

Redox

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Redox
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: 65 minutes

Score: /54

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 (a) State and explain the variation in the oxidation numbers of the chlorides of the elements Na, Mg, Al and Si.

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..... [2]

- (b) Describe the reaction of phosphorus(V) chloride with water, and write an equation for the reaction.

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..... [2]

- (c) When microwave radiation is passed through phosphorus(III) chloride, PCl_3 , at low pressure, a new chloride of phosphorus, **B**, is formed. **B** contains 69.6% by mass of chlorine and 30.4% by mass of phosphorus, and its M_r is approximately 200.

- (i) Calculate the empirical and molecular formulae of **B**.

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- (ii) Assuming phosphorus and chlorine show their typical valencies, draw the displayed formula of **B**, showing all bonds and lone pairs.

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- (iii) Calculate the oxidation number of phosphorus in **B**.

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- (iv) One mole of **B** reacts with four moles of water. Suggest the structure of the phosphorus-containing product of this reaction.

.....

[6]

[Total: 10]

2 (a) Complete the electronic configurations of the following ions.

Cr³⁺: 1s²2s²2p⁶.....

Mn²⁺: 1s²2s²2p⁶.....

[2]

(b) Both KMnO₄ and K₂Cr₂O₇ are used as oxidising agents, usually in acidic solution.

(i) Use information from the *Data Booklet* to explain why their oxidising power increases as the [H⁺(aq)] in the solution increases.

.....
.....
.....

(ii) What colour changes would you observe when each of these oxidising agents is completely reduced?

- KMnO₄ from to
- K₂Cr₂O₇ from..... to

[4]

(c) Manganese(IV) oxide, MnO₂, is a dark brown solid, insoluble in water and dilute acids. Passing a stream of SO₂(g) through a suspension of MnO₂ in water does, however, cause it to dissolve, to give a colourless solution.

(i) Use the *Data Booklet* to suggest an equation for this reaction, and explain what happens to the oxidation states of manganese and of sulfur during the reaction.

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(ii) The pH of the suspension of MnO₂ is reduced. Explain what effect, if any, this would have on the extent of this reaction.

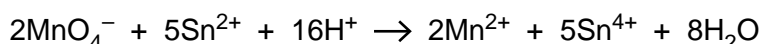
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[4]

- (d) The main ore of manganese, pyrolusite, is mainly MnO_2 . A solution of SnCl_2 can be used to estimate the percentage of MnO_2 in a sample of pyrolusite, using the following method.
- A known mass of pyrolusite is warmed with an acidified solution containing a known amount of SnCl_2 .
 - The excess $\text{Sn}^{2+}(\text{aq})$ ions are titrated with a standard solution of KMnO_4 .

In one such experiment, 0.100 g of pyrolusite was warmed with an acidified solution containing $2.00 \times 10^{-3} \text{ mol Sn}^{2+}$. After the reaction was complete, the mixture was titrated with $0.0200 \text{ mol dm}^{-3} \text{ KMnO}_4$, and required 18.1 cm^3 of this solution to reach the end point.

The equation for the reaction between $\text{Sn}^{2+}(\text{aq})$ and $\text{MnO}_4^{-}(\text{aq})$ is as follows.



- (i) Use the *Data Booklet* to construct an equation for the reaction between MnO_2 and Sn^{2+} ions in acidic solution.

.....

- (ii) Calculate the percentage of MnO_2 in this sample of pyrolusite by the following steps.

- number of moles of MnO_4^{-} used in the titration
- number of moles of Sn^{2+} this MnO_4^{-} reacted with
- number of moles of Sn^{2+} that reacted with the 0.100 g sample of pyrolusite
- number of moles of MnO_2 in 0.100 g pyrolusite. Use your equation in (i).
- mass of MnO_2 in 0.100 g pyrolusite
- percentage of MnO_2 in pyrolusite

percentage =%

[6]

[Total: 16]

3 The alkali metals are a series of six elements in Group I of the Periodic Table. The first ionisation energy of these elements shows a marked trend as the Group is descended.

(a) Define the term *first ionisation energy*.

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..... [2]

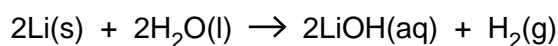
(b) (i) State and explain the trend in first ionisation energy as Group I is descended.

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(ii) Suggest how this trend helps to explain the increase in the reactivity of the elements as the Group is descended.

.....
..... [3]

(c) In a redox reaction, 0.83 g of lithium reacted with water to form 0.50 dm³ of aqueous lithium hydroxide.



(i) Calculate the amount, in moles, of lithium that reacted.

(ii) Calculate the volume of hydrogen produced at room temperature and pressure.

(iii) Calculate the concentration, in mol dm^{-3} , of the LiOH(aq) formed.

[5]

(d) When heated in chlorine, all of the alkali metals react to form the corresponding chloride.

Describe what you see when sodium is heated in chlorine and write a balanced equation for the reaction.

description

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.....
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equation

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[2]

[Total: 12]

- 4 Sulfur and its compounds are found in volcanoes, in organic matter and in minerals. Sulfuric acid, an important industrial chemical, is manufactured from sulfur by the Contact process.

The Contact process may be considered to be a three-stage process in which sulfur is converted into sulfuric acid. Each stage consists of a single chemical reaction.

- (a) Write a balanced equation for **each** of these reactions **in the correct sequence**. Where appropriate, use \rightleftharpoons to indicate that the reaction is an equilibrium.

first reaction

second reaction

third reaction [4]

- (b) Give **three** different operating conditions that are used in the **second** stage.

condition 1

condition 2

condition 3 [3]

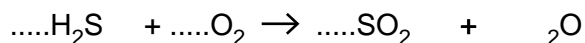
- (c) State **one** large scale use of sulfuric acid.

..... [1]

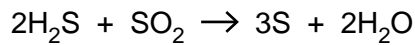
- (d) Most of the sulfur that is used in the Contact process is recovered from sulfur compounds present in crude oil and natural gas by using the Claus process.

- (i) In this process, about one third of the hydrogen sulfide, H_2S , present in the oil or gas, is converted into sulfur dioxide, SO_2 .

Balance the equation for this reaction.



- (ii) The SO₂ formed is then reacted catalytically with the remaining H₂S, producing sulfur and water.



What are the oxidation numbers of each of the sulfur-containing substances in this reaction?

H₂S..... SO₂ S

Which substance is reduced? Explain your answer.

substance

explanation [3]

The sulfur present in crude oil is removed in order to prevent the formation of sulfur dioxide when fuels such as petrol (gasoline) or diesel fuel are burned in internal combustion engines.

Other substances that may be present in the exhaust gases of motor vehicles include CO, CO₂, NO/NO₂, and unburnt hydrocarbons.

The emission of sulfur dioxide can produce ‘acid rain’.

- (e) (i) Outline, with the aid of equations, how acid rain is formed from the exhaust gases of motor vehicles.

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- (ii) State **one** environmental effect of acid rain.

..... [4]

- (f) Sulfur dioxide is used to preserve dried fruits and vegetables.

What chemical property of SO₂ enables it to be used as a food preservative?

..... [1]

[Total: 16]