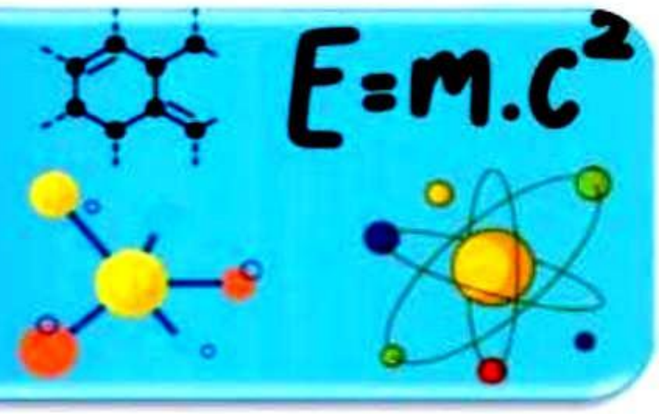
EXPERIMENT



AIM

To observe the action of Zn, Fe, Cu and Al metals on the following salt solutions:

$ZnSO_4$ (aq), $FeSO_4$ (aq), $CuSO_4$ (aq), $Al_2(SO_4)_3$ (aq)

To arrange Zn, Fe, Cu and Al metals in the decreasing order of reactivity based on the above results.

MATERIALS REQUIRED

Aluminium foil, copper turnings, zinc granules, iron filings, ferrous sulphate solution, copper sulphate solution, zinc sulphate solution, aluminium sulphate solution, test tubes, test tube stand and four beakers of 50 ml.

THEORY

Different metals have different reactivities towards chemical reagents. Some metals are more reactive than others. The metals, which can lose electron more readily to form positive ions are more reactive.

According to the reactivity series (or activity series) of metals, a more reactive metal displaces a less reactive metal from its aqueous salt solution. These reactions are called **displacement reactions.**

Displacement reactions can be used to find out the relative reactivities of metals.

Example: If a piece of zinc metal is dipped in a solution of copper sulphate, zinc will displace copper from copper sulphate. The blue colour of copper sulphate solution will gradually fade, and finally colourless solution of zinc sulphate will be obtained.

$$\underset{\text{Blue}}{Zn(s) + CuSO_4(aq)} \longrightarrow \underset{\text{Colourless}}{ZnSO_4(aq)} + \underset{\text{Reddish brown}}{Cu(s)}$$

It means that zinc has displaced copper from copper sulphate solution, i.e., zinc is more reactive than copper.

1. Al can displace Zn, Fe, Cu from their salt solutions, therefore it is more reactive than Zn, Fe and Cu.
   - **(i)** $2Al(s) + 3ZnSO_4(aq) \longrightarrow Al_2(SO_4)_3 + 3Zn\ (s)$
   - **(ii)** $2Al(s) + 3FeSO_4(aq) \longrightarrow Al_2(SO_4)_3 + 3Fe(s)$
   - **(iii)** $2Al(s) + 3CuSO_4(aq) \longrightarrow Al_2(SO_4)_3 + 3Cu(s)$
2. Zn can displace Fe and Cu from their salt solutions; therefore, zinc is more reactive than Fe and Cu.
   - **(i)** $Zn(s) + CuSO_4\ (aq) \longrightarrow ZnSO_4(aq) + Cu(s)$
   - **(ii)** $Zn(s) + FeSO_4(aq) \longrightarrow ZnSO_4(aq) + Fe(s)$
   - **(iii)** $Zn(s) + Al_2\ (SO_4)_3(aq) \longrightarrow$ No reaction
   - **(iv)** $Zn(s) + ZnSO_4(aq) \longrightarrow$ No reaction
3. Fe can displace copper from copper sulphate solution; therefore, it is more reactive than copper.
   - **(i)** $Fe(s) + CuSO_4(aq) \longrightarrow FeSO_4(aq) + Cu(s)$
   - **(ii)** $Fe(s) + ZnSO_4\ (aq) \longrightarrow$ No reaction

(iii) $Fe(s) + FeSO_4(aq) \longrightarrow$ No reaction

(iv) $Fe(s) + Al_2(SO_4)_3(aq) \longrightarrow$ No reaction

4. Cu cannot displace any of the given metals from their salt solutions, therefore it is least reactive than the other given metals.

