A-Level Chemistry

Redox

Question Paper

Time available: 61 minutes
Marks available: 50 marks

1. This question is about redox reactions.

(a) State, in terms of electrons, the meaning of the term oxidising agent.

_____

(1)

(b) $Cr_2O_7^{2-}$ can oxidise SO_3^{2-} in acidic conditions to form Cr^{3+} and SO_4^{2-}

Deduce a half-equation for the oxidation of SO_3^{2-} to SO_4^{2-}

Deduce a half-equation for the reduction of $Cr_2O_7^{2-}$ to Cr^{3+}

Deduce the overall equation for the oxidation of SO_3^{2-} by $Cr_2O_7^{2-}$

Half-equation for the oxidation of SO_3^{2-} to SO_4^{2-}

_____

Half-equation for the reduction of $Cr_2O_7^{2-}$ to Cr^{3+}

_____

Overall equation

_____

(3)

(Total 4 marks)

2. This question is about emissions of oxides of nitrogen from petrol and diesel engines.

(a) Explain how oxides of nitrogen are formed in engines.

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_____

_____

_____

(2)

(b) State why it is desirable to decrease emissions of oxides of nitrogen from vehicles.

_____

_____

_____

(1)

(c) Modern diesel vehicles use diesel exhaust fluids, such as AdBlue, to decrease emissions of oxides of nitrogen.

AdBlue reacts with water in the hot exhaust gases to form ammonia.
In the presence of a catalyst the ammonia reacts with oxides of nitrogen to form nitrogen and water.

Give the oxidation state of nitrogen in each of NO_2, NH_3 and N_2

Complete the equation for the reaction between NO_2 and NH_3

Oxidation state of nitrogen in

NO_2_____ NH_3_____ N_2_____

Equation

_____ NO_2 + _____ NH_3 → _____ N_2 + _____ H_2O

(2)

(d) Petrol vehicles have a catalytic converter which decreases emissions of oxides of nitrogen. Platinum in the catalytic converter acts as a heterogeneous catalyst.

State the meaning of the term heterogeneous catalyst.

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_____

_____

_____

(2)

(e) Some carbon particulates are also formed in both diesel and petrol vehicles.

Explain why carbon particulates are formed.

_____

_____

(1)

(Total 8 marks)

3. Chlorine is used to decrease the numbers of microorganisms in water.

When chlorine is added to water, there is a redox reaction, as shown by the equation

$$Cl_2 + H_2O \rightleftharpoons HClO + HCl$$

(a) Deduce the oxidation state of chlorine in HClO and the oxidation state of chlorine in HCl

Oxidation state of chlorine in HClO _____

Oxidation state of chlorine in HCl _____

(1)

(b) Give two half-equations to show the oxidation and reduction processes that occur in this redox reaction.

Oxidation half-equation _____

Reduction half-equation _____

(2)

(c) Chlorine is reacted with cold, aqueous sodium hydroxide in the manufacture of bleach.

Give an equation for this reaction between chlorine and sodium hydroxide.

_____

(1)

(d) The concentration of ClO^- ions in bleach solution can be found by reaction with iodide ions.

The overall equation for this reaction is shown.

$$ClO^- + 2I^- + 2H^+ \rightarrow I_2 + Cl^- + H_2O$$

A sample of bleach solution was found to contain ClO^- ions with a concentration of 0.0109 mol dm^{-3}
Potassium iodide is added to a 20.0 cm^3 portion of this bleach solution.

Calculate the mass, in mg, of potassium iodide needed to react with all of the ClO^- ions in the sample of bleach.
Give your answer to the appropriate number of significant figures.
Give **one** observation during this reaction.

Mass of potassium iodide _____ mg

Observation _____

_____

_____

_____

(4)

(e) Potassium chlorate(VII), $KClO_4$, is used in fireworks. When potassium chlorate(VII) decomposes, it produces potassium chloride and oxygen.

Give an equation for the decomposition of potassium chlorate(VII).
Use the data in the table to calculate the enthalpy change for this reaction.

Substance	**$\Delta_f H$ / kJ mol^{-1}**
$KClO_4(s)$	– 434
KCl(s)	– 436

Equation _____

Enthalpy change _____ kJ mol^{-1}

(2)

(Total 10 marks)

4. When an acidified solution of sodium nitrite ($NaNO_2$) is added to aqueous potassium iodide, iodine and nitrogen monoxide (NO) are formed.

(a) Give the oxidation state of nitrogen in the following species.

