo hydrolysis in water forming sulphite ions, and hydroxonium ions that make the resultant solution acidic, hence pH < 7.



- (c) When hydrogen sulphide is bubbled through an aqueous solution of iron(III) chloride, a yellow precipitate is observed. (3 marks)

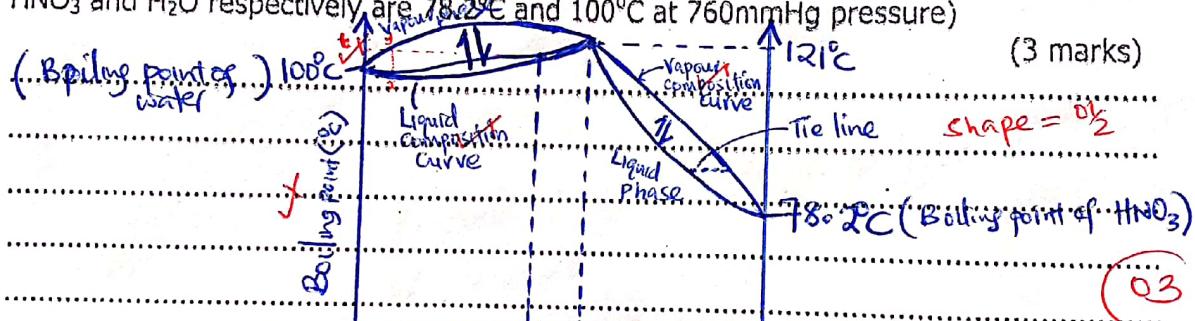
Iron(III) ions from Iron(II) chloride, are reduced to iron(II) ions by hydrogen sulphide and itself oxidised to sulphur and hydrogen ions. (03)



12. (a) State Raoult's law as applied to binary liquid systems. (1 mark)  
Accept:  $P_A = X_A P_A^0$  for ideal solution - let the student define each term used. (1 mark)  
constant temp. in expression

The partial vapour pressure of a component of an ideal solution consisting of two components is the product of its mole fraction and vapour pressure it exerts in its pure state at that temperature. Accept other correct alternative definitions. (01)

- (b) The mixture of water and nitric acid deviates negatively from Raoult's law. The mixture forms an azeotropic mixture at 68.2% nitric acid and boiling point 121°C.  
(i) Sketch a labelled 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)



- (ii) Describe briefly what happens when a mixture containing 50% nitric acid is distilled. (2 1/2 marks)

When the mixture boils at a temperature,  $t^\circ\text{C}$ , giving off a vapour of composition,  $y$ , richer in nitric acid, the more volatile component. (0.5)

When the vapour is cooled, a liquid of composition,  $x$ , is formed richer in nitric acid. (0.5)

Successive distillations and condensations yield pure nitric acid as a distillate and azeotropic mixture as the residue. (0.5)

- (c) Explain why the mixture deviates negatively from Raoult's law. (1 1/2 marks)  
 This is because the mixture has a maximum boiling point and thus the mixture has a minimum vapour pressure composition than that expected from Raoult's law. 0.5

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

- Distillation using a third component ✓ 01

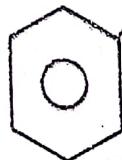
{ - Solvent extraction

- Separation by adsorption

- Addition of drying agents such as Calcium oxide.

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.

- (a)



COOH and HCOOH

Reagent

Rej; without solution  
Reject wrong spelling of reagent.

(3marks)

(1) Ammoniacal silver nitrate solution ✓

(2) { Fehling's solution

Observation

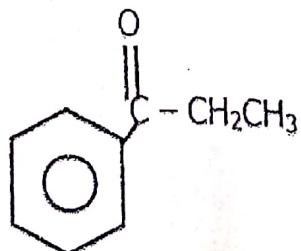
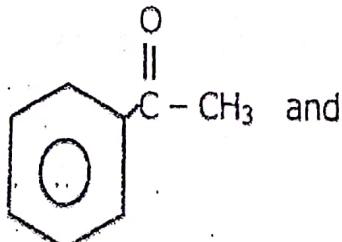
Don't award (1)  
If reagent is wrong.

{ With COOH, No observable change. (0.5)

{ With HCOOH, A silver mirror.

{ with COOH, No observable change.  
with HCOOH, A reddish brown precipitate.

- (b)



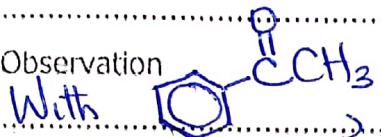
(3 marks)

Reagent

Reject; If solution missing

Iodine solution ✓ and Solution hydroxide solution.

