1.1/ Convective Heat Transfer Summary:

Convective Heat Transfer is one of three types of heat transfer. It happens between two moving fluids or a solid and a moving fluid. When there is a difference of temperature between two bodies, the heat is transferred from the hotter to the cooler one, facilitated by the moving of fluid. Generally, the heated fluid will become lighter and move up; the cooled fluid will become heavier and move down. This is because of the difference in density of the fluid in different temperature.

There are two types of convection:

- Natural Convection: happens without external force, only thanks to the difference of fluid density in different temperature mentioned above
- Forced Convection: happens with external force that affect the moving speed of fluid (for example: wind in exterior side of the wall)

Convection Heat Transfer Rate between fluid and a solid surface is proportional to the surface area, the difference of surface temperature and consistent environmental temperature, and heat transfer coefficient (h). It is independent with the material of the surface.

$$\dot{Q} = \Delta TAh$$

1.2/ Explain why increasing the thickness of a single pane glass does not increase the total resistance:

The conduction thermal resistance of a glass panel is minor in comparison to the convection thermal resistance between glass and air (exterior and interior). Glass conduction thermal resistance is proportional with glass thickness, this means increasing the glass thickness can help increase the conduction resistance, but that will not really affect the total resistance.

3/solve the same probelm as that of double pane window with with the air-gap thickness of 13 mm and glass thickness of 6 mm

$$A = \ 0.8 \times 1.5 = 1.2$$

$$R_{glass_1} = R_{glass_2} = \frac{L_{glass}}{\left(K_{glass} \times A\right)} = \frac{0.006}{0.78 \times 1.2} = 0.0064\ ℃/W$$

$$R_{airgap} = \frac{L_{airgap}}{\left(K_{airgap} \times A\right)} = \frac{0.013}{0.026 \times 1.2} = 0.4167 \ ℃/W$$

$$R_{conv_1} = \frac{1}{h_1 A} = \frac{1}{10 \times 1.2} = 0.0833 \ ℃/W$$

$$R_{conv_2} = \frac{1}{h_2 A} = \frac{1}{40 \times 1.2} = 0.0208 \ ℃/W$$

$$R_{total} = R_{conv_1} + R_{conv_2} + 2 \times R_{glass} + R_{airgap}$$
$$= 0.0833 + 0.0208 + 2 \times 0.0064 + 0.4167 = 0.5333 \ ℃/W$$

$Heat\ Transfer\ Rate$:

$$\dot{Q} = \frac{\Delta T}{R_{total}} = \frac{20 - (-10)}{0.5333} = 56.3\ W$$

$Inner\ Surface\ Temperature$:

$$\dot{Q} = \frac{T_{\infty 1} - T_{s_1}}{R_{conv_1}} = 56.3 = \frac{20 - T_{s_1}}{0.0833} \rightarrow T_{s_1} = 15.3℃$$

The reason of optimal class distance:

Below a certain number, increasing the class distance will help increase the thermal conduction resistance of the air layer, thus increase R_{total} of the whole system. Over that number, the resistance will not increase or even decrease because convection begins to take place in the air layer.