

Oxidation numbers and balancing redox equations

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to assign oxidation numbers, identify oxidising and reducing agents, balance half-equations in acid and alkali, and use redox titrations. They begin with recall and finish with multi-step analysis of real samples.

The level suits A Level, IB Chemistry, CBSE Class 11-12 and senior WAEC and NECO students. Show the change in oxidation number, then check atoms and charge in every equation.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R3.2

Problem 1 Oxidation numbers of common species (easy)

Assign the oxidation number of the named element in each species.

1. Sulfur in H_2SO_4
2. Manganese in KMnO_4
3. Nitrogen in NH_4^+
4. Oxygen in H_2O_2
5. Chlorine in ClO_3^-

Problem 2 Sparkler chemistry (easy)

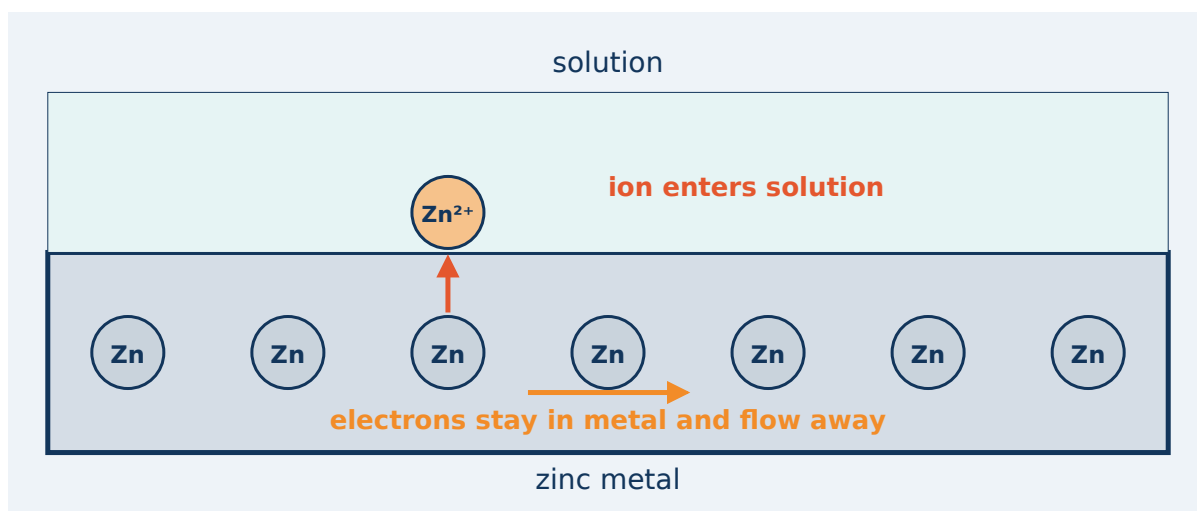
Kofi in Accra watches a magnesium sparkler burn at a festival: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$.

1. Write the oxidation number of each element before and after.
2. State which substance is oxidised and which is reduced.
3. Name the oxidising agent and the reducing agent.

Problem 3 Zinc coating on a nail (easy)

Zinc on a galvanised nail loses atoms to the solution as shown in the diagram.

1. Write the half-equation for zinc forming Zn^{2+} .
2. State whether this is oxidation or reduction and why.
3. State how many electrons are released by 3 mol of zinc.



A zinc atom leaving the surface of galvanised steel.

Problem 4 Redox or not? (easy)

Decide whether each reaction is a redox reaction. Give a reason using oxidation numbers.

1. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
2. $2\text{KI} + \text{Cl}_2 \rightarrow 2\text{KCl} + \text{I}_2$
3. $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$

Problem 5 Roman numerals in names (easy)

Use oxidation numbers to answer.

1. Name Fe_2O_3 .
2. Name CuSO_4 .
3. Write the formula of chromium(III) oxide.
4. Name SnCl_2 .

Problem 6 Harder oxidation numbers (medium)

Find the oxidation number of the named element.

1. Chromium in $\text{Cr}_2\text{O}_7^{2-}$
2. Sulfur in $\text{S}_2\text{O}_3^{2-}$
3. Carbon in $\text{C}_2\text{H}_5\text{OH}$ (take both carbons together, then give the average)
4. Iron in Fe_3O_4 (give the average)

Problem 7 Balancing two half-equations in acid (medium)

Balance each half-equation in acidic solution by adding H^+ , H_2O and e^- .

