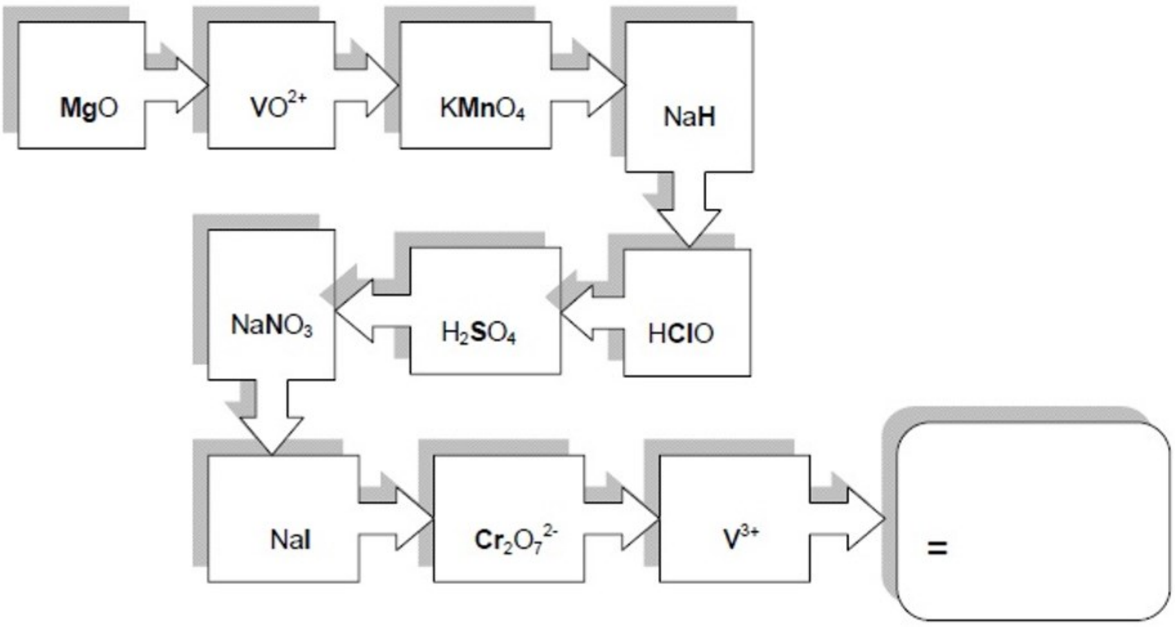
Redox

Oxidation and reduction

Oxidation numbers

Work out the oxidation numbers for the **bold** elements in the compounds and perform the calculation.
Present your answer to your teacher. There is 1 mark for each correct oxidation number you have deduced.

Note: You are calculating the oxidation number of the element, not its overall contribution to the compound eg, $CaCl_2$ you would give the answer for Cl as -1, not as …Cl2 (-2).



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Writing half equations

Balance the half equations by balancing the atoms and adding

Electrons	H^+	H_2O
1. Mg	→	Mg^{2+}
2. Cl_2	→	Cl^-
3. H_2O_2	→	O_2
4. SO_4^{2-}	→	SO_2
5. CH_3CH_2OH	→	CH_3COOH
6. CH_3CH_2OH	→	CH_3CHO
7. $Cr_2O_7^{2-}$	→	Cr^{3+}
8. MnO_4^-	→	Mn^{2+}
9. H_2S	→	S
10. IO_3^-	→	I_2

