

## CHEMISTRY PAPER 1 FACILITATION CONTENT

NOTE: When seen in this pamphlet, the following symbols refer to:

Right answer (✓)

Wrong answer (✗)

- Students need to know how to correctly write symbols of common elements. Common elements where students meet challenges include symbols for: *copper, zinc, manganese, iron, aluminium, lead, etc.* These should be practiced.
- Students also need to know how to write formulae of common compounds and how to differentiate them. For example:

Name of compound/ ion	Formula	Colour
Chromate(VI)	$CrO_4^{2-}$	Yellow
Dichromate(VI)	$Cr_2O_7^{2-}$	Orange
Manganate(VI)	$MnO_4^{2-}$	Green
Manganate(VII)	$MnO_4^-$	Purple

- Correct spellings should also be checked especially during revision to ensure that correct spellings are presented. Common word where students meet issues include:

Triple	<b>NOT</b>	Tripple
Reciprocal	<b>NOT</b>	Reciprical
Beryllium	<b>NOT</b>	Berryllium
Froth <b>Flotation</b>	<b>NOT</b>	Froth Floatation
Iron <b>pyrites</b>	<b>NOT</b>	iron pyrite
Tertiary	<b>NOT</b>	Tertially

- When asked to “**name**”, write the **names** only and not formulae. However, when asked to “**identify**”, you can either put the name or the formula but **NOT** both. For example  
A mixture of Copper(II) carbonate and Zinc sulphate was shaken with water and then filtered.

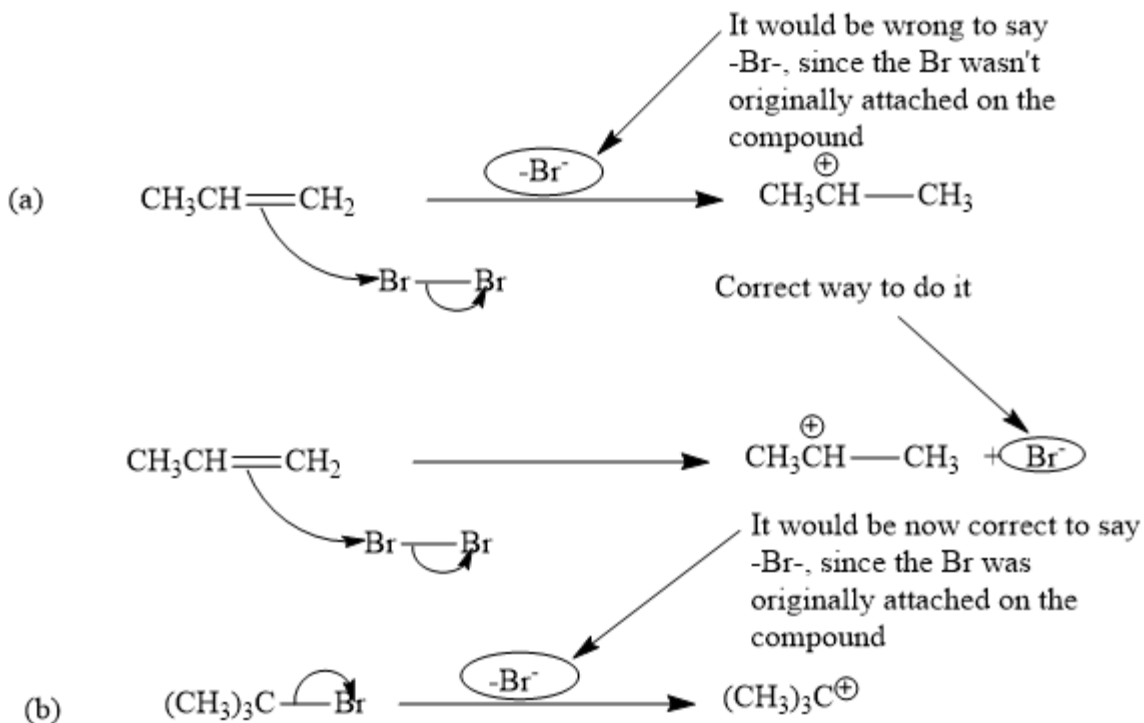
(i) Name the cation in the filtrate.

$Zn^{2+}$	<b>✗</b>	Zinc(II) ions	<b>✓</b>
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(ii) Identify the cation in the filtrate.

$\text{Zn}^{2+}$	✓	Zinc(II) ions	✓	$\text{Zn}^{2+}$ or Zinc(II) ions	✗
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- Primary alkylhalides cannot be converted to alkenes using ethanolic potassium hydroxide. They only form **ethers**. It is only tertiary alkyl halides and to some extent secondary alkylhalides that form alkenes.
- Note the following as well.