1. $\text{NO}_3^- \rightarrow \text{NO}$
2. $\text{H}_2\text{O}_2 \rightarrow \text{O}_2$

Problem 8 Rhubarb leaves and permanganate (medium)

Oxalate ions in rhubarb leaves are oxidised by acidified permanganate. Half-equations:



1. State how the half-equations must be multiplied.
2. Write the overall ionic equation.
3. Check the charge balance.

Problem 9 Thermite reaction (medium)

Railway workers in Lahore weld rails with thermite: $2\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$.

1. Give the oxidation numbers of Al and Fe before and after.
2. Identify the oxidising agent and the reducing agent.
3. State the number of electrons transferred per formula unit of Fe_2O_3 .

Problem 10 Silver recovery from waste (medium)

A photo lab in Singapore recovers silver by placing copper in silver nitrate solution: $\text{Cu} + 2\text{Ag}^+ \rightarrow \text{Cu}^{2+} + 2\text{Ag}$.

1. Write the two half-equations.
2. Calculate the moles of Cu in 0.635 g ($A_r \text{ Cu} = 63.5$).
3. Calculate the mass of silver formed ($A_r \text{ Ag} = 107.9$).

Problem 11 Making bleach (medium)

Emma in Leeds studies the manufacture of household bleach: $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$.

1. Give the oxidation number of chlorine in Cl_2 , NaCl and NaClO .
2. Explain why this is called disproportionation.
3. State the number of electrons transferred per Cl_2 molecule.

Problem 12 Balancing by oxidation numbers (medium)

Wanjiru in Nairobi dissolves copper in dilute nitric acid: $\text{Cu} + \text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{NO} + \text{H}_2\text{O}$.

1. Give the change in oxidation number of Cu and of N (the N in NO).
2. Choose coefficients so that the electron changes are equal.
3. Balance the full equation.

Problem 13 Permanganate in alkali (medium)

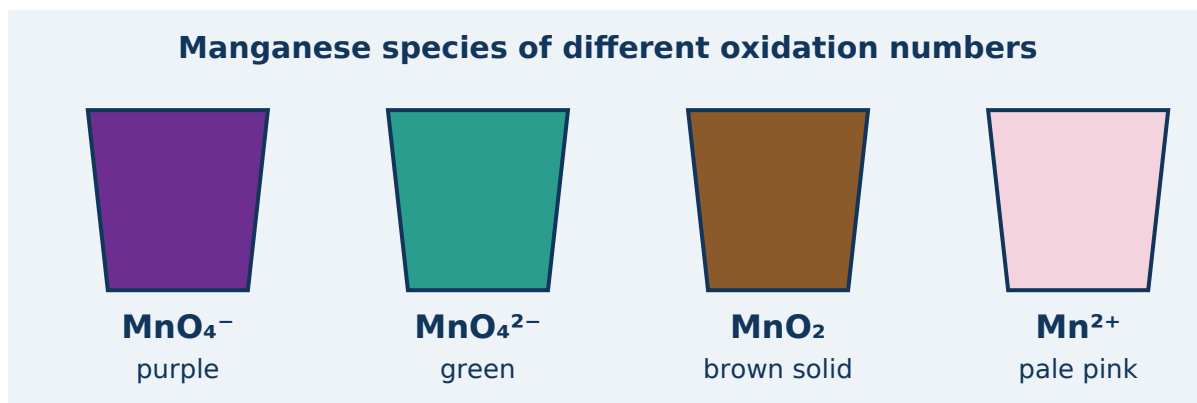
In alkaline solution MnO_4^- is reduced to solid MnO_2 .

1. First balance the half-equation as if it were in acid.
2. Convert it to alkaline conditions by adding OH^- .
3. Check atoms and charge.

Problem 14 Reading oxidation numbers from colours (medium)

Mei in Singapore reduces permanganate with different reagents and records the colours in the diagram (left to right).

1. Assign the oxidation number of manganese in each species.
2. State the number of electrons gained per Mn in going from MnO_4^- to MnO_2 and to Mn^{2+} .
3. Predict the colour change when MnO_4^- is reduced to Mn^{2+} in acid.



Four common manganese species and their colours.

Problem 15 Iron supplement tablet (hard)

Chiamaka dissolves one iron(II) supplement tablet and makes the solution up to 250 cm^3 . Samples of 25.0 cm^3 need 22.40 cm^3 of $0.00200 \text{ mol/dm}^3 \text{ MnO}_4^-$ in acid ($A_r \text{ Fe} = 55.8$).