5. No reaction takes place when any of the metals copper, iron, zinc and aluminium are placed in aqueous aluminium sulphate solution. From this, it can be concluded that aluminium is the most reactive and copper is the least reactive among the given four metals (Fe, Zn, Cu and Al). Thus, the decreasing order of reactivity of metals is:

$$Al > Zn > Fe > Cu$$

Metals and their aqueous salt solutions exhibit colours as follows:

S. No.	Name and formula	Colour
1.	Zinc sulphate ($ZnSO_4$)	Colourless
2.	Ferrous sulphate ($FeSO_4$)	Light green
3.	Copper sulphate ($CuSO_4$)	Blue
4.	Aluminium sulphate $Al_2(SO_4)_3$	Colourless
5.	Aluminium (Al)	White
6.	Iron (Fe)	Blackish grey
7.	Copper (Cu)	Reddish brown
8.	Zinc (Zn)	Silvery white (greyish)

PROCEDURE

(i) Prepare 50 ml solutions of 5% concentration (by volume) of zinc sulphate, iron (II) sulphate, copper (II) sulphate and aluminium sulphate in distilled water in four different beakers. Label these beakers as P, Q, R and S (as shown in Fig. 1).

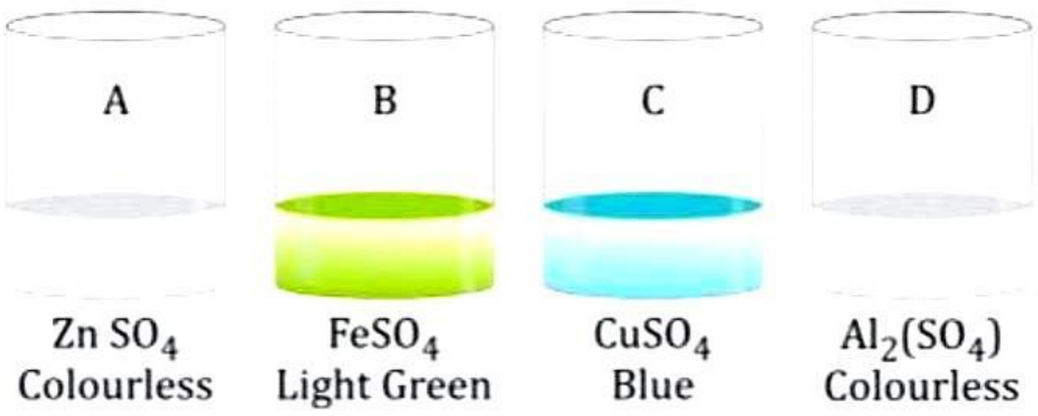
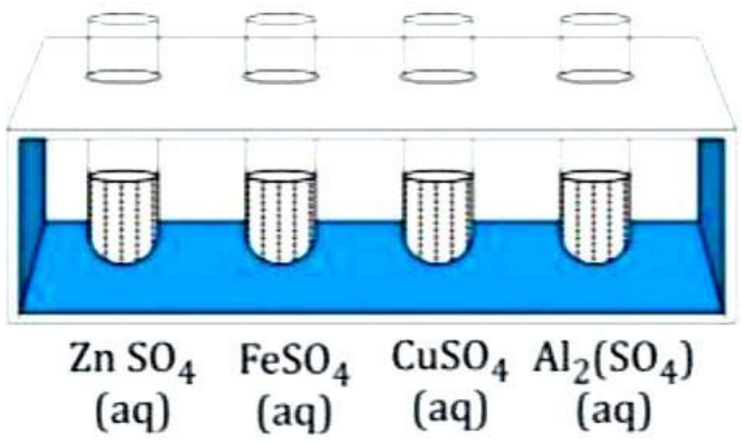


Fig. 1

(ii) Take about 10 ml of saturated solution of zinc sulphate ($ZnSO_4$), ferrous sulphate ($FeSO_4$), copper sulphate ($CuSO_4$) and aluminium sulphate [$Al_2(SO_4)_3$] in the respective test tubes (as shown in Fig. 2). Observe the colour of the solutions.



Observation of colour of the solutions

Fig.2

(iii) Take zinc, copper, iron and aluminium metal strips and clean their surfaces.

(iv) Put zinc metal strip in all the four test tubes A, B, C and D and observe the change that follows.

(v) Repeat the above experiment with other metal strips by dipping them in fresh salt solutions of metal and observe for displacement reactions.