- In making your conclusion after determining empirical formula or molecular formula, don't say, thus empirical formula = ..., Simply say empirical formula is ...
- Make sure that in reduction reactions involving lithium tetrahydridoaluminate(III),  $\text{LiAlH}_4$ , in presence of dry ether, the "i" is dotted, otherwise, it will be assumed to be upper case.
- Wrong conditions anywhere in synthesis nullifies whatever follows. i.e. if the conditions in the first step are wrong, regardless of whether the product is correct and the following conditions are all correct, the student gets zero. The same is true if we are in the middle, marking stops where a problem is detected. I believe the reason is, wrong conditions can't give correct products. For instance, without **heat**, alkylhalides can't react with aqueous sodium hydroxide to form alcohols.

10. In determining the empirical formula, if the calculated ratios are direct, e.g 2.999, round off and write the whole number, don't first 2.999 and then round off....do it directly. Special cases are when you get 1.5 or 1.3. still, multiply and then write directly.
- 11.
12. In drawing structures of compounds:
- (a) Avoid hanging bonds. The bonds should be connected or almost touch but not too far from the letters to which they are to be connected (hanging). E.g



- (b) The letters should all be of the same size.
13. In organic chemistry, when using **Lucas reagent**, Don't use "cloudiness after 5 – 10 minutes" but rather use cloudy solution after 5 – 10 minutes.
14. Abbreviations and formulae should not be used in statements. For example

Anhydrous <b>ZnCl<sub>2</sub></b> <b>✗</b>	Anhydrous zinc chloride <b>✓</b>
<b>Conc.</b> Sulphuric acid <b>✗</b>	Concentrated sulphuric acid <b>✓</b>

Other abbreviations that should be avoided include:

Liq. For liquid (You could instead write NH<sub>3</sub>(l), for liquid ammonia, say.)

Cat. For Catalyst

Etc.

Ppt

Avoid them, Conc. May be accepted.

15. For diagonal relationships, students should:
- (a) Know the correct definition of diagonal relationship.
- (b) Know the three **pairs** of elements that show diagonal relationship.
- (c) Not confuse "**properties**" with "**reasons**". For example:
- (i) State two *properties* in which lithium resembles magnesium
- Both lithium and magnesium when heated in oxygen form normal oxides only.
  - Both lithium and magnesium when heated combine directly with nitrogen to form nitrides.
- (ii) Give two *reasons* why lithium shows some similarities with magnesium.
- Both lithium and magnesium have almost the same value of electronegativity, electronegativity and electrode potential.
  - Their cations have almost the same charge density and polarizing power hence form compounds which are predominantly covalent.

(d) Use **highest, lowest** or **smallest** when comparing two elements or an element with elements in a certain group (e.g Lithium and other group(I) elements). However, when asked for only “**reasons for the anomalous behavior**” of a certain element use **high, low** or **small**. For example:

- (i) State two reasons why lithium behaves differently from other group(I) elements.
  - Lithium atom has the **smallest** atomic radius.
  - The lithium *cation* has the **highest** charge density/ polarizing power.  
**Note:** You can use lithium **ion** instead of lithium cation (but not lithium **atom**) when talking about charge density or polarizing power.
  - Lithium has the **lowest** electropositivity value.
- (ii) State two reasons for the anomalous behavior of lithium
  - Lithium atom has a **small** atomic radius.
  - The lithium cation has a **high** charge density/ polarizing power.
  - Lithium has a **low** electropositivity value.

16. On ores and extraction of metals. Students should:

- (a) Know the common elements dealt with. i.e *copper, zinc, aluminium & iron*.
- (b) Know the common ores and have enough *necessary* chemistry on extraction of the above elements.

17. On complexes:

- (a) When asked to determine the oxidation state, show the working. e.g. The oxidation state of chromium in  $\text{Cr}_2\text{O}_7^{2-}$  is obtained as:

*Let the oxidation state of Cr be x*

$$2x + 74(-2) = -2$$

$$2x - 14 = -2$$

$$2x = 12$$

$$x = +6$$

- (b) (i) Names of complexes **should** be written as one word (space only before putting the word ion if the complex is charged).
- (ii) **Also**, space if a compound is made of a metal cation and then the complex anion e.g **Lithium** tetrahydridoaluminate(III)-  $\text{LiAlH}_4$ .
- (iii) **Or** the name begins with the complex anion and ends with the metal cation. E.g. Hexaammineiron(III) **chloride** -  $[\text{Fe}(\text{NH}_3)_4]\text{Cl}_3$
- (c) Always indicate the oxidation state of the central atom in brackets as either zero or any other number which should be written in upper case Roman numerals.

