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CHEMISTRY

OCR AS & A LEVEL

Topic Questions

Module 2: Foundatons in chemistry

1 Sulfur, atomic number 16, is found within the Earth's crust. Sulfur is released into the atmosphere at times of volcanic activity.

A sample of sulfur from a volcano was analysed to give the following composition of isotopes.

isotope	abundance (%)
^{32}S	95.0
^{33}S	0.76
^{34}S	4.22

(a) Define the term *relative atomic mass*.

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

(b) Calculate the relative atomic mass of the sample of sulfur.

Give your answer to **two** decimal places.

answer = ... **[2]**

(c) John Dalton, an early 19th century scientist, believed that elements were made up of tiny particles called atoms which could not be divided. Nowadays, chemists know of the existence of sub-atomic particles in atoms and in ions.

Complete the table to show the number of sub-atomic particles in the ^{33}S atom and $^{34}S^{2-}$ ion.

	protons	neutrons	electrons
^{33}S			
$^{34}S^{2-}$			

[2]

(d) Solid sulfur exists as a lattice of S_8 molecules. Each S_8 molecule is a ring of eight atoms.

How many atoms of sulfur are there in 0.0120 mol of S_8 molecules?

answer = ... atoms **[2]**

(e) The only intermolecular forces in solid sulfur are van der Waals'.

(i) Describe how van der Waals' forces arise.

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

(ii) Suggest why there are **no** other intermolecular forces in solid sulfur.

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

(f) Sodium thiosulfate is a compound of sulfur used to develop photographs.

Hydrated sodium thiosulfate has the formula $Na_2S_2O_3 \cdot 5H_2O$.

What is the oxidation number of sulfur in $Na_2S_2O_3 \cdot 5H_2O$?

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

(g) A student heats 12.41 g of hydrated sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$, to remove the water of crystallisation. A white powder called anhydrous sodium thiosulfate forms.

(i) What does the term *anhydrous* mean?

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

(ii) What is the relative formula mass of $Na_2S_2O_3 \cdot 5H_2O$?

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

(iii) Calculate the expected mass of anhydrous sodium thiosulfate that forms.

mass = ... g **[2]**

(h) Sulfur hexafluoride, SF_6, exists as non-polar covalent molecules with an octahedral shape.

(i) Explain why a molecule of SF_6 has an octahedral shape.

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

(ii) Fluorine has a higher electronegativity than sulfur, yet SF_6 molecules are non-polar.

Explain what is meant by the term *electronegativity* and suggest why SF_6 molecules are non-polar.

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

2 Chlorine and its compounds have wide uses in chemistry.

(a) In drinking water, HC*l*O kills bacteria.

(i) Write an equation to show how HC*l*O can form in drinking water.

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

(ii) Some scientists believe that chlorine compounds should **not** be present in drinking water.

Suggest **one** reason why scientists may be worried by the presence of these compounds.

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

(b) Chlorine reacts directly with Group 2 elements to form chlorides that are very soluble in water.

Aqueous chloride ions can be detected by adding aqueous silver nitrate.
The appearance of solid silver chloride, AgC*l*, confirms the presence of chloride ions.

(i) State the type of reaction that has taken place.

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

(ii) Write the ionic equation for this reaction.
Include state symbols.

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

(c) A student is given a sample of an unknown Group 2 chloride.

- The student dissolves 2.86 g of the chloride in water.
- The student adds excess aqueous silver nitrate.
- 8.604 g of solid silver chloride, AgC*l*, forms.

(i) Calculate the amount, in moles, of AgC*l* that forms.

The molar mass of AgC*l* = 143.4 g mol^{-1}.

answer = ... mol **[1]**

(ii) Deduce the amount, in moles, of the Group 2 chloride that the student dissolves.

Hence deduce the relative atomic mass and the identity of the Group 2 metal.
Give the relative atomic mass to **one** decimal place.

You **must** show your working.

relative atomic mass = ...

Group 2 metal = ... **[3]**

(d) Ammonium chloride, NH_4Cl, is a salt which has covalent bonding, dative covalent (coordinate) bonding and ionic bonding.

