

Solutions

2.1 C Their heat rate is the same; $\Delta T_i = Q \cdot R_i$ gives 1:3.

Compare the rejected options: 1:1; 3:1; 1:9; Zero in both. Use the stated model and conditions.

2.2 C All in-plane lengths, including the hole boundary, scale by $1 + \alpha \Delta T$; volume scaling is a different quantity.

Compare the rejected options: Shrinks; Stays fixed; Increases by fractional $3\alpha \Delta T$; Must close. Use the stated model and conditions.

2.3 20. $\tau = C/(hA) = 200/10 = 20$ s.

2.4 True. Mechanical strain must cancel positive thermal strain; tensile-signed stress is $-Y\alpha\Delta T$.

3.1 Cooling water to zero releases $mc\Delta T = (0.20)(4200)(40) = 33600$ J. Melting all ice needs $m\ell = (0.050)(334000) = 16700$ J, so all ice melts. Remaining energy heats 0.25 kg water: $T_f = (33600 - 16700)/(0.25 \times 4200) = 16.10$ degrees Celsius. Award cooling budget, melt budget, phase decision, final heat capacity and temperature. If cooling energy were insufficient, final temperature would be zero with some ice left.