O Level Pure Chemistry Structured

Redox Test 1.0

Q1

A6 Oxides of nitrogen in the upper atmosphere cause damage to the ozone layer.

Nitrogen monoxide, NO, damages the ozone layer by reacting with ozone in a two-step reaction.

$$NO + O_3 \rightarrow NO_2 + O_2 \quad \text{step 1}$$
$$NO_2 + O_3 \rightarrow NO + 2O_2 \quad \text{step 2}$$

(a) Use oxidation states to identify which element is **oxidised** in step 1.

element ....

change in oxidation state .... [2]

Q2

The ethanol concentration in wine can be determined by titrating a known volume of wine with a solution of acidified potassium manganate (VII). The ionic equation for the reaction is

$$4\ MnO_4^-\ (aq) + 5\ C_2H_5OH\ (aq) + 12\ H^+\ (aq) \rightarrow 4\ Mn^{2+}\ (aq) + 5\ CH_3COOH\ (aq) + 11\ H_2O\ (l)$$

i. State the colour change of acidified potassium manganate (VII) in this reaction. [1]

....

ii. Explain, using oxidation state, why the manganate (VII) ion is reduced in this reaction. [2]

....

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Q3

The information below is about the extraction of zinc.

The method of extraction of zinc has changed, as different ores containing the element have been discovered, and as technology has improved.

Extraction Process 1

In the earliest process, calamine (impure zinc carbonate) was heated with charcoal in earthenware pots. This two-stage process gives a low yield of zinc.

$$ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$$

$$ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$$

Extraction Process 2

A new two-stage process was developed using zinc sulfide ores. All of the waste gases from this process were released into the atmosphere.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

$$ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$$

Extraction Process 3

This uses the electrolysis of aqueous solutions of very pure zinc sulfate. The first step in this process is the same as the first step in Extraction Process 2. The second step uses sulfuric acid made from SO_2 collected in the first step. The third step involves the electrolysis of zinc sulfate solution to form pure zinc.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

$$ZnO(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2O(g)$$

$$ZnSO_4(aq) \rightarrow Zn(s) \quad \text{[electrolysis]}$$

The electrolysis of zinc sulfate solution can be carried out by using graphite or zinc as anode. When zinc is used, the anode needs to be replaced frequently.

(a) **(i)** Identify one equation that represents a redox equation.

.... [1]

(ii) Explain, in terms of oxidation states, why the equation identified in **(a)(i)** is a redox reaction.

....

....

.... [2]

Q4

Lead white is basic lead(II) carbonate. It is a complex salt, containing both carbonate and hydroxide ions. It has the chemical formula $Pb_2CO_3(OH)_2$. It can be considered to be made up of two compounds, $PbCO_3$ and $Pb(OH)_2$.

Lead white has been the principal white pigment used in classical European oil painting. It is believed that lead white reacts with trace amounts of hydrogen sulfide, H_2S, in the air to produce black lead(II) sulfide. This causes the old paintings to darken over time. Treating the darkened painting with hydrogen peroxide causes the black lead(II) sulfide to be oxidised to lead(II) sulfate which is white in colour. This restores the paintings to their original colour.

(a) Write the chemical equation to show the reaction of lead(II) carbonate with hydrogen sulfide to produce lead(II) sulfide.

....[1]

(b) The chemical equation shows the reaction between lead(II) sulfide and hydrogen peroxide.

.....PbS + ...H_2O_2 → .....$PbSO_4$ + ...H_2O

Hydrogen peroxide acts as an oxidising agent in this reaction.

(i) Balance the chemical equation by writing down the appropriate numbers in blanks where necessary. [1]

(ii) Explain, using ideas about oxidation states, why hydrogen peroxide is considered to be an oxidising agent in this reaction.

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....[4]

Q5

Hydrogen peroxide (H_2O_2) has an interesting chemistry. It can function as an oxidizing agent and reducing agent in different solutions. The equations below illustrate this ability.

Reaction 1: H_2O_2 is reduced to form H_2O

$2KI(aq) + H_2O_2(aq) + H_2SO_4(aq) \rightarrow I_2(aq) + K_2SO_4(aq) + 2H_2O(l)$

Reaction 2: H_2O_2 is oxidised to form O_2

$2KMnO_4(aq) + 5H_2O_2(aq) + 3H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 5O_2(g) + 2MnSO_4(aq) + 8H_2O(l)$

(a) Draw a 'dot and cross' diagram to show the bonding in a molecule of hydrogen peroxide. Show only the valence electrons.