**Example:**

Name the following complexes

- (i)  $[Cu(H_2O)_4]^{2+}$  : *Tetraaquacopper(II) ion*
  - (ii)  $Na_2[NiCl_4]$ : *Sodium tetrachloronicklate(II)*
  - (iii)  $Ni(CO)_5$  : *Pentacarbonylnickel(0)*
- (d) (i) Remember that **ammonia** in complexes is “*ammine*” while ammonia in organic chemistry is “*amine*”.
- (ii) Also remember that names of negatively charged complexes end with “*ate*”. E.g  $[Cu(CN)_4]^{2-}$  is named as *Tetracyanocuprate(II) ion*.
- (iii) Names of positively charged complexes use the usual names of the central atoms. e.g.  $[Cu(H_2O)_4]^{2+}$  is named as *Tetraaquacopper(II) ion*

#### 18. Equations.

- (a) **Reactions of elements.** The following are the elements in common dealt with:

Category	Elements whose Chemistry should be understood
Group(I)	Li, Na, K
Group(II)	Be, Mg, Ca, Sr, Ba
Group(III)	Al
Group(IV)	C, Si, Ge, Sn, Pb
Group(V)	None
Group(VI)	None
Group(VII)	F <sub>2</sub> , Cl <sub>2</sub> , Br <sub>2</sub> , I <sub>2</sub>
Transition Elements	Mn, Cr, Fe, Ni, Cu, Zn

**Note:** Students are advised to understand chemistry of other elements not mentioned in the above table but **put much emphasis** on the chemistry of the elements listed in the above categories.

While reading about the reactions of the above elements, take note of the following:

Reaction of the elements with:

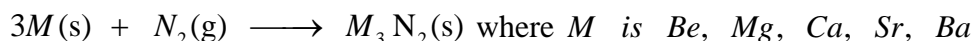
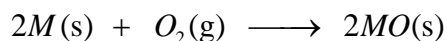
- ✓ Air
- ✓ Water (Cold water, hot water or steam )

- ✓ Acids (behavior with concentrated and dilute acids)
- ✓ Alkalis (behavior with concentrated and dilute acids)
- ✓ Halogens
- ✓ Hydrogen

(b) When describing the **general properties** affecting a number of elements in a certain category, use a letter to represent **all** the elements and then list all the affected elements. For example:

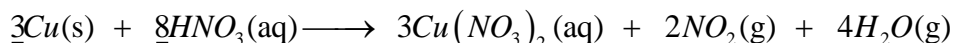
**Question:** Elements beryllium, magnesium, calcium, strontium and barium belong to group(II) of the periodic table. Write equations and state the conditions under which group(II) elements react with air.

**Answer:** All group(II) elements react with air when *heated* to produce a corresponding oxide and nitride.



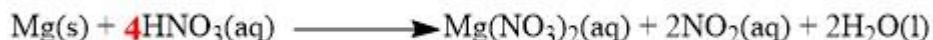
(c) For a particular **observation** for a particular element, state the **particular** name of the product. Magnesium oxide

(d) Devise means to remember how to balance equations. There is no general formula applicable to all equations. Familiarize yourself with various equations and do them over and over again. E.g. One can only remember “**38**” in the following equation to represent **3** behind Cu and behind HNO<sub>3</sub> for the reaction of copper with concentrated nitric acid.



**Note:** Thus, the following equations can also be balanced as follows:

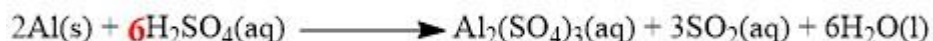
(a) Reaction of some metals in oxidation state +2 with concentrated acids



In those equations, you should only remember **2** and **4** and then the products.

The same is true for reaction with **Cu, Pb, Mn**

(b) Reaction of some metals with oxidation state +3 with concentrated acids.



The same is true for **Cr**.

**Note:** These metals in oxidation state +3 are rendered passive by concentrated nitric acid due to formation of a small layer of the oxide.

(c) Reaction of alcohols with Iodine solution in presence of sodium hydroxide solution.

(Remember **46**; **4** behind I<sub>2</sub> and **6** behind NaOH)



For this particular reaction, remember **4** behind iodine and **6** behind sodium hydroxide, also make sure that the order iodine and then sodium hydroxide is followed.

Also, you should know that the methyl group attached to the carbinol carbon is converted to iodoform while the remaining part is the one that is oxidized to the carboxylic salt.

This oxidation is caused by iodate(I) ions from the reaction below:



It's the **NaOI** that leads to formation of HCOONa, the NaI and H<sub>2</sub>O are the ones that appear in the above equation.