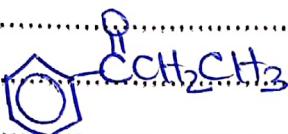
Observation



✓ A yellow precipitate

Reject; Orange precipit

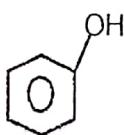
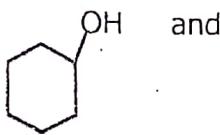
With



No observable change.

O<sub>2</sub>

(c)



Reagent

(1) Bromine water ✓

Reject; Anhydrous zinc chloride  
in presence of concentrated  
hydrochloric acid.

(2) { Neutral Iron(III) chloride solution

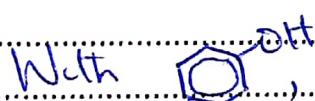
Observation



No observable change

(2) { With A purple colouration  
with No observable change

(1)



With A white precipitate

14. (a) 0.111g of a vaporized sample of an organic compound R occupied 48.0cm<sup>3</sup> at 20°C and 700mmHg pressure. Calculate the relative molecular mass of R.

From  $PV = nRT$  ✓

(2 1/2 marks)

$PV = \frac{m}{Mr} \cdot RT$

Use R given in the paper

Rej; R = 8.314

$$\left( \frac{101325 \times 700}{760} \right) \times 48.0 \times 10^{-6} = \frac{0.111 \times 8.31 \times 293}{Mr}$$

$$Mr = 60.33 \text{ g.}$$

0.212

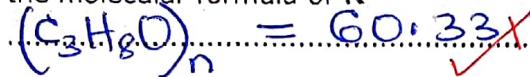
∴ Relative molecular mass of R is 60.33

✓

- (b) R consists 59.9% carbon, 13.5% hydrogen and the rest is oxygen. Determine the empirical formula of R.  $\% O = 100 - (59.9 + 13.5) = 26.6$  (2½ marks)

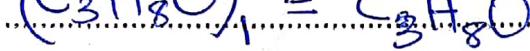
Elements	C	H	O
Composition	59.9	13.5	26.6
Moles	$\frac{59.9}{12}$	$\frac{13.5}{1}$	$\frac{26.6}{16}$
	4.99	13.50	1.66
Mole ratio	$\frac{4.99}{1.66}$	$\frac{13.50}{1.66}$	$\frac{1.66}{1.66}$
Simplest ratio	3	8	1

- (ii) the empirical formula is  $C_3H_8O$  ✓ (1½ marks)



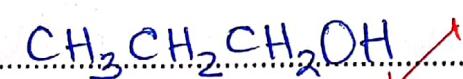
$$(12 \times 3)n + (1 \times 8)n + 16n = 60.33$$

$$n = 1$$

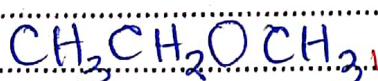


∴ Molecular formula of R is  $C_3H_8O$

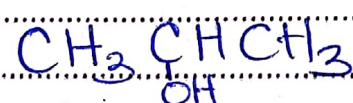
- (c) Write down the structural formulae and give the IUPAC names of all isomers of R.



Propan-1-ol ✓ (3 marks)



Methoxyethane ✓ 63



Propan-2-ol ✓

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

- Has variable oxidation states ✓ (2marks)

- Forms Coloured Compounds ✓ 62

{ - forms Complexes

- It is paramagnetic

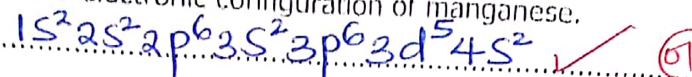
- Acts as a Catalyst

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June Mock 2022

- Forms Interstitial Compounds -

any 2

- (b) (i) Write the electronic configuration of manganese. (1 marks)

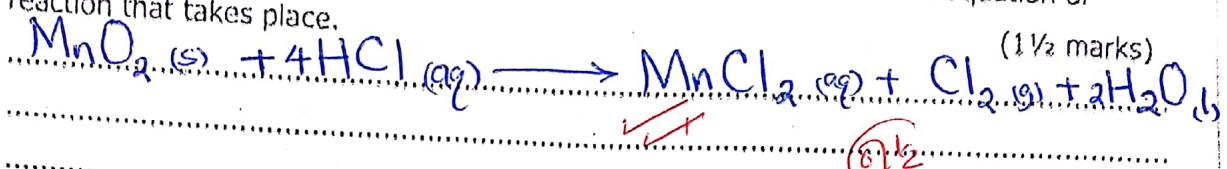


- (ii) State the common oxidation states exhibited by manganese in its compounds. (1½ marks)

+2, +4, +7 (0½)

