Redox

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Redox
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Write a balanced equation for the reaction of each of the following chlorides with water.

phosphorus(V) chloride .....

silicon(IV) chloride.....
[2]

(b) When sulfur is heated under pressure with chlorine, the major product is SCl_2 (Cl-S-Cl).

$$S_8(g) + 8Cl_2(g) \longrightarrow 8SCl_2(g)$$

Use data from the *Data Booklet* to calculate the enthalpy change, ΔH, for this reaction. The eight sulfur atoms in the S_8 molecule are all joined in a single ring by single bonds.

ΔH = ...kJ mol^{-1}
[2]

(c) Under suitable conditions, SCl_2 reacts with water to produce a yellow precipitate of sulfur and a solution **A**. Solution **A** contains a mixture of SO_2(aq) and compound **B**.

(i) What is the oxidation number of sulfur in SCl_2?.....

(ii) Work out how the oxidation number of sulfur changes during the reaction of SCl_2 with water.

.....

.....

(iii) Suggest the identity of compound **B**. .....

(iv) Construct an equation for the reaction between SCl_2 and water.

.....

(v) What would you observe when each of the following reagents is added to separate samples of solution **A**?

$AgNO_3$(aq).....

$K_2Cr_2O_7$(aq) .....
[7]

[Total: 11]

2 The elements of the third period of the Periodic Table form chlorides of general formula ECl_x where *E* represents the element. These chlorides show a variation in oxidation number from sodium to sulfur.

(a) (i) Use the information given to complete the table below.

formula of chloride	$NaCl$	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3	SCl_2
oxidation number of element in the chloride						

(ii) By considering the electron configurations of the elements, explain the variation in oxidation number in the chlorides from Na to Al and from Si to S.

Na to Al .....

.....

Si to S .....

.....

[5]

Sodium hydride, NaH, is a colourless crystalline solid which melts at 800 °C and has the same crystal structure as sodium chloride which has a melting point of 808 °C. When molten sodium chloride is electrolysed using graphite electrodes, a shiny deposit, **D**, forms on the cathode and a greenish-yellow gas is evolved from the anode. When molten sodium hydride is electrolysed, under suitable conditions using graphite electrodes, the same shiny deposit **D** is formed on the cathode and a colourless gas, **G**, is evolved from the anode.

(b) (i) Describe with the aid of a diagram the bonding in a sodium chloride crystal.

(ii) Suggest the type of bonding that is present in sodium hydride.

.....

(iii) What is the oxidation number of hydrogen in sodium hydride?

.....

(iv) Draw a 'dot-and-cross' diagram for sodium hydride. Show outer electrons only.

(v) The metals magnesium and aluminium form hydrides with formulae MgH_2 and AlH_3. The non-metals phosphorus and sulfur form hydrides with formulae PH_3 and H_2S.
By considering their positions in the Periodic Table, suggest oxidation numbers for these four elements in their hydrides.

compound	MgH_2	AlH_3	PH_3	H_2S
oxidation number of element in the hydride				

[8]

At room temperature, the chlorides of sodium, magnesium and aluminium are all solids which dissolve in water.
The hydrides of sodium, magnesium and aluminium are also solids which react with water with the rapid evolution of the **same** colourless gas **G** in each case.

(c) (i) What is the pH of the solutions formed when separate samples of sodium chloride, magnesium chloride, and aluminium chloride are dissolved in water?

chloride	sodium	magnesium	aluminium
pH			

(ii) Suggest an equation for the reaction between sodium hydride and water.

.....

(iii) Suggest a value for the pH of the solution formed in **(ii)**.

.....

[4]

At room temperature, the chlorides of silicon, phosphorus and sulfur are all low melting point solids or low boiling point liquids that can be seen to react with water.

(d) (i) Suggest what type of bonding is present in sulfur dichloride, SCl_2.

.....

(ii) Write a balanced equation for the reaction between the chloride of silicon, $SiCl_4$, and water.

..... [2]

[Total: 19]

3 The elements phosphorus, sulphur, and chlorine are regarded as having simple molecular structures.

(a) What are the molecular formulae of **each** of these three elements?

phosphorus .....

sulphur .....

chlorine ..... [3]

(b) **(i)** Place the three elements in order of their melting points **with the highest first**.

highest ..... lowest

(ii) Suggest an explanation for the order you have given in **(i)**.

