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A Procedure Employing for Redox Titration: Balancing the Redox Chemical Equation in Acidic or Basic Medium

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ABSTRACT

Graduate and post graduate students find much more difficulty during the concept of the balancing redox chemical equation in acidic or basic medium. Teachers are well aware of the importance of the balancing redox chemical equation in both medium and also teaching difficulty associated with it. In an attempt to improving the understanding of the balancing the redox chemical equation with reduced difficulty, a mathematical approach that provides easier understanding has been developed and successfully employed in graduate and post graduate students. In this study, relation between an oxidising agent (Oxidant) and reducing agent (reductant) can be employed in redox chemical titration, using potassium permanganate ($KMnO_4$) is an oxidant itself act as the indicator, during the titration of Cr (III) ion, as reducing agent with $KMnO_4$, the second titration oxidation of H_2O_2, is used as a reducing agent against the $KMnO_4$. Data obtained from titrations will lead to balancing each redox chemical equation in an acidic or basic medium.

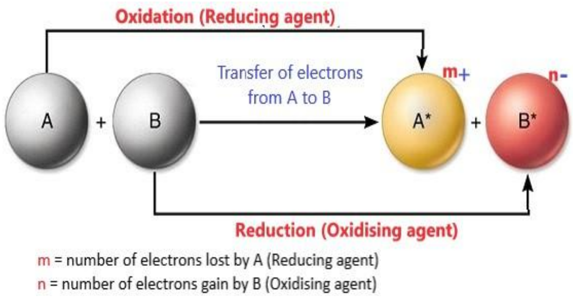
Keywords: Oxidising agent, potassium permanganate, Reducing agent, Redox titration.

INTRODUCTION

A redox chemical equation is an emblematic representation of a chemical reaction. To fulfil the law of conservation of mass these conditions must be balanced[2]. Balanced chemical conditions are basic to take care of issues in the concept of stoichiometry and electrochemical cell[4]. Fundamentally, balancing redox chemical equation is a numerical methodology[8]. Most of the redox chemical equations might be balanced by a basic experimentation or assessment method[3]. In any case, for balanced chemical equations are marked as redox chemical reactions, it might appear that there are some theoretical methods such as oxidation number[1,5] and ion electron method are preferred[6] and no basic technique or method for balancing the redox reactions in acidic or basic medium. There is an enormous number of articles distributed everywhere to managing an assortment of redox chemical reactions[6,7,8]. These range from investigation to algebraic or logarithmic technique. In redox chemical equation, the number of electrons moved from a reducing agent (oxidized species) to an oxidizing agent (reduced species) must be balanced[10].

In general form, a symbolic representation of every type of redox chemical equation may be presented as the following way,

mA (Reductant)+ nB (oxidant) -----→P (Product)



m x moles of reductant = *n* x moles of oxidant.

Where, *m* and *n* are the stoichiometric coefficients.

$$\frac{m}{n} = \frac{moles\ of\ an\ oxidising\ agent\ (oxidant)}{moles\ of\ reducing\ agent\ (reductant)}$$

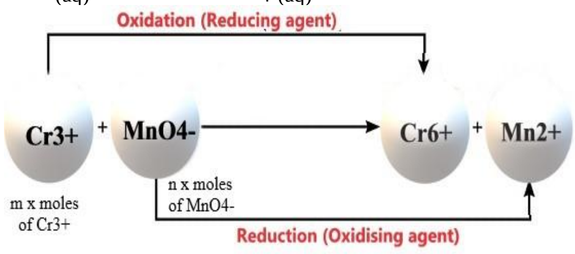
In the above equation indicates that the number of electrons is inversely proportional to moles of respectively agents. To find the ratio of m/n molarity and volume of reducing agent solution used in titration and molarity of MnO_4^- solution are provided.

