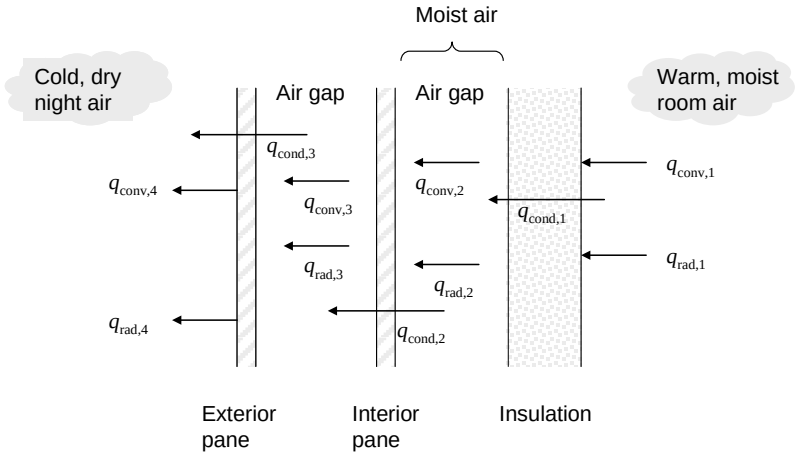
PROBLEM 1.62(c)

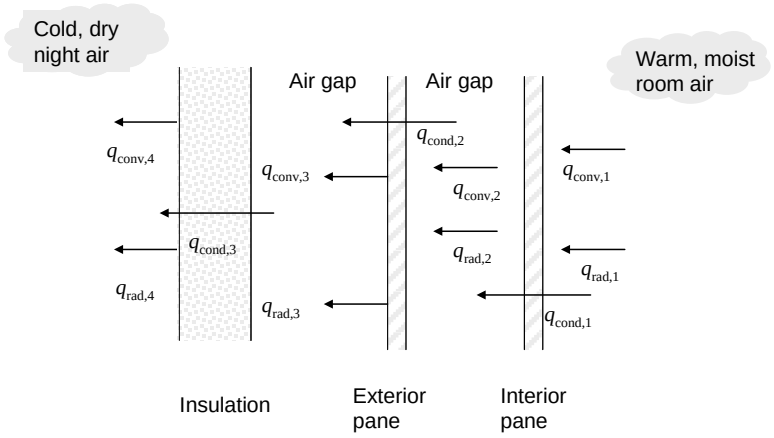
KNOWN: Double-pane windows with foamed insulation inside or outside. Cold, dry air outside and warm, moist air inside.

FIND: Identify heat transfer processes. Which configuration is preferred to avoid condensation?

SCHEMATIC:



Insulation on inside of window.



I

Insulation on outside of window.

ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional heat transfer through window and insulation.

ANALYSIS: With the insulation on the inside, heat is transferred from the warm room air to the insulation by convection ($q_{conv,1}$) and from the warm interior surfaces of the room by radiation ($q_{rad,1}$). Heat is then conducted through the insulation ($q_{cond,1}$). From there, heat is transferred across the air gap between the insulation and the window by free convection ($q_{conv,2}$) and radiation ($q_{rad,2}$). Heat is transferred through the first glass pane by conduction ($q_{cond,2}$). Heat transfer across the air gap between the window panes occurs by free convection ($q_{conv,3}$) and radiation ($q_{rad,3}$). Heat is then transferred through the second glass pane by conduction ($q_{cond,3}$). From there, heat is transferred to the cold air by convection ($q_{conv,4}$) and to the cold surroundings by radiation ($q_{rad,4}$). The same mechanisms occur with the insulation on the outside of the window, just in a different order.

Continued...

PROBLEM 1.62(c) (Cont.)

Condensation may occur on any surface that is exposed to moist air if the surface temperature is below the dewpoint temperature. Condensation causes an additional heat transfer mechanism because when water vapor condenses it releases the enthalpy of vaporization (q_{condense}), which heats the surface on which condensation is occurring. For example, if condensation occurs on the inside surface of the window, this will increase the temperature of that surface and the rate of heat transfer through that window pane. The condensation heat transfer processes are not shown on the schematics.

We know that condensation does not occur on the window's interior pane when there is no insulation in place. If insulation were to be placed on the outside of the window, it will increase the temperature difference between the outside air and the window panes, increasing the window pane temperatures. Therefore condensation will still not occur. <

If the insulation is placed on the inside of the window, it will increase the temperature difference between the warm room air and the window's interior pane. Both the inner surface of the window and the side of the insulation facing the window may experience temperatures below the dewpoint temperature. Because the insulation is loosely-fitting, moist air infiltrates the gap between the insulation and the inner window pane, and condensation may occur. Liquid water may accumulate and cause water damage. To avoid condensation and associated water damage, the insulation should be placed on the outside of the window. <

COMMENTS: (1) The potential water damage is *not* caused by window leakage. Any condensation problem would be exacerbated by adding more insulation to the inside of the window. (2) The potential for condensation damage would be reduced by lowering the humidity in the room, at the risk of increasing discomfort and the potential for illness. (3) Moisture may infiltrate through the insulation. Even tightly-fitting, improperly placed insulation can lead to condensation and water damage. (4) Adding the insulation to the exterior of the window will reduce the possibility of water damage due to condensation, but it cannot be easily removed to enjoy a bright winter day.