(d) Reaction of carbonyl compounds with Iodine solution in presence of sodium hydroxide solution. (Remember **34**; **3** behind I<sub>2</sub> and **4** behind NaOH)



(e) Reaction of copper pyrites with oxygen (a 3 behind SO<sub>2</sub>, then a 2 behind CuFeS<sub>2</sub>)



(f) Reaction of phosphorus halides with water (**5** behind HCl for PCl<sub>5</sub> and **3** behind HCl for PCl<sub>3</sub>)

(Keep in mind that PCl<sub>5</sub> gives **Phosphoric** acid while PCl<sub>3</sub> gives **Phosphorous** acid, also, PCl<sub>5</sub> is a **solid** while PCl<sub>3</sub> is a **liquid**.)



**Note:** The chloride of sulphur, S<sub>2</sub>Cl<sub>2</sub> forms sulphurous acid. For it, remember a **3** behind sulphur.



- (g) Half Equations for  $\text{MnO}_4^-$ ,  $\text{Cr}_2\text{O}_7^{2-}$ ,  $\text{BiO}_3^-$  in acidic medium (remember 4 behind water, 7 behind water and 3 behind water respectively equal to the number of oxygen atoms in reactants)



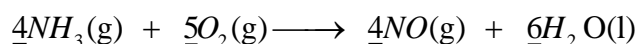
- (h) Check how to balance half equations involving odd number of oxygen atoms, add water to balance. e.g half equation for  $\text{NO}_2^-$ ,  $\text{SO}_3^{2-}$ ,  $\text{SO}_2$ ,  $\text{IO}_3^-$ .



- (e) Applied inorganic

Read thoroughly on preparation of nitric acid and sulphuric acid.

For preparation of nitric acid from catalytic oxidation of ammonia remember **45** and **46** behind reactants and products respectively when balancing the equation.



**Note:** In all the cases considered, the learner **must know** the products and their state symbols.

## 19. Redox equations and qualitative analysis.

- (a) Common cations dealt with in chemistry theory papers (and qualitative inorganic analysis) include:



Category	Cations whose behavior with various reagents should be understood
Group(II)	$Mg^{2+}$ , $Ca^{2+}$ , $Ba^{2+}$
Group(III)	$Al^{3+}$
Group(IV)	$Sn^{2+}$ , $Sn^{4+}$ , $Pb^{2+}$
Group(V)	None (Give anions e.g $PO_4^{3-}$ , $NO_3^-$ )
Group(VI)	None (Give anions e.g $SO_4^{2-}$ , $SO_3^{2-}$ )
Group(VII)	None (Give anions e.g $Cl^-$ , $Br^-$ , $I^-$ )
Transition Elements	$Cr^{3+}$ , $Co^{2+}$ , $Mn^{2+}$ , $Ni^{2+}$ , $Fe^{2+}$ , $Fe^{3+}$ , $Cu^{2+}$ , $Zn^{2+}$

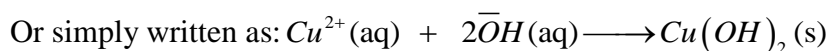
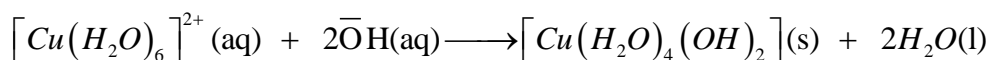
(b) Students need to read and understand the observations when each of the above cations is treated with:

- Sodium hydroxide solution
- Ammonia solution
- Common confirmatory tests.

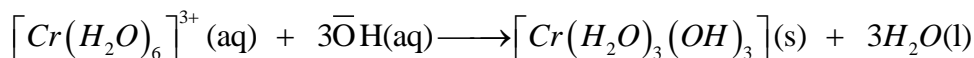
(c) The reactions of transition metal ions with sodium hydroxide are mostly acid-base reactions. In these reactions, hydroxide ions remove hydrogen ions from the water ligands attached to the transition metal cation. The hydrogen ions removed will always correspond to the oxidation state of the central atom. Once the hydrogen ions have been removed, a complex with no charge (Neutral) is formed. E.g.

Consider addition of excess sodium hydroxide to the following aqueous cations.

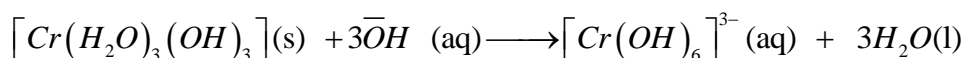
(i) With copper, a blue precipitate insoluble in excess.



(ii) With chromium, a green precipitate soluble in excess to form a green solution.

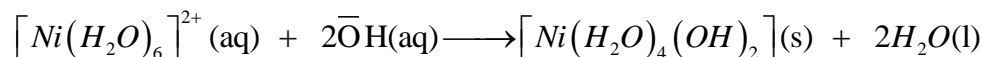


On addition of excess alkali, the remaining protons are replaced to form the green solution. i.e.

