PRACTICAL PROBLEMS

PROBLEM 1 (practical)

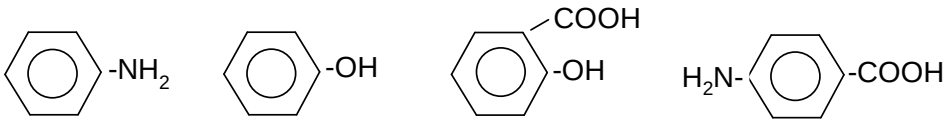
In test tubes **A**, **B**, **C**, and **D** there are four benzene derivatives containing one or two functional groups of three distinct types. Identify the functional groups of compounds **A**, **B**, **C**, and **D** using the available reagents.

– Justify your choice by writing down the identification reactions.

– Using as reagents the four compounds **A**, **B**, **C**, and **D** synthesize four organic dyes and write the equations for the reactions performed.

SOLUTION

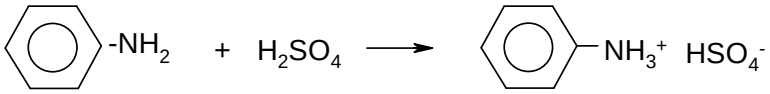
The four compounds are as follows:

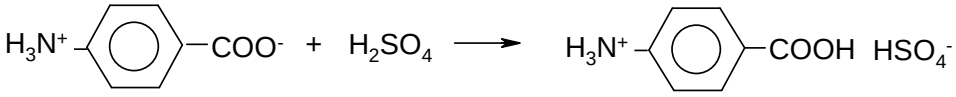


A **B** **C** **D**

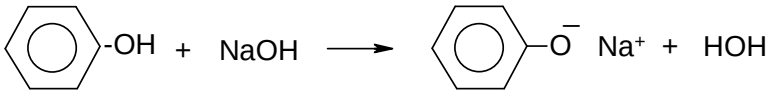
The identification reactions:

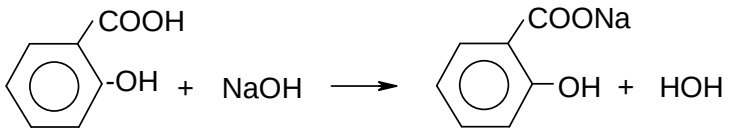
a) With H_2SO_4:

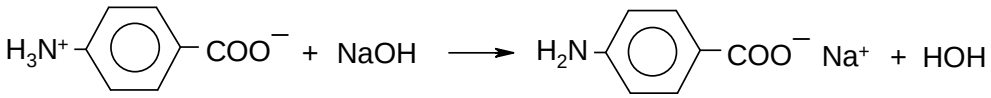




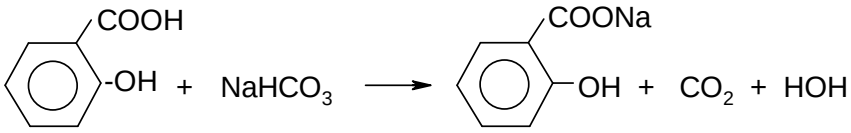
b) With NaOH:

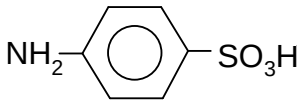


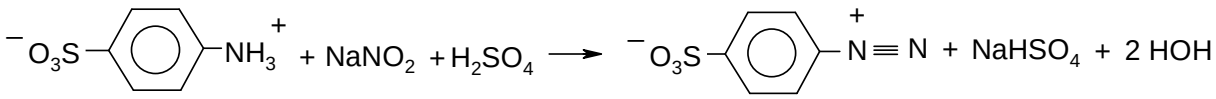


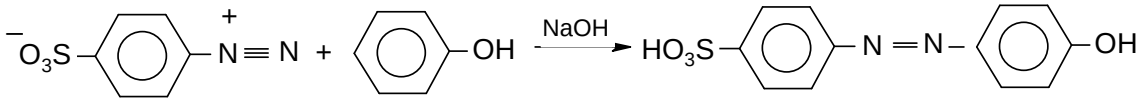


c) With $NaHCO_3$:

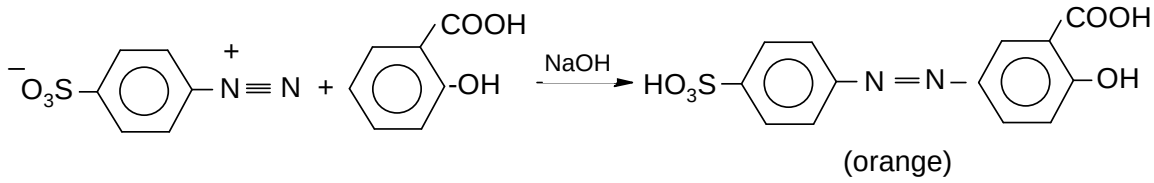


d) With 

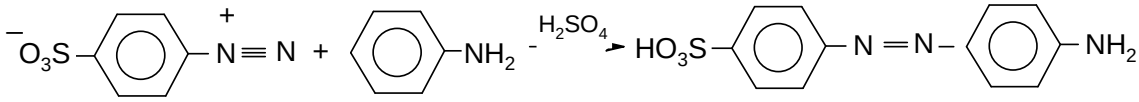




(orange)