.....

.....

.....[3]

(c) Sulphur and chlorine can be reacted together to form disulphur dichloride, S_2Cl_2.

Disulphur dichloride, S_2Cl_2, is decomposed by water forming sulphur and a mixture of hydrochloric acid and sulphurous acid.

When 2.7 g of S_2Cl_2 is reacted with an excess of water, 0.96 g of sulphur, S, is produced.

(i) What is the amount, in moles, of S_2Cl_2 present in 2.7 g?

(ii) What is the amount, in moles, of S produced from 1.0 mol of S_2Cl_2?

(iii) Construct a balanced equation for the reaction of S_2Cl_2 with water.

.....

[4]

(d) The reaction between S_2Cl_2 and water is a redox reaction.

Which product has been formed by oxidation and which by reduction?

product formed by oxidation .....

product formed by reduction ..... [2]

[Total: 12]

4 **(a)** What do you understand by the term *standard electrode potential*?

.....

..... [2]

(b) By reference to relevant $E^{\ominus}$ data in the *Data Booklet*, explain how the halogen/halide electrode potentials relate to the relative reactivity of the halogens as oxidising agents.

.....

.....

..... [2]

(c) Use data from the *Data Booklet* to construct redox equations, and calculate the standard cell potentials, for the reactions between

(i) Acidified H_2O_2(aq) and KI(aq),

.....

(ii) Cl_2(aq) + SO_2(aq).

.....

[4]

(d) Use data from the *Data Booklet* to predict the likely product of the reaction between I_2(aq) and tin metal, writing a balanced equation for the reaction.

..... [2]

[Total: 10]

5 **(a)** Write down what you would see, and write equations for the reactions that occur, when silicon(IV) chloride and phosphorus(V) chloride are separately mixed with water.

silicon(IV) chloride

.....

.....

phosphorus(V) chloride

.....

.....
[4]

(b) Iron(III) chloride, $FeCl_3$, is used to dissolve unwanted copper from printed circuit boards (PCBs) by the following reaction.

$$2FeCl_3(aq) + Cu(s) \rightarrow 2FeCl_2(aq) + CuCl_2(aq)$$

A solution in which $[Fe^{3+}(aq)]$ was originally equal to $1.50\,mol\,dm^{-3}$ was re-used several times to dissolve copper from the PCBs, and was then titrated as follows.

A $2.50\,cm^3$ sample of the partially-used-up solution was acidified and titrated with $0.0200\,mol\,dm^{-3}$ $KMnO_4$.
This oxidised any $FeCl_2$ in the solution back to $FeCl_3$.
It was found that $15.0\,cm^3$ of $KMnO_4(aq)$ was required to reach the end point.

(i) Construct an ionic equation for the reaction between Fe^{2+} and MnO_4^- in acid solution.

.....

(ii) State here the $Fe^{2+} : MnO_4^-$ ratio from your equation in **(i)**. .....

(iii) Calculate the number of moles of MnO_4^- used in the titration.

(iv) Calculate the number of moles of Fe^{2+} in $2.50\,cm^3$ of the partially-used-up solution.

(v) Calculate the $[Fe^{2+}]$ in the partially-used-up solution.

(vi) Calculate the mass of copper that could still be dissolved by 100 cm^3 of the partially-used-up solution.

mass of copper = ... g
[6]

(c) When $SiCl_4$ vapour is passed over Si at red heat, Si_2Cl_6 is formed. Si_2Cl_6 contains a Si-Si bond.
The reaction of Si_2Cl_6 and Cl_2 re-forms $SiCl_4$.

$$Si_2Cl_6(g) + Cl_2(g) \rightarrow 2SiCl_4(g)$$

Use bond energy data from the *Data Booklet* to calculate $\Delta H^{\ominus}$ for this reaction.

$\Delta H^{\ominus}$ = ... $kJ\,mol^{-1}$
[2]

(d) Calcium forms three calcium silicides, Ca_2Si, CaSi and $CaSi_2$. The first of these reacts with water as follows.

$$.....Ca_2Si + ...H_2O \rightarrow .....Ca(OH)_2 + ...SiO_2 + ...H_2$$

(i) Balance this equation. You may find the use of oxidation numbers helpful.

(ii) During this reaction, state

which element(s) have been oxidised, ...

which element(s) have been reduced. .....
[2]

[Total: 14]