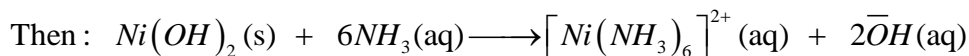
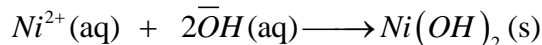


(d) Reaction with ammonia solution can either be acid-base or ligand exchange.

For example reaction of  $\text{Ni}^{2+}$  with ammonia solution. The formation of the green precipitate is acid-base while the formation of the blue solution is ligand exchange.



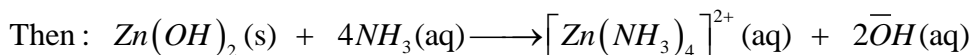
Or simply written as:



- (e) Of all the above cations, **only three** cations complex with **dilute** ammonia solution. i.e.  $\text{Zn}^{2+}$ ,  $\text{Ni}^{2+}$  and  $\text{Cu}^{2+}$ . The corresponding observations & equations are:

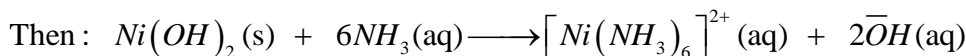
- (i) With  $\text{Zn}^{2+}$ , a white precipitate soluble in excess forming a colourless solution.  

$$\text{Zn}^{2+}(\text{aq}) + 2\overline{\text{OH}}(\text{aq}) \longrightarrow \text{Zn}(\text{OH})_2(\text{s})$$



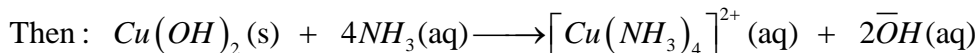
- (ii) With  $\text{Ni}^{2+}$ , a green precipitate soluble in excess forming a blue solution.  

$$\text{Ni}^{2+}(\text{aq}) + 2\overline{\text{OH}}(\text{aq}) \longrightarrow \text{Ni}(\text{OH})_2(\text{s})$$



- (iii) With  $\text{Cu}^{2+}$ , a blue precipitate soluble in excess forming a deep blue solution.  

$$\text{Cu}^{2+}(\text{aq}) + 2\overline{\text{OH}}(\text{aq}) \longrightarrow \text{Cu}(\text{OH})_2(\text{s})$$

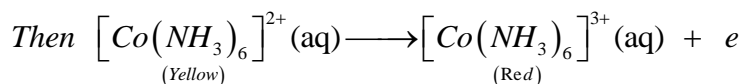
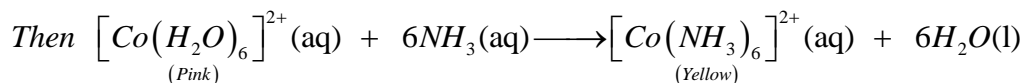
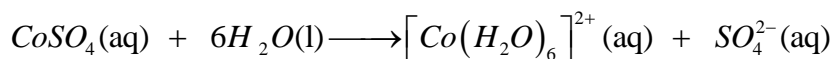


**Note:** With **concentrated** ammonia solution,  $\text{Cr}^{3+}$  and  $\text{Co}^{2+}$  also form a complex and the reaction that takes place is purely ligand exchange reaction. i.e.

- With  $\text{Cr}^{3+}$ , the green solution turns to purple.
- With  $\text{Co}^{2+}$ , the colour of the solution turns from pink to yellow or brown or orange solution. On standing in air, the solution turns from yellow to red.

**Question:** Write equations for the reactions which would take place when concentrated ammonia solution is added drop-wise until in excess to a solution of cobalt(II) sulphate and the resultant solution allowed to stand in air. (UNEB 2004, p.1 Qn 15a)

**Answer:**

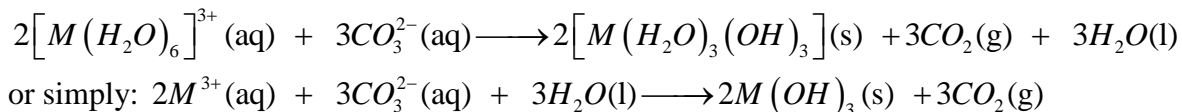


- (f) Reaction of hexaaqua metal ions with carbonate ions.

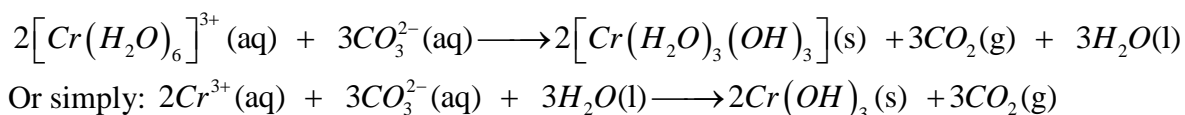
There is a difference in reactions depending on whether the central atom of the hexaaqua ion carries a +2 or +3 oxidation state.

