Detection of Functional Groups in Organic sample:

A functional group is the reactive part of the organic molecule. This reactive part may be an atom or a group of atoms. For an unsaturated compound the reactive part may be a double or triple bond.To determine the functional groups in an organic sample we have to carry out a systematic protocol step by step. Some organic functional groups contain Nitrogen and some do not contain Nitrogen rather they contain C, H and O as primary elements. Among these the nitrogen containing functional groups are aliphatic and aromatic $-NH_2$, $-CONH_2$, $-NO_2$ etc. whereas the functional groups containing C, H and O are $-COOH$, $-COOR$, $-CHO$, Ar-CO-R (Keto), Ar-OH, R-OH etc.

Detectable Functional groups present in Organic Compounds in the Chemistry Laboratory:

Name of the Functional Group	**Symbol**
Unsaturation	$>C=C<$
Halo	$-X$
Hydroxy	$-OH$
Formyl	$-CHO$
Keto or Oxo	$>C=O$
Ester	$-COOR$
Amino	$-NH_2$
Amido	$-CONH_2$
Nitro	$-NO_2$

Tests for functional groups containing Nitrogen as an element:

Prepare approx. 10 - 20 ml of the saturated OS by dissolving in ethanol or suitable solvents for carry out the following experiments.

Experiments	Observations	Inferences
1.(a) **Test for amino group (─NH_2):** Take approx. 0.2gm of the sample (OS) in a t.t and dissolve in 2ml conc. HCl and then add 2 – 3 ml cold water. Cool the mix. in ice cold water and then add very dil. Soln. of $NaNO_2$. **(b)** If a clear sol. is obtained then add 1ml alkaline β-naphthol sol. into above soln. **2. S.K.Dasgupta Test:** 0.2gm OS dissolve in acetic	(a) Evolution of gas with effervescence. OR No such observation (b) Orange or Red dye appears. OR No such observation 2. Orange or Red dye	(a) Primary **aliphatic** ─NH_2 present OR Primary **aliphatic** ─NH_2 absent. (b) **Aromatic** primary -NH_2 is present (Ar- NH_2) OR (Ar- NH_2) absent 2. Ar-NH_2 is present

acid + 1ml α-nitroso-β-naphthol. Warm the mixture in a small beaker containing water. 3.**Test for ─NO_2 group:** (a) 0.2 gm of OS + 1ml ethanol + small amt. of tin metal + 1ml HCl. Heat the mix. on water bath for 15 minutes. Filter and cool the sol. + 1ml $NaNO_2$ sol + 1ml alkaline β-naphthol sol. **(b) Mullikan Test:** 0.2gm OS + 1ml ethanol + a pinch of Zn dust + few drops of NH_4Cl sol. Boil and cool. Filter this sol. directly into 2ml Tollen's reagent taken in another t.t. warm this sol, in a small beaker containing water. **4. Test for Amido group ─$CONH_2$**: 0.5gm of OS + few drops NaOH soln. and heat gently.	appears. OR No such observation 3(a) Orange or Red dye appears. OR No such observation (b) Black/ grey ppt. appears or a silver mirror produced in the side of the t.t. OR No such observation Smell of ammonia occurs and the gas turns red litmus blue. OR No such observation	OR (Ar- NH_2) absent (a) ─NO_2 present. OR ─NO_2 absent (b) ─NO_2 present. OR ─NO_2 absent ─$CONH_2$ present. OR ─$CONH_2$ absent

Tests for functional groups containing Carbon, Hydrogen and Oxygen:

Experiments	Observations	Inferences
1.**Tests for Carboxylic group ─COOH** (a) **Litmus test:** Take 1ml soln. of OS in a t.t and put a small piece of blue litmus paper into it. (b) **Bicarbonate Test:** Prepare 1ml of sodium	1.(a)The litmus paper turns into red. (b) CO_2 gas evolves and the	(a). ─COOH may be present (This test also shown by Phenolic compounds) (b) ─COOH is present.

