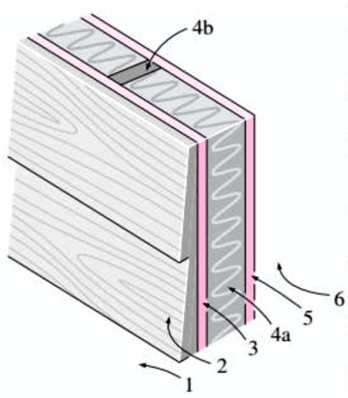
Determine the overall unit thermal resistance (the R value) of a wood frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400 mm. The 90-mm-wide cavity between the studs is filled with urethane rigid insulation. The inside is finished with 13-mm gypsum wallboard and the outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding.



The insulated cavity constitutes 75 percent of the heat transmission area while the studs, plates, and sills constitute 21 percent. The headers constitute 4 percent of the area, and they can be treated as studs. Also, determine the rate of heat loss through the walls of a house whose perimeter is 50 m and wall height is 2.5 m in Las Vegas, Nevada, whose winter design temperature is -2 C. Take the indoor design temperature to be 22 C and assume 20 percent of the wall area is occupied by glazing (glass) (Wall without glass 80%).

$R_{\text{wood}} + R_{\text{wood bevel}} + R_{\text{plywood(13mm)}} + R_{\text{gypsum wallboard}} + R_{\text{inside}} = 1{,}19 \, \frac{\text{m}^2\,°\text{C}}{\text{W}}$

With insulation

$R_{\text{urethane r. f.}} = 0.98 \times \frac{90}{25} = 3.528 \, \frac{\text{m}^2\,°\text{C}}{\text{W}}$

$\mathbf{R'_{tot}} = 1{,}19 + 3{,}528 = \mathbf{4{,}718} \, \frac{\mathbf{m^2\,°C}}{\mathbf{W}}$

With wood stunds

$R_{\text{plywood}} = 0{,}63 \, \frac{\text{m}^2\,°\text{C}}{\text{W}}$

$\mathbf{R'_{tot}} = 0{,}63 + 1{,}19 + = \mathbf{1{,}82} \, \frac{\mathbf{m^2\,°C}}{\mathbf{W}}$

$\mathbf{U_{tot}} = U_{ins} \times \frac{\text{A insul}}{\text{A tot}} + U_{wood} \times \frac{\text{A wood}}{\text{A tot}}$

$U_{tot} = U_{ins} \times 0.75 + U_{wood} \times 0.25$

$U_{insul} = \frac{1}{\text{R' insul}} = \frac{1}{4.718} = 0{,}2119 \, \frac{W}{\text{m}^2\,°\text{C}}$

$U_{wood} = \frac{1}{R'\,wood} = \frac{1}{1.82} = 0,549\ \frac{W}{m^2\ °C}$

$\mathbf{U_{tot}}$ = 0,2119 x 0.75 + 0,5494 x 0.25 = 0.1589 + 0.1373 = $\mathbf{0.296\ \frac{W}{m^2\ °C}}$

A_{tot} = 50 x 2.5 x 0.8 = 100 m^2

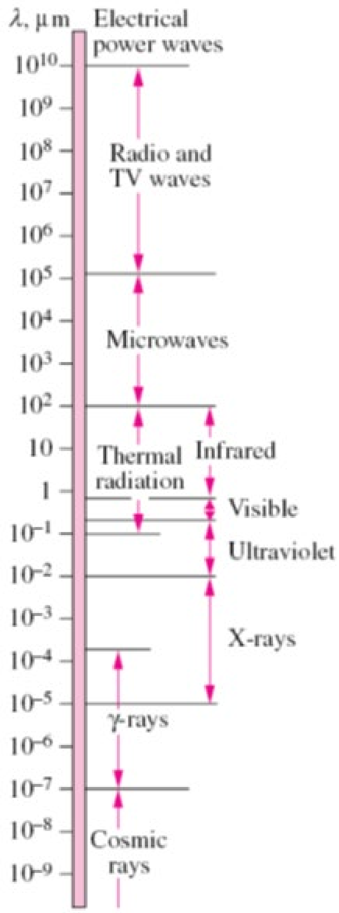
ΔT = 22 – (-2) = 24 °C

$\mathbf{Q_{tot}}$ = U_{tot} * A_{tot} * ΔT = **710,4 W**

RADIATION

Radiation is a way of transferring energy from one body to another. Radiative energy transfer doesn't need any material mediums (while matter is needed in case of conduction and convection) because it goes through electromagnetic waves. However, it can occur also through a material, along with convection or conduction.

Electromagnetic waves are due to electric current created by the motion of molecules. Also thermal energy is transferred through electromagnetic waves, and the rate of its transfer depend on the differences of temperature. In general, the higher the temperature of a body, the more thermal energy it emits. Thermal energy is carried within a specific range of waves in the electromagnetic spectrum, it encludes the visible light and the infrared and ultraviolet ranges as well. We call a light source a body that emits thermal energy within the visible light range.



