Understanding the greenhouse effect

1) Radiation emission

2) Visible and infra-red radiation

3) The thermal equilibrium

4) Thermal equilibrium of a black enlightened surface

5) The greenhouse effect

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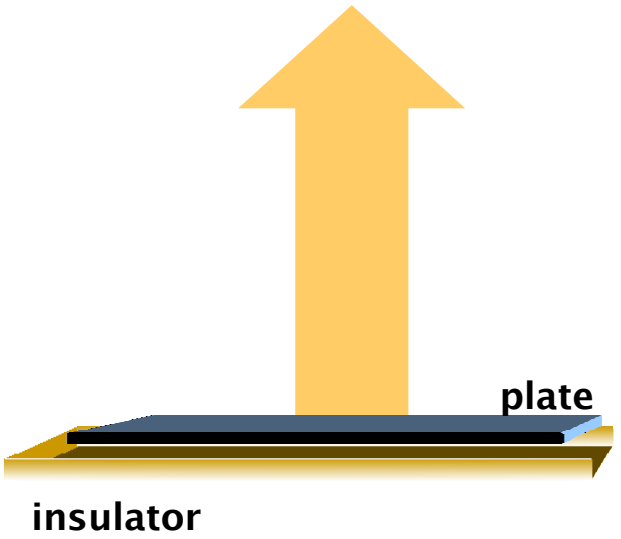
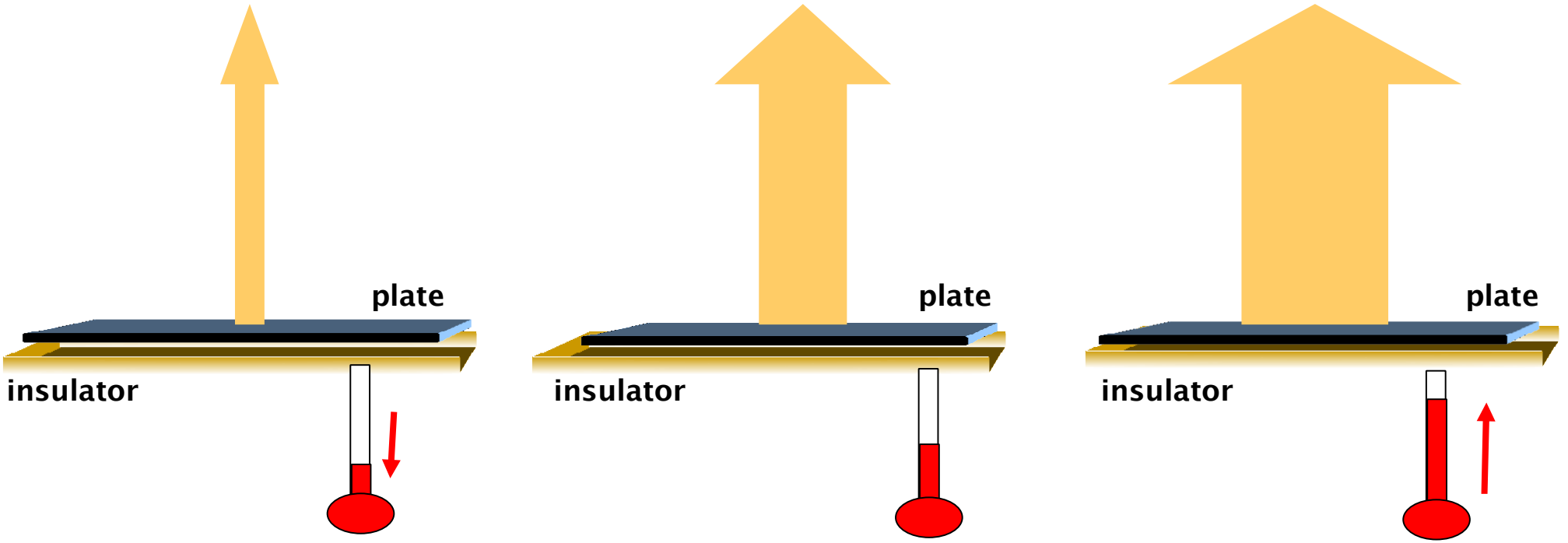
1) Radiation emission



Any material (here a plate, thermally insulated on one side) emit radiation and therefore loose energy

1) Radiation emission

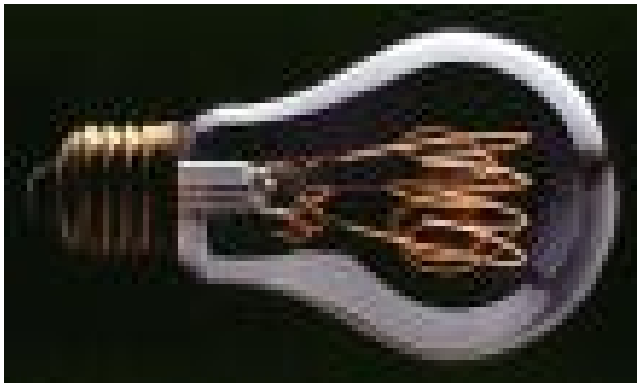


The highest the temperature is, the highest the energy emission is.

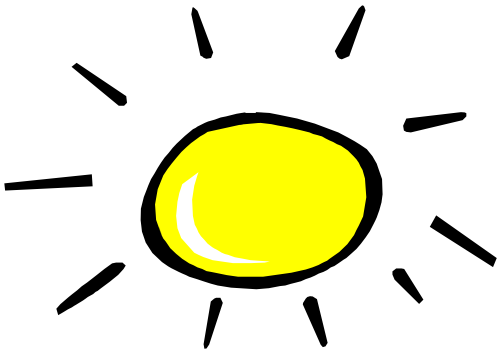
2) Visible and infra-red radiation

a) When the temperature is higher then approximately 700°C, we can see part of the radiation emitted by the object:

This is the visible radiation



Incandescent lamp :
T= 2500 °C



Sun :
T=6000 ° C

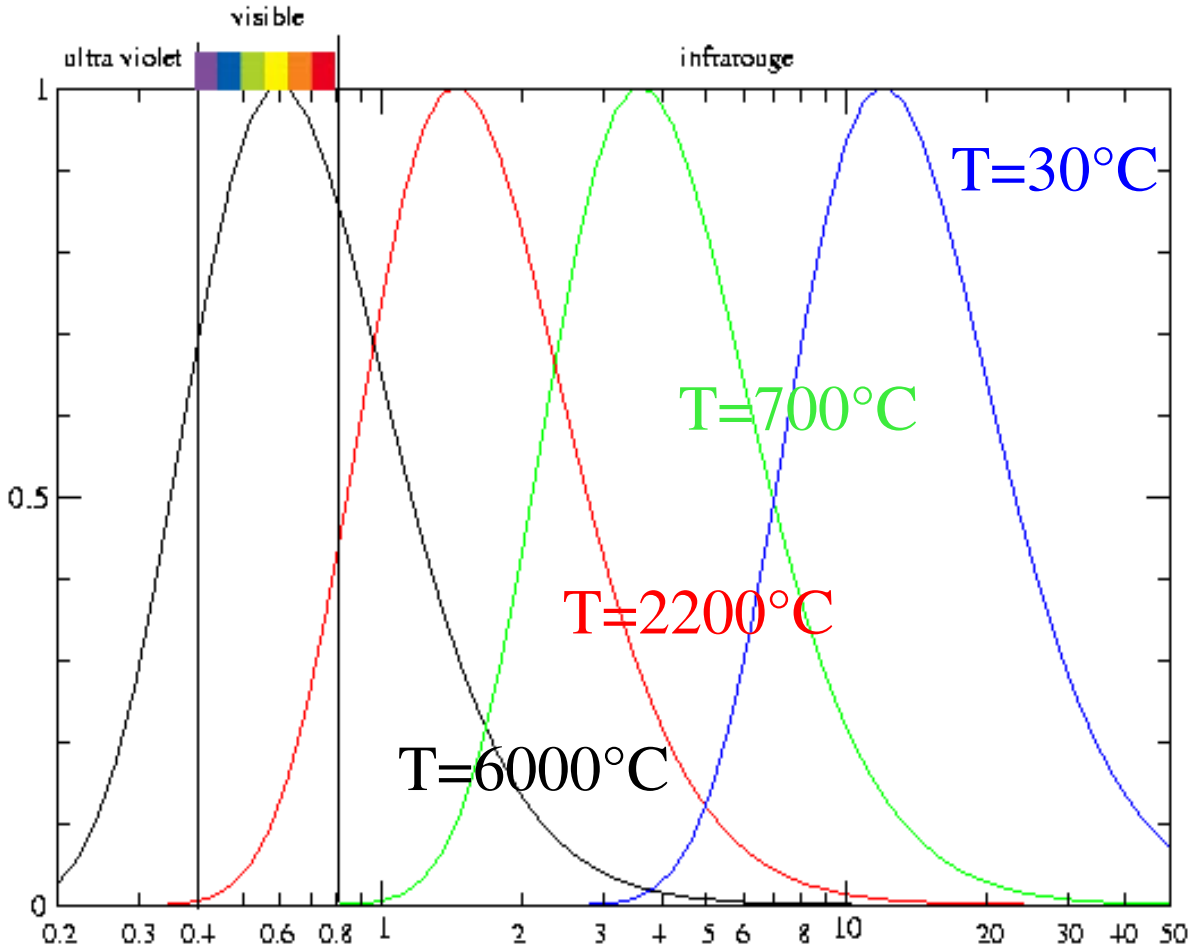
Volcano lava:
T= 1000° C

2) Visible and infra-red radiation

b) When the temperature is lower then approximately 700°C, we can't see any radiation emitted by the object:

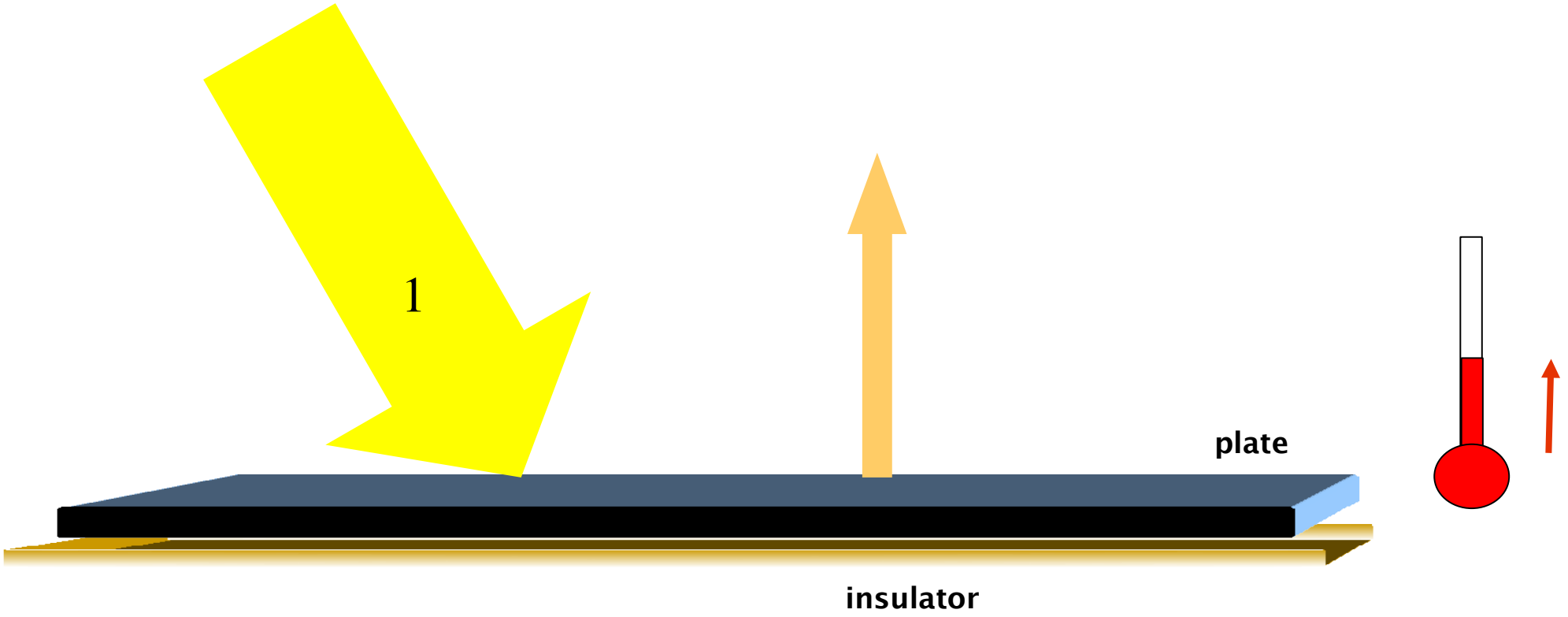
This is the infra-red radiation

2) Visible and infra-red radiation



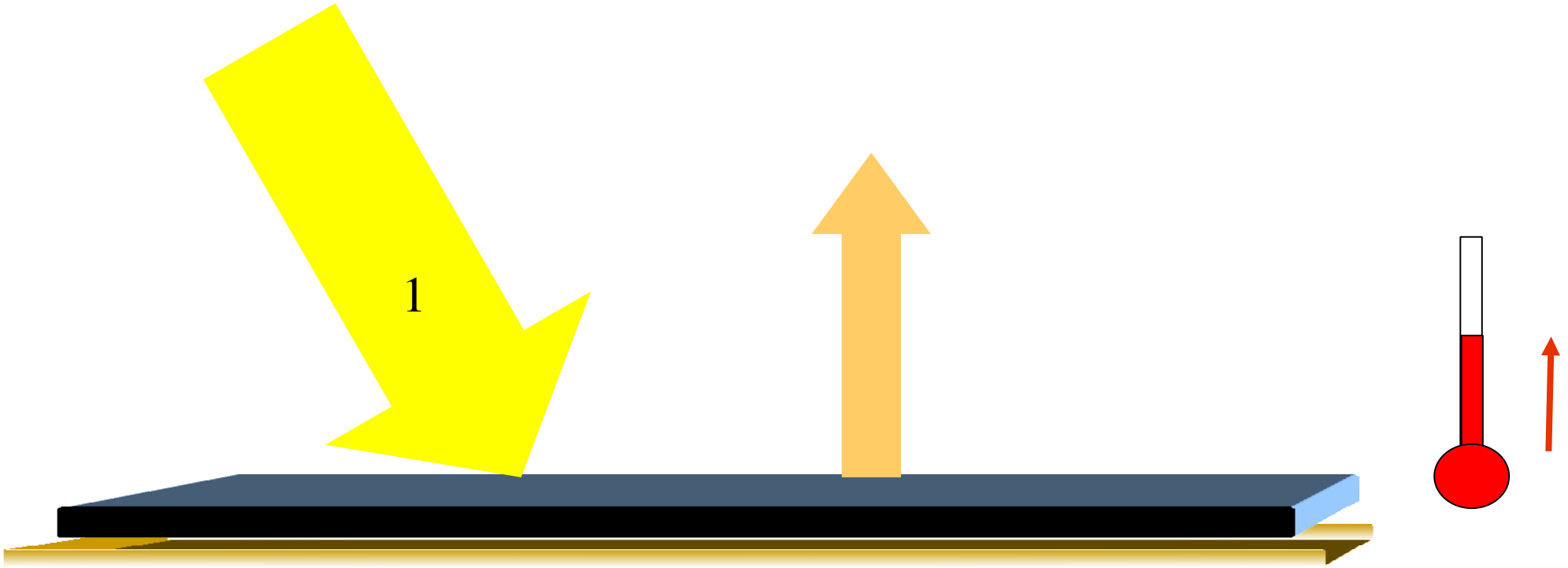
Normalized spectra of the radiation emitted by a material at 6000°C (the sun, black line), at 2200°C (an incandescent lamp, red line), at 700°C (volcano lava, green line) and at 30°C (blue line).

3) The thermal equilibrium



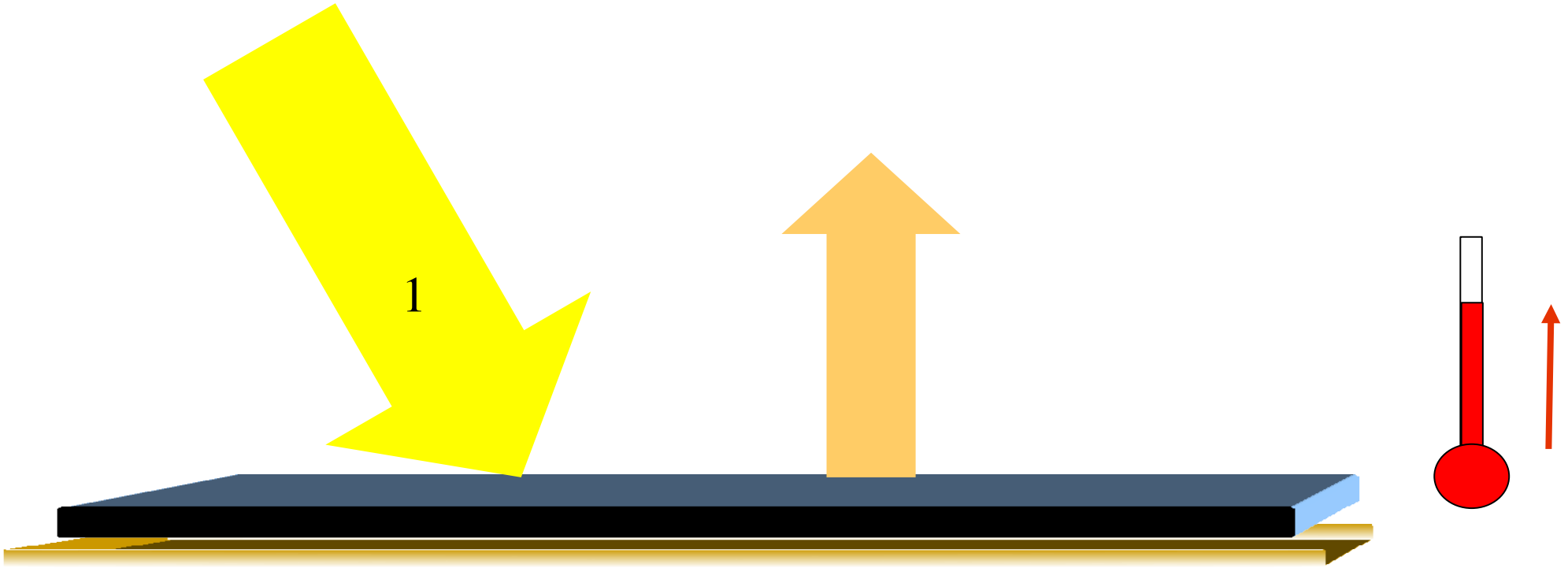
When a material receives more energy than it loses, its temperature increases.

3) The thermal equilibrium



Because its temperature increases, the energy lost by emission of radiation also increases.

3) The thermal equilibrium



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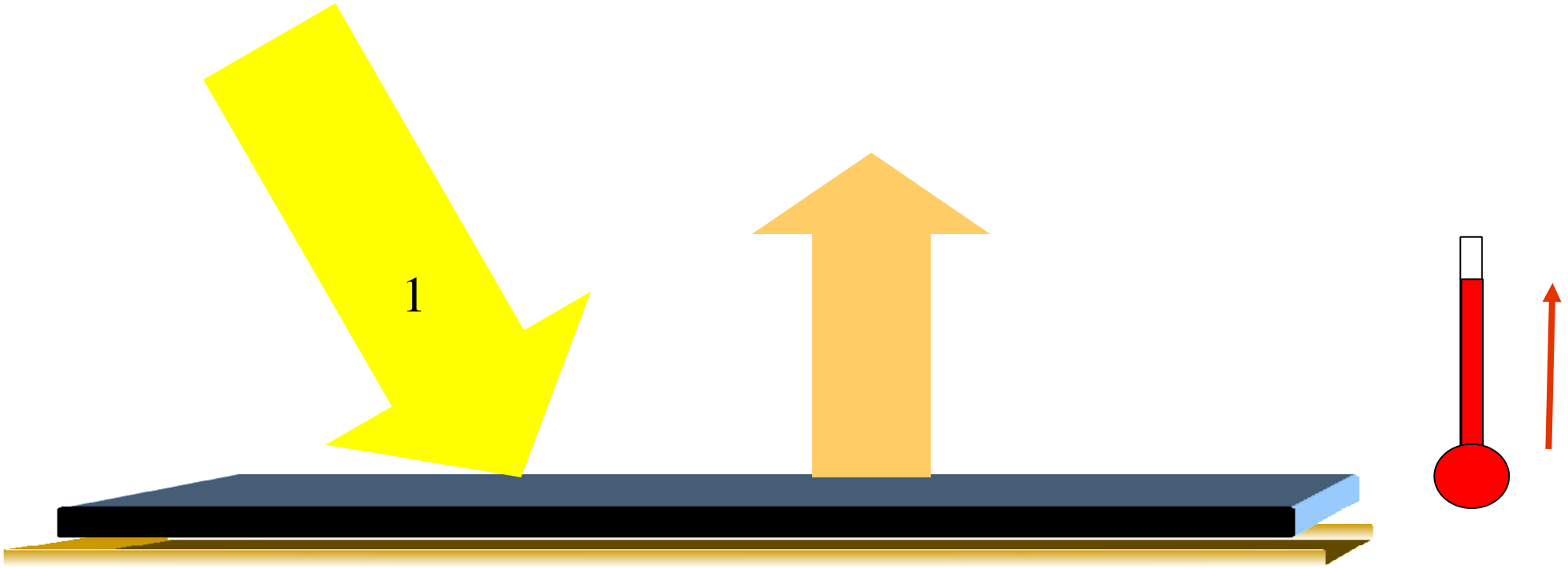
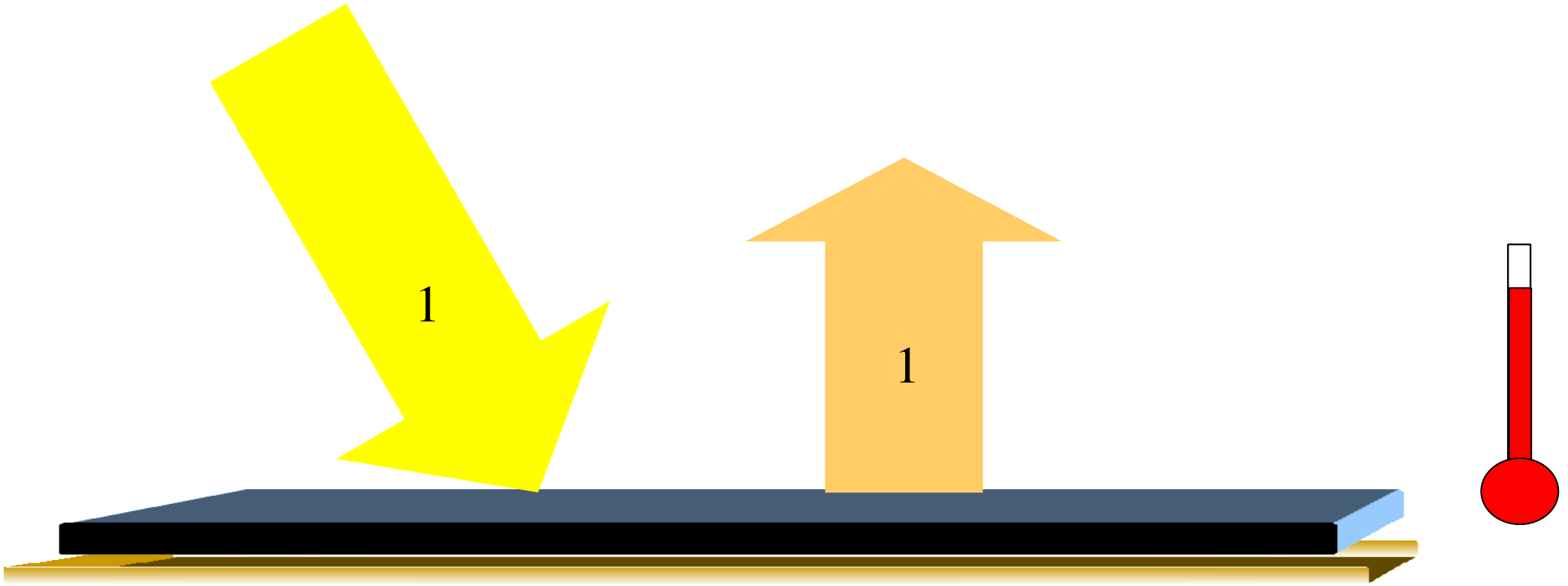
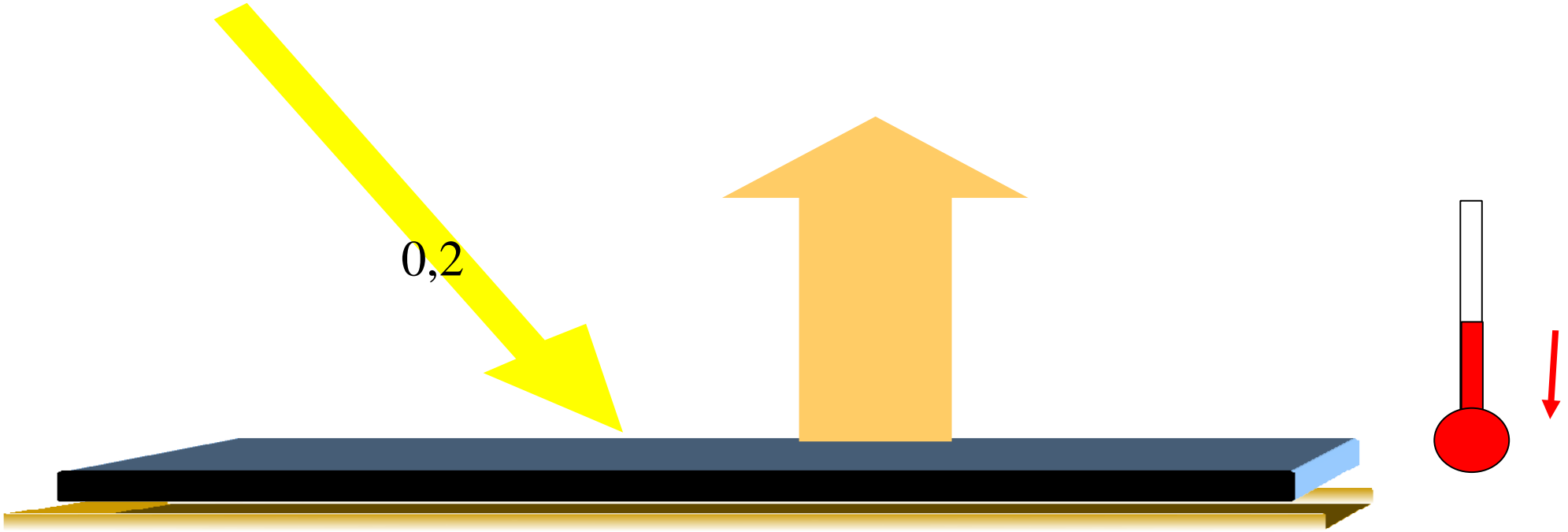


