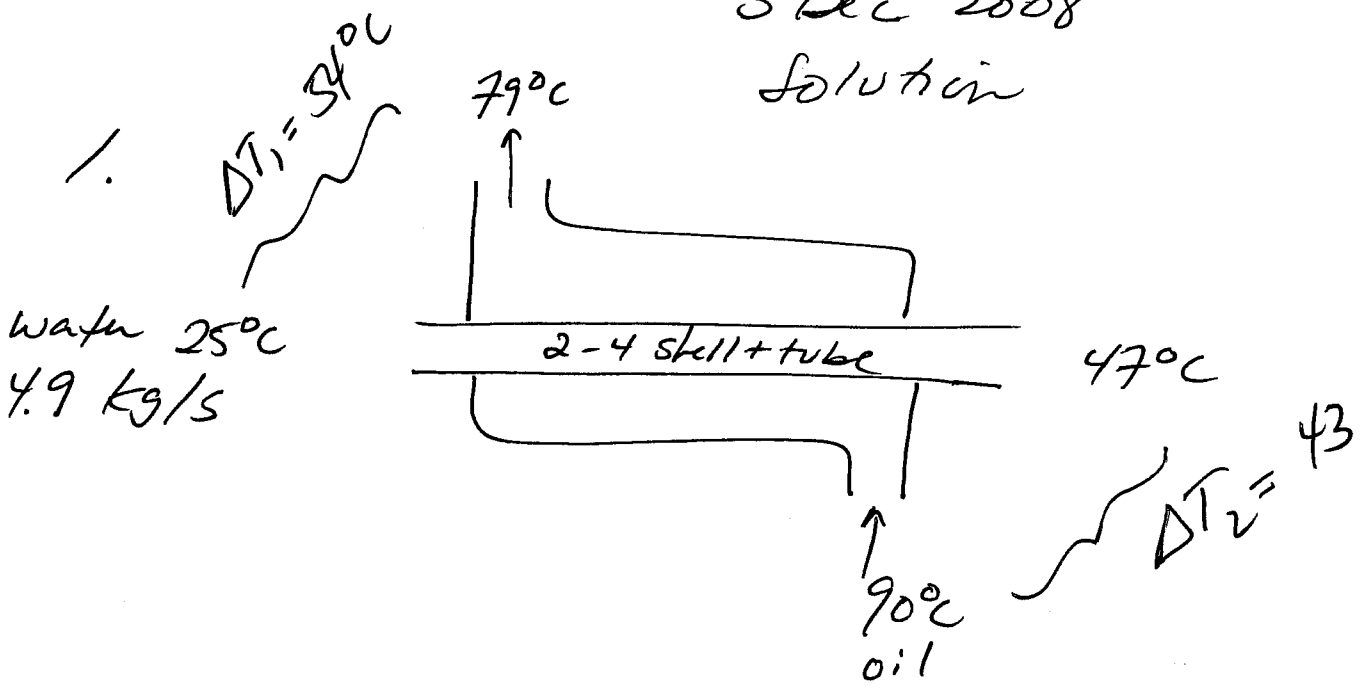
Mini Exam 4
CM3110
3 Dec 2008
solution

1.



@ driving force $= \Delta T_m = F_T \Delta T_{lm}$

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln \frac{\Delta T_1}{\Delta T_2}}$$

$$= \frac{54 - 43}{\ln \frac{54}{43}} = 48.291\ ^\circ C$$

F_T – get from chart page 270 (3rd Ed Geankoplis)

$$Z = \frac{T_{hi} - T_{ho}}{T_{co} - T_{ci}} = \frac{90 - 79}{47 - 25} = 0.5$$

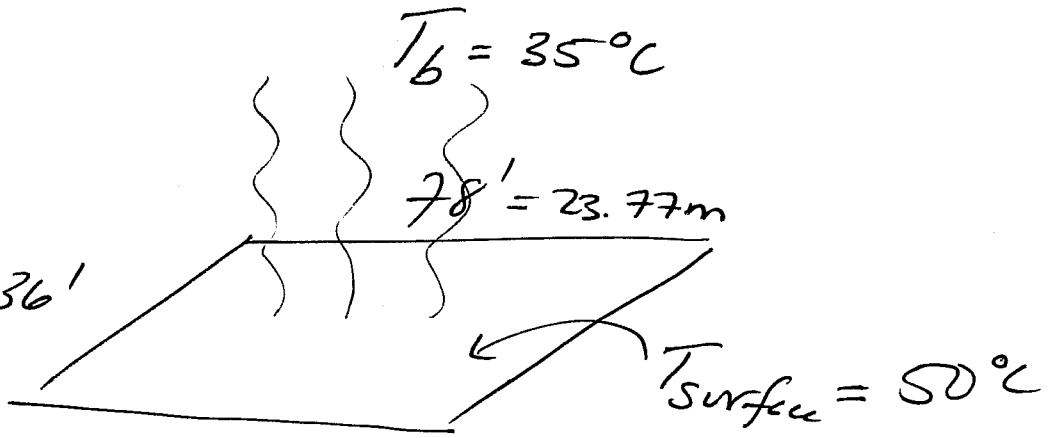
$$Y = \frac{T_{co} - T_{ci}}{T_{hi} - T_{ci}} = \frac{47 - 25}{90 - 25} = 0.338$$

$\Rightarrow \boxed{F_T = 1}$

$$\boxed{\Delta T_m = \Delta T_{lm} = 48^\circ C}$$ //

5. same $\Delta T_m = 48^\circ C$

2.



neglect radiation

$$\Rightarrow \quad q = h A \left(\underbrace{T_{surface} - T_{bulk}}_{15°C} \right)$$