bicarbonate soln. in a t.t and add a pinch of OS into it.	gas turns lime water milky. OR No such observation	OR ─COOH is absent
2.**Test for alcoholic group (R─OH)** (i) **Ester test:** Take 1ml of the OS soln + 1ml of acetyl chloride, transfer this soln. into another t.t containing cold water.	2.(i) Fruity smell is observed. OR No such observation	(i) Alcoholic group (R─OH) is present OR (R─OH) is absent
(ii) **Cerric ammonium nitrate test:** 1ml of the OS soln, + few drops Cerric ammonium nitrate + 1ml water.	(ii) Soln. turns red OR No such observation	(ii) Alcoholic group (R─OH) is present OR (R─OH) is absent
3.**Test for phenolic hydroxyl group (─OH):**		
(a) **Ferric chloride test:** 1ml of neutral $FeCl_3$ soln. in a t.t + Few drops of the OS soln.	(a) The colour of the soln. turns blue/green/violet. OR No such observation	(a)Phenolic ─OH present. OR Phenolic ─OH absent
(b) **Libermann's Test**: In a t.t take few crystals of $NaNO_2$ + 0.2gm of OS and 1ml of conc.H_2SO_4 and warm gently.	(b) The colour of the soln. turns blue/green. OR No such observation	(b) Phenolic ─OH present. OR Phenolic ─OH absent
(i) Take a few portions of the above content in a t.t and pour 1ml water into it.	(i) Soln. becomes red in colour. OR No such observation	(i) Phenolic ─OH present. OR Phenolic ─OH absent
(ii) Take a few portions of the above content in a t.t and pour dil. NaOH soln.	(ii) Soln. becomes blue or green. OR No such observation	(ii) Phenolic ─OH present. OR Phenolic ─OH absent

4. **Test for carbonyl group (Aldehyde or Ketone)** **(a).Brady'sTest: (2,4-dinitrophenyl hydrazine)** Take 2ml of Brady's reagent in a t.t and add few drops of OS into it and shake thoroughly or warm gently in a small beaker containing water.	(a) Orange or yellow ppt. is formed OR No such observation	(a) Carbonyl group (Aldehyde or ketone) is present OR Carbonyl group is absent
(b) Test for aldehyde: **(i) Tollen's test**: Take 1ml of Tollen's reagent (freshly prepared) in a t.t + 0.5ml of the OS soln. and heat the t.t in a water bath for 10minutes. Then throw the soln. from the t.t.	b.(i) Silver mirror is appeared by the side of the t.t.	b.(i) Aldehyde group ─CHO is present
(ii)Fehling's test: Take 1ml each of Fehling A and Fehling B in a t.t + few drops the OS sol. and boil for 2minutes in a water bath.	(ii) Red ppt. is formed.	(ii) Aldehyde group ─CHO is present
## If the OS does not respond to aldehyde test, then the compound is assumed to be a ketone.		
© Test for ketone: **(i) Iodoform test:** 1ml OS soln. + few crystals of Iodine + few drops NaOH soln. (This test is not shown by all ketones). So if a carbonyl compound does not respond to Tollen's test or Fehling's solution test then the compound is assumed to be a ketone.	Yellow ppt. appears OR No such observation	Ketonic (Methyl ketone) group present OR Methyl ketone is absent

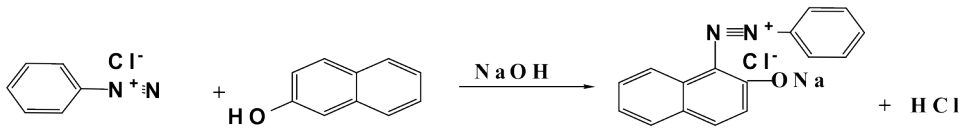
Chemistry involved with the experiments mentioned in the table ( ) above:

1.a) Test for Amino group:

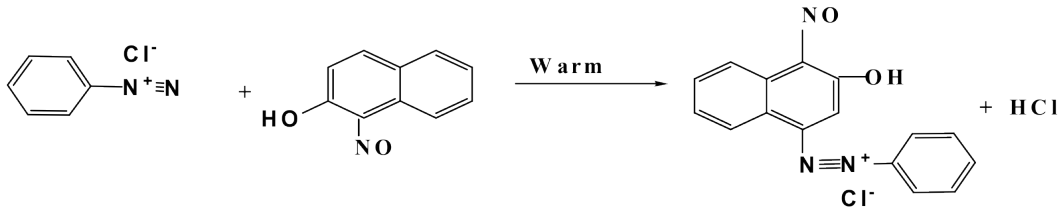
$$RNH_2 + HNO_2 \xrightarrow[0 - 5^0C]{NaNO_2 + HCl} ROH + N_2\uparrow + H_2O$$

The effervescence is due to the evolution of **nitrogen gas**.

b) Aromatic primary amine reacts with nitrous acid to form diazonium salts. This diazonium salt react with β-naphthol produces orange or red colour dye.