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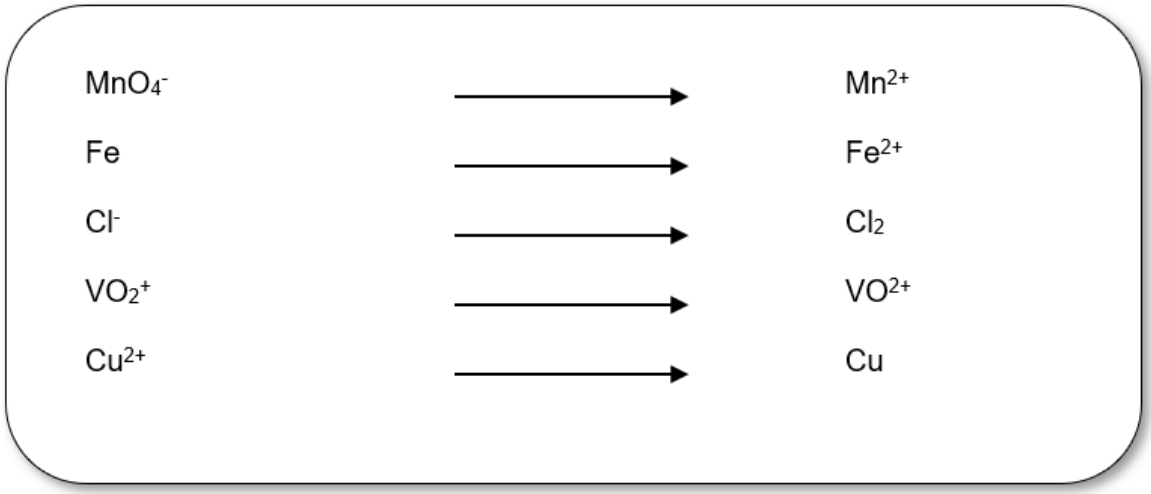
Half equations to overall equations



1) Balance the half equations above

(5 marks)

2) Using the equations you have balanced above, construct overall equations to show -

a) The reduction of manganate(VII) by chloride ions

(1 mark)

b) The reduction of copper(II) to copper by iron

(1 mark)

3) Construct an overall equation to show how the $VO2^+$ ion is reduced by zinc metal

(2 marks)

$Cr_2O_7^{2-} + 14H^+ + 3CH_3CHO + H_2O \longrightarrow 2Cr^{3+} + 3CH_3COOH + 6H^+ + 7H_2O$

4) The reaction above shows the oxidation of an aldehyde to a carboxylic acid using the dichromate ion.

5) From this equation deduce the half equation for the dichromate reduction.

(1 mark)

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Extraction of metals

Electrolysis of aluminium

Al^{3+} ⟶ Al

O^{2-} ⟶ O_2

1. The above equations show the transformations occurring during electrolysis of aluminium oxide, Al2O3.
Balance the equations for stoichiometry and charge.

(2 marks)

2. On first consideration the electrolysis process does not produce the greenhouse gas carbon dioxide.
Give 2 reasons why the process does in fact produce CO2.

(3 marks)

3. Why does the aluminium oxide have to be molten for electrolysis to occur?

(1 mark)

4. The cheapest method of metal extraction available is reduction with carbon. Why can aluminium not be extracted in this way?

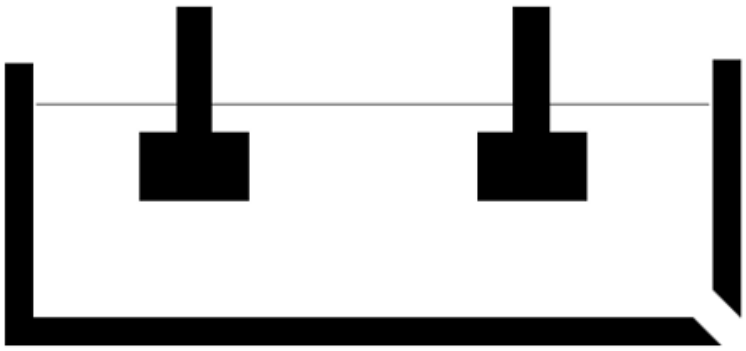
(1 mark)

5. The melting point of bauxite, the main aluminium ore is 2050°C. How is the ore made into the molten state for the electrolysis process?