MATERIALS & METHODS

Part-I:

The redox chemical reaction representation as

$Cr^{3+}{}_{(aq)}$ /Cr^{6+} // $MnO_4^-{}_{(aq)}$/Mn^{2+}



The redox chemical reaction of Cr^{3+} with $KMnO_4$ is presented above by an unbalanced chemical equation in which m and n are the stoichiometric coefficients of reducing and oxidising agent respectively. Here the unbalanced redox reaction may be employed as,

$mCr^{3+}{}_{(aq)} + nMnO_4^-{}_{(aq)}$ -------→$mCr^{6+}{}_{(aq)} + n\ Mn^{2+}{}_{(aq)}$

m x moles of reductant Cr^{3+} = *n* x moles of oxidant MnO_4^-

$$\frac{m}{n} = \frac{moles\ of\ an\ oxidant}{moles\ of\ reductant}$$

$$\frac{m}{n} = \frac{moles\ of\ an\ oxidant\ MnO4-}{moles\ of\ reductant\ Cr3+}$$

$w = N\ x\ m\ x\ v$ [9]

$$\frac{m}{n} = \frac{N(MnO4-)\ x\ V(Volume\ of\ MnO4-)}{N(H2O2)\ x\ V(Volume\ of\ H2O2)}$$

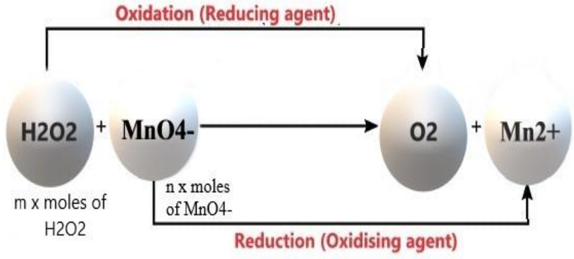
$$\frac{m}{n} = \frac{W(MnO4-)\ x\ M\ (Cr3+)}{M\ (MnO4-)\ x\ W\ (Cr3+)}$$

w (Weight of a compound) = *N* (Normality) x *m* (molar mass) x *v* (Volume of a solution) students performed the titration experiments for the above redox reaction, in which get the following (m/n) ratio in terms of known the Normality of Oxidant (MnO_4^-) and Reductant (Cr^{3+}) and Volume of Cr^{3+} which was taken initially in the titration flask. However, at the equivalence point the volume of MnO_4^- was considered. The following results was generated

$\frac{m}{n}$ = 1.66 ± 0.05 =5/3 ------------------ (1)

Part-II: The redox chemical reaction representation as,

$H_2O_{2(l)}$ /$O_{2(g)}$ // $MnO_{4(aq)}^-$/$Mn^{2+}{}_{(aq)}$



The above an unbalanced redox chemical reaction of hydrogen peroxide with $KMnO_4$ is presented in which *m* and *n* are the stoichiometric coefficients of reducing and oxidising agent respectively. Here the unbalanced redox reaction may be employed as,

$m\ H_2O_{2(l)} + n\ MnO_4^-{}_{(aq)}$ ------→$m\ O_{2(g)} + n\ Mn^{2+}{}_{(aq)}$

m x moles of reductant $H_2O_{2(l)}$ = *n* x moles of oxidant MnO_4^-

$$\frac{m}{n} = \frac{moles\ of\ an\ oxidant}{moles\ of\ reductant}$$

$$\frac{m}{n} = \frac{moles\ of\ an\ oxidant\ MnO4-}{moles\ of\ reductant\ H2O2}$$

$w = N\ x\ m\ x\ v$

$$\frac{m}{n} = \frac{N(MnO4-)\ x\ V(Volume\ of\ MnO4-)}{N(H2O2)\ x\ V(Volume\ of\ H2O2)}$$

$$\frac{m}{n} = \frac{W(MnO4-)\ x\ M\ (H2O2)}{M\ (MnO4-)\ x\ W\ (H2O2)}$$

w (Weight of a compound) = *N* (Normality) x *m* (molar mass) x *v* (Volume of a solution) students performed the experiments for the above redox reaction, in which get the following (m/n) ratio here also known the Normality of Oxidant (MnO_4^-) and Reductant (H_2O_2) and Volume of H_2O_2 which was taken initially. However, at the equivalence point of the redox reaction the volume of MnO_4^- was taken. The following results was generated