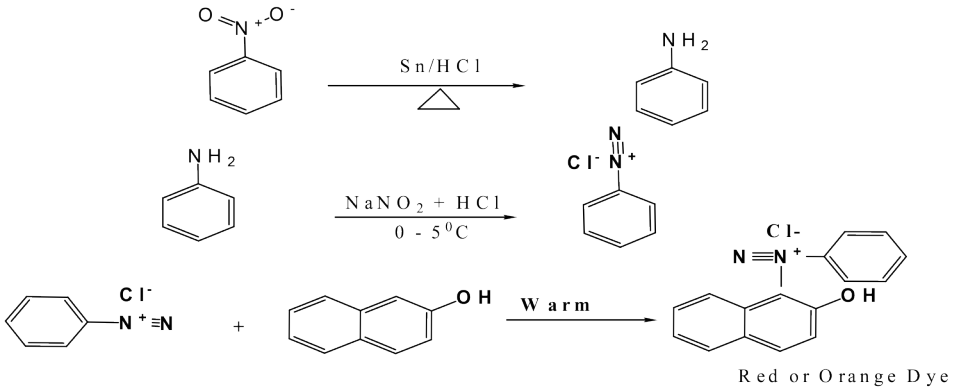


2. In this experiment too the organic sample reacts with α-nitroso-β-naphthol to form a **dye**.

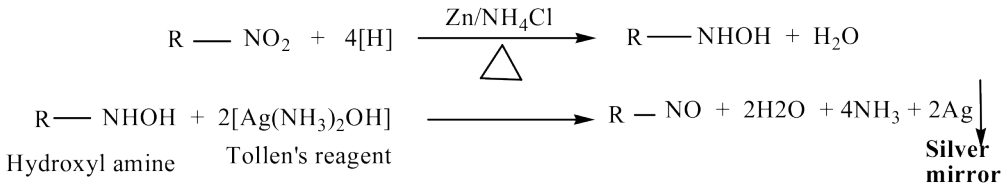


3.a) Test for Nitro group:

In this experiment nitro compound is first reduced to amino compound and the converted into diazonium salt by reacting with $NaNO_2$ and HCl. The diazonium salt is allowed to react with β-naphthol to form red or orange dye.

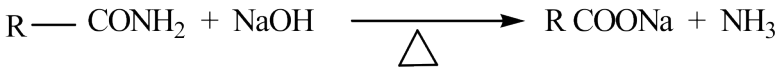


(b) In this experiment the nitro group is reduced to hydroxylamine by using Zn/ NH_4Cl and this hydroxyl amine reduces Tollen's reagent to form silver mirror along the side of the test tube.



4. Test for Amide group:

For the test of amide group the compound is heated with NaOH, releases NH3 gas which turns red litmus blue and gives white fumes with HCl.



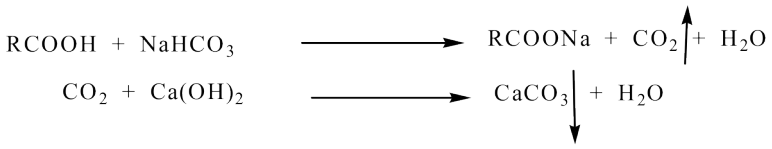
NH_3 turns red litmus blue and also reats with HCl to form NH_4CL

Chemistry involved with the experiments mentioned in the table ( ) above:

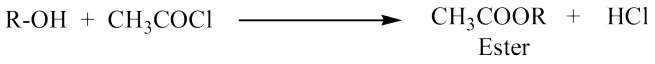
1.Tests for Carboxylic group –COOH

i) Litmus Test: Carboxylic acid being acidic hence always turns blue litmus into red.

ii) **Sodium bicarbonate test:**

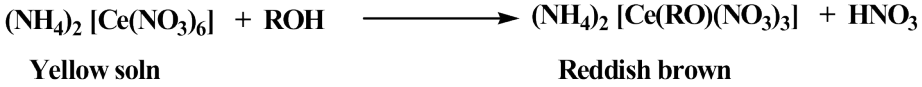


2. (i) Ester test for Alcoholic group:



(ii) Cerric ammonium nitrate (CAN) test:

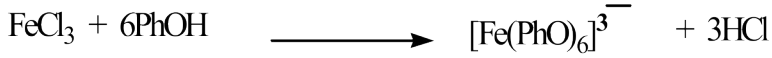
CAN is a strong oxidizing agent and reacts with -OH group to form red or reddish brown coloured complex of cerium.