3) The thermal equilibrium



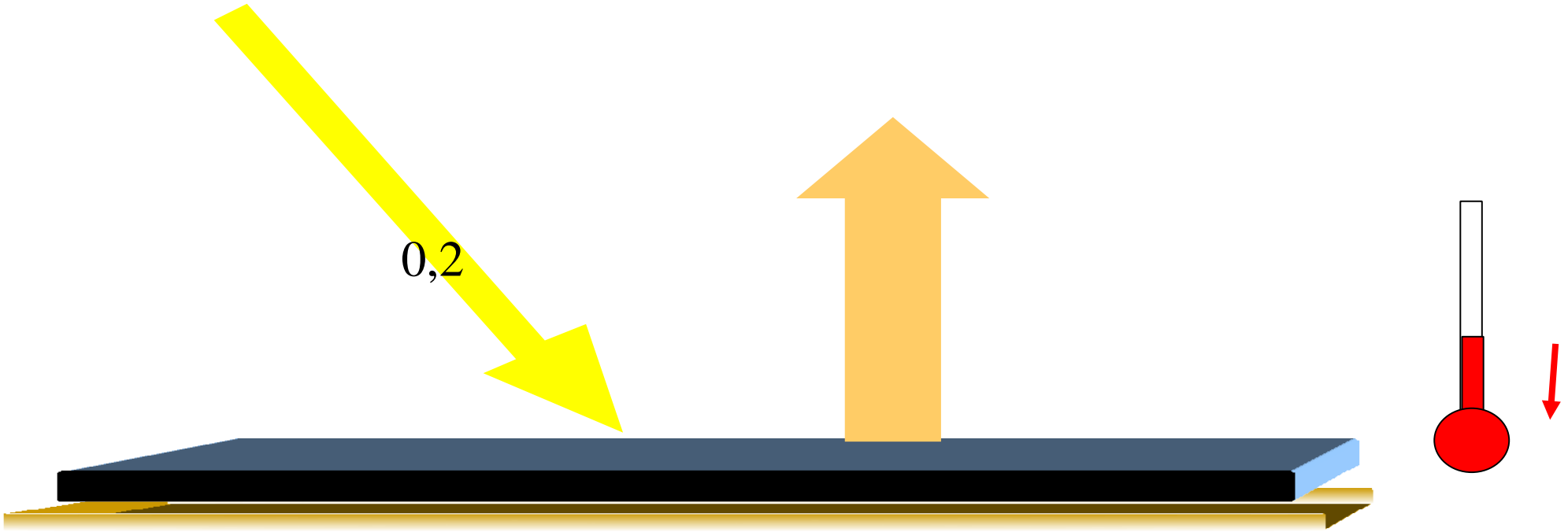
... until a thermal equilibrium is reached

3) The thermal equilibrium



When a material receives less energy than it loses, its temperature decreases.

3) The thermal equilibrium



Because its temperature decreases, the energy lost by emission of radiation also decreases.

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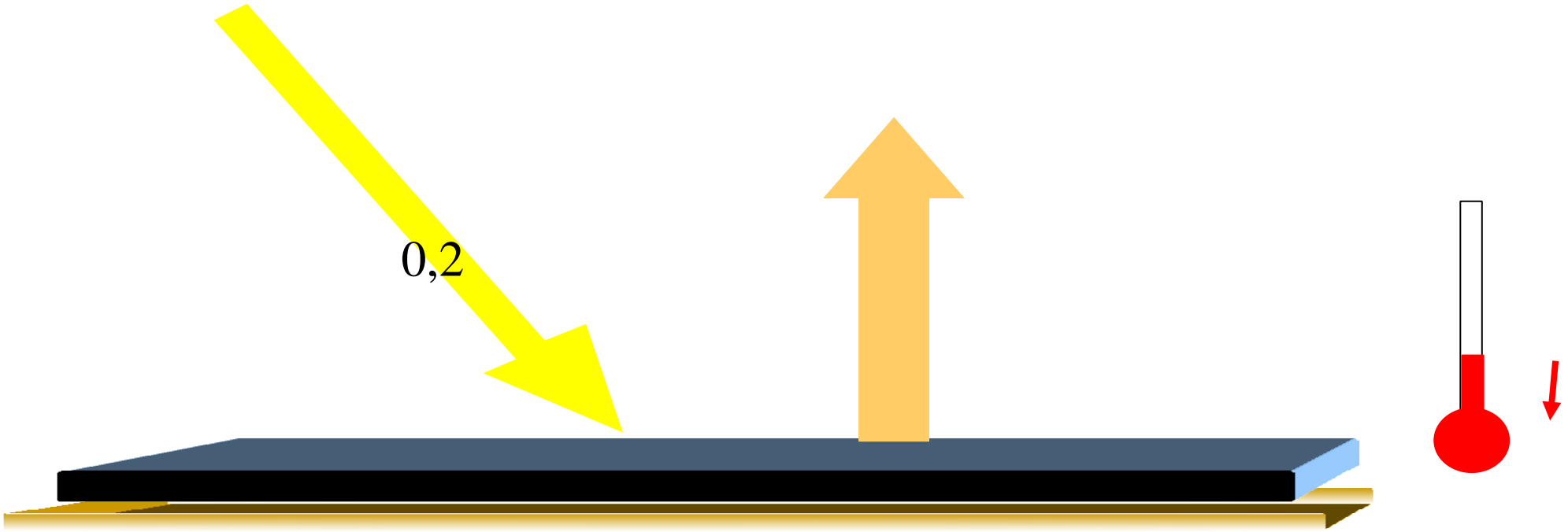