(i) What is a *dative covalent* (*coordinate*) bond?

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

(ii) Give the formulae of the ions present in NH_4Cl.

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

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in NH_4Cl.
Show the outer electrons only.

[2]

(e) A teacher heats potassium chlorate(V), $KClO_3$. The equation is given below.

$$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$$

(i) This is an example of a redox reaction.

What other type of reaction takes place?

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

(ii) The teacher heats 0.824 g of $KClO_3$.

Calculate the volume of oxygen produced, in cm^3, measured at room temperature and pressure.

Give your answer to the **nearest whole number**.

answer = ... cm^3 **[3]**

[Total: 16]

3 Sodium tartrate and copper(II) nitrate are both salts.

(a) Sodium tartrate is a salt of tartaric acid. The formula of tartaric acid can be represented as H_xA. In this formula, x is the number of H^+ ions that can be replaced by metal ions to form salts.

A student carries out a titration to find the value of x in the formula of tartaric acid, H_xA.
In the titration, 25.00 cm^3 of 0.0500 mol dm^{-3} tartaric acid, H_xA, exactly reacts with 12.50 cm^3 of 0.200 mol dm^{-3} sodium hydroxide, NaOH. A solution of sodium tartrate is produced.

(i) Calculate the amount, in mol, of H_xA used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of NaOH used.

amount = ... mol **[1]**

(iii) Deduce the value for x in the formula of tartaric acid, H_xA.

x = ... **[1]**

(b) Copper(II) nitrate is a salt of nitric acid.

(i) A student prepares a solution of copper(II) nitrate, $Cu(NO_3)_2$, by adding, with stirring, an excess of copper(II) oxide to some hot dilute nitric acid.

Construct the equation for this reaction.

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(ii) Copper(II) nitrate has ionic bonding.

What is meant by the term *ionic bonding*?

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

(iii) Explain why a solution of copper(II) nitrate conducts electricity.

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

(iv) What is the oxidation number of nitrogen in $Cu(NO_3)_2$?

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

(c) Hydrated crystals of copper(II) nitrate can be prepared by allowing water to evaporate from a solution of copper(II) nitrate.

Hydrated copper(II) nitrate has the empirical formula $CuN_2O_{12}H_{12}$.

Write the formula of hydrated copper(II) nitrate to show its water of crystallisation.

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

[Total: 9]

4 Chlorine, bromine and iodine are halogens commonly used in school and college experiments.

(a) Halogens have van der Waals' forces between their molecules.

(i) Describe how van der Waals' forces arise.

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

(ii) State **and** explain the trend in the boiling points of chlorine, bromine and iodine.

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

(b) The halogen astatine does **not** exist in large enough quantities to observe any of its reactions.

Why would astatine be expected to react similarly to other halogens?

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

(c) A student investigated the reactivity of halogens by attempting some redox reactions.

(i) The student added bromine water to aqueous solutions of sodium chloride and sodium iodide in separate test-tubes. The student then added an organic solvent, cyclohexane, to each test-tube and these were shaken.

- State what colour you would see in the cyclohexane in each test-tube after shaking.
- Write **ionic** equations for any chemical reactions that take place.
- State and explain the trend in reactivity shown by these observations.

In your answer you should use appropriate technical terms spelled correctly.

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..... **[6]**

(ii) Suggest why the student carried out the reactions in a well ventilated area.

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

(d) The halogen fluorine is too reactive to use in a school or college laboratory. Fluorine is a powerful oxidising agent. It will react with water as shown below.

(i) Complete and balance the equation for the reaction of fluorine with water.

$F_2(g)$ + $_2O(l)$ → ..... + $_2(g)$ **[1]**

(ii) Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

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

(e) Fluorine will react violently with gallium to produce gallium fluoride.

Mendeleev originally called gallium 'eka-aluminium' as he predicted that gallium would have similar properties to aluminium.

(i) Complete the electron structure of the gallium atom.

$1s^2$ ..... **[1]**

(ii) Use Mendeleev's prediction to suggest the empirical formula of gallium fluoride.

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

[Total: 19]