

Exemplar exam questions – Chapter 4

- 1 a** Explain the following:
- i** the first ionisation energy of chlorine is higher than the first ionisation energy of sodium [2]
 - ii** chlorine has a lower first ionisation energy than fluorine [2]
 - iii** a chloride ion is larger than a chlorine atom. [2]
- b** Explain whether the following will conduct electricity when molten:
- i** sodium chloride [2]
 - ii** silicon chloride. [2]

Higher Level only

- c** Write an equation for the reaction of phosphorus(V) chloride with water and suggest whether the resulting solution is acidic, alkaline or neutral. [2]
- d** Explain why a solution of CoCl_2 in water is coloured. [3]
- e** Explain what colour you would expect a solution of ScCl_3 to be. [2]

Commentary

It is not necessary to write in full sentences and very often bullet points convey the information better than full sentences.

- a** Model answers:
- i** Sodium and chlorine are in the same period and so have the same number of shells of electrons. Therefore they have approximately the same amount of shielding of the outer electrons from inner shells. [1]
Chlorine has a higher nuclear charge (17+) than sodium (11+) and therefore the outer electron is more strongly attracted to the nucleus. [1]
 - ii** Chlorine is a larger atom than fluorine [1]
and therefore the outer electron is further from the nucleus and less strongly attracted by the nucleus. [1]
 - iii** A chlorine atom and a chloride ion have the same nuclear charge [1]
a chloride ion has one more electron and therefore there is more electron–electron repulsion for the same attractive forces from the nucleus, therefore the electron cloud expands. [1]
- b** This question requires explanation and is also worth 4 marks, so it is not enough just to state whether they conduct electricity or not. It is always, however, better to state this specifically in the answer.
- i** Molten sodium chloride conducts electricity. [1]
Sodium chloride is an ionic compound and the molten salt contains mobile ions. [1]

The word ‘ions’ is essential and there should be no mention of electrons here.

ii Molten silicon chloride does not conduct electricity. [1]

Silicon chloride is a covalent molecular compound and only SiCl_4 molecules are present in the liquid state – there are no mobile ions or free electrons. [1]

c An equation always refers to a **symbol** equation and not a word equation. Equations must always be balanced. The question does not state that state symbols are required, so it is probably better to leave them out. Generally, except for questions about energetics (where they are essential) or they are specifically required in a question, it is better to leave state symbols out rather than get them wrong!

Model answer:



The reaction produces phosphoric(V) acid and hydrochloric acid and therefore the resulting solution is acidic. [1]

d There are several points that could be made, and it is sometimes difficult to know exactly what the marks are to be awarded for. In these cases it is OK to write down extra points as long as they are all correct. Any points that are incorrect are, however, likely to be penalised.

This model answer contains five relevant points. It is probably safer to write all of these down, even though the question is only worth three marks:

Co^{2+} has a partially filled d subshell

in the complex ion the d orbitals are split into two groups

a certain frequency of visible light is absorbed

to promote an electron from the lower set of d orbitals to the higher set

the complementary colour is transmitted

e Here it is important to show that you understand the principles and show the examiner that you have all the required knowledge. Again in this answer, more points have been included as it is not clear where the marks will be awarded.

Sc^{3+} has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$ and therefore has no d electrons.

As Sc^{3+} does not have a partially filled d subshell, electrons cannot be promoted between d orbitals and it cannot absorb visible light.

Therefore, ScCl_3 is colourless.