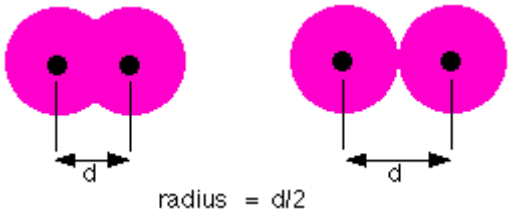
ATOMIC AND IONIC RADIUS

1. These diagrams are copied directly from the web page:



The van der Waals radius is measured from the distance between two oxygen atoms which are just touching each other, with no more than van der Waals attractions between them – as in the right-hand diagram.

The covalent radius is worked out from the left-hand diagram, by measuring the distance between the two nuclei, and dividing the result by 2. The shared electrons are attracted to both nuclei, and pull them together. That means that a covalent radius is bound to be smaller than a van der Waals radius.

2. The simple answer is that as you go down the Group, you are adding extra layers of electrons, and so the radii are bound to increase.

However, in an exam (depending on how many marks were available), you might want to look at this more deeply. As you go from Li (2,1) to Na (2,8,1), for example, you are adding 8 more protons to the nucleus as well as the 8 extra electrons. Why doesn't the extra attraction from the nucleus make the radius smaller?

This, of course, is because the 3-level electron in the sodium (the electron on the outside which defines the radius) is screened from the 8 extra protons by the 8 extra electrons. The only important thing is therefore that 3-level electrons are found further from the nucleus than 2-level ones, and so the atom must be bigger.

This is a good example of where you need to look carefully at how many marks are being given for a question. In UK-based exams, you tend to get 1 mark for each bit of information that you give.

If there is only 1 mark, then "You are adding extra layers of electrons, and so the radii are bound to increase." is enough – it contains 1 fact (the extra layers of electrons). However, if there are 2 or 3 marks, then you have to give more explanation. The extra mark or marks can only be given if you have added enough extra relevant information.

On Chemguide, I keep on and on about checking past papers and mark schemes. It is an essential part of your learning process if you are aiming at a particular exam.

3. a) Apart from the noble gases, the radii of all the other atoms are measured when they are combined – either as a metallic radius or a covalent radius. At this level, data books often just give van der Waals radii for the noble gases – even for those (such as Xe) which do form covalent compounds.

You can't make any meaningful comparison if you try to include both types of radii ("squashed" and "unsquashed").

b) In each of these atoms, the outer electrons are in the 3-level, and are screened by the 1- and 2-level electrons. So the screening is the same for them all. But the number of protons on the nucleus is increasing as you go across the period. The outer electrons are pulled closer to the nucleus by the greater attractions.

4. The radius of the atoms is defined by the 4s electrons. For each proton that is added to the nucleus, there is an additional 3d electron which is on average closer to the nucleus than the 4s. The effect of the extra protons is more or less screened by the extra 3d electrons.

5. a) Isoelectronic means that the ions have the same number of electrons in the same arrangement. All of these have the structure 2,8.

   b) They are all 2,8,8

   c) Since the electronic structures are the same within both sets, the outer electrons must have identical screening. As you go from Na^+ to Mg^{2+} to Al^{3+}, the number of protons in the nucleus increases and so pulls the outer electrons in more and more. The same thing is true for the other set of ions as well.

   d) They have an extra layer of electrons. The ones on the left are 2,8; those on the right are 2,8,8.

6. Make life easier by first sorting them into Periodic Table order:

   N^{3-} O^{2-} F^- Na^+ Mg^{2+} Al^{3+}

   These are all isoelectronic with the structure 2,8.

   The smallest ion will be the one with the largest number of protons – Al^{3+}; the biggest, the one with the least protons – N^{3-}.

   Smallest to biggest:

   Al^{3+} Mg^{2+} Na^+ F^- O^{2-} N^{3-}