Topic 9.1AB Oxidation & Reduction

Past Exam Questions (Paper 2)

1a. *[1 mark]*

Define oxidation in terms of electron transfer.

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1b. *[2 marks]*

Chlorine can be made by reacting concentrated hydrochloric acid with potassium manganate(VII), $KMnO_4$.

$$2KMnO_4(aq) + 16HCl(aq) \rightarrow 2MnCl_2(aq) + 2KCl(aq) + 5Cl_2(aq) + 8H_2O(aq)$$

State the oxidation number of manganese in $KMnO_4$ and in $MnCl_2$.

$KMnO_4$

$MnCl_2$

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1c. *[2 marks]*

Deduce which species has been oxidized in this reaction and state the change in oxidation number that it has undergone.

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2. *[3 marks]*

Brass is a copper containing alloy with many uses. An analysis is carried out to determine the percentage of copper present in three identical samples of brass. The reactions involved in this analysis are shown below.

$Step\ 1\text{: } Cu(s) + 2HNO_3(aq) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + 2NO_2(g) + 2H_2O(l)\ Step\ 2\text{: } 4I^-(aq) + 2Cu^{2+}($

(a) (i) Deduce the change in the oxidation numbers of copper and nitrogen in step 1.

Copper:

Nitrogen:

(ii) Identify the oxidizing agent in step 1.

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3a. *[4 marks]*

Deduce the balanced chemical equation for the reaction between sodium and sulfur. State the electron arrangements of the reactants and product, and explain whether sulfur is oxidized or reduced.

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3b. *[1 mark]*

Consider the following reaction sequence:

$$\underset{\textbf{A}}{Cr_2O_3(s)} \rightarrow \underset{\textbf{B}}{Na_2CrO_4(aq)} \rightarrow \underset{\textbf{C}}{Cr_2O_7^{2-}(aq)}$$

Describe the redox behaviour of chromium with reference to oxidation numbers in the conversion of **B** to **C**.

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3c. *[2 marks]*

Define the term *oxidizing agent* and identify the oxidizing agent in the following reaction.

$$Cr_2O_7^{2-}(aq) + I^-(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + IO_3^-(aq) + 4H_2O(l)$$

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4a. *[1 mark]*

The element antimony, Sb, is usually found in nature as its sulfide ore, stibnite, Sb_2S_3. This ore was used two thousand years ago by ancient Egyptian women as a cosmetic to darken their eyes and eyelashes.

Deduce the oxidation number of antimony in stibnite.

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4b. *[1 mark]*

Deduce **one** other common oxidation number exhibited by antimony in some of its compounds.

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4c. *[2 marks]*

One method of extracting antimony from its sulfide ore is to roast the stibnite in air. This forms antimony oxide and sulfur dioxide. The antimony oxide is then reduced by carbon to form the free element.

Deduce the chemical equations for these **two** reactions.

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5a. *[1 mark]*

Chromium is a typical transition metal with many uses.

Distinguish between the terms *oxidation* and *reduction* in terms of oxidation numbers.

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5b. *[2 marks]*

State the names of Cr_2O_3 and CrO_3.

Cr_2O_3:

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CrO_3:

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5c. *[1 mark]*

Define the term *oxidizing agent*.

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5d. *[3 marks]*

$Cr_2O_7^{2-}(aq)$ and $I^-(aq)$ ions react together in the **presence of acid** to form $Cr^{3+}(aq)$ and $IO_3^-(aq)$ ions. Deduce the balanced chemical equation for this redox reaction and identify the species that acts as the oxidizing agent.

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6a. *[3 marks]*

Nitrogen monoxide may be removed from industrial emissions via a reaction with ammonia as shown by the equation below.

$$4NH_3(g) + 6NO(g) \rightarrow 5N_2(g) + 6H_2O(l)$$

Deduce the oxidation number of the nitrogen in the reactants and product.