($T_{surface} = 50°C$, $T_{bulk} = 35°C$)

get from correlation

$(10.97m)(23.77m)$

$A = 260.7569\ m^2$

use mean of lengths of 2 sides per Geankoplis p257

$= 17.37m$

$$\frac{hL}{k} = a\, Gr^m Pr^m$$

Natural convection

for horizontal, flat plate

(need Gr Pr first)

Table 4.7-1 Geankoplis 3rd ed.

all physical properties are evaluated at the film temp:

$$T_f = \frac{T_w + T_b}{2} = 42.5^\circ C$$

From table

$$\boxed{Pr = 0.704}$$

$$Gr = \frac{L^3 \rho^2 g \beta \Delta T}{\mu^2}$$

$$= L^3 \Delta T \left(\frac{\rho^2 g \beta}{\mu^2} \right)$$

← in table $1.06 \times 10^8 \frac{1}{K m^3}$

$$= (17.37 m)^3 (15^\circ C)\left(1.06 \times 10^8 \frac{1}{K m^3}\right)$$

$$\boxed{Gr = 8.3329 \times 10^{12}}$$

↑ TOO HIGH, BUT WE'LL ASSUME HIGHER GrPr correlation is OK.

$$(Pr\,Gr) = 5.8644 \times 10^{12}$$

high; use $a = 0.14$
$m = \frac{1}{3}$

$$h = \frac{k}{L} a\, Gr^{\frac{1}{3}} Pr^{\frac{1}{3}}$$

$$= \frac{\left(0.02738 \frac{W}{mK}\right)}{17.37 m} (0.14)(5.8644 \times 10^{12})^{\frac{1}{3}}$$

$$\boxed{h = 3.9800 \frac{W}{m^2 K}}$$

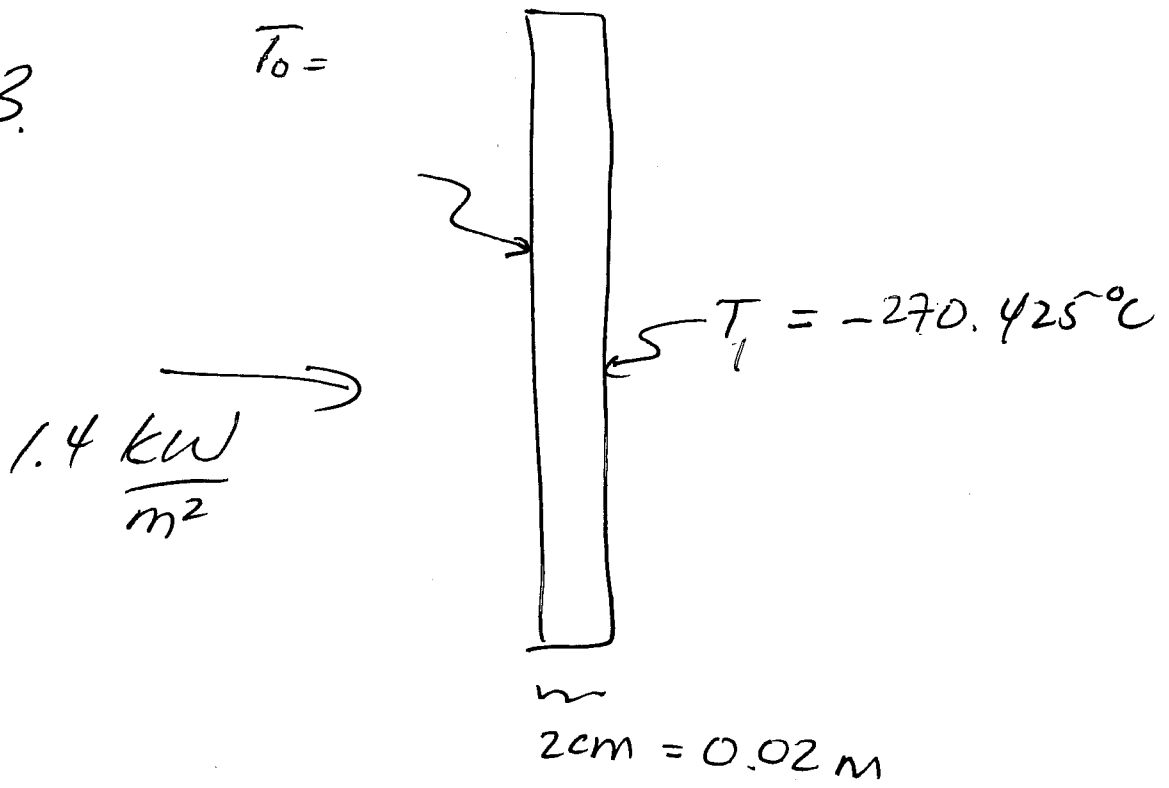
$$q = h A \Delta T$$

$$= \left(\frac{3.98 W}{m^2 K}\right)(260.7569 m^2)(15 K)$$

$$= 15.527 kW = \boxed{16 kW}$$

//

3.



$$\text{const} = \frac{q_x}{A} = -k\frac{dT}{dx}$$

$$\frac{dT}{dx} = -\frac{1}{k}\left(\frac{q_x}{A}\right)$$

$$T = -\frac{1}{k}\left(\frac{q_x}{A}\right)x + C_1$$

BC: $X = .02$ $T = T_1$

$$-270.425^\circ C = \underbrace{-\left(\frac{mK}{54W}\right)\left(\frac{1400\,W}{m^2}\right)(.02m)}_{-0.5185} + C_1$$

$$C_1 = -269.9065^\circ C$$

$$\boxed{T = -\frac{0.5185^\circ C}{m}x - 269.9065^\circ C}$$

at $x = 0$ $T = T_0$

$$\boxed{T = -269.907^\circ C}$$

$$= 3.244\,K \quad //$$