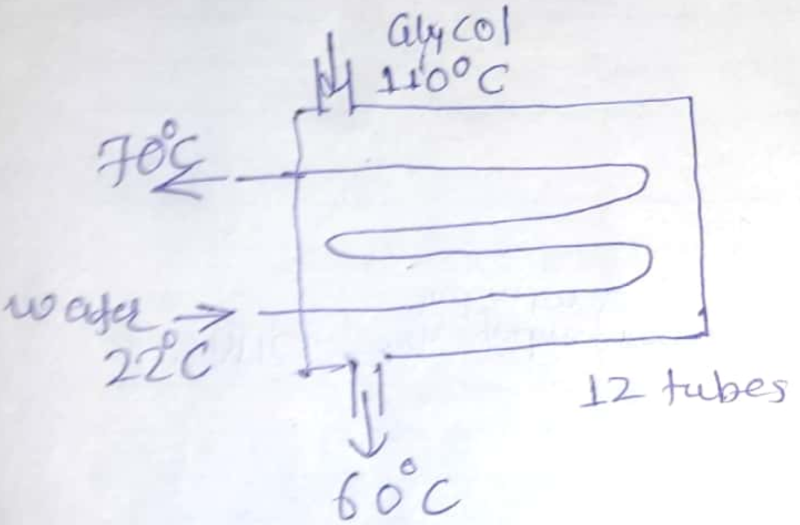
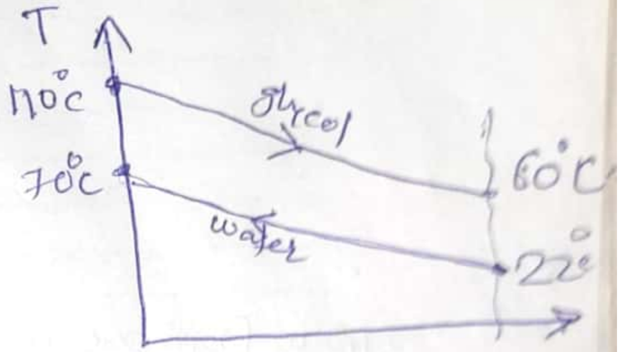
Q.1

Ans → Considering Last ID No-2
for which
mass flow rate of water $\dot{m}_w = 1$ kg/sec

Also given
Overall heat transfer coefficient $U = 280$ W/m^2°C
Specific heat capacity of water $C_{pw} = 4180$ J/kg°C
Specific heat capacity of glycol $C_{pg} = 2680$ J/kg°C





To determine
a) The rate of heat transfer
b) Heat transfer area of the surface.

No. of transfer units

$$NTU = \frac{UA}{C_{min}} \quad -(1)$$

NTU is unknown & can be found out by
finding effectiveness ε &

$$C = \frac{C_{min}}{C_{max}}.$$

Heat capacity rates can be found by

$$C_{water} = \dot{m}_c C_{pw} = 1 \times 4180 = 4180 \text{ J/°C s} = 4180 \text{ W/°C}$$

Equating the energy balance relation

$$C_{glycol} = C_{water} \frac{(T_{wo} - T_{wi})}{(T_{gi} - T_{go})} = 4180 \times \frac{48}{50}$$

$$C_{glycol} = 4012.8 \text{ W/°C}$$

$$C_{min} = C_{glycol} = 4012.8 \text{ W/°C}$$

$$\therefore \quad C = \frac{4012.8}{4180} = 0.96$$

Heat transfer rate

$$Q = \dot{m}_w C_{pw} (\Delta T)_{water}$$

$$= 1 \times 4180 \times (48)$$

$$Q = 200.64 \text{ KJ/sec}$$

$$Q_{max} = C_{min}(T_{hi} - T_{ci}) = 4012.8 \times (110 - 22)$$

$$Q_{max} = 353.126 \text{ KJ/sec}$$

$$\therefore \text{ effectiveness } (\varepsilon) = \frac{Q}{Q_{max}} = \frac{200}{353.126}$$

$$\varepsilon = 0.566$$

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$$(NTU)_{1shell} = -(1+C^2)^{-1/2} \ln\left(\frac{E-1}{E+1}\right)$$

$$E = \frac{2/\varepsilon_1 - (1+C)}{(1+C^2)^{1/2}}$$

$$(NTU)_{2shell} = \text{no.of shell} \times (NTU)_{1shell}$$

$$\varepsilon_1 = \frac{F-1}{F-C} \quad ; \quad F = \left(\frac{\varepsilon C-1}{\varepsilon-1}\right)^{1/n}$$

$$\therefore \quad F = \left(\frac{0.566 \times 0.96 - 1}{0.566-1}\right)^{1/2} = (1.0521)^{1/2}$$

$$F = 1.0257$$

$$\varepsilon_1 = \left(\frac{1.0257-1}{1.0257-0.96}\right) = 0.3914$$

$$E = \frac{\left(\frac{2}{0.3914}\right) - (1+0.96)}{(1+0.96^2)^{1/2}} = \frac{3.15}{1.386}$$

$$= 2.27$$

$$(NTU)_{1shell} = -(1+0.96^2)^{-1/2} \ln\left(\frac{2.27-1}{2.27+1}\right)$$

$$= 0.6822$$

$$(NTU)_{2shell} = 2 \times 0.6822 = 1.364$$

From equn (1)

$$A = \frac{(NTU)_{2\,Shell} \times C_{min}}{U}$$

$$= \frac{1.364 \times 4012.8}{280}$$

$$A = 19.55\ m^2$$

$\therefore$ Heat transfer area of surface

$$\boxed{A = 19.55\ m^2}$$

Heat transfer rate

$$Q = \varepsilon\, C_{min} \left(T_{glycol\ inlet} - T_{water\ inlet} \right)$$

$$\boxed{Q = 200.64\ \text{watt}}$$