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6b. *[3 marks]*

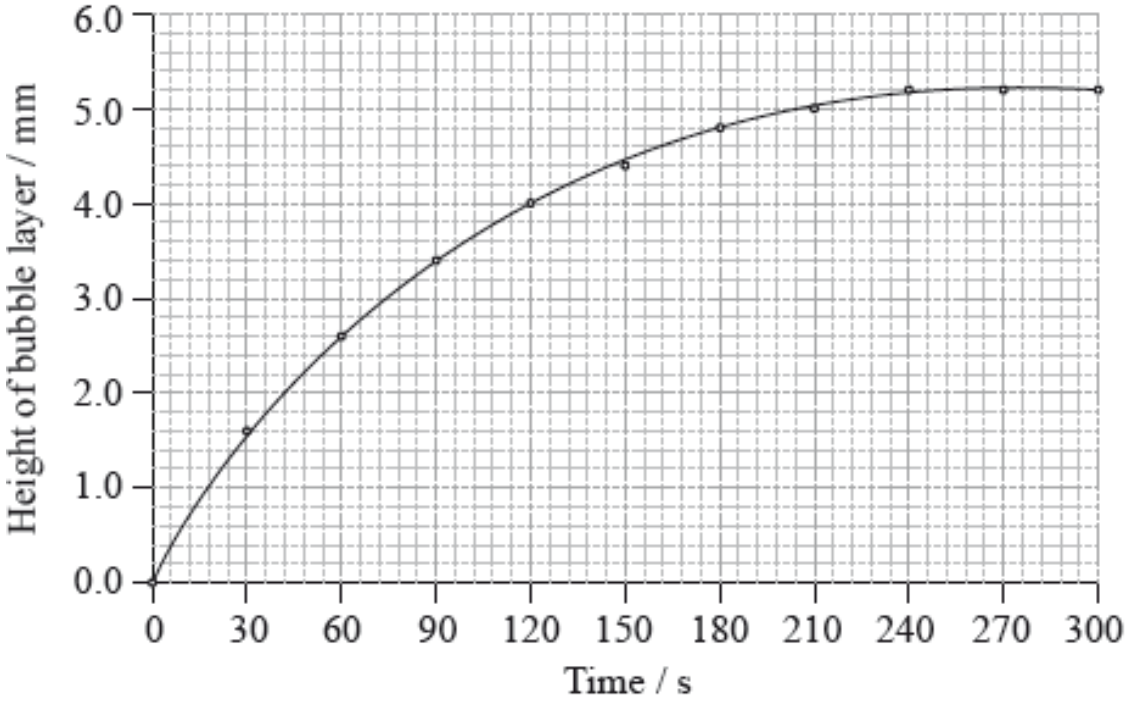
Deduce the oxidation and reduction half-equations and identify the oxidizing agent for the reaction.

7. *[4 marks]*

Hydrogen peroxide, $H_2O_2(aq)$, releases oxygen gas, $O_2(g)$, as it decomposes according to the equation below.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

50. 0 cm^3 of hydrogen peroxide solution was placed in a boiling tube, and a drop of liquid detergent was added to create a layer of bubbles on the top of the hydrogen peroxide solution as oxygen gas was released. The tube was placed in a water bath at 75 °C and the height of the bubble layer was measured every thirty seconds. A graph was plotted of the height of the bubble layer against time.



The decomposition of hydrogen peroxide to form water and oxygen is a redox reaction.

(i) Deduce the oxidation numbers of oxygen present in each of the species below.

Species	Oxidation number of oxygen
H_2O_2	
H_2O	
O_2	

(ii) State two half-equations for the decomposition of hydrogen peroxide.

Oxidation:

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Reduction:

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8a. *[1 mark]*

Ethanedioic acid (oxalic acid), $(COOH)_2$, reacts with acidified potassium permanganate solution, $KMnO_4$, according to the following equation.

$$5(COOH)_2(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 10CO_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$$

The reaction is a redox reaction.

Define *oxidation* in terms of electron transfer.

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8b. *[2 marks]*

Calculate the change in oxidation numbers of carbon and manganese in 8a..

Carbon:

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Manganese:

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8c. *[1 mark]*

Identify the oxidizing and reducing agents.

Oxidizing agent:

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Reducing agent:

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9. *[1 mark]*

Ethanedioic acid (oxalic acid), $(COOH)_2$, reacts with acidified potassium permanganate solution, $KMnO_4$, according to the following equation.

$$5(COOH)_2(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow 10CO_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$$

The reaction is a redox reaction.

Deduce the half-equation involving ethanedioic acid.

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10. *[1 mark]*

Iron is a transition metal.

Deduce the oxidation number of iron in $[Fe(CN)_6]^{3-}$.

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11. *[5 marks]*

Iron rusts in the presence of oxygen and water. Rusting is a redox process involving several steps that produces hydrated iron(III) oxide, $Fe_2O_3 \bullet nH_2O$, as the final product.

The half-equations involved for the first step of rusting are given below.

Half-equation 1: $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

Half-equation 2: $O_2(aq) + 4e^- + 2H_2O(l) \rightarrow 4OH^-(aq)$

(i) Identify whether half-equation 1 represents oxidation or reduction, giving a reason for your answer.

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(ii) Identify the oxidation number of each atom in the three species in half-equation 2.

$O_2(aq) + 4e^- + 2H_2O(l) \rightarrow 4OH^-(aq)$

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(iii) Deduce the overall redox equation for the first step of rusting by combining half-equations 1 and 2.

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(iv) Identify the reducing agent in the redox equation in part (iii).

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