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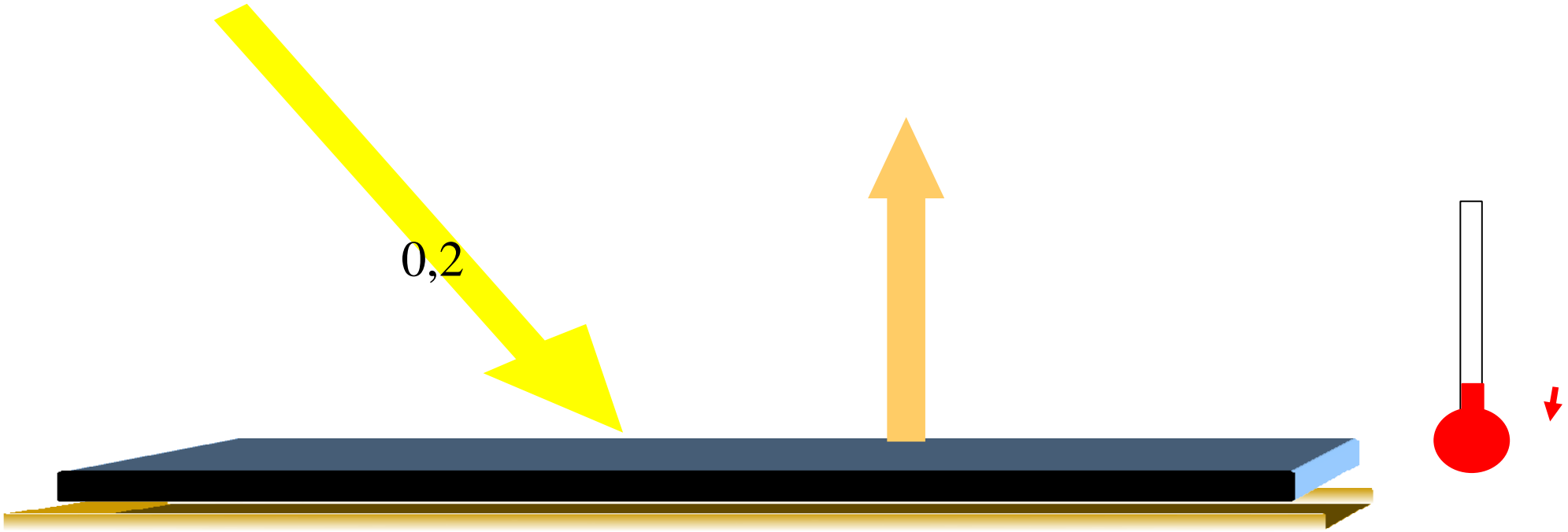
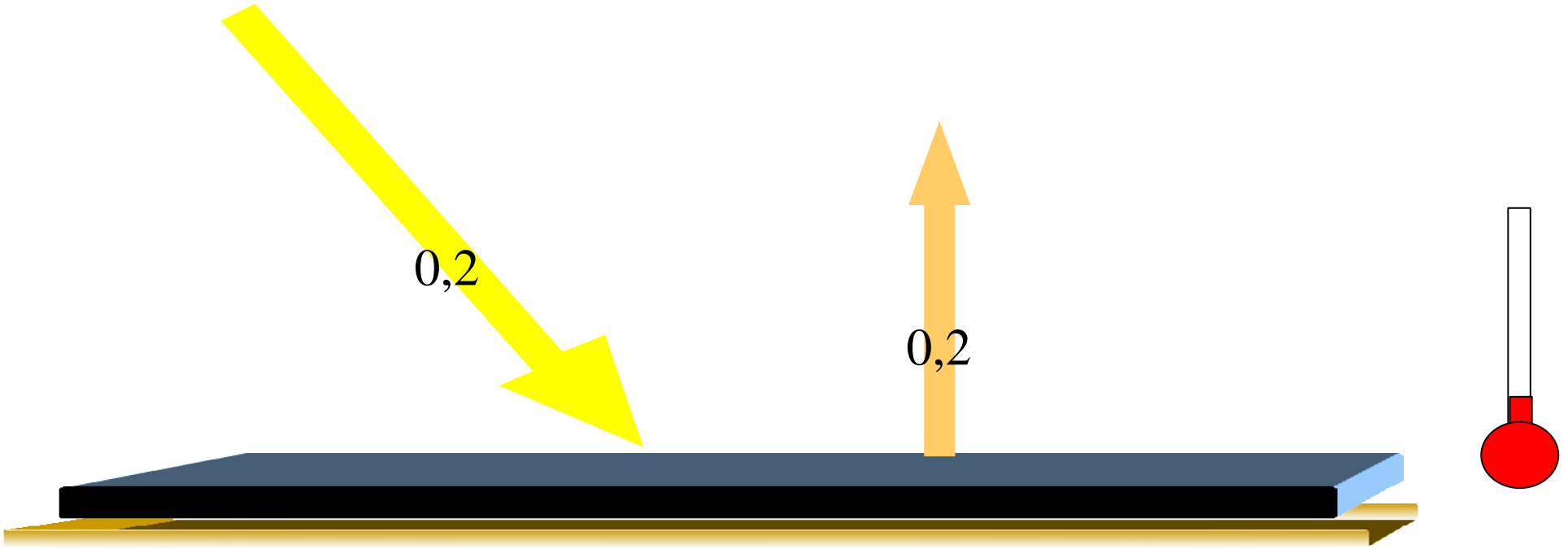
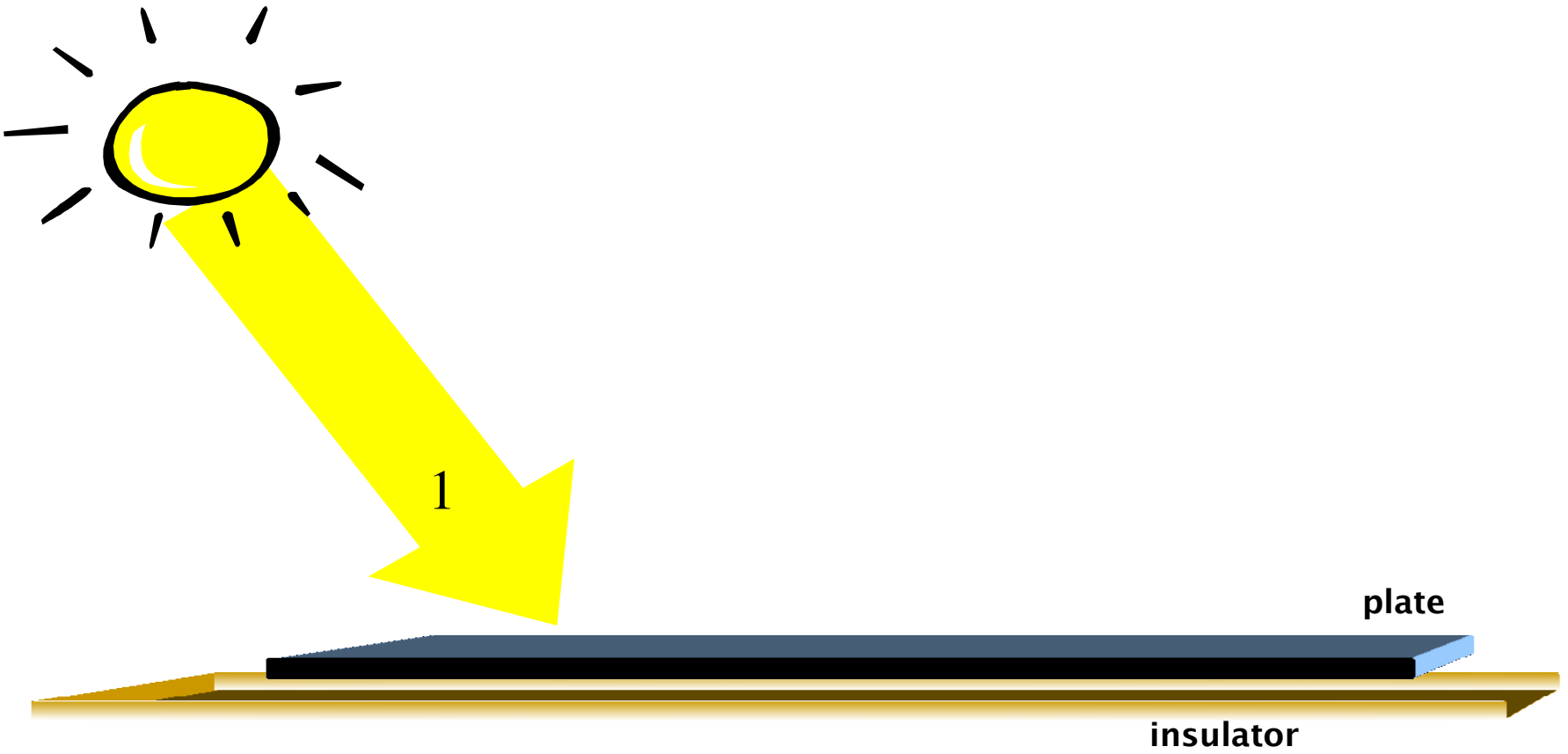


3) The thermal equilibrium



... until a new equilibrium is reached

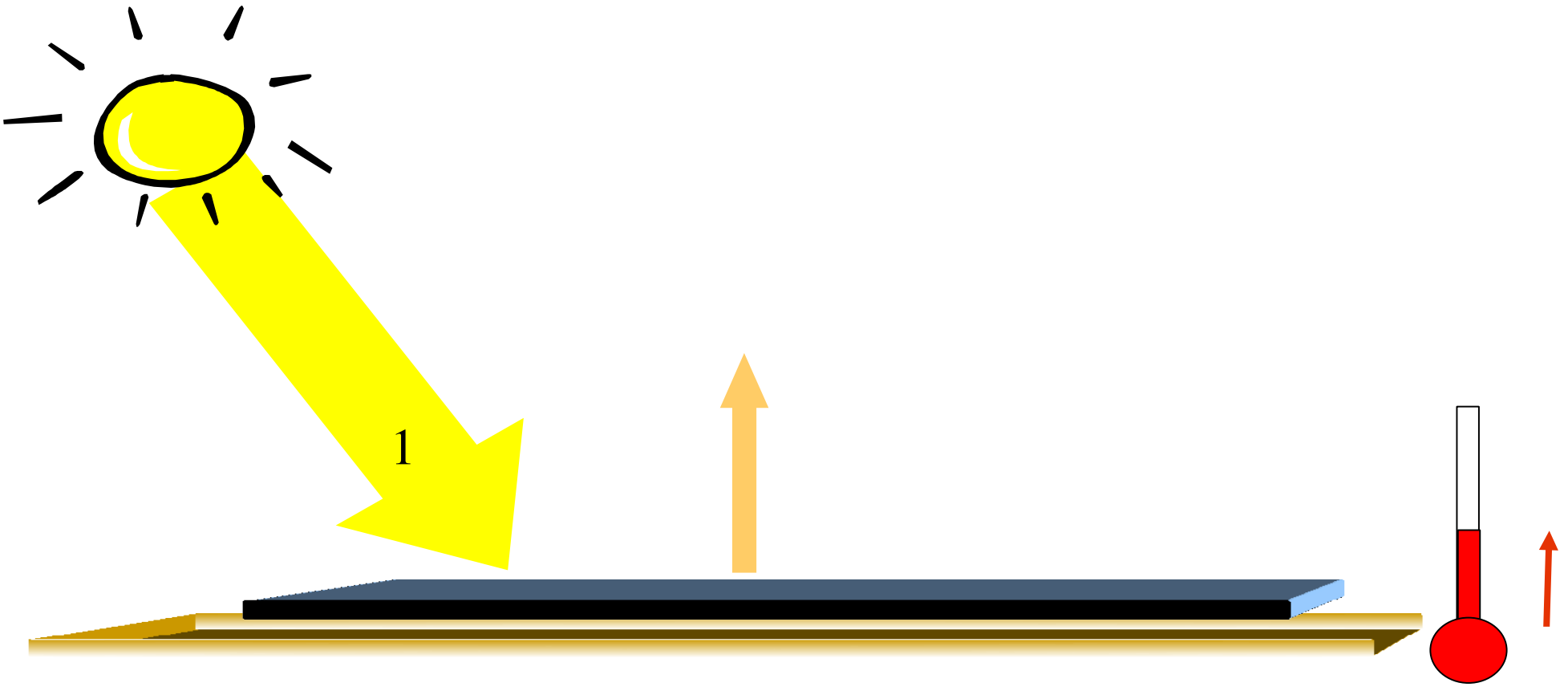
4) Thermal equilibrium of a black enlightened surface



We consider a black plate, receiving sun light on one sight and insulated on the other sight.

Its temperature is T=0K, there is no thermal emission.

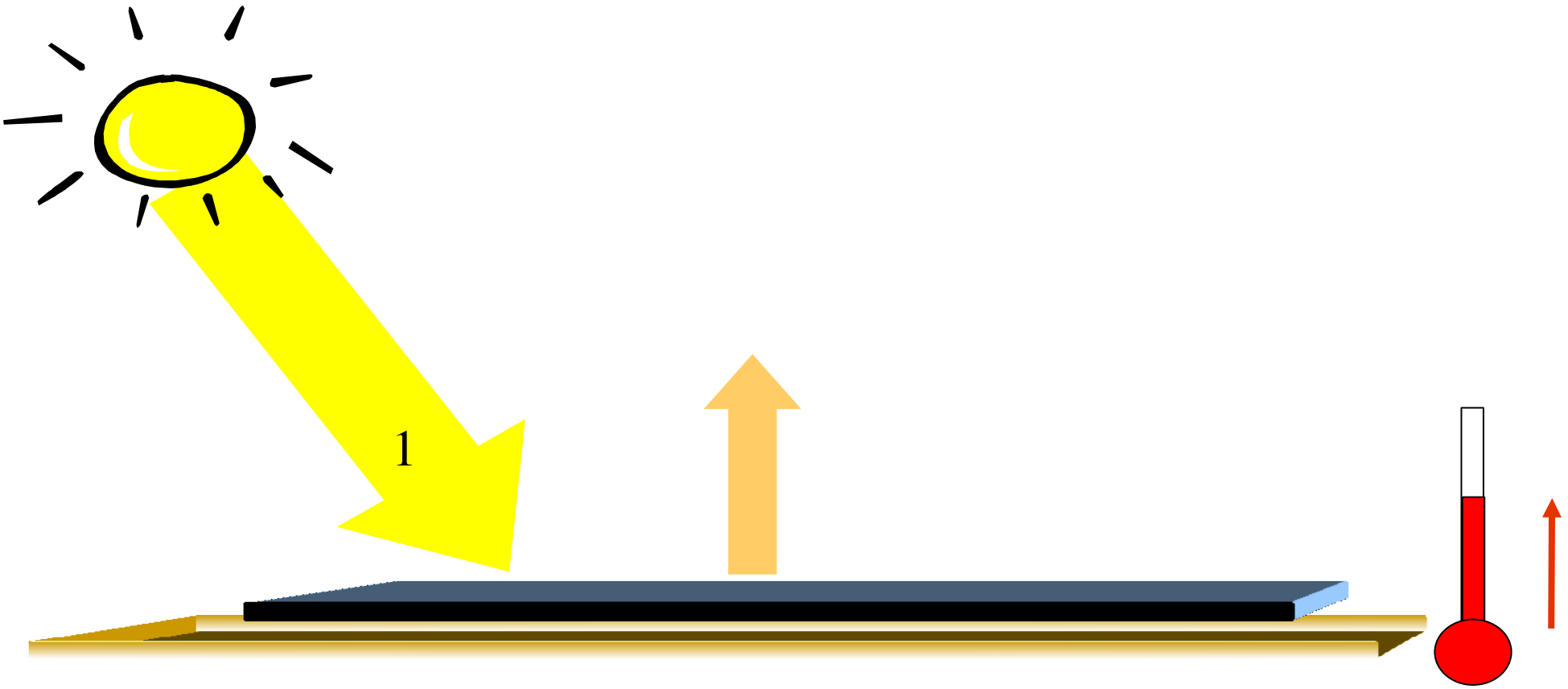
4) Thermal equilibrium of a black surface



The plate receives more energy than it loses.