1. Write the overall ionic equation.
2. Calculate the moles of MnO_4^- used.
3. Calculate the moles of Fe^{2+} in 25.0 cm^3 and in the whole 250 cm^3 .
4. Calculate the mass of iron in the tablet in mg.

Problem 16 Breathalyser chemistry (hard)

Diego in Texas studies a dichromate breath test: orange $\text{Cr}_2\text{O}_7^{2-}$ turns green Cr^{3+} when it oxidises ethanol to ethanoic acid. Half-equations: $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ and $\text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^-$.

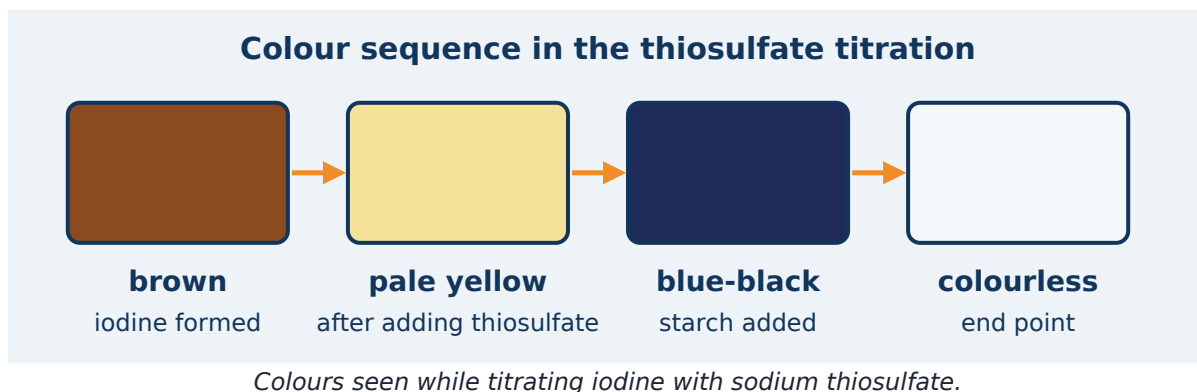
1. Find the oxidation number change of chromium per $\text{Cr}_2\text{O}_7^{2-}$ and of the carbon of the CH_2OH group.
2. Combine the half-equations into an overall equation.
3. Check that H, O and charge balance.

Problem 17 Analysing bleach with thiosulfate (hard)

Bilal in Lahore dilutes 10.0 cm^3 of bleach to 250 cm^3 . A 25.0 cm^3 portion is mixed with excess KI and acid: $\text{ClO}^- + 2\text{I}^- + 2\text{H}^+ \rightarrow \text{Cl}^- + \text{I}_2 + \text{H}_2\text{O}$. The iodine needs 21.50 cm^3 of 0.100 mol/dm^3 thiosulfate: $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$. The colour sequence is shown.

1. Calculate the moles of thiosulfate and of I_2 .
2. Calculate the moles of ClO^- in the 25.0 cm^3 portion and in the original 10.0 cm^3 .

3. Calculate the concentration of ClO^- in the bleach in mol/dm^3 and in g/dm^3 ($M_r \text{ NaClO} = 74.4$).



Problem 18 Spot the error in a redox equation (hard)

A student writes: $\text{MnO}_4^- + 8\text{H}^+ + \text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + \text{Fe}^{3+}$.

1. Show that the equation is not balanced for charge.
2. Find the correct coefficient for Fe^{2+} and Fe^{3+} .
3. Write the corrected equation and check the charge.

Problem 19 Iodine in table salt (hard)

Kofi tests iodised salt. He dissolves 50.0 g of salt, adds excess iodide and acid: $\text{IO}_3^- + 5\text{I}^- + 6\text{H}^+ \rightarrow 3\text{I}_2 + 3\text{H}_2\text{O}$. The iodine formed needs 12.60 cm^3 of 0.00500 mol/dm^3 thiosulfate ($\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$). $A_r \text{ I} = 126.9$.

1. Show that the equation is balanced for atoms and charge.
2. Calculate the moles of I_2 and of IO_3^- .
3. Calculate the mass of iodine in the form of iodate in mg per kg of salt.

Problem 20 Oxidation numbers in electron count (hard)

Aarav in Pune oxidises iodide with dichromate: $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{I}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{I}_2$.

1. Show that the equation balances for charge.
2. Calculate the total change in oxidation number for chromium and for iodine.
3. Calculate the mass of iodine formed from 25.0 cm^3 of 0.0200 mol/dm^3 dichromate in excess iodide ($A_r \text{ I} = 126.9$).