Balancing redox equations

N Goalby
chemrevise.org

Redox equations have to be balanced using a different method to usual balancing.

To do this method we use half equations.
•A reduction half equation only shows the parts of a chemical equation involved in reduction
•An oxidation half equation only shows the parts of a chemical equation involved in oxidation

Half equations always have electrons in them.

They are there to balance the differences in oxidation number

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ This is a reduction half equation. The electron is on the left

$Fe^{2+} \rightarrow Fe^{3+} + e^-$ This is an oxidation half equation. The electron is on the right

Writing half equations

1. Work out oxidation numbers for element being oxidised/ reduced

$Zn \rightarrow Zn^{2+}$

0 +2

2. Add electrons equal to the change in oxidation number

For reduction add e's to reactants

For oxidation add e's to products

$Zn \rightarrow Zn^{2+} + 2e^-$

3 check to see that the sum of the charges on the reactant side equals the sum of the charges on the product side

$Zn \rightarrow Zn^{2+} + 2e^-$

0 +2 –2 =0

Questions

Write half equations for the following changes.

1. $Sn \rightarrow Sn^{2+}$
2. $Cl^- \rightarrow Cl_2$
3. $Ti^{3+} \rightarrow Ti$
4. $Br_2 \rightarrow Br^-$
5. $Na \rightarrow Na^+$
6. $C_2O_4^{2-} \rightarrow CO_2$

More complex Half equations

If the substance that is being oxidised or reduced contains a varying amount of O (eg MnO_4^- → Mn^{2+}) then the half equations are balanced by adding H^+, OH^- ions and H_2O.

In acidic conditions use H^+ and H_2O

MnO_4^- + 8 H^+ +5 e^- ⟶ Mn^{2+} + $4H_2O$

+7 +2

1. Balance the change in O.N. with electrons
2. Add H_2O in products to balance O's in MnO_4^-
3. Add H^+ in reactants to balance H's in H_2O

More complex Half equations

Write the half equation for the reduction of acidified $Cr_2O_7^{2-}$ into Cr^{3+} ions

In acidic conditions use H^+ and H_2O

$Cr_2O_7^{2-}$ + 14 H^+ +6 e^- ⟶ $2Cr^{3+}$ + $7H_2O$

+6 x2 +3x2

1. Balance the change in O.N. with electrons
2. Add H_2O in products to balance O's in MnO_4^-
3. Add H^+ in reactants to balance H's in H_2O

Questions

Write half equations for the following changes

1. NO_2^- → NO_3^-
2. H_2SO_4 → SO_2
3. H_2SO_4 → H_2S
4. FeO_4^{2-} → Fe^{3+}
5. V^{3+} → VO^{2+}

Combining half equations

To make a full redox equation combine a reduction half equation with a oxidation half equation

Reduction $MnO_4^- + 8\ H^+ + 5\ e^- \rightarrow Mn^{2+} + 4\ H_2O$ **x2**

Oxidation $C_2O_4^{2-} \rightarrow 2\ CO_2 + 2\ e^-$ **x5**

To combine two half equations there must be equal numbers of electrons in the two half equations so that the electrons cancel out

1 Multiply the half equations to get equal electrons

2 Add half equations together

$2MnO_4^- + 16\ H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 10\ CO_2 + 8\ H_2O$

Questions

Combine the following half-equations together to make a redox equation

$Fe^{3+} + e^- \rightarrow Fe^{2+}$

$Zn \rightarrow Zn^{2+} + 2e^-$

$2\ Fe^{3+} + Zn \rightarrow 2\ Fe^{2+} + Zn^{2+}$

Combine the following half-equations together to make a redox equation

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$Cl_2 + 2e^- \rightarrow 2Cl^-$

$2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$

Questions

Combine the following half-equations together to make a redox equation

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$MnO_4^- + 8\ H^+ + 5\ e^- \rightarrow Mn^{2+} + 4\ H_2O$

$MnO_4^- + 8\ H^+ + 5\ Fe^{2+} \rightarrow Mn^{2+} + 4\ H_2O + 5\ Fe^{3+}$

Combine the following half-equations together to make a redox equation

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

$Cr_2O_7^{2-} + 14\ H^+ + 6\ e^- \rightarrow 2Cr^{3+} + 7\ H_2O$

$Cr_2O_7^{2-} + 14\ H^+ + 6\ Fe^{2+} \rightarrow 2Cr^{3+} + 7\ H_2O + 6\ Fe^{3+}$

Exam questions 1

In acidic conditions, hydrogen peroxide, H_2O_2, oxidises iodide ions to iodine. The hydrogen peroxide is reduced to water. In H_2O_2, oxygen has an oxidation state of –1.

(i) Construct a half-equation for the reduction of hydrogen peroxide to water in acidic conditions.

(ii) Construct a half-equation for the oxidation of I^- ions to iodine.

(iii) Construct an equation for the overall reaction.

Exam questions 2

- In a reaction, bromine and sulphur dioxide are evolved when concentrated sulphuric acid is warmed with solid potassium bromide.

(i) Deduce the oxidation state of sulphur in H_2SO_4.

(ii) State the role of sulphuric acid in the conversion of Br^- into Br_2.

(iii) Write a half equation for the conversion of Br^- into Br_2.

(iv) Write a half equation for the conversion of H_2SO_4 into SO_2.

(v) Use your answers to (iii) and (iv) above to deduce the overall equation for this reaction.

Exam questions 3

When chlorine gas is bubbled into an aqueous solution of sulphur dioxide, hydrogen ions, sulphate ions and chloride ions are formed.

(i) Write a half-equation for the formation of chloride ions from chlorine.

(ii) Write a half-equation for the formation of hydrogen ions and sulphate ions from sulphur dioxide and water.

(iii) Hence, deduce an overall equation for the reaction which occurs when chlorine is bubbled into aqueous sulphur dioxide.

Exam Questions 4

Lead(IV) oxide, PbO_2, reacts with concentrated hydrochloric acid to produce chlorine, lead(II) ions, Pb^{2+}, and water.

(i) Write a half-equation for the formation of Pb^{2+} and water from PbO_2 in the presence of H^+ ions.

(ii) Write a half-equation for the formation of chlorine from chloride ions.

(iii) Hence deduce an equation for the reaction which occurs when concentrated hydrochloric acid is added to lead(IV) oxide, PbO_2