$\frac{m}{n}$ = 2.5 ± 0.05 =5/2 --------------------- (2)

RESULT AND DISCUSSION

Two redox chemical reactions were performed by taking same oxidant (oxidising agent) $KMnO_4$, according to the stoichiometric ratio of the above two redox chemical reaction as shown in equation (1) and (2), then it will be possible to balancing the redox chemical reaction in acidic as well as in basic medium. The results are obtained as below

Part-I

$$mCr^{3+}_{(aq)} + nMnO_4^-{}_{(aq)} \text{------}\rightarrow mCr^{6+}_{(aq)} + n\,Mn^{2+}_{(aq)}$$

The stoichiometric ratio for the above redox reaction is m/n = 5/3, which is replaced in the reaction,

$$5Cr^{3+}_{(aq)} + 3MnO_4^-{}_{(aq)} \text{---------}\rightarrow 5Cr^{6+}_{(aq)} + 4Mn^{2+}_{(aq)}$$

The question is arising how to balanced the redox chemical equation in acidic as well as in basic medium?

In *Acidic medium* to complete balancing the reaction in which oxygen and hydrogen must be balanced. One oxygen becomes equal to the one water molecule but water molecules must be added on opposite side of the oxygen atom, here adding $12H_2O$ molecules on the right-hand side. To balancing, finally adding hydrogen atoms and getting the complete balanced redox reaction.

$$5Cr^{3+} + 3MnO_4^- + 24H^+ \text{-----}\rightarrow 5Cr^{6+} + 3Mn^{2+} + 12H_2O$$

In *Basic medium* to complete balancing the reaction in which the water molecules must be added on same side of the oxygen atom, here adding $12H_2O$ molecules on the left-hand side. To balancing, finally adding hydroxide ions (OH^-) ions and getting the complete balanced redox reaction.

$$5Cr^{3+} + 3MnO_4^- + 12H_2O \text{-----}\rightarrow 5Cr^{6+} + 3Mn^{2+} + 24OH^-$$

Part-II

$$mH_2O_{2(aq)} + nMnO_4^-{}_{(aq)} \text{----------}\rightarrow mO_{2(g)} + n\,Mn^{2+}_{(aq)}$$

The stoichiometric coefficient ratio for the redox reaction is m/n = 5/2, which is mentioned in the redox reaction,

$$5H_2O_{2(aq)} + 2MnO_4^-{}_{(aq)} \text{------------}\rightarrow 5O_{2(g)} + 2Mn^{2+}_{(aq)}$$

Similar method which is mentioned in the part I is applying for balancing the redox reaction in acidic as well as in basic medium.

In *Acidic medium:* adding $8H_2O$ molecules on the right-hand side using hydrogen atoms for complete balancing redox reaction.

$$5H_2O_2 + 2MnO_4^- + 6H^+ \text{--------}\rightarrow 5O_{2(g)} + 2Mn^{2+} + 8H_2O$$

In *Basic medium* to complete balancing the reaction in which the water molecules must be added on same side of the oxygen atom, here adding $8H_2O$ molecules on the left-hand side. To balancing, finally adding hydroxide ions (OH^-) ions and getting the complete balanced redox reaction. The final complete balance redox reaction in basic medium is

$$5H_2O_2 + 2MnO_4^- + 8H_2O^- \text{-----}\rightarrow 5O_{2(g)} + 2Mn^{2+} + 16OH^- + 10H^+$$

CONCLUSION

This is the sophisticated method or procedure to balancing the redox chemical equation either in acidic or in basic medium after performing the experimental redox titration and more work is needed using different oxidising agent in the redox titrimetric methods for balancing the redox chemical equations.

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