[2]

(b) (i) Give the oxidation states of Mn in $KMnO_4$ and $MnSO_4$ in **Reaction 2**.

In $KMnO_4$: ....[1] In $MnSO_4$: ....[1]

(ii) Hence, explain whether **Reaction 2** is a redox reaction in terms of oxidation state.

....

....[2]

(c) Describe **all** observations that would help you to identify the function of hydrogen peroxide if **Reactions 1** and **2** are both carried out in the laboratory.

....

....

....[3]

Answers

Redox Test 1.0

Q1

(a) Nitrogen [1]; from +2 (in NO) to +4 (in NO_2) [1] [2]

Q2

)i	**Purple to colourless**	1
)ii	**The oxidation state of manganese decreases in the reaction from +7 in MnO_4^- to +2 in Mn^{2+}.** **[Award 1 m only if at least one of the oxidation states is correct]**	1 1

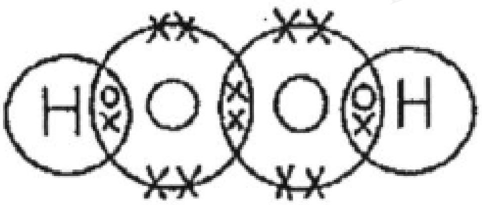
Q3

(a)	**(i)**	ZnO (s) + C (s) → Zn (s) + CO (g) **or** 2ZnS (s) + $3O_2$ (g) → 2ZnO(s) +$2SO_2$ (g)	1
	(ii)	<u>ZnO (s) + C (s) → Zn (s) + CO (g)</u> Oxidation state of zinc <u>decreases from +2 in ZnO to 0 in Zn</u>. Hence, ZnO is reduced. Oxidation state of carbon <u>increases from 0 in carbon to + 2 in CO</u>. Hence, C is oxidised. (Accept 2+ or +2) OR <u>2ZnS (s) + $3O_2$ (g) → 2ZnO(s) +$2SO_2$ (g)</u> Oxidation state of sulfur <u>increases from -2 in ZnS to +4 in SO_2</u>. Hence, ZnS is oxidised. Oxidation state of oxygen <u>deceases from 0 in O_2 to -2 in ZnO (or SO_2)</u>. Hence, oxygen is reduced.	1 1 1 1

Q4

(a)		$PbCO_3 + H_2S \rightarrow PbS + CO_2 + H_2O$ *The 2 products, carbon dioxide and water are correctly deduced. [1]*
(b)	(i)	$PbS + \underline{4}H_2O_2 \rightarrow PbSO_4 + \underline{4}H_2O$
	(ii)	During the reaction hydrogen peroxide oxidises PbS to $PbSO_4$. This can be seen in the increase in oxidation of state of sulfur from -2 in PbS, to +6 in $PbSO_4$. *Identify the oxidation of PbS to $PbSO_4$ – [1]* *Oxidation states of S before and after the reaction are correctly calculated – [1]* During the reaction, hydrogen peroxide itself is reduced. This can be seen in the decrease in the oxidation state of oxygen from -1 in H_2O_2, to -2 in H_2O. *Identify the reduction of H_2O_2 to H_2O – [1]* *Oxidation states of O before and after the reaction are correctly calculated – [1]*

Q5

(a)		 Correct bonding [1], electronic configuration [1] Award only if covalent bonding is shown.
(b)	(i)	+7 [1]; +2 [1]
	(ii)	Oxidation state of manganese decreases from +7 to +2, thus it is reduced. [1] Oxidation state of oxygen increases from -1 to 0, thus it is oxidised. [1] Therefore it is a redox reaction.
(c)		If KI changes from colourless to brown, H_2O_2 is acting as an oxidising agent. [1] If $KMnO_4$ decolourises // changes from purple to colourless [1], and a gas that relights/ rekindles a glowing splint// effervescence [1] is formed, H_2O_2 is acting as a reducing agent. Max 2m if function of hydrogen peroxide is not stated.