- (i) The +3 hexaaqua ions are sufficiently **acidic** to react with carbonate ions to release carbon dioxide gas. A precipitate of the metal hydroxide is also obtained. Three protons are abstracted from the complex by the carbonate to form 3 moles of CO<sub>2</sub> and the precipitate.

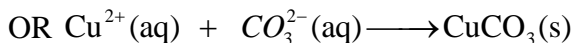
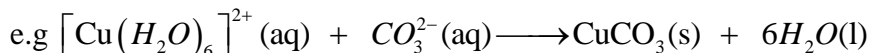
Generally:



**Note:** The colour of the precipitate formed is similar to that formed on addition of a little alkali. For example, with Cr<sup>3+</sup>, a **green precipitate** and **bubbles** of a colourless gas are formed according to the following equation.

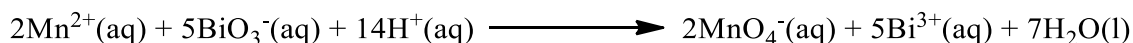


- (ii) Hexaaqua ions with +2 oxidation state are **not sufficiently** acidic to liberate carbon dioxide from carbonates. Instead, you get a precipitate which you can think of as being the metal carbonate:



- (g) The order of addition of reagents especially for confirmatory tests is very important.  
For example:

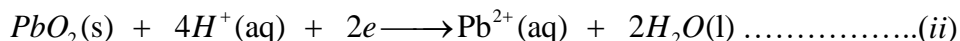
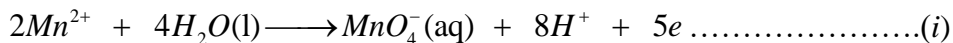
- (i) Mn<sup>2+</sup> is confirmed as follows: Add a few drops of concentrated nitric acid followed by solid sodium bismuthate(V) and warm gently.



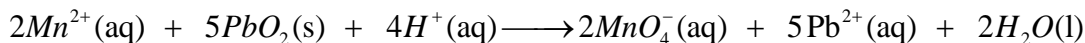
**Observation:** A purple solution is formed.

**Alternatively:** Add a few drops of concentrated nitric acid followed by solid lead(IV) oxide and warm gently.

Half equations:



2(i) + 5(ii), gives



**Observation:** A purple solution is formed.



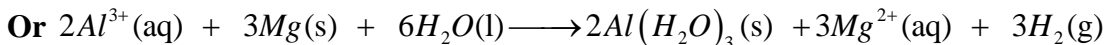
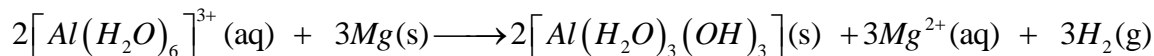
Or Simply:  $2Cr^{3+}(aq) + 3SO_3^{2-}(aq) + 3H_2O(l) \longrightarrow 2Cr(OH)_3(s) + 3SO_2(g)$

(iii) With Magnesium ribbon

(Remember that when acids react with metals, a salt and hydrogen only are formed).

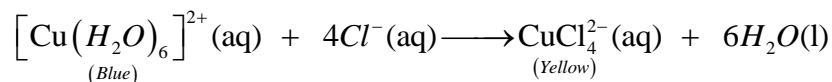
Three protons are abstracted from the acid and they react with the metal to form a salt

And hydrogen gas. E.g.



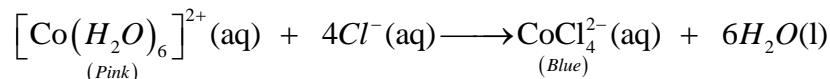
(d) Ligand exchange reactions involving chloride ions.

(i) When concentrated hydrochloric acid is added to a solution containing hexaaquacopper(II) ions, the solution turns from its original **blue** colour to **yellow**. In this reaction, the six water molecules are replaced by four chloride ions. (probably because chloride ions are bigger than water molecules). i.e.



**Observation:** A **blue** solution turns **yellow**.

(ii) Similarly, when concentrated hydrochloric acid is added to a solution containing hexaaquacobalt(II) ions, the solution turns from its original **pink** colour to **blue**. i.e



**Note:** When the above resultant solutions are diluted, we go back to the original colour.

## 21. Diffusion

**Question:** An alkyne Y diffuses 1.3 times slower than oxygen.

- Calculate the formula mass of Y.
- Determine the molecular formula of Y
- State isomers and names of Y.

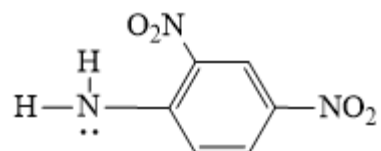
**Note:** This simply implies that oxygen diffuses faster than Y.