(1 mark)

6. Below is a simplified diagram of a cell used for aluminium electrolysis. Label the anode and cathode.

(2 marks)



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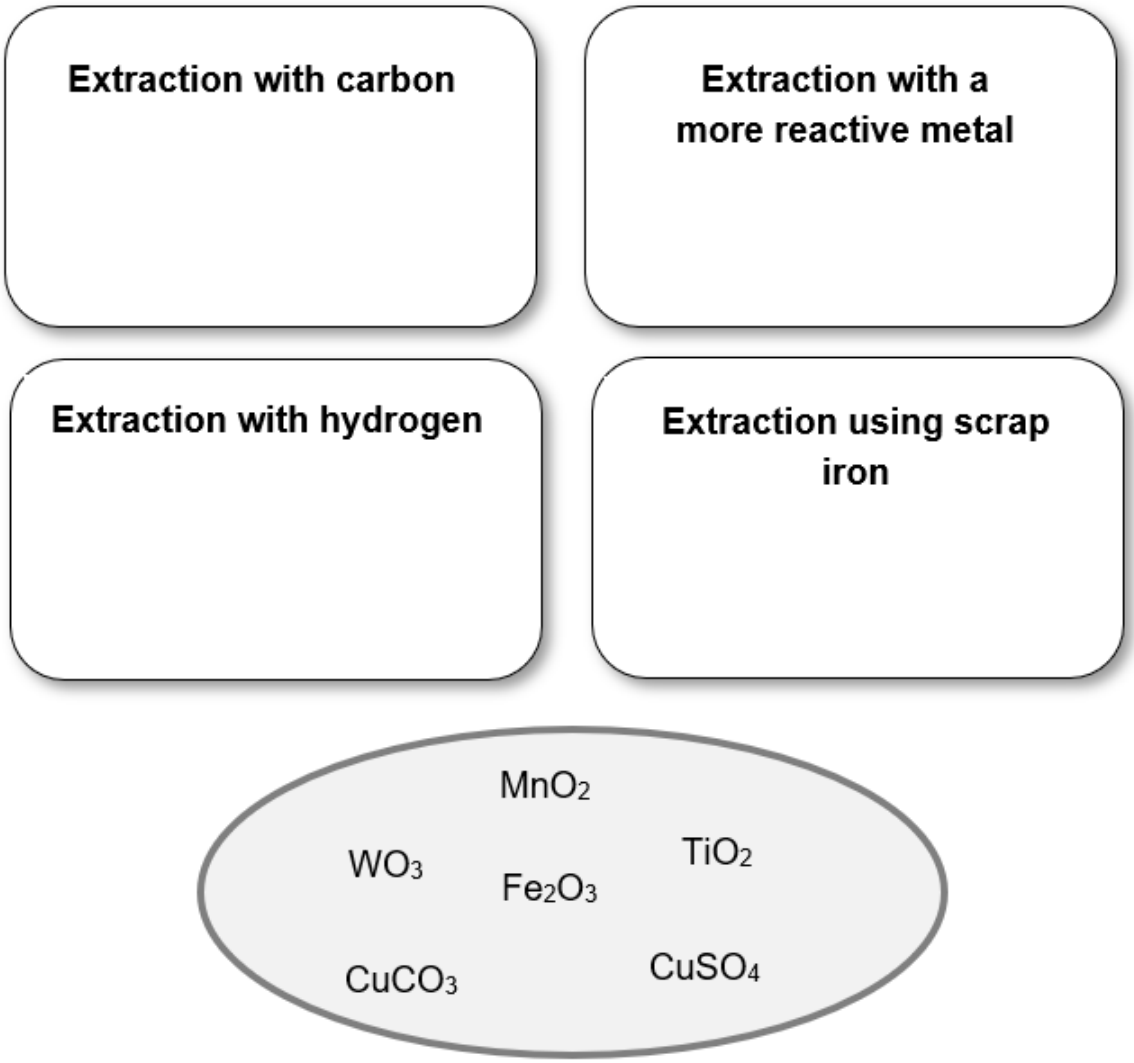
Extraction of other metals



1. Place the ores above into the appropriate box showing the method used to extract the metal from them.

(4 marks)

2. For the metals that are extracted using a more reactive metal or with hydrogen, state why they cannot simply be extracted using carbon.

(2 marks)

3. Titanium is an abundant and useful metal and is extracted using a batch process in 2 stages. Outline the stages using equations and annotate the 2nd stage using oxidation numbers to show that it is a redox process.

