Task 2

Find the net radiative heat exchange between the surface 1 and 2 where $A_1 = 1.5m^2$, $\epsilon_1 = \epsilon_2 = 0.1$, $T_1 = 298\,K$, $T_2 = 308\,K$, $\sigma = 5.67 \times 10^{-8}\ \frac{W}{m^2K^4}$.
Solution:

According to the formula,

$$\dot{Q}_{net_{2-1}} = \frac{A\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_2} + \frac{1}{\epsilon_1} - 1}$$

By introducing the values mentioned in the question into the formula,

$$\dot{Q}_{net_{2-1}} = \frac{1.5m^2 \times \left(5.67 \times 10^{-8}\ \frac{W}{m^2K^4}\right) \times \left(308^4 - 298^4\right)K^4}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \approx 4.9823\,W$$

Meanwhile, under situation, based on the following formula

$$F_{2-1} = \frac{1}{\frac{1}{\epsilon_2} + \frac{1}{\epsilon_1} - 1} = \frac{1}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \approx 0.0526$$

So, when $F_{1-2} = 0.01$,

$$\dot{Q}_{net_{1-2}} = AF_{1-2}\sigma(T_2^4 - T_1^4)$$

$$= 1.5m^2 \times 0.01 \times \left(5.67 \times 10^{-8}\ \frac{W}{m^2K^4}\right) \times \left(298^4 - 308^4\right)K^4$$

$$\approx -0.9466\,W$$

$$\because\ A_1 = A_2, \quad i.e, \quad \frac{A_1\sigma(T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = -\frac{A_2\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_2} + \frac{1}{\epsilon_1} - 1}$$

$$\therefore\ \dot{Q}_{net_{2-1}} = -\dot{Q}_{net_{1-2}} \approx 0.9466\,W$$

By Comparing the two values of net heat exchange under different situation, we can see that the value of emissivity would greatly affect the radiative heat exchange between the surfaces.