OBSERVATION TABLE

S. No.	Metal	Salt Solution in which added	Observations	Inference
1	Al	$ZnSO_4$	No colour change occur in the solution but a greyish Zn metal get deposited on Al metal $2Al(s) + \underset{\text{Colourless}}{3ZnSO_4\,(aq)} \rightarrow \underset{\text{Colourless}}{Al_2(SO_4)_3} + \underset{\text{Blackish grey}}{3Zn(s)}$	Al is more reactive than Zn. (Al^{3+} ions replace Zn^{2+} ions)
2.	Al	$FeSO_4$	The green colour solution becomes colourless and greyish black iron metal get deposited on Al metal $\underset{\text{white}}{2Al(s)} + \underset{\text{Blue}}{3FeSO_4(aq)} \rightarrow \underset{\text{Colourless}}{Al_2(So_4)_3} + 3Cu(s)$	Al is more reactive than Fe. (Al^{3+} ions replace Fe^{2+} ions)
3	Al	$CuSO_4$	The blue colour solution becomes colourless and reddish brown copper metal get deposited $2Al(s) + \underset{\text{Blue}}{3CuSO_4(aq)} \rightarrow \underset{\text{Colourless}}{Al_2(SO_4)_3} + 3Cu(s)$	Al is more reactive than Cu. (Al^{3+} ions replace Cu^{2+} ions)
4	Al	$Al_2(SO_4)_3$	No reaction took place	Al does not react with $Al_2(SO_4)_3$
5	Zn	$ZnSO_4$	No reaction took place	Zn does not react with $ZnSo_4$ solution. There is an equilibrium between Zn^{2+} and Zn
6	Zn	$FeSO_4$	The light green colour solution becomes colourless and greyish black Fe metal get deposited on Zn metal $Zn(s) + \underset{\text{Light green}}{FeSO_4(aq)} \rightarrow \underset{\text{Colourless}}{ZnSO_4(aq)} + \underset{\text{Blackish grey}}{Fe(S)}$	Zn is more reactive than iron. (Zn^{2+} ion replace Fe^{2+} ion in solution).
7	Zn	$CuSO_4$	The blue colour solution becomes colourless and copper metal (reddish brown)get deposited on Zn metal $Zn(s) + \underset{\text{Blue}}{CuSO_4(aq)} \rightarrow \underset{\text{Colourless}}{ZnSO_4(aq)} + \underset{\text{Reddish brown}}{Cu(s)}$	Zn is more reactive than Cu . Zn^{2+} ions replace Cu^{2+} ions in solution.
8	Zn	$Al_2(SO_4)_3$	No reaction took place	Zn is less reactive than Al.

9	Fe	$FeSO_4$	No reaction took place	Fe does not react with $FeSO_4$
10	Fe	$ZnSO_4$	No reaction took place	Iron is less reactive than Zn .
11	Fe	$CuSO_4$	Reddish brown copper metal get deposited on Fe metal and solution becomes light green. $Fe(s) + \underset{\text{Blue}}{CuSO_4(aq)} \rightarrow \underset{\text{Light green}}{feSO_4(aq)} + \underset{\text{Reddish brown}}{Cu(s)}$	Iron is more reactive than Cu .
12	Fe	$Al_2(SO_4)_3$	No reaction took place	Iron is less reactive than Al.
13	Cu	$CuSO_4$	No reaction took place	Copper Does not react with $CuSO_4$. Cu^{2+} ions is in equilibrium with Cu.
14	Cu	$FeSO_4$	No reaction took place	Copper is less reactive than Fe .
15	Cu	$ZnSO_4$	No reaction took place	Copper is less reactive than Zn .
16	Cu	$Al_2(SO_4)_3$	No reaction took place	Copper is less reactive than Al .