(3 marks)

4. What is the main hazard with the use of hydrogen in metal extraction?

(1 mark)

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The halogens

Displacement reactions

	KCl(aq) Colourless solution	**KBr(aq)** Colourless solution	**KI(aq)** Colourless solution
Cl_2(aq) Colourless solution	x		
Br_2(aq) Orange solution	No reaction	x	
I_2(aq) Brown solution	No reaction	No reaction	x

1. A more reactive halogen will displace a less reactive halide form its salt. The table above shows the results from displacement reactions of the halogens. Complete the table to show what you would see if you carried out the reactions.

(4 marks)

2. Write ionic equations for these displacement reactions.

(2 marks)

3. Using the reaction of Br2 with KI as an example, describe why displacement reactions are redox processes.

(1 mark)

4. When the halogens react they gain an electron. Explain why iodine is the least reactive halogen.

(2 marks)

5. If you were able to use a solution of fluorine water to react with the halide solutions shown above which ones would you expect to show a reaction?

(1 mark)

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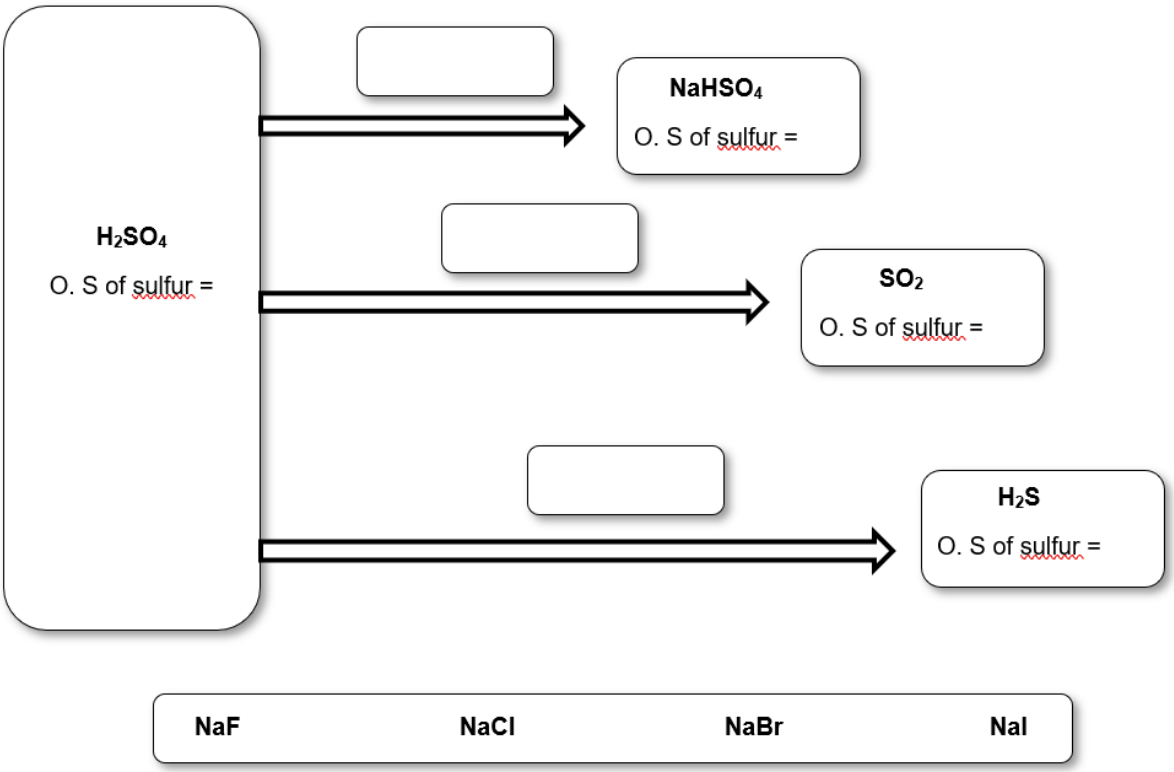
Ability to reduce sulfuric acid



1. The above diagram illustrates how sulfuric acid, H2SO4 reacts with halides. Complete the diagram by showing the O.S of sulfur for each species and which halide salt(s) achieve each reaction.