3.**Test for phenolic hydroxyl group (−OH):**

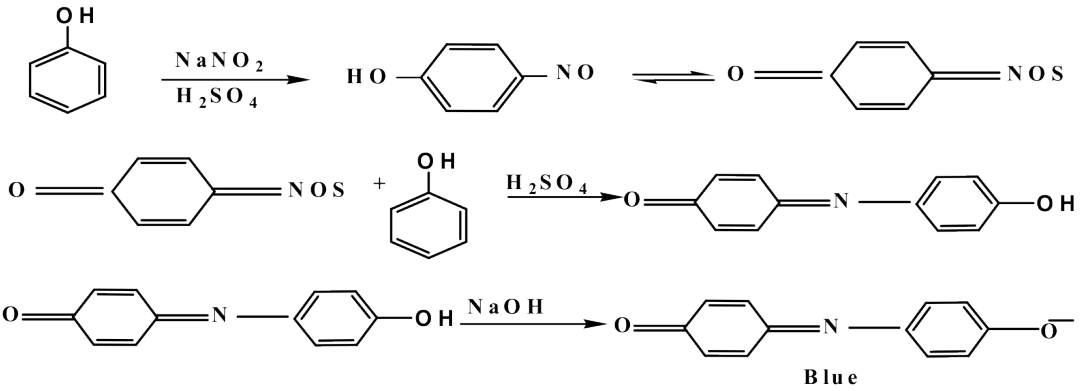
(a) **Ferric chloride test:**

Aqueous solution of phenol reacts with neutral ferric chloride to form violet or blue coloured complex $[Fe(PhO)_6]^{3-}$



(b) Libermann's Test:

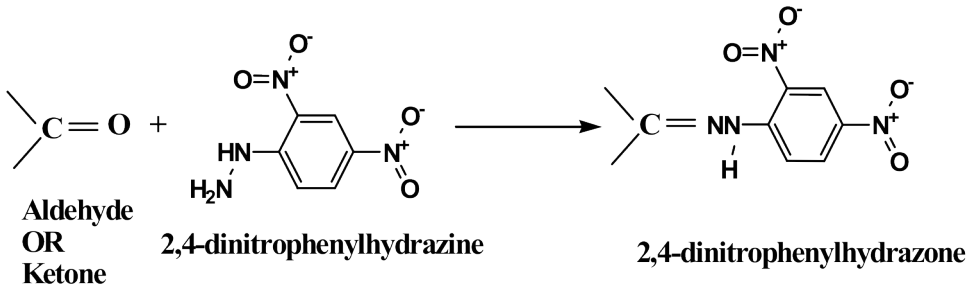
Phenol reacts with nitrous acid (HNO_2), which is generated from the mixture of $NaNO_2$ and conc. H_2SO_4 to form blue coloured indophenol. This on dilution with water changes colour into red and then regain its colour (Blue) on adding dilute alkali.



4. **Test for carbonyl group (Aldehyde or Ketone)**

(a).Brady'sTest: (2,4-dinitrophenyl hydrazine)

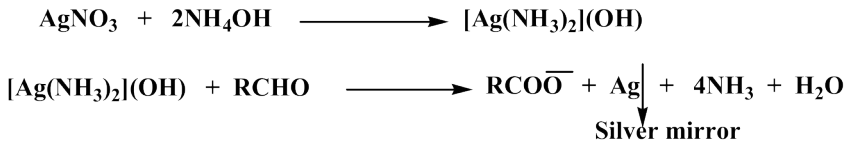
Aldehydes and ketones react with Brady's reagent to produce orange or yellow precipitate of 2,4-dinitrophenylhydrazone.



(b) Test for aldehyde:

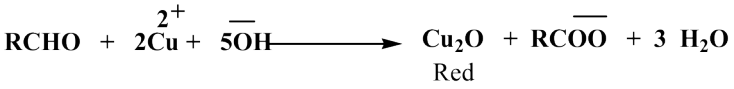
(i) Tollen's test:

Aldehydes on heating with Tollen's reagent (Ammonical silver nitrate solution) oxidized to corresponding carboxylic acids whereas the reagent is reduced to **metallic silver**. The metallic silver is observed inside the wall of the test tube.



(ii)Fehling solution test:

Fehling solution is a mixture of Fehling-A (CuSO4 soln + dil H2SO4) and Fehling-B (Sodium-potassium tartrate + NaOH soln). Aldehydes react with Fehling's solution to form **red coloured** precipitate of cuprous oxide **Cu_2O**.



© Test for ketone:

Methyl ketone reacts with iodine in presence of sodium hydroxide to form yellow coloured Iodoform**.**