Atoms, Molecules & Stoichiometry

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Atoms, Molecules & Stoichiometry
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: **69 minutes**

Score: **/57**

Percentage: **/100**

Grade Boundaries:

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

1 **(a)** Atoms and ions of elements are made up from the three subatomic particles, protons, electrons and neutrons, in varying amounts.

Complete the following table to show the number of each particle in $^{14}C^{2-}$.

	protons	electrons	neutrons
$^{14}C^{2-}$			

[2]

(b) Describe the observations you would make during the reactions, if any, of the following chlorides with water.
Write equations for any reactions that occur.

CCl_4 observation .....

.....

equation .....

$GeCl_4$ observation .....

.....

equation .....

$SnCl_4$ observation .....

.....

equation .....

[4]

(c) Suggest a reason for any difference in the reactivities of the chlorides given in **(b)**.

.....

..... [1]

(d) Use data from the *Data Booklet* to explain why an aqueous solution of $SnCl_2$ reacts with Cl_2(g) but an aqueous solution of $PbCl_2$ does not.

Write an equation for the reaction.

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.....

..... [3]

(e) State the relationship between the Faraday constant and the Avogadro constant.

..... [1]

(ii) When a current of 1.2 A was passed through dilute sulfuric acid for 30 minutes, it was found that 130 cm^3 of oxygen, measured at 25 °C and 1 atm, was collected at the anode. The following reaction takes place.

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

Use these data and data from the *Data Booklet* to calculate a value for the Avogadro constant, *L*, by calculating

- the number of moles of oxygen produced,
- the number of moles of electrons needed for this,
- the number of coulombs passed,
- the number of electrons passed,
- the number of electrons in one mole of electrons (*L*).

L = ... mol^{-1}
[4]

[Total: 15]

2 Chile saltpetre is a mineral found in Chile and Peru, and which mainly consists of sodium nitrate, $NaNO_3$. The mineral is purified to concentrate the $NaNO_3$ which is used as a fertiliser and in some fireworks.

In order to find the purity of a sample of sodium nitrate, the compound is heated in NaOH(aq) with Devarda's alloy which contains aluminium. This reduces the sodium nitrate to ammonia which is boiled off and then dissolved in acid.

$$3NaNO_3(aq) + 8Al(s) + 5NaOH(aq) + 18H_2O(l) \rightarrow 3NH_3(g) + 8NaAl(OH)_4(aq)$$

The ammonia gas produced is dissolved in an excess of H_2SO_4 of known concentration.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

The amount of unreacted H_2SO_4 is then determined by back-titration with NaOH of known concentration.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) A 1.64 g sample of impure $NaNO_3$ was reacted with an excess of Devarda's alloy.
The NH_3 produced was dissolved in 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4.
When all of the NH_3 had dissolved, the resulting solution was titrated with NaOH(aq).
For neutralisation, 16.2 cm^3 of 2.00 mol dm^{-3} NaOH were required.

(i) Calculate the amount, in moles, of H_2SO_4 present in the 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4.

(ii) Calculate the amount, in moles, of NaOH present in 16.2 cm^3 of 2.00 mol dm^{-3} NaOH.

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of H_2SO_4 that reacted with 16.2 cm^3 of 2.00 mol dm^{-3} NaOH.

(iv) Use your answers to **(i)** and **(iii)** to calculate the amount, in moles, of H_2SO_4 that reacted with the NH_3.

(v) Use your answer to **(iv)** to calculate the amount, in moles, of NH_3 that reacted with the H_2SO_4.

(vi) Use your answer to **(v)** to calculate the amount, in moles, of $NaNO_3$ that reacted with the Devarda's alloy.

(vii) Hence calculate the mass of $NaNO_3$ that reacted.

(viii) Use your answer to **(vii)** to calculate the percentage by mass of $NaNO_3$ present in the impure sample.
Write your answer to a suitable number of significant figures.

[9]

(b) The above reaction is an example of a redox reaction.
What are the oxidation numbers of nitrogen in $NaNO_3$ and in NH_3?

$NaNO_3$ ..... NH_3 ..... [1]

[Total: 10]

3 When 0.42 g of a gaseous hydrocarbon **A** is slowly passed over a large quantity of heated copper(II) oxide, CuO, **A** is completely oxidised.

The products are collected and it is found that 1.32 g of CO_2 and 0.54 g of H_2O are formed. Copper is the only other product of the reaction.

(a) (i) Calculate the mass of carbon present in 1.32 g of CO_2.

Use this value to calculate the amount, in moles, of carbon atoms present in 0.42 g of **A**.

(ii) Calculate the mass of hydrogen present in 0.54 g of H_2O.

Use this value to calculate the amount, in moles, of hydrogen atoms present in 0.42 g of **A**.

(iii) It is thought that **A** is an alkene rather than an alkane.

Use your answers to **(i)** and **(ii)** to deduce whether this is correct.

Explain your answer.

