Solutions

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

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

2.1

$kd^{-1/2} = 180$ MPa; $d^{-1/2} = 243$ m$^{-1/2}$; $d =$ **17** μ**m**

2.2

$\%\text{CW} = \dfrac{25 - 16}{25} =$ **36**%; strength and hardness rise, ductility falls

2.3

liquid with 32% Ni and solid α with 43% Ni; $W_L = \dfrac{43 - 35}{43 - 32} =$ **0.73**, $W_\alpha =$ **0.27**

2.4

lever rule between 0.76% and 6.70%: $W_{Fe_3C} = \dfrac{1.0 - 0.76}{6.70 - 0.76} =$ **0.040**; it forms on the old austenite grain boundaries, around the pearlite, and makes the steel brittle

3.1

$W_P = \dfrac{0.25 - 0.022}{0.738} =$ **0.31**, proeutectoid ferrite **0.69**

total $\text{Fe}_3\text{C} = \dfrac{0.25 - 0.022}{6.70 - 0.022} =$ **0.034**, total ferrite **0.966**

mostly soft ferrite: ductile and easy to form, so a **car body panel** (a file needs a high-carbon hardened steel)

3.2

solution treat (dissolve Cu), quench (trap it in a supersaturated solid solution), age (fine precipitates form)

fine, closely spaced precipitates pin dislocations best; after the peak they grow and spread apart, so dislocations bow round them: **overageing**

at 200°C diffusion is faster, so fewer, coarser precipitates form and the peak is earlier and lower

3.3

(a) $\sigma_y = 70 + 0.74/\sqrt{2.0 \times 10^{-5}} =$ **235 MPa**; $d^{-1/2} = 446$, $d =$ **5** μ**m**, too fine for normal rolling

(b) $250 + 8.0\,\text{CW} \geq 400$: $\text{CW} \geq$ **18.75**%; $30 - 0.80\,\text{CW} \geq 14$: $\text{CW} \leq$ **20**%; the window is only 1.25% wide

(c) $d_0 = \dfrac{12.0}{\sqrt{1 - 0.194}} =$ **13.4 mm**; not robust: a small error in the drawing takes the bolt out of the window; use a medium-carbon steel, quenched and tempered

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