Its temperature increases, as well as the emitted radiation.

4) Thermal equilibrium of a black surface



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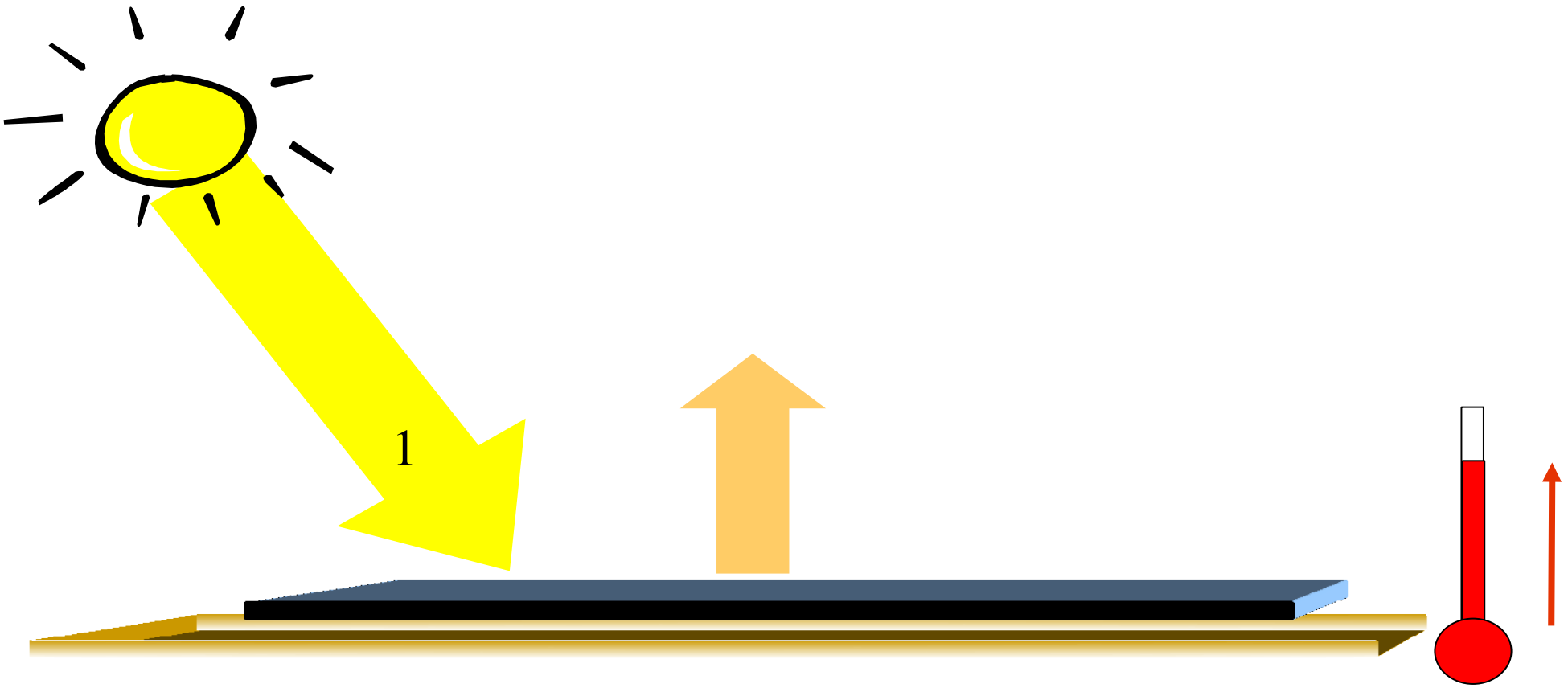
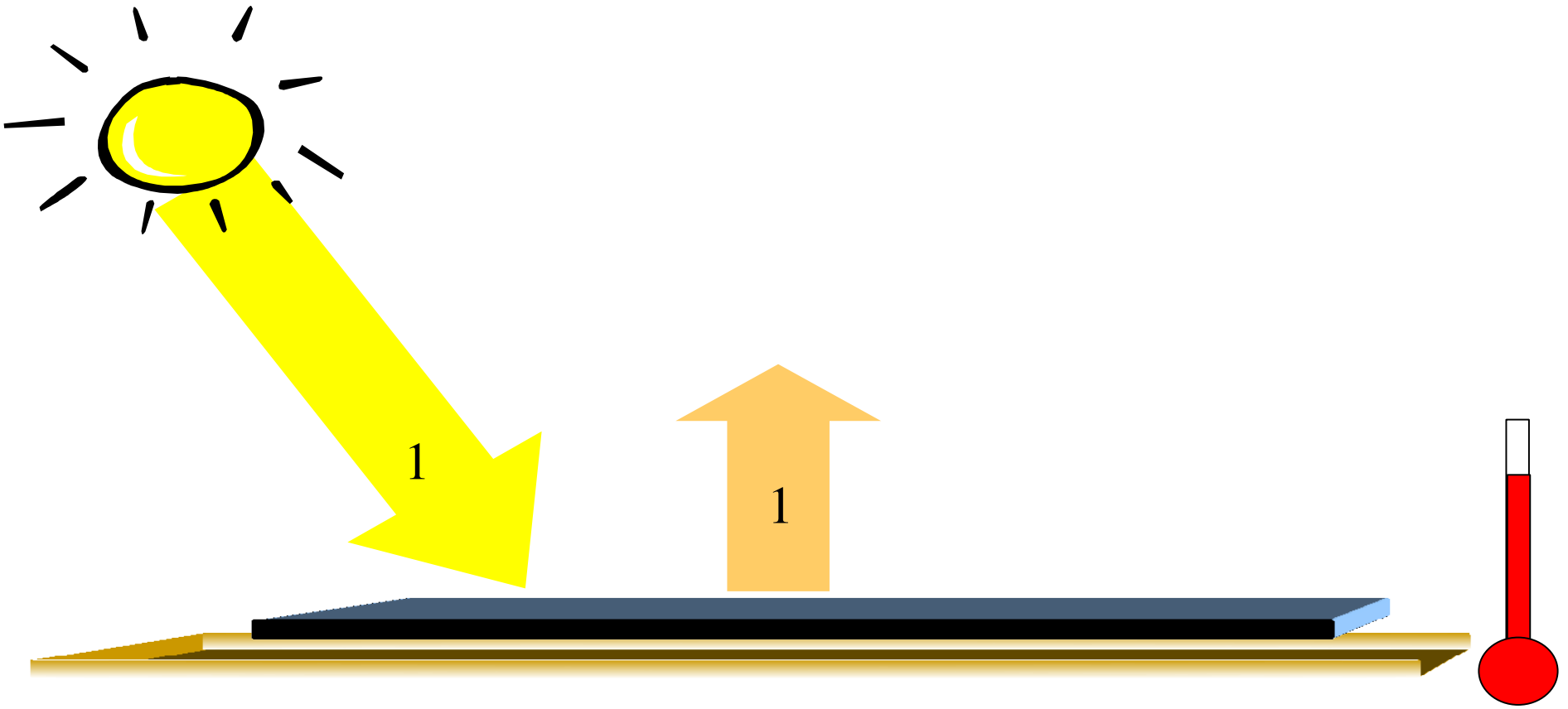
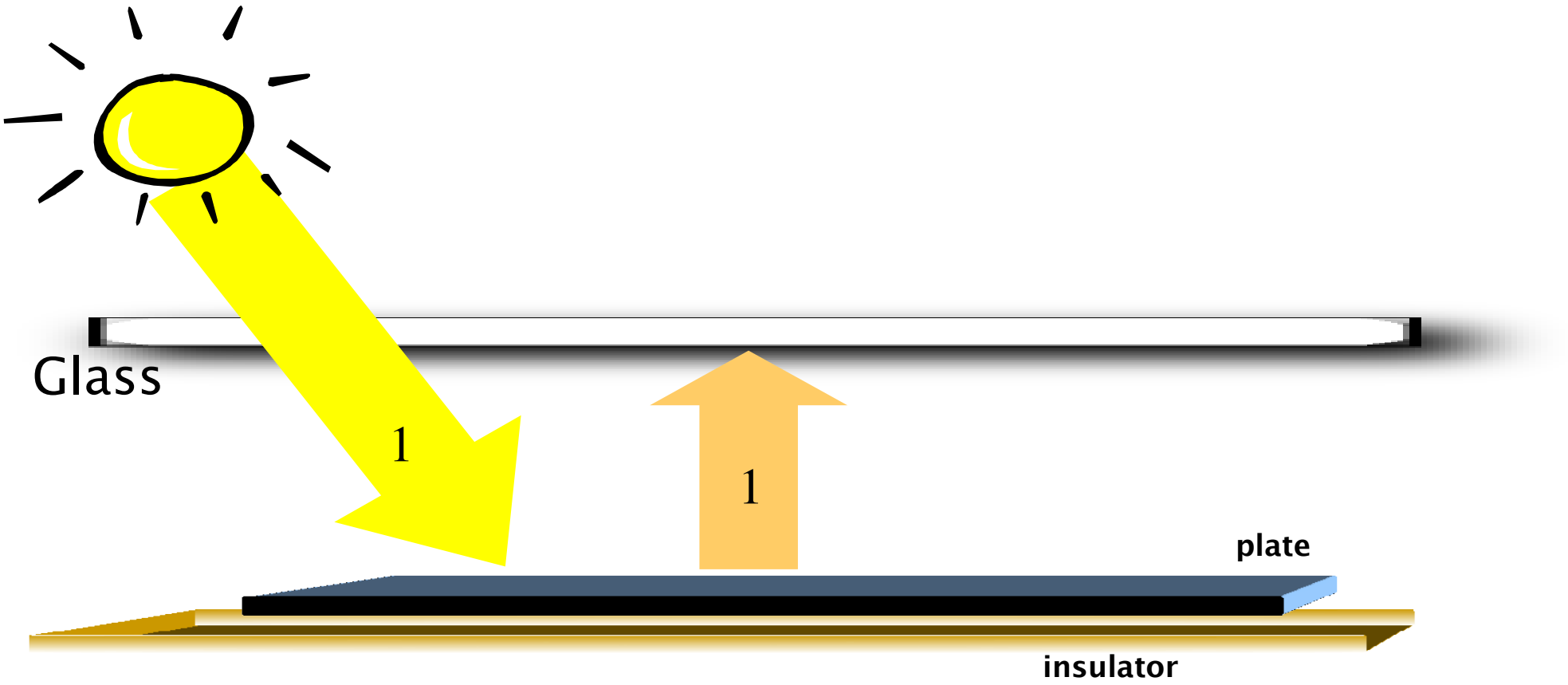