(7 marks)

2. Which of the transformations is not a redox reaction?

(1 mark)

3. State the general trend in reducing ability of the halides and the 2 factors about the atoms that lead to this trend.

(2 marks)

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Uses of chlorine and chlorate(I)

1) Chlorination has been used for many years as a way of protecting public health by disinfecting water supplies thus preventing the growth of harmful microorganisms. Chlorination can be carried out by bubbling chlorine gas through water.

(a) Write an equation to show how chlorine reacts with water

(1 mark)

(b) Explain how this process is an example of a disproportionation reaction.

(2 mark)

Bacteria are killed by the chlorate(I) ion.

(c) Show using an equation how the chlorate(I) ion is formed from a product of the reaction of chlorine with water.

(1 mark)

(d) Give 2 reasons why people object to chlorination of drinking water.

(2 mark)

(e) Given the objections to chlorination, why does the UK government continue to chlorinate drinking water?

(1 mark)

2) Chlorine can also be used in the production of bleach.

(a) Write an equation to show how chlorine is used to produce bleach. Indicate which compound in your equation is responsible for the 'bleaching' property and show that the reaction is another example of disproportionation.

(3 marks)

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Halogens summary

A student carried out an experiment to identify some solid sodium halides. Below is his incomplete results table showing what he observed. Complete the results table with observations (take care to use suitable technical language) and identify the halide anion in the solids A, B, C.

Solid	Addition of $AgNO_3/H^+$ to solution of the halide	Addition of dil. NH_3 to silver precipitate from test 1	Addition of conc. NH_3 to tube from test 2	Addition of conc. H_2SO_4 to the solid
A	White precipitate formed			Misty fumes seen which turn litmus paper red
B		No visible change, precipitate remains		
C			No visible change, precipitate remains	Purple vapour visible and solid crystals seen on the top of the test tube

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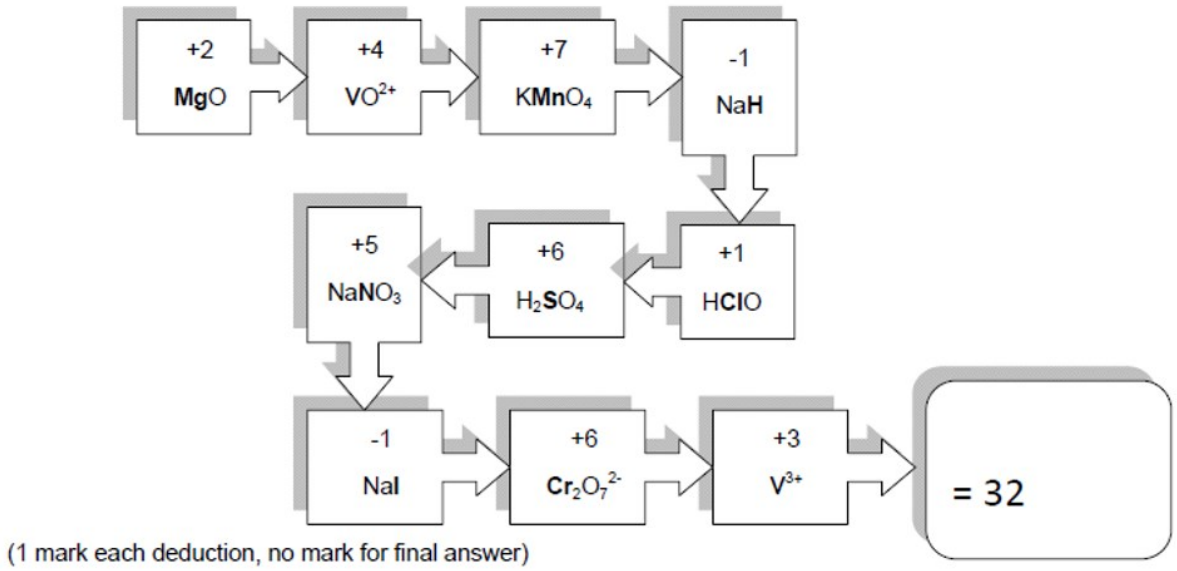
Redox – Answers