Each body which temperature is above the absolute zero radiates thermal energy and the total emissive power of a body always depends on its temperature. The higher the temperature of a body the higher is the rate of heat which it emits and more easily it can overcome the heat transferred by conduction or convection. In the case of a black body, the relation between the emissive its power and temperature is:

$$\mathbf{E_b}(T) = \sigma T^4 \quad [\frac{W}{m^2}]$$

$\sigma = 5.670 * 10^{-8} \quad \frac{W}{m^2 * K^4}$ -------> Stefan–Boltzmann constant

A back body is a hypothetic simplified body that is able to absorb and emit all the radiations without reflecting any part of it. That means that emits the maximum amount of radiation by a surface at a given temperature. There aren't bodies that are perfectly able to radiate always the maximum radiation in each direction, the black body is an idealization that is useful for studying the proprieties and the behaviors of real surfaces. F.i., the Sun is considered to be a black body at a temperature of 5780 K.

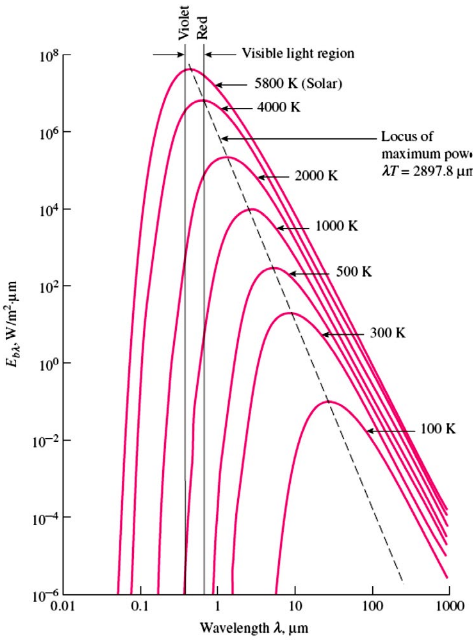
Other proprieties of the electromagnetic waves are its frequency and wavelenght. When it comes to study the electromagnetic waves thorugh a material medium (most of cases in our planet) we can use the relation:

$$\nu = \frac{c}{\lambda}$$

where:
c = c0 /n
c, the speed of propagation of a wave in that medium

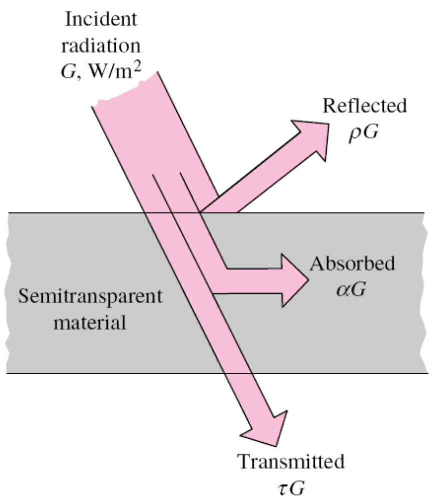
c0 = 2.9979□108 m/s, the speed of light in a vacuum
n, the index of refraction of that medium
n =1 for air and most gases, n = 1.5 for glass, and n = 1.33 for water

The emitted radiation is a continuous function of wavelength. As demonstrated by this graphic, At any specified temperature, the radiation of a black body increases with wavelength, reaches a peak, then decreases with increasing wavelength again.



By looking at the graphic we can tell some important considerations: the radiation emitted by the sun, which has a temperature of around 5800 K, reaches its *peak* in the visible light region of the spectrum.
With increasing temperatures, the curves of the emissive power shift to the left towards the shorter wavelength region. This means that a larger fraction of the radiation is emitted at shorter wavelengths with higher temperatures.
at a temperature inferior than 800 K the radiation is emitted almost entirely in the infrared region, this means that surfaces which has T < 800 K are not visible to human eye (unless they reflect light coming from other sources). Of course, they still radiate heat.

The emissivity of a surface is a complex problem which involves three parameters: the *absorbitivity, the reflectivity* and the *transmissivity,* since every surface in reality absorbs a part of incident energy, reflects another part and transmitt a third one.



the directional distribution of emitted (or incident) radiation is not uniform: the intensity of radiation emitted by a surface usually varies with direction (especially with the zenith angle) Thus it can be determined only through a complicated formula. However, many surfaces in practice can be approximated as being diffuse. For a diffusely emitting surface, the intensity of the emitted radiation is independent of direction and thus the emissivity is constant and can be determined with:

$\mathbf{E} = \pi I_e$ (diffusely emissive surface)

The radiation flux incident on a surface from all directions is called irradiation G, and is expressed as (considering a diffuse surface):

$\mathbf{G} = \pi I_i$

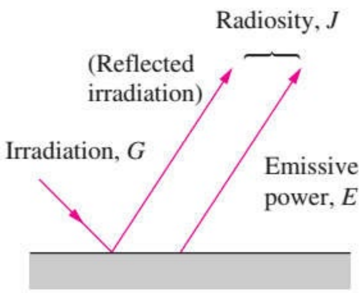
All the other parameters: absorbitivity, reflectivity and transmissivity are referred to **G** and can be expressed in the following way:

$$\text{Absorbitivity} = \frac{\text{Absorbed radiation}}{\text{Incident radiation}} = \frac{Gabs}{\text{G}}$$

$$\text{Reflectivity} = \frac{\text{Reflected radiation}}{\text{Incident radiation}} = \frac{Gref}{\text{G}}$$

$$\text{Transmissivity} = \frac{\text{Transmitted radiation}}{\text{Incident radiation}} = \frac{Gtr}{\text{G}}$$

The radiosity is defined as the rate at which radiation energy leaves a unit area of a surface in all directions. It involves the total radiation which streams away from a surface regardless of its origins, since surfaces emit radiation as well as reflecting it.



Considering a diffuse surface, radiosity is expressed as

J= πI_{e+r}