36.40 Equal mass flow rates of water and a 50/50 glycol-water mixture with specific heat capacity $0.75\frac{Btu}{lb_m{}^\circ F}$ flow on either side of a shell and tube heat exchanger. Water enters at $90^\circ F$ and the glycol mixture enters at $38^\circ F$. What could be the leaving temperatures of the water and glycol-water mixture, respectively?

A. $74^\circ F$ / $50^\circ F$

B. $74^\circ F$ / $54^\circ F$

C. $78^\circ F$ / $50^\circ F$

D. $78^\circ F$ / $54^\circ F$

Assuming 100% efficiency, all the heat extracted from the water is added to the glycol mixture. Equate the heat transfer for the two sides of the heat exchanger. The mass flow rates are the same and thus cancel out. Derive a ratio of the temperature differentials.

$$\dot{Q}_{water} = \dot{Q}_{glycol}$$

$$(\dot{m}c_p\Delta T)_{water} = (\dot{m}c_p\Delta T)_{glycol}$$

$$c_{p,water}\Delta T_{water} = c_{p,glycol}\Delta T_{glycol}$$

$$\frac{\Delta T_{water}}{\Delta T_{glycol}} = \frac{c_{p,glycol}}{c_{p,water}} = \frac{0.75\frac{Btu}{lb_m{}^\circ F}}{1\frac{Btu}{lb_m{}^\circ F}} = 0.75$$

$$\Delta T_{water} = 0.75 \times \Delta T_{glycol}$$

To validate this result against intution, consider that water has a *greater* specific heat capacity than the glycol mixture, and as such, it will have a *smaller* ΔT. Examine the answer choices and note that only one option produces ΔT values in the correct proportion.

$$\Delta T_{water} = 90^\circ F - 78^\circ F = 12^\circ F$$

$$\Delta T_{glycol} = 54^\circ F - 38^\circ F = 16^\circ F$$

These values make the established relation true. Note there are an infinite number of possible solutions, and without multiple choice options being provided, this problem would be underdefined.

Answer D