4) Thermal equilibrium of a black surface



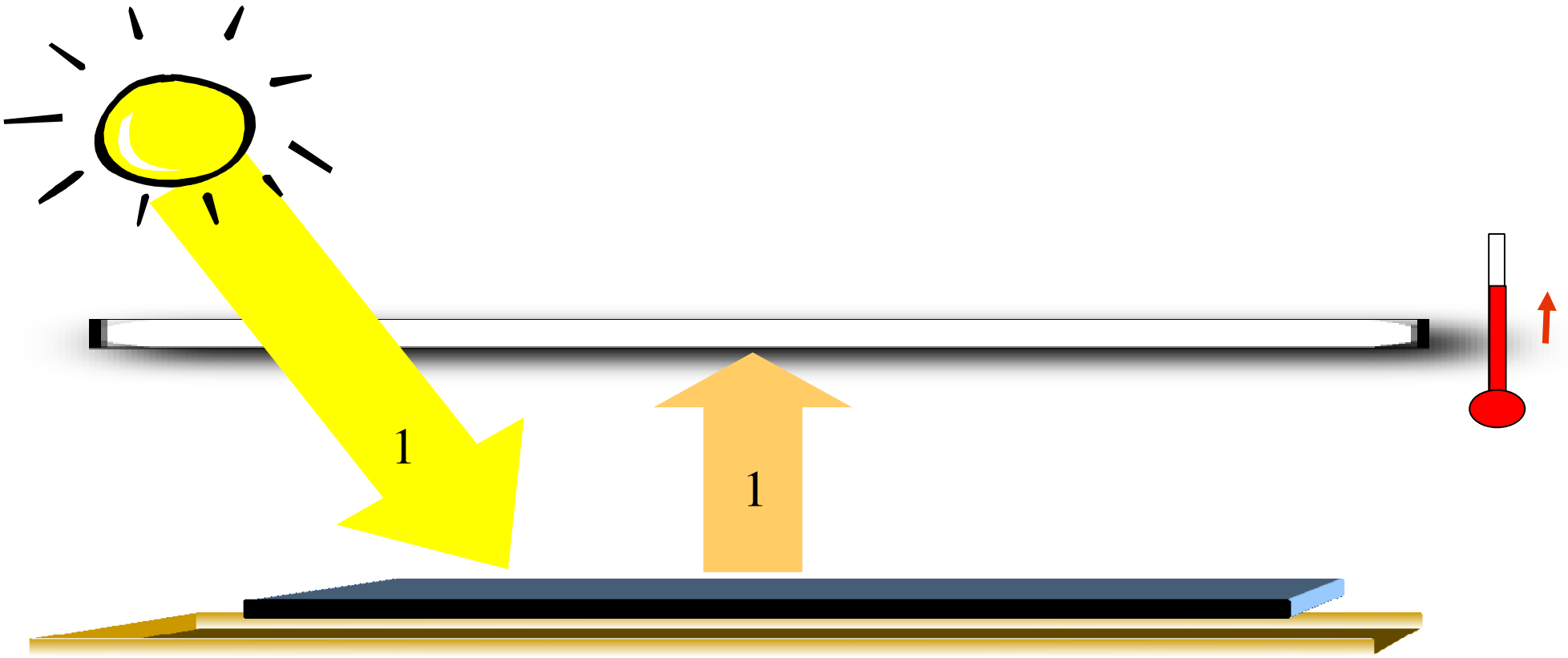
... until a thermal equilibrium is reached.

5) The greenhouse effect



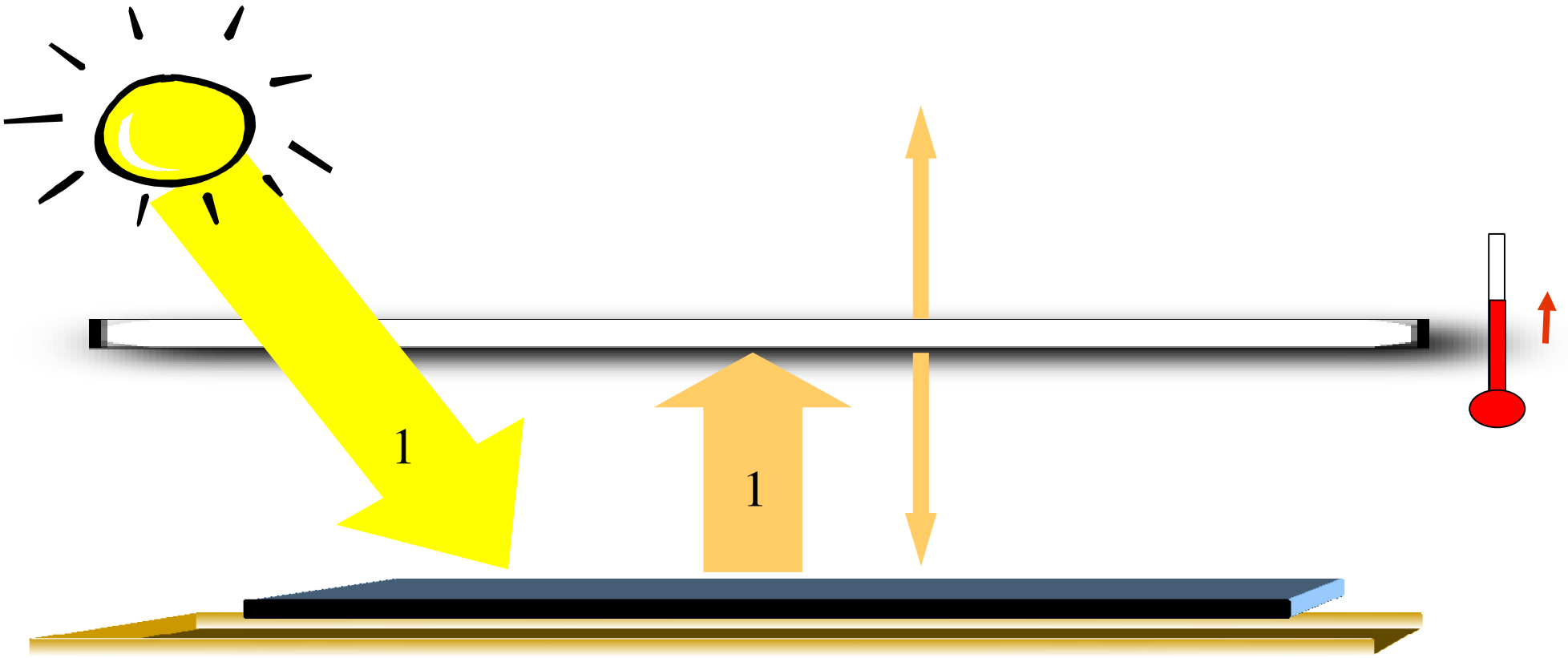
A glass, at T=0K, is put above the black surface. The glass is transparent to the solar radiation and is opaque to the infra-red radiation.

5) The greenhouse effect



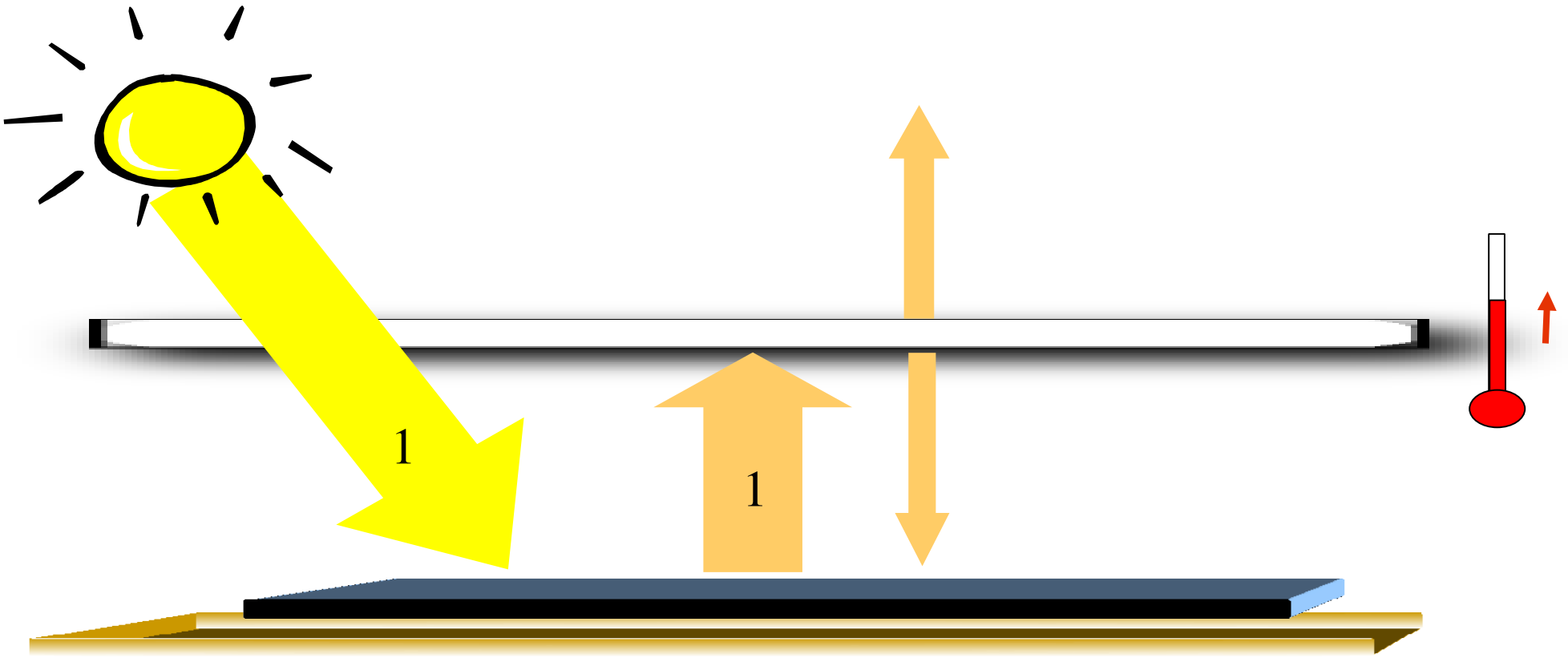
The glass absorb the infra-red radiation emitted by the surface, it gains energy and therefore its temperature increases.

5) The greenhouse effect



The temperature of the glass increases, it emits more radiation, half above and half below the glass.

