Chlorides of Sulfur

A Level

Sulfur and chlorine can react together to form S_2Cl_2. When $1.00\,g$ of this sulfur chloride reacted with water, $0.36\,g$ of a yellow precipitate was formed, together with a solution containing a mixture of sulfurous acid, H_2SO_3, and hydrochloric acid.

Part A Reaction with water

Use the above data to deduce the equation for the reaction between S_2Cl_2 and water. Balance it by using the lowest possible integer coefficients and include state symbols.

Part B Neutralisation

What volume of $1.00\,mol\,dm^{-3}$ sodium hydroxide would be required to neutralise the final solution?

Adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 1, Question 6.

Periods 1-3

A Level

This question refers only to the elements in the first three periods ($\mathrm{H}-\mathrm{Ar}$) of the Periodic Table.

Identify an element that, at room temperature and pressure,

Part A $2-$ **ion**

forms a $2-$ ion with the same electronic configuration as neon.

Part B $2+$ **ion**

forms a $2+$ ion with an electronic configuration of $1\mathrm{s}^2\ 2\mathrm{s}^2\ 2\mathrm{p}^6$.

Part C $\mathrm{X}_4\mathrm{O}_{10}$

reacts with oxygen forming an oxide $\mathrm{X}_4\mathrm{O}_{10}$.

Part D **Giant molecular oxide**

forms an oxide with a giant molecular structure.

Part E $\mathrm{XO_3}$

forms an oxide $\mathrm{XO_3}$ that gives a strongly acidic solution in water.

Part F **Trigonal planar fluoride**

forms a trigonal planar fluoride.

Part G $\mathrm{XCl_4}$

forms a chloride $\mathrm{XCl_4}$, $M_r = 153.8$.

Adapted with permission from UCLES, A-Level Science, June 1996, Chemistry Foundation, Question 1.

Ionisation of Elements

A Level

The table below shows the first five ionisation energies of five elements in the same group of the Periodic Table.

		Element	Ionisation Energy / $\mathrm{kJ\,mol^{-1}}$				
			1st	2nd	3rd	4th	5th
Increasing proton (atomic) number	↓	A	1090	2350	4610	6220	37830
		B	786	1580	3230	4360	16090
		C	762	1540	3300	4390	6970
		D	707	1410	2940	3930	6970
		E	716	1450	3080	4080	6640

Part A Group

In which group of the Periodic Table are the elements found?

Part B Ionisation of Na

Write an equation, with state symbols, to define the first ionisation energy of Na.

Part C Decrease in ionisation energy

Why does the first ionisation energy of the element tend to show a decrease down the table?

- Electronegativity decreases.
- Lattice energy decreases.
- Hydration energy decreases.
- Electrons are being removed from higher energy shells.
- Electron affinity decreases.
- The effective nuclear change experienced by the electron decreases down the group.

Part D A^{2+}

Calculate the energy change of:

$$A\,(\mathrm{g}) \longrightarrow A^{2+}\,(\mathrm{g}) + 2\,\mathrm{e}^{-}\,(\mathrm{g})$$

Part E E^{2+}

Calculate the energy change of:

$$E\,(\mathrm{g}) \longrightarrow E^{2+}\,(\mathrm{g}) + 2\,\mathrm{e}^{-}\,(\mathrm{g})$$

Part F A bonding

What sorts of bond would you expect A to form?

Adapted with permission from UCLES, A-Level Chemistry, December 1995, Paper 3, Question 3.

Iodate Ions

A Level

Each Group 2 element forms an iodate(V) with the formula $M(IO_3)_2$.

Part A Structure of iodate ion

Use the structure editor to draw the structure of the iodate(V) ion.

Enter your answer as a SMILES string.

Part B Decomposition

These iodates readily decompose on heating.

Write a likely equation (including state symbols) for the decomposition of $Mg(IO_3)_2$, balancing it so as to use the lowest possible integer coefficients.

Adapted with permission from UCLES, A-Level Chemistry, June 1990, Special Paper, Question 5.

Al and Fe

A Level

Aluminium, Al, and iron, Fe, are both metallic elements. However, their compounds show significant differences in their properties. For example, aluminium compounds are usually colourless and they contain the metal in only one oxidation state. In contrast, most iron compounds are coloured and the metal can be present in a variety of oxidation states.

Part A Al configuration

What is the ground-state electron configuration of Al?

Items:

[Ne] [Ar] [Kr] [Xe] 3s 4s 3p 3d 4p 1 2 3 4 5 6

Part B Fe configuration

What is the ground-state electron configuration of Fe?

Items:

[Ne] [Ar] [Kr] [Xe] 3s 4s 3p 3d 4p 1 2 3 4 5 6

Part C Al oxidation state

What is the only non-zero oxidation state observed for aluminium?

Part D Oxidation states of Fe

What are the two commonly found non-zero oxidation states for Fe?

- [ ] +1
- [ ] +2
- [ ] +3
- [ ] +4
- [ ] +6
- [ ] +7
- [ ] +8

Part E Maximum oxidation state of Fe

In theory, what is the highest oxidation state possible for Fe?

Part F Thiocyanate ion

A common test for the presence of Fe ions is the addition of thiocyanate ions, $(\mathrm{SCN})^{-}$. The result is a blood-red colour, caused by the formation of the complex ion $[\mathrm{Fe(SCN)}]^{2+}$.

Using the structure editor, draw a possible structure for the thiocyanate ion. Give your answer as a SMILES string copied from the editor (click the smiley face in the top left of the editor to generate this).

Adapted with permission from OCSEB, STEP Chemistry, June 1995, Question 6.