Oxidation numbers



(1 mark each deduction, no mark for final answer)

Writing half equations

1. $Mg \rightarrow Mg^{2+} + 2e^-$
2. $Cl_2 + 2e^- \rightarrow 2Cl^-$
3. $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$
4. $SO_4^{2-} + 4H^+ + 2e^- \rightarrow SO_2 + 2H_2O$
5. $CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$
6. $CH_3CH_2OH \rightarrow CH_3CHO + 2H^+ + 2e^-$
7. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
8. $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
9. $H_2S \rightarrow S + 2H^+ + 2e^-$
10. $IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$

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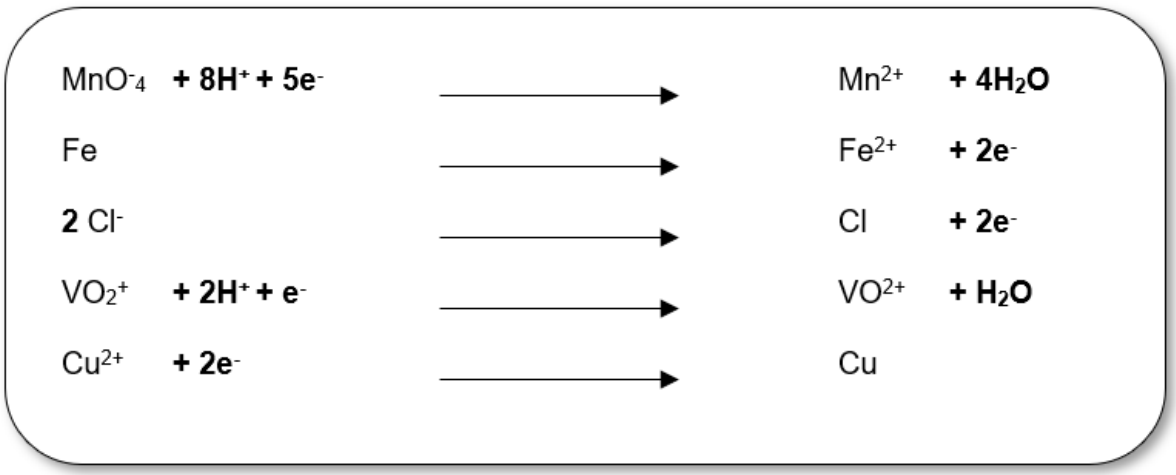
Half equations to overall equations

1.



2. (a) $2\ MnO_4^- + 16H^+ + 10Cl^- \rightarrow 5Cl_2 + 2Mn_2^+ + 8H_2O$

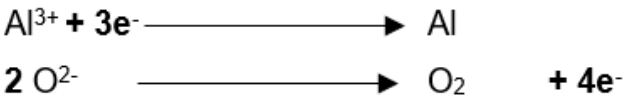
(b) $Cu^{2+} + Fe \rightarrow Fe^{2+} + Cu$

3. $2VO_2^+ + 4H^+ + Zn \rightarrow 2VO^{2+} + 2H_2O + Zn^{2+}$

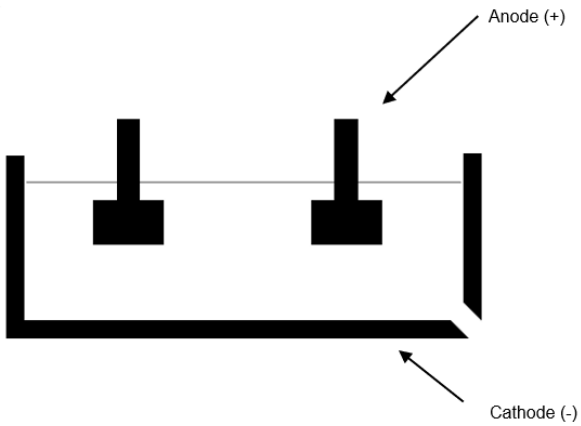
4. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Electrolysis of aluminium

1.