5) The greenhouse effect



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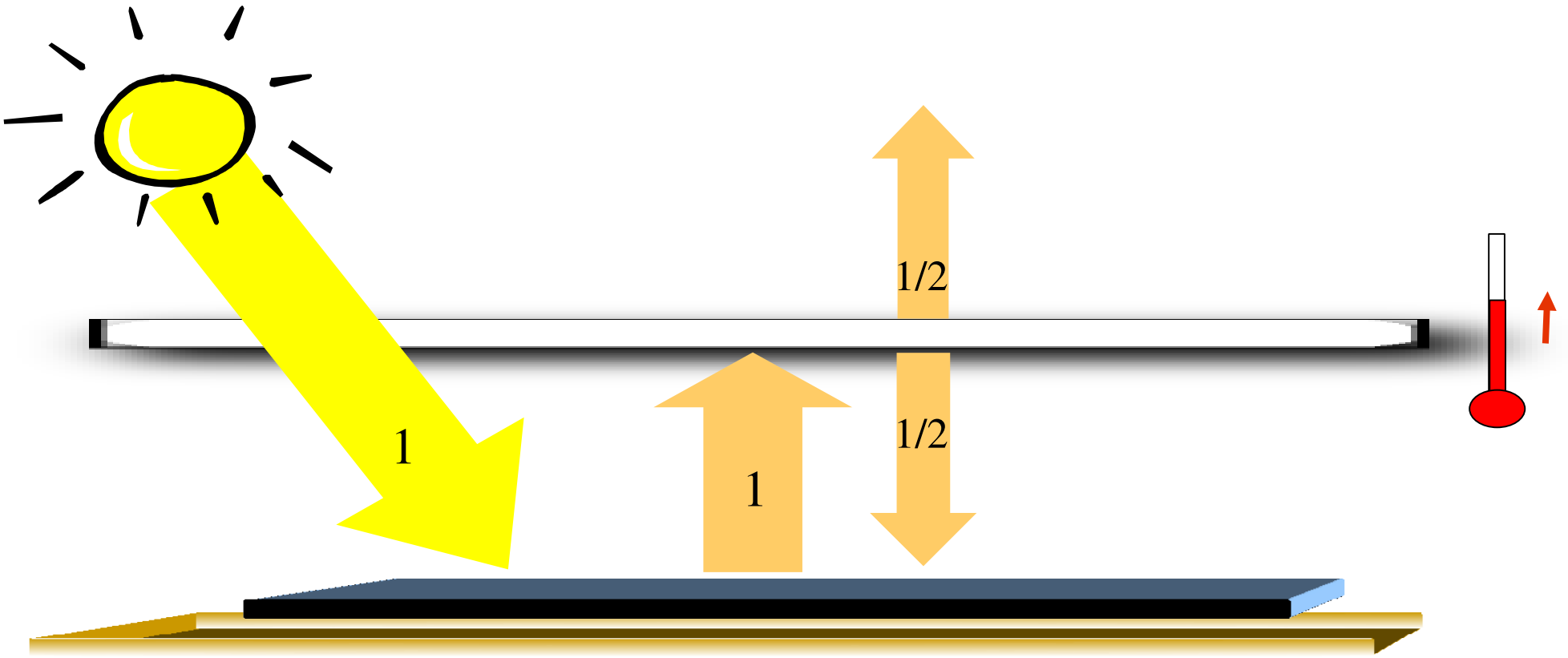
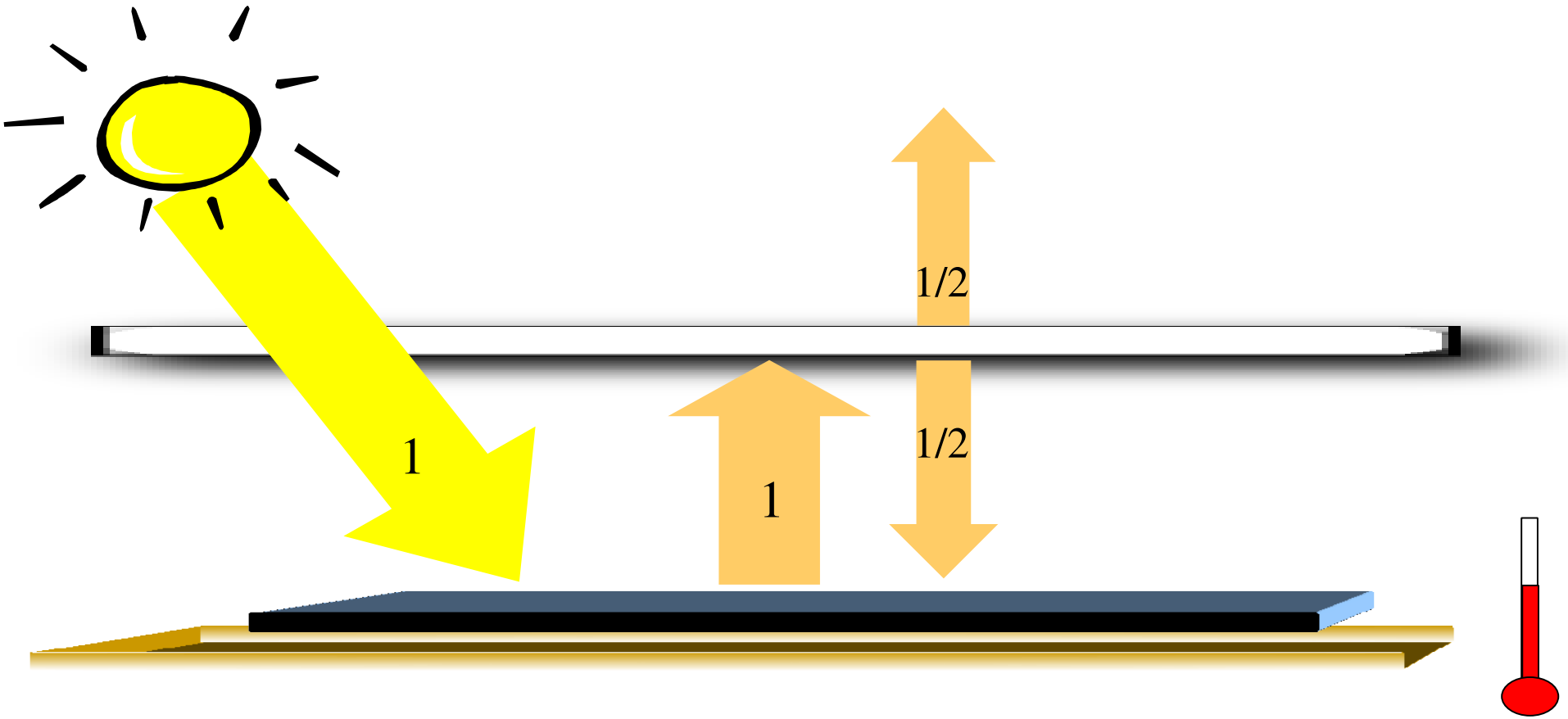


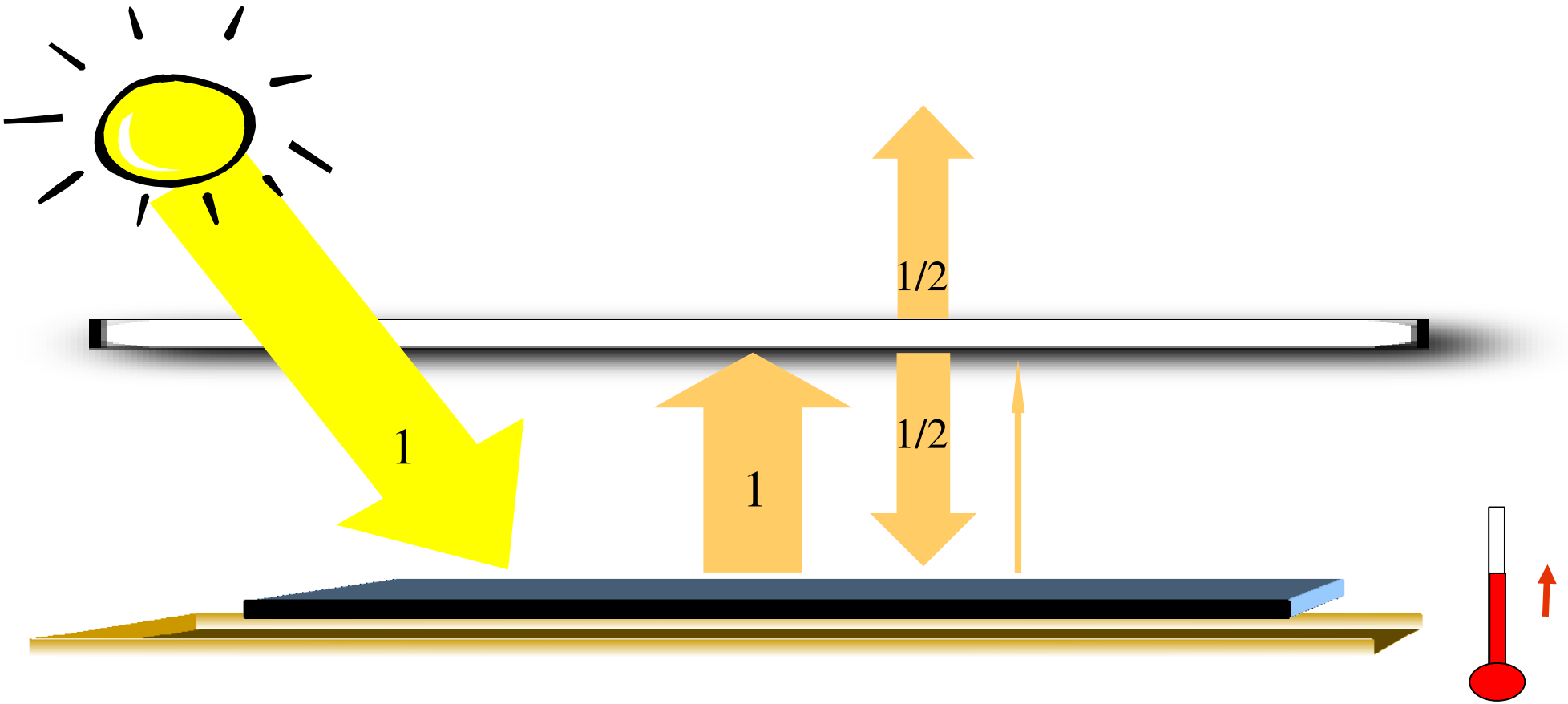
... until a new equilibrium is reached.

5) The greenhouse effect



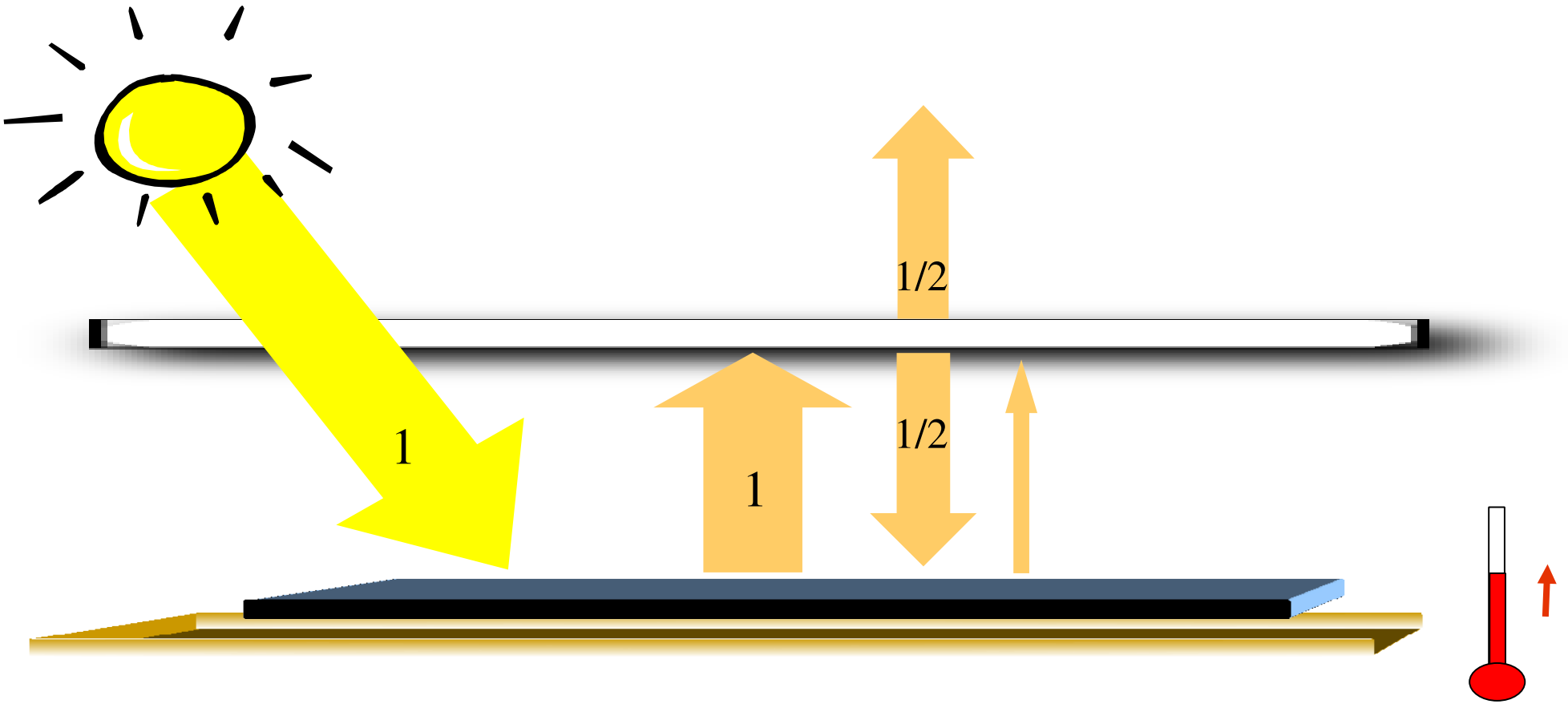
The radiation emitted below the glass is absorbed by the surface, which temperature increases.

