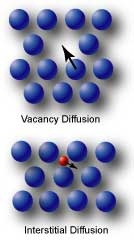
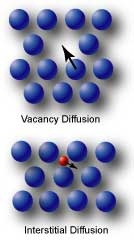
Statement: Nitrogen diffuses rapidly through ion whereas chromium does not.  
  
Answer: In order to prove that this statement partially correct, mechanisms of diffusion for nitrogen and chromium will in a first place be described and then alternative ways that could change the usual diffusion rate in these materials are going to be analysed.

Diffusion is the migration of atoms from a region of high concentration to a region of low concentration. There are two main different ways to diffuse in the bulk of a crystal: interstitial diffusion and vacancy diffusion.

Interstitial diffusion is considered first. As shown in the figure 1[[1]](#footnote-2), for any possible crystal material, there is always space between atoms of the lattice.

  
Figure 1: interstitial diffusion

In order to move, atoms have to get a certain amount of energy and also have to fit into the interstitial sites. As a consequence, depending of the size of the atoms diffusing in the material considered, diffusion through the interstices is possible. Furthermore, because of their exceptionally small value of normalized activation energy (Q/RTM), atoms which usually diffuse interstitially through crystals can do it very quickly.

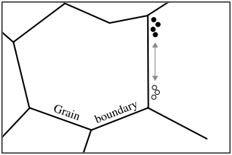
This is what happens for the diffusion of Nitrogen in ferrite for instance. The small nitrogen atoms (65 pm)[[2]](#footnote-3) fit very well in the interstitial sites of the BCC crystal structure ferrite (FIND THE SIZE) their normalized activation energy is very low: atoms can move easily. That explains why nitrogen diffuses rapidly through ion.

On the contrary, compared to nitrogen atoms, the chromium atoms are much bigger: more than twice the size (140 pm)[[3]](#footnote-4). As a consequence they do not fit anymore in the interstitial sites of ion and are force to diffuse by the second mechanism: through vacancies as show figure 21.

Figure 2: Vacancy diffusion

Obviously this mechanism is much slower than the first one detailed in this question because an atom willing to diffuse has to wait for a vacancy or a missing atom in the crystal structure close to him. Also, the bigger the number of vacancies in the material is, the faster the diffusion is. But still, this way of diffusing remains slower than the diffusion through interstices. It explains why generally chromium doesn’t diffuse quickly through ion.

Another way of diffusing through a material, and which only makes this statement partially correct, exists. Indeed sometime, what is called grain boundary diffusion can occur. The gap between grains of a microstructure can sometimes be two atoms wide. As a consequence, the diffusion rate inside theses boundaries can be as much as 106 greater than in the bulk.[[4]](#footnote-5)

  
Figure 3: Grain boundary diffusion

It is interesting in our study to know if chromium could use this way of diffusion through ion. The answer is yes probably. If grains size of ion are small enough (typically by varying the cooling rate of the material while manufactured), and as a consequence the number of the boundaries increased to a certain amount, this mechanism would have an important contribution on the global diffusion rate. Considering this, yes chromium could diffuse also quickly into ion.

As a conclusion it has been proved that the statement is partially correct. Indeed because of the interstitial and vacancy diffusion mechanisms, nitrogen generally diffuses rapidly through ion whereas chromium does not. But grain boundary diffusion could also in particular cases have a significant contribution.

1. http://www.ndt-ed.org/EducationResources/CommunityCollege/Materials/Structure/diffusion.htm, viewed 11 Nov 2008. [↑](#footnote-ref-2)
2. http://en.wikipedia.org/wiki/Nitrogen, viewed 11 Nov 2008. [↑](#footnote-ref-3)
3. http://en.wikipedia.org/wiki/Chromium, viewed 11 Nov 2008. [↑](#footnote-ref-4)
4. Ashby, M. F., Jones D. R., (2005), *Engineering Materials 1*, Butterworth Heinemann, p. 296 [↑](#footnote-ref-5)