RESULT

1. The action of metals on respective salt solutions are given below:
   - **(i)** Al metal is able to displace Zn, Fe and Cu from their salt solutions, therefore Al is most reactive.
   - **(ii)** Zn metal is able to displace Fe and Cu from their salt solutions therefore, Zn is more reactive than Fe and Cu.
   - **(iii)** Fe metal is able to displace Cu from its salt solution, therefore Fe is more reactive than copper.
   - **(iv)** Cu is unable to displace any metal (among Al, Fe and Zn) from their salt solutions, therefore Cu is least reactive.
2. The decreasing order of reactivity, based on the above results, follows the order: Al > Zn > Fe > Cu

PRECAUTIONS

- **(i)** All the apparatus should be clean and dry.
- **(ii)** Handle the chemicals carefully.
- **(iii)** Some reactions may occur slowly, so observe the changes carefully.
- **(iv)** Do not touch or taste the chemicals.
- **(v)** Clean the metals by rubbing them with a piece of sandpaper before dipping them in the salt solutions.
- **(vi)** Wash the test tubes after every set of observations of interaction of a particular metal with the four salt solutions.
- **(vii)** For the preparation of solutions use only distilled water and add small quantity of sulphuric acid.
- **(viii)** Clean your hands properly after the experiment because the salt solutions are poisonous.

VIVA VOCE

Q 1. In the following reaction, A and B are metals and BX is a salt of metal B:

A + BX → AX + B

Which one of the two metals is more reactive? Give reason.

Ans. A is more reactive as it displaces B from its salt solution BX.

Q 2. Name any two metals that are more reactive than iron.

Ans. Zinc (Zn) metal and aluminium (Al) metal are more reactive than iron.

Q 3. Why did the colour of copper (II) sulphate solution change, when zinc metal was dipped in it?

Ans. Zinc is more reactive than copper, so it displaces Cu from $CuSO_4$ solution and blue colour of $CuSO_4$ turns to colourless due to the formation of $ZnSO_4$.

Q 4. What is your observation when copper is added to iron (II) sulphate solution?

Ans. When copper is added to iron (II) sulphate solution, then no reaction takes place because copper is less reactive than iron.

Q 5. Which is the most and the least reactive metal in the above experiment?

Ans. In the above experiment, aluminium is most reactive, and copper is least reactive metal.

Q 6. Why can be safely preserve iron (II) sulphate in a copper vessel whereas the same cannot be safely preserved in zinc vessel?

Ans. Since, copper is less reactive than iron so, we can safely preserve iron (II) sulphate in a copper vessel. But zinc is more reactive than iron, so we cannot safely preserve iron (II) sulphate in zinc vessel.

Q 7. When an aluminium strip is kept immersed in freshly prepared ferrous sulphate solution taken in a test tube, what change would you observe?

Ans. The light green colour of the solution turns colourless due to the displacement reaction.

Q 8. Solutions of copper sulphate, iron sulphate and zinc sulphate are prepared and marked I, II and III respectively. Few pieces of aluminium are added to each solution. In which test tube would you see a change?

Ans. In all the three solutions, changes occur. Aluminium displaces all the other metals from their salt solution.

Q 9. What does the reactivity series of metals indicate?

Ans. The reactivity series of metals indicates the reactivities of different metals in decreasing order while going from top to bottom.

Q 10. Can we store $ZnSO_4$ in an aluminium container? Justify your answer.

Ans. No, we cannot store $ZnSO_4$ in an aluminium container because Al is more reactive than Zn.

Q 11. Why does the colour of copper sulphate change when an iron nail is dipped in it?

Ans. On adding iron nail in copper sulphate, the displacement reaction takes place. Iron being more reactive than copper displaces copper to form green solution of iron sulphate and copper (pinkish brown) metal is displaced.

Q 12. How would you devise the procedure to show that Mg > Fe > Cu in reactivity series?

Ans. **Step 1:** Add Mg metal in ferrous sulphate, taken in one test tube and to copper sulphate taken in another test tube, wait for some time and note the observations.

Step 2: Add Fe metal in magnesium sulphate taken in one test tube and to copper sulphate taken

in another test tube, wait for some time and record the observations.

Step 3: Add Cu metal in a test tube with magnesium sulphate and to other test tube with ferrous sulphate in it. Observe and record.

You will note that magnesium can displace Fe and Cu from their salt solutions, Fe can displace only copper from its salt solution and Cu cannot displace any of the metals from the salt solutions. Hence, the reactivity can be checked and proved that Mg is the most reactive metal and copper is the least reactive metal among Mg, Fe and Cu.

Q 13. What is the basic principle involved in this experiment?

Ans. The more reactive metal can displace the less reactive metal.

Q 14. Why does the following reaction take place?

Ans. Chlorine is more reactive than iodine, hence it displaces the iodide ions from its aqueous solution and release iodine.

$$2I^-(aq) + Cl_2(aq) \xrightarrow{CCl_4} 2Cl^-(aq) + I_2(\text{solvated})$$