Reject: +3, +5  
Accept: +6

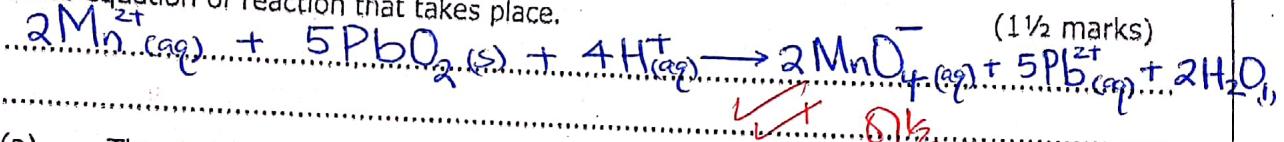
- (c) Manganese (IV) oxide reacts with concentrated hydrochloric. Write the equation of reaction that takes place. (1½ marks)



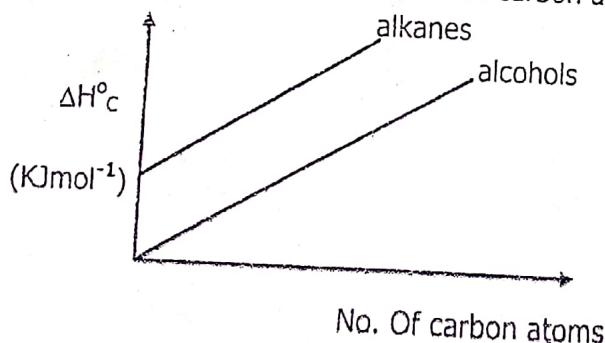
- (d) Lead(V) oxide was added to an aqueous solution of manganese(II) chloride, followed by concentrated nitric acid. The mixture was then heated.

- (i) State what was observed. (1½ marks)
- Dark brown solid dissolves in the colourless solution forming a purple solution. ✓ (0½)

- (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.



- (a) Explain the shape of the graphs. (5marks)

The graphs are linear and parallel because there is a constant increase in enthalpy associated with addition of a successive methylene group ( $-CH_2-$ ) whose bonds are broken during combustion.

For alcohols, the graph passes through the origin because  $n=0$  for Carbon atoms corresponds to a water molecule that has zero enthalpy of combustion.

For alkanes, the graph has an intercept because  $n=0$  for Carbon atoms corresponds to the enthalpy of combustion of hydrogen.

- (b) Explain why the graph of enthalpy of combustion for alkanes does not pass through Zero yet for the alcohols passes through Zero.

For alcohols, the graph passes through Zero because  $n=0$  for Carbon atoms corresponds to a water molecule that has zero enthalpy of combustion. (04)

For alkanes, the graph has an intercept; doesn't pass through zero because  $n=0$  for Carbon atoms corresponds to the enthalpy of hydrogen. (1 mark)

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

An ion consisting of a central metal ion that is dative bonded to ligands. (01) (1 mark)

Accept any other correct alternative definition

OR An ion positive or negative in which atoms or groups of atoms with a negative charge or lone pair of electrons form co-ordinate bonds with central metal ion.

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

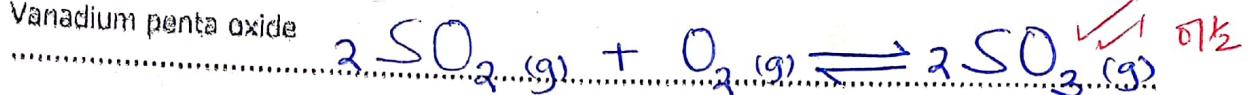
Formulae of complex ion	Coordination number	Oxidation state	
$\text{CoCl}_4^{2-}$	4 ✓	$\checkmark +2$ Reject; $\frac{+2}{2}$	(01)
$\text{Fe}(\text{CN})_6^{3-}$	6 ✓	$\checkmark +3$ Reject; $\frac{+3}{3}$	
$\text{Ag}(\text{NH}_3)_2^+$	2 ✓	$\checkmark +1$ (03)	

Reject without charg

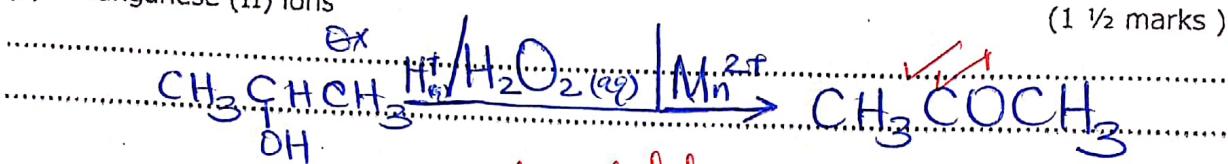
- (ii) Explain why transition metals form complex ions.
- They have vacant or partially filled 3d-orbitals to accommodate lone pair of electrons from ligands. (2 marks)
  - Have small ionic radius hence high charge density and high polarising power for the lone pair of electrons on the ligands in order to form a stable complex. (2 marks)
- (c) In each case, write an equation catalyzed by the following ions/species.

(1 marks)

(i) Vanadium penta oxide



(ii) Manganese (II) ions



Accept; any secondary alcohol.

END