2. Electrodes are made of carbon and are oxidised to CO_2
Uses electricity which is generated from the burning of fossil fuels.
3. So the ions are free to move
4. It is more reactive than carbon
5. Dissolved in molten cryolite
6.



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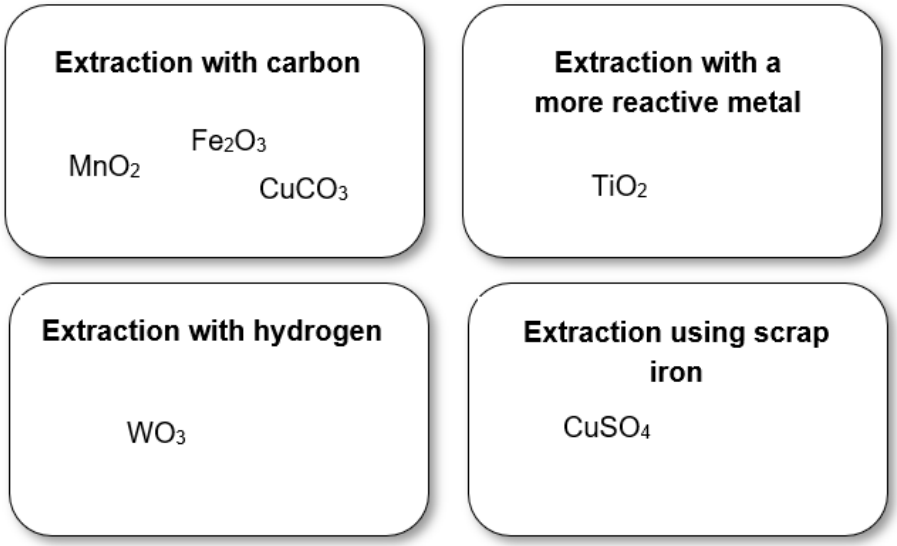
Extraction of other metals

1.



(1 mark each correct box = 4 marks)

2. Tungsten and titanium – **Stable carbides** are formed which make the metals **brittle**.

(2 marks)

3.

$$\underset{\textbf{+4}\quad\textbf{0}}{TiO_2 + 2Cl_2 + 2C} \longrightarrow \underset{\textbf{0}\quad\textbf{+1}}{TiCl_4 + 2CO}$$

$$TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$$

OR with magnesium

$$\underset{\textbf{+4}\quad\textbf{0}}{TiCl_4 + 2Mg} \longrightarrow \underset{\textbf{0}\qquad\textbf{+2}}{Ti + 2MgCl_2}$$

4. Hydrogen is flammable/explosion.

Displacement reactions

	KCl(aq) Colourless solution	**KBr(aq)** Colourless solution	**KI(aq)** Colourless solution
Cl_2(aq) Colourless solution	x	**Orange solution formed**	**Brown solution formed (some black crystals of iodine may be seen)**
Br_2(aq) Orange solution	No reaction	x	**Brown solution formed (some black crystals of iodine may be seen)**
I_2(aq) Brown solution	No reaction	No reaction	x

(1 mark each, iodide observation does not need observation of crystals for the mark)

2.

$$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$$

$$Cl_2 + 3I^- \longrightarrow 2Cl^- + I_2$$

$$Br_2 + 2I^- \longrightarrow 2Br^- + I_2$$

3. The Br goes from an O.S of 0 in Br2 to -1 in KBr so **it is reduced**.

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The I goes from an O.S of -1 in KI to 0 in I2 so **it is oxidised**.

