

# Course C6: Answer Sheet 1

H. K. D. H. Bhadeshia

- [011] is common to (0 $\bar{1}$ 1) and (2 $\bar{1}$ 1). [12 $\bar{1}$ ] is common to (101) and ( $\bar{1}$ 11). (3 $\bar{1}$ 1) contains [011] and [12 $\bar{1}$ ].
- For carbon at 0,0,0 and  $\frac{1}{4}, \frac{1}{4}, \frac{1}{4}$  centres of symmetry at  $\frac{1}{8}, \frac{1}{8}, \frac{1}{8}$  and  $\frac{5}{8}, \frac{5}{8}, \frac{5}{8}$ . Mirror planes at {110},  $\bar{3}$  parallel to <111>.

$$F_{hkl} = f_{Si} \left\{ 1 + \exp \pi i(h+k) + \exp(\pi i(h+l) + \exp \pi i(k+l) \right\} \left\{ 1 + \exp \frac{\pi i}{2}(h+k+l) \right\}$$

where the first four terms come from the distribution of the four lattice points at 0,0,0;  $\frac{1}{2}, \frac{1}{2}, 0$ ;  $\frac{1}{2}, 0, \frac{1}{2}$ ;  $0, \frac{1}{2}, \frac{1}{2}$ . The second set of terms and the factor  $f_{Si}$  are due to the motif at 0,0,0 and  $\frac{1}{4}, \frac{1}{4}, \frac{1}{4}$ .

Six lowest Bragg reflections are therefore at  $N = 3, 8, 11, 16, 19, 24$  with corresponding Bragg angles of  $14.2^\circ, 23.7^\circ, 28.1^\circ, 34.6^\circ, 38.2^\circ$  and  $44.1^\circ$ .

- Austenite 74.05%, ferrite 68.02%.

Austenite has octahedral interstices at positions such as  $\frac{1}{2}, \frac{1}{2}, \frac{1}{2}$ , tetrahedral interstices at positions such as  $\frac{1}{4}, \frac{1}{4}, \frac{1}{4}$  and  $\frac{3}{4}, \frac{3}{4}, \frac{3}{4}$

Ferrite octahedral interstices at positions such as  $0, 0, \frac{1}{2}$  and  $\frac{1}{2}, \frac{1}{2}, 0$  and tetrahedral interstices at positions such as  $\frac{1}{2}, 0, \frac{1}{4}$ .

One octahedral and 2 tetrahedral interstices per iron atom in austenite; 3 octahedral and 6 tetrahedral interstices per iron atom in ferrite.

If  $r$  is the radius of an iron atom in austenite, the largest sphere fitting in an octahedral interstice is  $(2\sqrt{2} - 2)r = 0.828r$ , and  $(\sqrt{\frac{3}{2}} - 1)r = 0.225r$  for tetrahedral interstices.

If  $r$  is the radius of an iron atom in ferrite, the largest spheres fitting in octahedral interstices are  $(\frac{2}{\sqrt{3}} - 1)r = 0.155r$ , and  $(\sqrt{\frac{5}{3}} - 1)r = 0.291r$  for tetrahedral interstices.

Carbon atoms preferentially occupy octahedral interstices in both austenite and ferrite. This is so for ferrite even though its octahedral interstices fit smaller spheres than tetrahedral, because the former are anisotropic and the location of a misfitting carbon atom causes expansion along just one of the axes of the irregular octahedron, thus giving a lower strain energy than the uniform expansion cause in the tetrahedral hole of ferrite.

The octahedral holes in ferrite are clearly smaller than in austenite, thus the latter has a higher solubility.