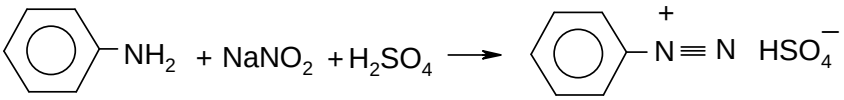


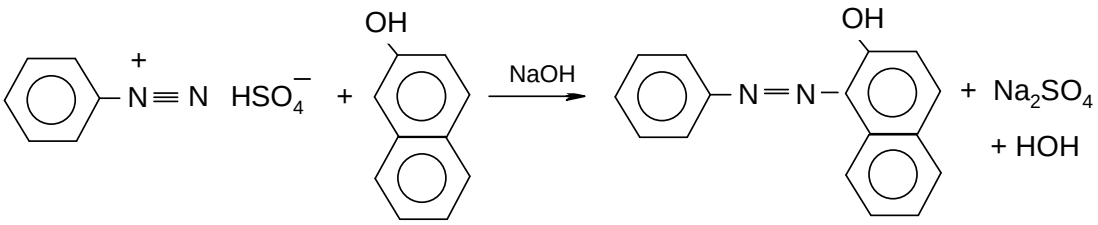
(orange)



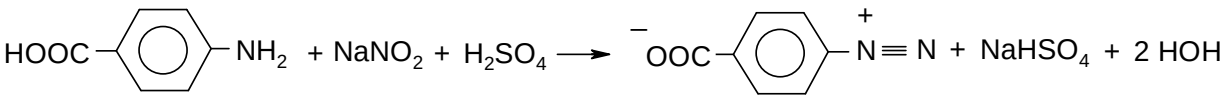
(orange)

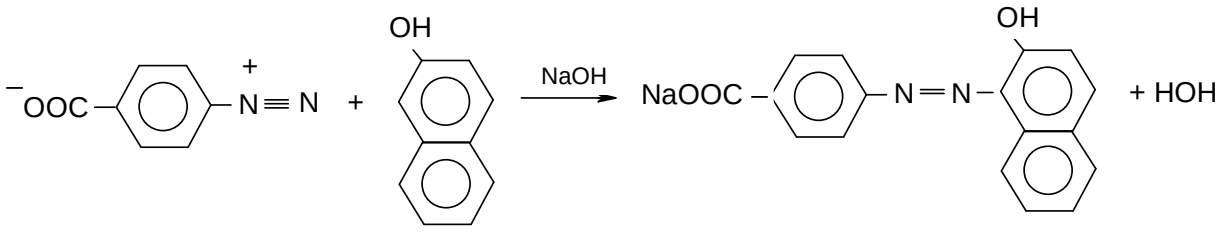
II. e) With β-naphthol:





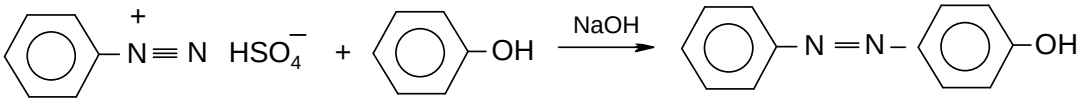
yellow - orange



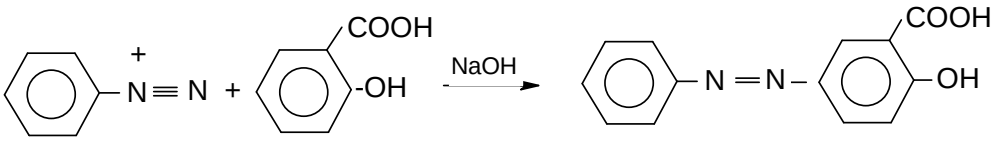


red

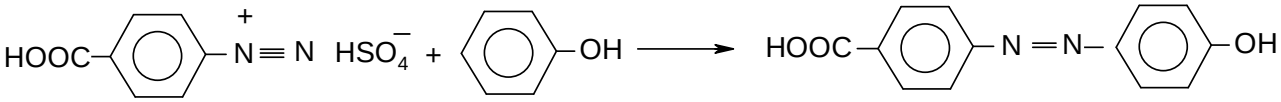
The following dyes can be obtained:



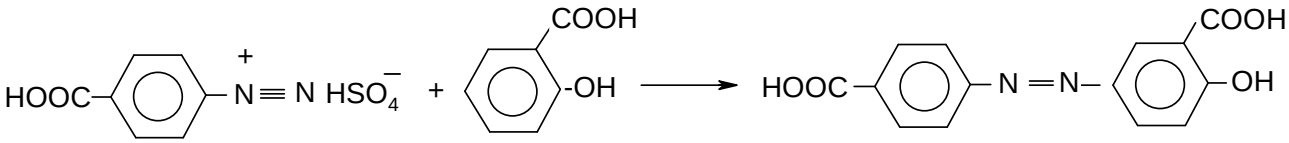
(red - orange)



(red - orange)



(red - orange)



(red - orange)

PROBLEM 2 (practical)

A solution in a graduated flask contains a mixture of oxalic acid and ammonium oxalate.

One of the bottles denoted X, Y, and Z contains a solution of a calibration substance with reducing character at a concentration of 0.1000 mol dm^{-3}.

You are required to solve the following tasks:

a) Determine the quantity of oxalic acid and of ammonium oxalate in the solution in the graduated flask. (The result will be given in grams.)

b) Write the formula for the substance with reducing character and the equations of the chemical reactions which led to its determination.

In order to carry out the analyses the following solutions are available:

HCl (c = 0.1000 mol dm^{-3}), NaOH (c = 2 mol dm^{-3}), $KMnO_4$ (c = 0.02 mol dm^{-3}), 25 % H_2SO_4, HNO_3 (c = 2 mol dm^{-3}), 5 % $BaCl_2$, 5 % $AgNO_3$, 5 % $Hg_2(NO_3)_2$, phenolphthalein 0.1 %, methyl red 1 %.

c) Describe the procedure used in the individual steps, indicators employed and partial results.

$M_r(H_2C_2O_4)$ = 90.04

$M_r((NH_4)_2C_2O_4)$ = 124.11

SOLUTION

ANSWER SHEET:

A_1 – Identification of the solution with the reducing substance X, Y, Z: $Fe(NH_4)_2(SO_4)_2$

A_2 – Identification reactions for the ions of the substance

- $Fe^{2+} + 2\ NaOH \rightarrow Fe(OH)_2 + 2\ Na^+$
- $NH_4^+ + NaOH \rightarrow NH_3 \uparrow + H_2O + Na^+$
- $4\ NH_3 + 2\ Hg_2(NO_3)_2 + H_2O \rightarrow O(Hg)_2NH_2.NO_3 + 3\ NH_4OH$
- $SO_4^{2-} + BaCl_2 \rightarrow BaSO_4 + 2\ Cl^-$

B_1– Preparation of the 0.1 M NaOH solution

. . . . . cm^3 in 200.0 cm^3

B_2 – Concentration of the NaOH in its solution: . . . . . M

Indicator used: . . . . . .

C – Concentration of $KMnO_4$ in its solution . . . . . M

D_1 – Mass of oxalic acid in the initial solution . . . . . g

Indicator used . . . . . .

D_2 – Mass of ammonium oxalate in the initial solution . . . . . g

S o l u t i o n

A_1 – 1-2 cm^3 of solution X, Y and Z are put into three test tubes. 6 N H_2SO_4 and a drop of $KMnO_4$ solution are added. The solution which loses colour is the one with reducing character.

A_2 – Establishment of the formula:

. . . . . + NaOH – greenish white precipitate $\Rightarrow Fe^{2+}$

. . . . . + NaOH at the upper end of the test-tube, filter paper with a drop of $Hg_2(NO_3)_2$, black spot $\Rightarrow NH_4^+$

. . . . . + $BaCl_2$ – white precipitate $\Rightarrow SO_4^{2-}$

. . . . . + $AgNO_3$ + HNO_3 $\Rightarrow$ Cl^- is absent

Accordingly the substance used is $Fe(NH_4)_2(SO_4)_2$.

The chemical reactions:

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

$NH_4^+ + Na^+ + OH^- \rightarrow NH_3 + H_2O + Na^+$

$4\ NH_3 + 2\ Hg_2(NO_3)_2 \rightarrow O(Hg)_2NH_2\ .\ NO_3 + 2\ Hg + 3\ NH_4NO_3$

$SO_4^{2-} + Ba^{2+} + 2\ Cl^- \rightarrow BaSO_4 + 2\ Cl^-$

B_1 – 5 cm^3 2 M solution $\Rightarrow$ 100 cm^3 0.1 M solution

B_2 – *V* cm^3 0.1000 N HCl + 0.1 N NaOH in the presence of phenolphthalein.

C – *V* cm^3 solution X + 10.0 cm^3 H_2SO_4 + H_2O is titrated at elevated temperature with $KMnO_4$.

D_1 – The solution which is to be analyzed is filled to the mark; V cm^3 of this solution is titrated with NaOH in the presence of methyl red. The quantity of oxalic acid (moles and g) is calculated.