(1 mark for either, must include bold)

4. Any one from the following for 1 mark

✓ Large atomic radius

✓ More shielding

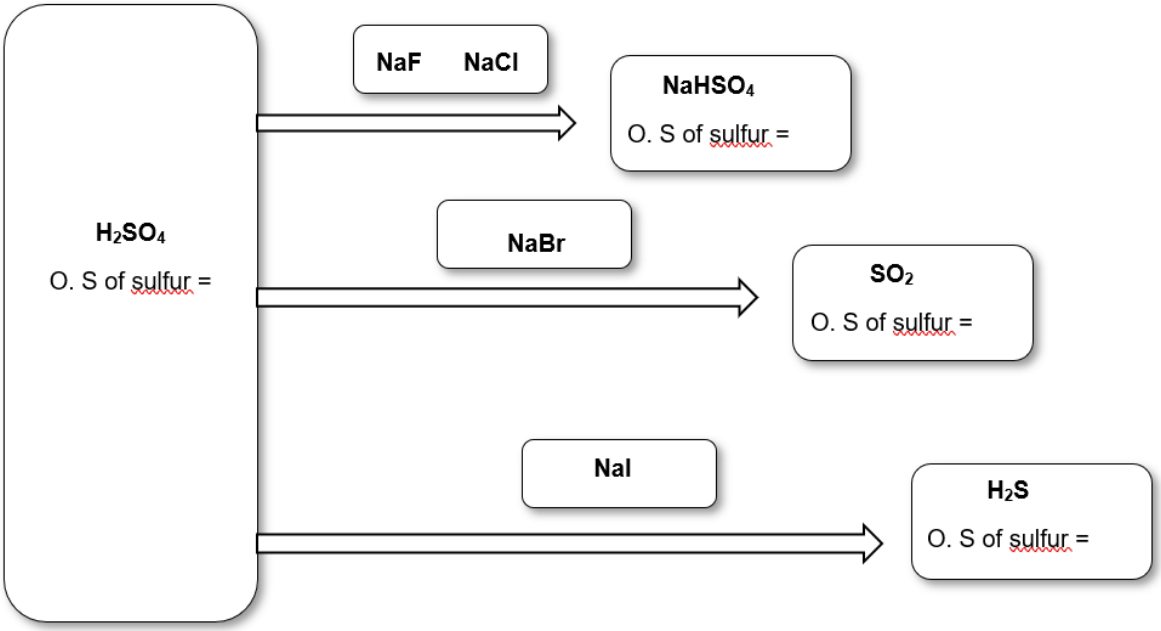
Plus for the other mark

✓ Lower effective nuclear charge

5. All of them.

Ability to reduce sulfuric acid

1.



(1 mark each correct box)

2. H2SO4 → NaHSO4 (the O.S of S does not change)

(1 mark)

3. Reducing ability increases down the group

(1 mark)

Atomic radius and shielding

(both needed for 1 mark or ½ mark each)

Uses of chlorine and chlorate(I)

1. (a) $Cl_2 + H_2O \rightarrow HClO + HCl$

(1 mark)

(b) Chlorine goes from an O.S of 0 in Cl_2 to +1 in HClO and -1 in HCl. It is both **oxidised and reduced**.

(1 mark for the O.S numbers, 1 for bold)

(c) $HClO + H_2O \rightarrow ClO^- + H_3O^+$

(1 mark)

(d) Any 2 from the following for 2 marks

✓ Chlorine can react with organic material in water to form carcinogens

✓ Chlorine gas is harmful

✓ No choice in it

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(e) The benefits outweigh the risks or WTTE.

(1 mark)

2. $NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$

(1 mark)

NaClO is the bleaching agent.

(1 mark)

Chlorine goes from an O.S of 0 in Cl_2 to +1 in HClO and -1 in HCl. It is both **oxidised and reduced.**

(1 mark)

Halogens summary

(1 mark for each correct box)

Solid	Addition of $AgNO_3/H^+$ to solution of the halide	Addition of dil. NH_3 to silver precipitate from test 1	Addition of conc. NH_3 to tube from test 2	Addition of conc. H_2SO_4 to the solid
A	White precipitate formed	Precipitate dissolves/solution goes clear	No visible change	Misty fumes seen which turn litmus paper red
B	Cream coloured precipitate formed	No visible change, precipitate remains	Precipitate dissolves/solution goes clear	Brown solution formed/acrid fumes produced
C	Pale yellow coloured precipitate formed	No visible change, precipitate remains	No visible change, precipitate remains	Purple vapour visible and solid crystals seen on the top of the test tube

A = NaCl, B = NaBr, C = NaI (1 mark each)

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