NO_2^- _____

NO _____

(2)

(b) Write a half-equation for the conversion of NO_2^- in an acidic solution into NO

_____

(1)

(c) Write a half-equation for the conversion of I^- into I_2

_____

(1)

(d) Write an overall ionic equation for the reaction of NO_2^- in an acidic solution with I^-

_____

(1)

(e) State the role of NO_2^- in the reaction with I^-

_____

(1)

(f) In aqueous solution, nitrite ions react with acidified chlorate(V) ions according to the equation

$$2ClO_3^- + 5NO_2^- + 2H^+ \longrightarrow Cl_2 + 5NO_3^- + H_2O$$

25.0 cm^3 sample of an aqueous solution of sodium nitrite required 27.40 cm^3 of a 0.0200 mol dm^{-3} solution of potassium chlorate(V) for complete reaction.

Calculate the concentration, in g dm^{-3}, of sodium nitrite in the sample.

Concentration of sodium nitrite _____ g dm^{-3}

(4)

(Total 10 marks)

5. Sodium bromate(V) is a primary standard. This means that its solution can be used to check the concentration of other solutions.

(a) The half-equations for the reaction between bromate(V) ions and thiosulfate ions in the presence of acid are

$$2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$$

$$BrO_3^- + 6H^+ + 6e^- \longrightarrow Br^- + 3H_2O$$

Use these half-equations to deduce an overall equation for this reaction.

_____

_____

(1)

(b) A laboratory technician decided to use a 5.00×10^{-3} mol dm^{-3} solution of sodium bromate(V) to check the concentration of a sodium thiosulfate solution that was labelled as 1.00×10^{-3} mol dm^{-3}. The sodium bromate(V) solution was placed in the burette and 25.0 cm^3 of the sodium thiosulfate solution was pipetted into a conical flask.

Use the concentration of the sodium thiosulfate solution to calculate the expected titre value in this experiment.
Show your working.

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_____

_____

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_____

(2)

(c) Consider the titre value that you have calculated in part **(b)**.

Suggest one change to the experimental procedure in part **(b)** that would enable you to calculate a more accurate value for the concentration of the sodium thiosulfate solution.

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_____

(1)

(Total 4 marks)

6. This question is about Group 7 chemistry.

(a) Sea water is a major source of iodine.
The iodine extracted from sea water is impure. It is purified in a two-stage process.

Stage **1** $I_2 + 2H_2O + SO_2 \longrightarrow 2HI + H_2SO_4$

Stage **2** $2HI + Cl_2 \longrightarrow I_2 + 2HCl$

(i) State the initial oxidation state and the final oxidation state of sulfur in Stage **1**.

Oxidation state of S in SO_2 _____

Oxidation state of S in H_2SO_4 _____

(2)

(ii) State, in terms of electrons, what has happened to chlorine in Stage **2**.

_____

_____

(1)

(b) When concentrated sulfuric acid is added to potassium iodide, iodine is formed in the following redox equations.

$$\text{.....KI + ...}H_2SO_4 \longrightarrow \text{.....}KHSO_4 + \text{.....}I_2 + S + \text{.....}H_2O$$

$$8KI + 9H_2SO_4 \longrightarrow 8KHSO_4 + 4I_2 + H_2S + 4H_2O$$

(i) Balance the equation for the reaction that forms sulfur.

(1)

(ii) Deduce the half-equation for the formation of iodine from iodide ions.

_____

(1)

(iii) Deduce the half-equation for the formation of hydrogen sulfide from concentrated sulfuric acid.

_____

(1)

(c) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

_____

(1)

(ii) State what is observed when concentrated ammonia solution is added to this yellow precipitate.

_____

_____

(1)

(iii) State why the silver nitrate solution is acidified when testing for iodide ions.

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_____

_____

(1)

(iv) Explain why dilute hydrochloric acid is **not** used to acidify the silver nitrate solution in this test for iodide ions.

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_____

_____

(1)

(d) Chlorine is toxic to humans. This toxicity does not prevent the large-scale use of chlorine in water treatment.

(i) Give **one** reason why water is treated with chlorine.

_____

_____

(1)

(ii) Explain why the toxicity of chlorine does **not** prevent this use.

_____

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_____

(1)

(iii) Write an equation for the reaction of chlorine with cold water.

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(1)

(e) Give the formulas of the **two** different chlorine-containing compounds that are formed when chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Formula 1 _____

Formula 2 _____

(1)

(Total 14 marks)