D_2 – V cm^3 solution to be analyzed + 10.0 cm^3 6 N H_2SO_4 + H_2O are heated and titrated with $KMnO_4$ solution.

The total amount of oxalate is calculated (in mol).

The difference gives the amount of ammonium oxalate (moles and g).

PROBLEM 3 (practical)

Six test-tubes contain aqueous solutions of $FeSO_4$, H_2SO_4, $Mn(NO_3)_2$, H_2O_2, $Pb(NO_3)_2$, NaOH.

a) Identify the content of each test-tube without using other reagents. Write the results in tabular form. Write the equations for the chemical reactions used for the identification.

b) After identification, perform four reactions each time using three of the identified compounds and write the equations.

SOLUTION

	$FeSO_4$	H_2SO_4	$Mn(NO_3)_2$	H_2O_2	$Pb(NO_3)_2$	NaOH
1) $FeSO_4$		–	–	$Fe(OH)SO_4$ yellowish	$PbSO_4\downarrow$ white	$Fe(OH)2\downarrow$ white-greenish $\downarrow$ $Fe(OH)3\downarrow$ brown-redish
2) H_2SO_4	–		–	–	$PbSO_4\downarrow$ white	–
3) $Mn(NO_3)_2$	–	–		–	–	$Mn(OH)_2\downarrow$ white $\downarrow$ $MnMnO_3\downarrow$ brown black
4) H2O2	$Fe(OH)SO_4$ yellowish	–	–		–	–
5) $Pb(NO_3)_2$	$PbSO_4\downarrow$ white	$PbSO_4\downarrow$ white	–	–		–
6) NaOH	$Fe(OH)_2\downarrow$ white-greenish $\downarrow$ $Fe(OH)_3\downarrow$ brown-redish	–	$Mn(OH)_2\downarrow$ white $\downarrow$ $MnMnO_3\downarrow$ brown black	–	$Pb(OH)_2\downarrow$ white $\downarrow$ $Pb(OH)_4^{2-}$	

	Reactions	Observation
(1) + (4)	$FeSO_4 + H_2O_2 \rightarrow 2\ Fe(OH)SO_4$	Colour change - yellowish (Fe^{3+})
(1) + (5)	$FeSO_4 + Pb(NO_3)_2 \rightarrow PbSO_4 \downarrow + Fe(NO_3)_2$	Appearance of a white precipitate.
(1) + (6)	$FeSO_4 + 2\ NaOH \rightarrow Fe(OH)_2 \downarrow + Na_2SO_4$ $Fe(OH)_2 + ½\ O_2 + H_2O \rightarrow Fe(OH)_3$	Appearance of a greenish white precipitate $Fe(OH)_2$ which after oxidation by air turns into a reddish brown precipitate $Fe(OH)_3$.
(2) + (5)	$H_2SO_4 + Pb(NO_3)_2 \rightarrow PbSO_4 \downarrow + 2\ HNO_3$	Appearance of a white precipitate $PbSO_4$.
(3) + (6)	$Mn(NO_3)_2 + 2\ NaOH \rightarrow Mn(OH)_2 + 2\ NaNO_3$ $2\ Mn(OH)_2 + ½\ O_2 \rightarrow MnMnO_3 + 2\ H_2O$ $Mn(OH)_2 + ½\ O_2 \rightarrow MnO_2 + H_2O$	Appearance of a white precipitate $Mn(OH)_2$ which after oxidation by air coverts into a brown-black precipitate $MnMnO_3$ which eventually changes into MnO_2 – a black-brown precipitate.
(5) + (6)	$Pb(NO_3)_2 + 2\ NaOH \rightarrow Pb(OH)_2 + 2\ NaNO_3$ $Pb(OH)_2 + 2\ NaOH \rightarrow Na_2Pb(OH)_4$	Appearance of a white precipitate $Pb(OH)_2$ which dissolves in excess reagent.
b)		
(1) + (2) + (4)	$2\ FeSO_4 + H_2O_2 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 2\ H_2O$	Colour change → yellowish (Fe^{3+})
(1) + (4) + (6)	$2\ FeSO_4 + H_2O_2 + 4\ NaOH \rightarrow Fe(OH)_3 + 2\ Na_2SO_4$	Appearance of a brown-reddish precipitate $Fe(OH)_3$
(3) + (4) + (6)	$Mn(NO_3)_2 + H_2O_2 + 2\ NaOH \rightarrow MnO_2 + 2\ NaNO_3 + 2\ H_2O$	Appearance of a brown precipitate MnO_2
(5) + (4) + (6)	$Pb(NO_3)_2 + H_2O_2 + 2\ NaOH \rightarrow PbO_2 + 2\ NaNO_3 + 2\ H_2O$	Appearance of a brown precipitate PbO_2.