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..... [5]

(b) Analysis of another organic compound, **B**, gave the following composition by mass: C, 64.86%; H, 13.50%, O, 21.64%.

(i) Use these values to calculate the empirical formula of **B**.

(ii) The empirical and molecular formulae of **B** are the same.

B is found to be chiral.

Draw displayed formulae of the two optical isomers of this compound, indicating with an asterisk (*) the chiral carbon atom.

(iii) There are three other structural isomers of **B** which are not chiral but which contain the same functional group as **B**.

In the boxes below, draw the structural formulae of these isomers.

[7]

[Total: 12]

4 **(a)** Chemists recognise that atoms are made of three types of particle.

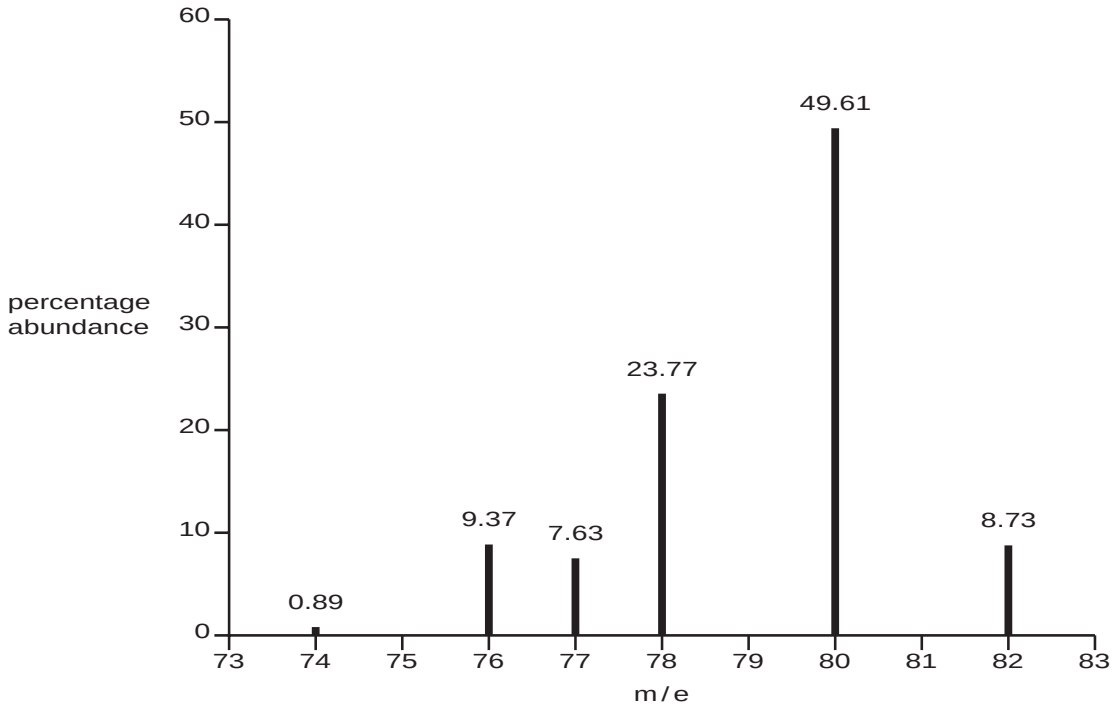
Complete the following table with their names and properties.

name of particle	relative mass	relative charge
		0
	1/1836	

[3]

(b) The relative atomic mass of an element can be determined using data from its mass spectrum.

The mass spectrum of element **X** is shown, with the percentage abundance of each isotope labelled.



(i) Define the terms *relative atomic mass* and *isotope*.

relative atomic mass .....

.....

.....

isotope .....

.....

[3]

(ii) Use the data in the mass spectrum to calculate the relative atomic mass, A_r, of **X**.
Give your answer to **two** decimal places and suggest the identity of **X**.

A_r of **X** .....

identity of **X** ..... [2]

(c) The element tellurium, Te, reacts with chlorine to form a single solid product, with a relative formula mass of 270. The product contains 52.6% chlorine by mass.

(i) Calculate the molecular formula of this chloride.

molecular formula ..... [3]

(ii) This chloride melts at 224 °C and reacts vigorously with water.

State the type of bonding **and** structure present in this chloride and explain your reasoning.

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.....

.....

..... [2]

(iii) Suggest an equation for the reaction of this chloride with water.

..... [1]

(d) Sodium and silicon also react directly with chlorine to produce the chlorides shown.

chloride	melting point / °C	difference between the electronegativities of the elements
NaCl	801	2.2
$SiCl_4$	–69	1.3

(i) Describe what you would **see** during the reaction between sodium and chlorine.

.....

.....

..... [2]

(ii) Explain the differences between the melting points of these two chlorides in terms of their structure **and** bonding. You should refer to the difference between the electronegativities of the elements in your answer.

NaCl structure **and** bonding .....

.....

$SiCl_4$ structure **and** bonding .....

.....

explanation .....

.....

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..... [4]

[Total: 20]