## 22. Polymerization

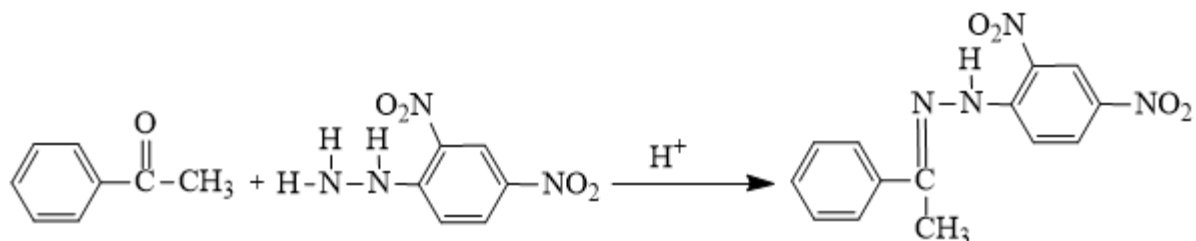
When reading on polymers, note the following:

- Structure of the monomer
- Name of monomer
- Equation leading to formation of polymer.
- Use of the polymer

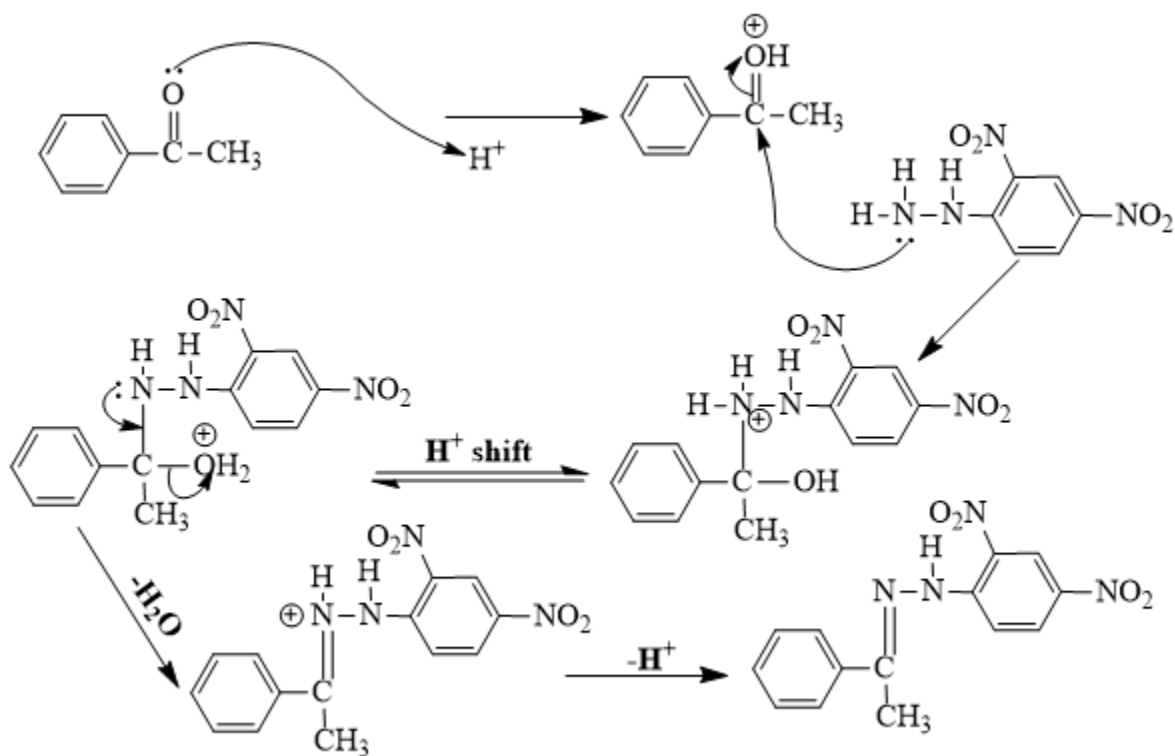
23. For Brady's reagent, the nitrogen atom should be the one bonded to benzene and not any other atom.



Using a structure of the above format, the mechanism below can be written conveniently as shown below.



