

# 6. Electrochemistry

## 6.1 Redox processes

### Paper 2

#### Question Paper

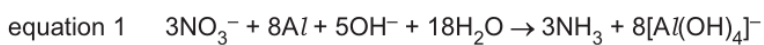
- 1 (c) Solid magnesium nitride,  $\text{Mg}_3\text{N}_2$ , is a crystalline solid.
- (i) Deduce the oxidation numbers of magnesium and nitrogen in magnesium nitride to complete Table 2.1.

Table 2.1

	oxidation number in $\text{Mg}_3\text{N}_2$
magnesium	
nitrogen	

[1]

- 2 (b) A common test for nitrates is the reaction with  $\text{NaOH}$  and  $\text{Al}$ . Equation 1 shows the reaction.



- (i) Deduce the oxidation state of nitrogen in  $\text{NO}_3^-$ .

..... [1]

- (ii) Identify the species that is oxidised in equation 1.

..... [1]

- 3 Potassium chlorate,  $\text{KClO}_3$ , is widely used as an oxidising agent and to make  $\text{O}_2(\text{g})$ .

- (a) Define oxidising agent.

.....  
 ..... [1]

- (c) When  $\text{KClO}_3$  is heated without a catalyst,  $\text{KClO}_4$  and  $\text{KCl}$  form.



Explain why this reaction is described as a disproportionation reaction.

.....  
 ..... [1]

- 4 (b)** When magnesium is heated in air, magnesium oxide, MgO, is the major product. Smaller amounts of magnesium nitride, Mg<sub>3</sub>N<sub>2</sub>, are also made.

- (i) Calculate the oxidation number for magnesium and for the nitrogen species in Mg<sub>3</sub>N<sub>2</sub> to complete Table 1.1.

**Table 1.1**

species	magnesium in Mg <sub>3</sub> N <sub>2</sub>	nitrogen in Mg <sub>3</sub> N <sub>2</sub>
oxidation number		

[1]

- (ii) Identify the type of reaction which takes place between magnesium and nitrogen. Explain your answer.

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- (iii) Define enthalpy change of formation.

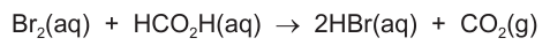
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- (iv) When 3.645 g of Mg(s) burns in excess N<sub>2</sub>(g) to form Mg<sub>3</sub>N<sub>2</sub>(s), 23.05 kJ of energy is released.

Calculate the enthalpy change of formation,  $\Delta H_f$ , of Mg<sub>3</sub>N<sub>2</sub>. Show your working.

$$\Delta H_f (\text{Mg}_3\text{N}_2) = \dots\dots\dots [3]$$

- 5** Aqueous bromine reacts with methanoic acid to form hydrogen bromide and carbon dioxide gas.



The table shows the oxidation numbers of bromine and carbon in the species involved in this reaction.

	Br in Br <sub>2</sub>	C in HCO <sub>2</sub> H	Br in HBr	C in CO <sub>2</sub>
oxidation number	0	+2	-1	+4

- (a) Identify the oxidising agent in this reaction. Explain your reasoning with reference to oxidation numbers.

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..... [1]

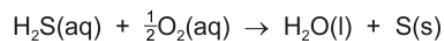
- (b) Suggest one change you would observe, ignoring temperature changes, when bromine reacts with methanoic acid.

..... [1]

**6** Sulfides are compounds that contain sulfur but not oxygen.

(c) Hydrogen sulfide gas,  $\text{H}_2\text{S}(\text{g})$ , is slightly soluble in water. It acts as a weak acid in aqueous solution.

(iii)  $\text{H}_2\text{S}(\text{aq})$  reacts slowly with oxygen dissolved in water. The reaction is represented by the following equation.

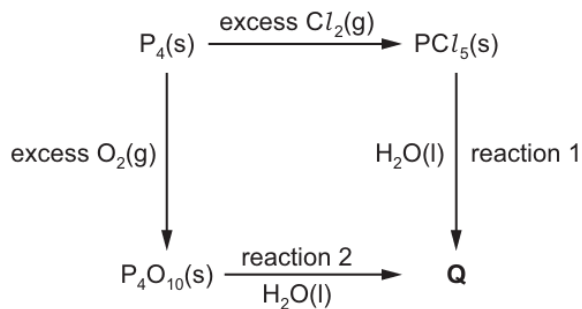


Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

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 ..... [2]

**7** Phosphorus is a reactive Period 3 element.

(b) Some reactions of  $\text{P}_4(\text{s})$  are shown in the reaction scheme.



(i) State the oxidation number of phosphorus in  $\text{P}_4\text{O}_{10}$ .

..... [1]

**8** Hydrogen iodide, HI, is a colourless gas at room temperature.

**(d)** HI reacts with oxygen to form iodine and water.

**(i)** Construct an equation for the reaction of HI with oxygen.

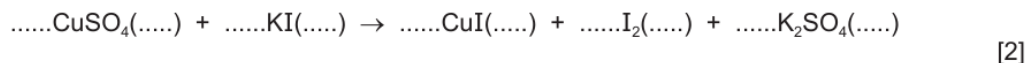
..... [1]

**(ii)** Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

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 .....  
 ..... [2]

**9 (a)** The equation shown in **(a)(i)** describes the reaction which occurs when aqueous potassium iodide is added to aqueous copper(II) sulfate. A white precipitate of copper(I) iodide forms in a brown solution of iodine and potassium sulfate.

**(i)** Balance the equation and include state symbols.



The table gives the oxidation numbers of iodine in the different species in the equation.

iodine-containing species	oxidation number of iodine
KI	-1
CuI	-1
I <sub>2</sub>	0

**(ii)** Deduce the oxidation number of copper in CuSO<sub>4</sub> and CuI.

- oxidation number of copper in CuSO<sub>4</sub> .....
- oxidation number of copper in CuI .....

[1]

**(iii)** Describe the type of reaction shown by the equation in **(a)(i)**. Explain your answer in terms of electron transfer.

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 ..... [2]

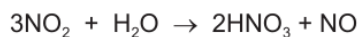
**10** Nitric acid can be made in a 3-stage process.

**Stage 1** Ammonia is oxidised by oxygen from the air, to form nitrogen monoxide and water. This reaction is carried out at 10–13 atmospheres pressure and 900 °C in the presence of a platinum catalyst.

**Stage 2** Nitrogen monoxide reacts with more oxygen to form nitrogen dioxide.



**Stage 3** Nitrogen dioxide reacts with water to make nitric acid and nitrogen monoxide.



(c) (i) In the boxes, give the oxidation numbers of nitrogen in the nitrogen-containing species for the reaction in stage 3.



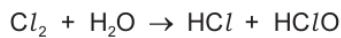
[2]

(ii) Explain why the reaction in stage 3 is described as a disproportionation reaction. Include reference to transfer of electrons in your answer.

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.....  
..... [2]

**11** Period 3 elements react with chlorine gas,  $Cl_2(g)$ , to form chlorides.

(b)  $Cl_2(g)$  dissolves in cold water and reacts with it.



(i) Identify the oxidation number of chlorine in each of the chlorine-containing species in this reaction.

chlorine-containing species	$Cl_2$	$HCl$	$HClO$
oxidation number of chlorine			

[2]

(ii) Name the type of reaction occurring.

..... [1]

**12** (a) Chlorine can be prepared using the following reaction.



(i) Explain why  $MnO_2(s)$  is described as an oxidising agent in this reaction.

Refer to oxidation numbers in your answer.

.....  
 ..... [1]