Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

covalent, ionic, metallic, covalent chains with van der Waals between them; order: diamond > NaCl > Al > polyethylene; melting only has to separate the chains, which are held by weak van der Waals forces

2.2

$a = \dfrac{4r}{\sqrt{3}} = \mathbf{0.286\ nm}$; $\rho = \dfrac{2 \times 55.85}{(2.864 \times 10^{-8})^3 \times 6.022 \times 10^{23}} = \mathbf{7.90\ g/cm^3}$

2.3

intercepts $\frac{1}{2},\ 1,\ \infty$; reciprocals $2,\ 1,\ 0$; (**210**)

2.4

$\dfrac{N_v}{N} = \exp\!\left(-\dfrac{0.90}{8.617 \times 10^{-5} \times 1273}\right) = \mathbf{2.7 \times 10^{-4}}$; $N_v = \mathbf{2.3 \times 10^{25}\ m^{-3}}$; atoms diffuse by jumping into vacancies, so diffusion speeds up quickly with temperature

3.1

BCC: $\dfrac{a^3}{2} = 0.01227\ \text{nm}^3$; FCC: $\dfrac{a^3}{4} = 0.01213\ \text{nm}^3$

change $= \mathbf{-1.2}\%$: iron **shrinks** when it becomes FCC; on cooling it grows again, and uneven change through a thick part causes distortion or cracks

3.2

a dislocation moves one row of bonds at a time, so slip needs far less stress than shearing a whole plane

FCC has 12 slip systems on close-packed planes, where dislocations move easily; in BCC the stress to move a dislocation rises sharply as temperature falls, so it can fracture before it slips

3.3

(a) $d = \dfrac{\lambda}{2\sin\theta} = \dfrac{0.1542}{2\sin 22.35^\circ} = \mathbf{0.2028\ nm}$

(b) $a = d\sqrt{2} = \mathbf{0.287\ nm}$; $\rho = \dfrac{2 \times 55.85}{a^3 N_A} = \mathbf{7.87\ g/cm^3}$; this matches **ferrite**

(c) $d = 0.2090$ nm, $a = d\sqrt{3} = \mathbf{0.362\ nm}$: FCC iron, **retained austenite**; it can change to martensite later and alter the size or crack the weld, so temper it (or treat it below zero) before service

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