**Mechanism:**

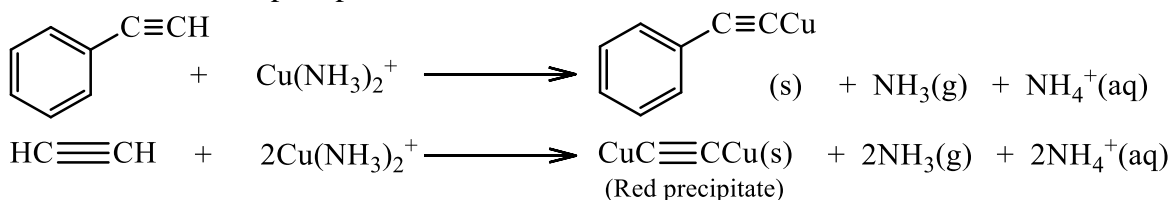


## 24. OTHER REACTIONS IN ORGANIC CHEMISTRY

(a) **Reaction of terminal alkynes** with ammoniacal copper(I) chloride solution and ammoniacal silver nitrate solution.

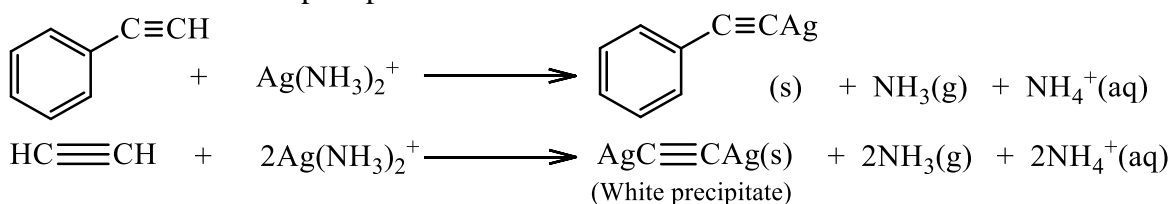
(i) With ammoniacal copper(I) chloride solution.

**Observation:** A red precipitate is formed.



(ii) With ammoniacal silver nitrate solution

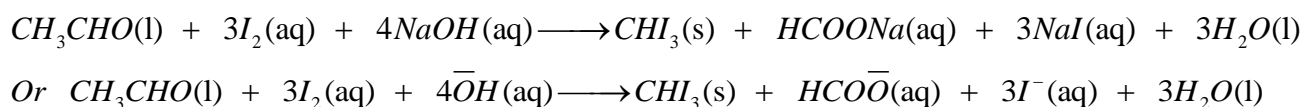
**Observation:** A white precipitate is formed.



### (b) Iodoform reaction

Aldehydes and ketones with a methyl group bonded to the carbonyl carbon or alcohols with a methyl group attached to the carbinol carbon (i.e one carrying the hydroxyl group) react with iodine solution in presence of sodium hydroxide solution to form a yellow precipitate. This yellow precipitate is called iodoform,  $\text{CHI}_3$ . The equations that take place are summarized below.

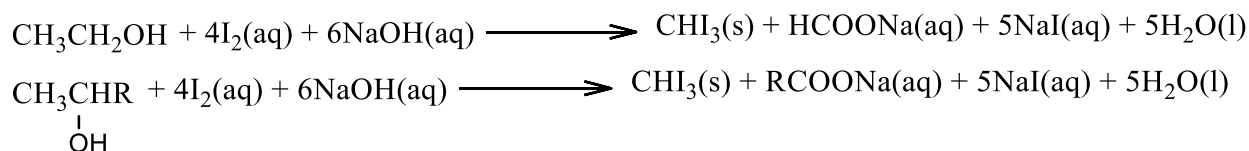
(i) With aldehydes



(ii) With ketones



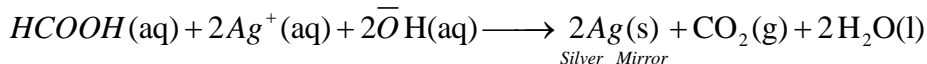
(iii) With alcohols



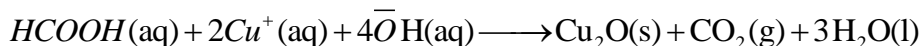
**(c) Oxidation reactions of Methanoic acid.**

Because of having an aldehydic group, methanoic acid is oxidized just like aldehydes, forming carbon dioxide gas. For example:

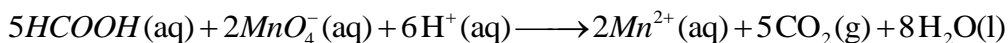
(i) With alkaline silver nitrate solution.



(ii) With alkaline copper(I) chloride solution



(iii) With acidified potassium manganate(VII)



**25. FUNDAMENTAL SECRET OF PASSING CHEMISTRY OR ANY OTHER**

**SUBJECT:** If you have a question bank, choose a certain year in either paper 1 or paper 2 and answer it without checking for answers. Alternatively choose a certain section in the papers for example organic chemistry in a certain year. Refer only to answers after working out on your own to check how well you did. You will find out that after doing many papers you will not only gain the confidence but you will gain a lot of chemistry.