5) The greenhouse effect



The surface temperature increases, and it emits more infra-red radiation.

5) The greenhouse effect



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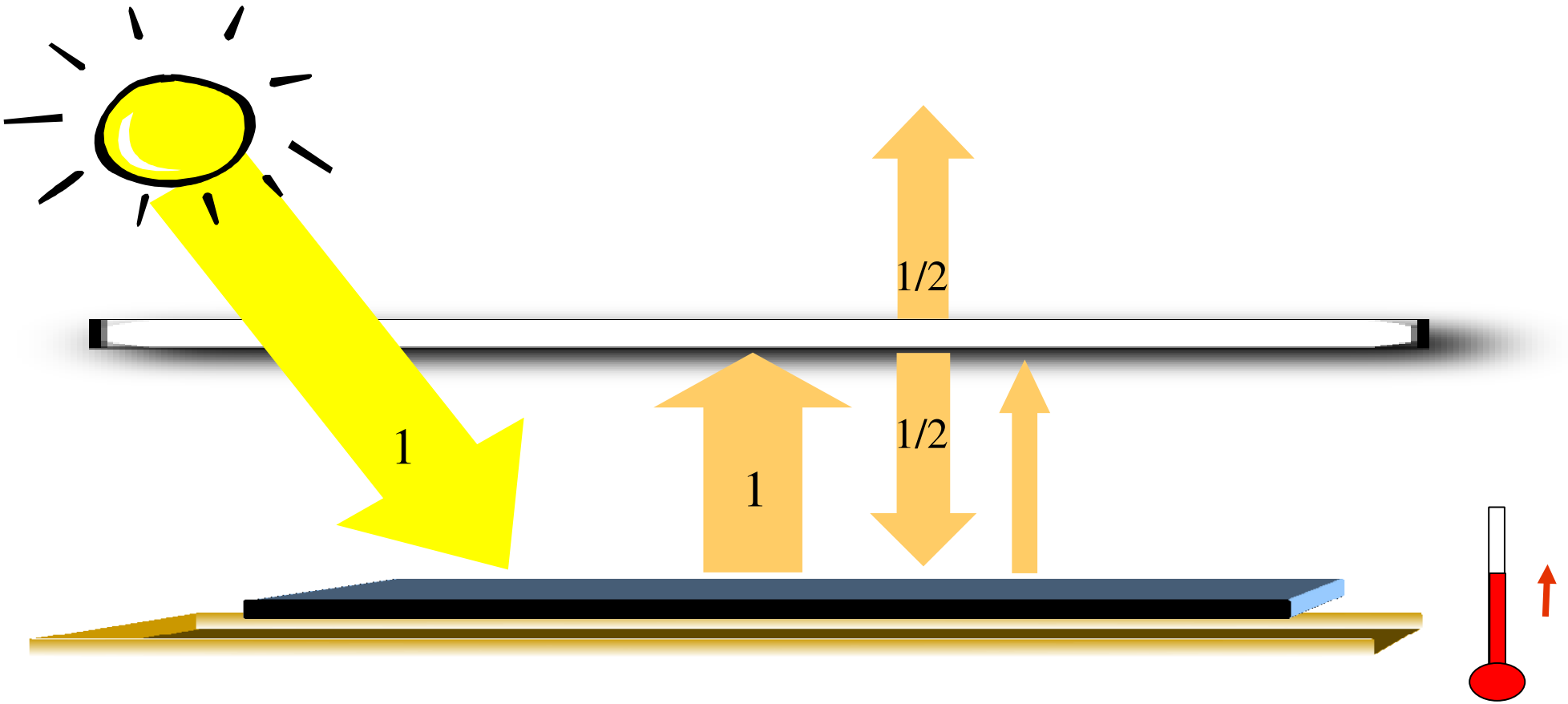
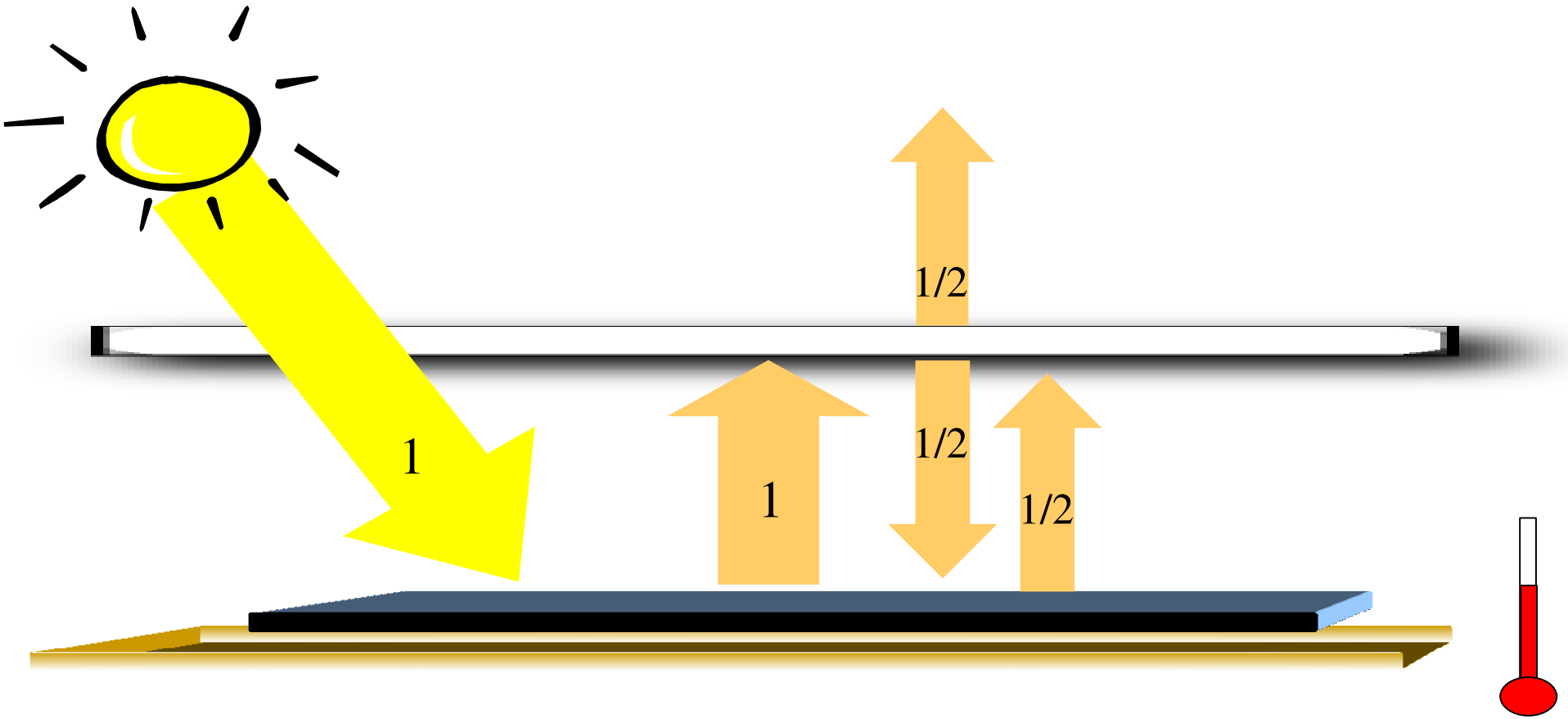
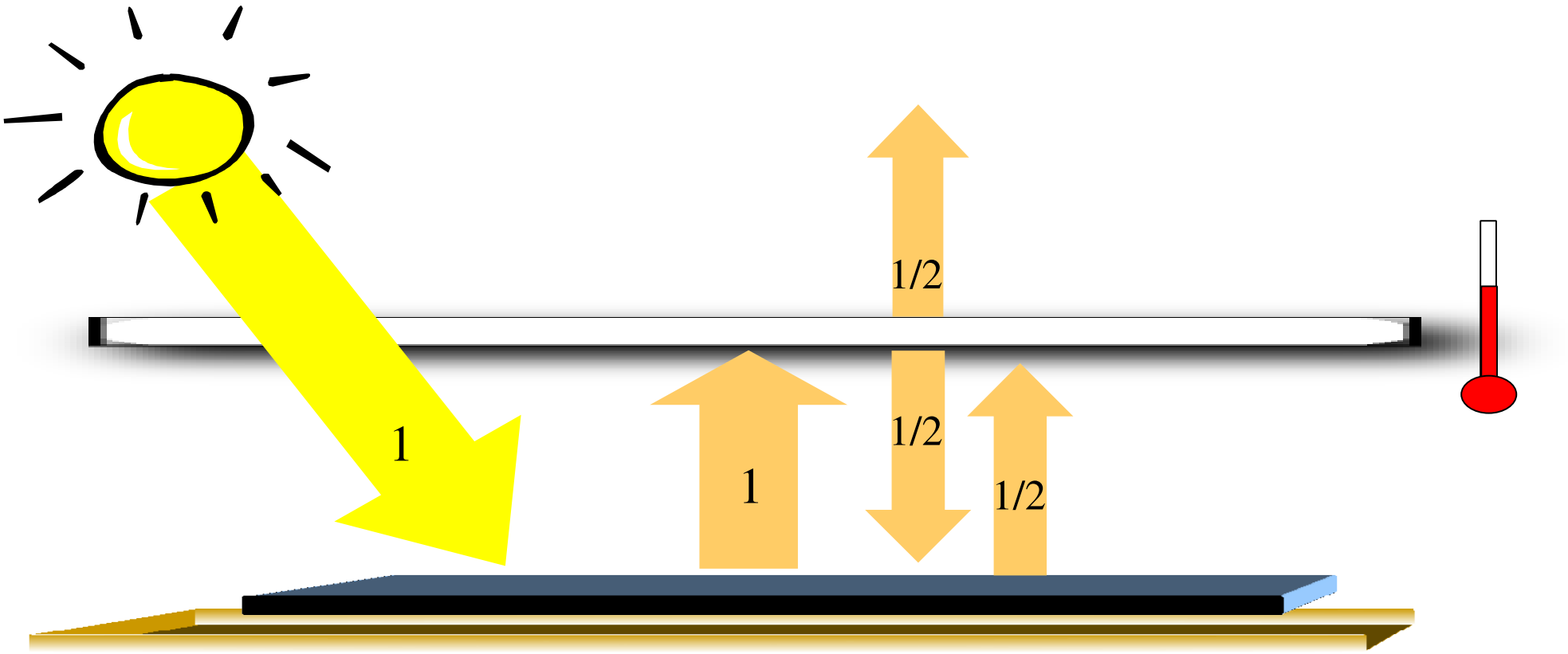


5) The greenhouse effect



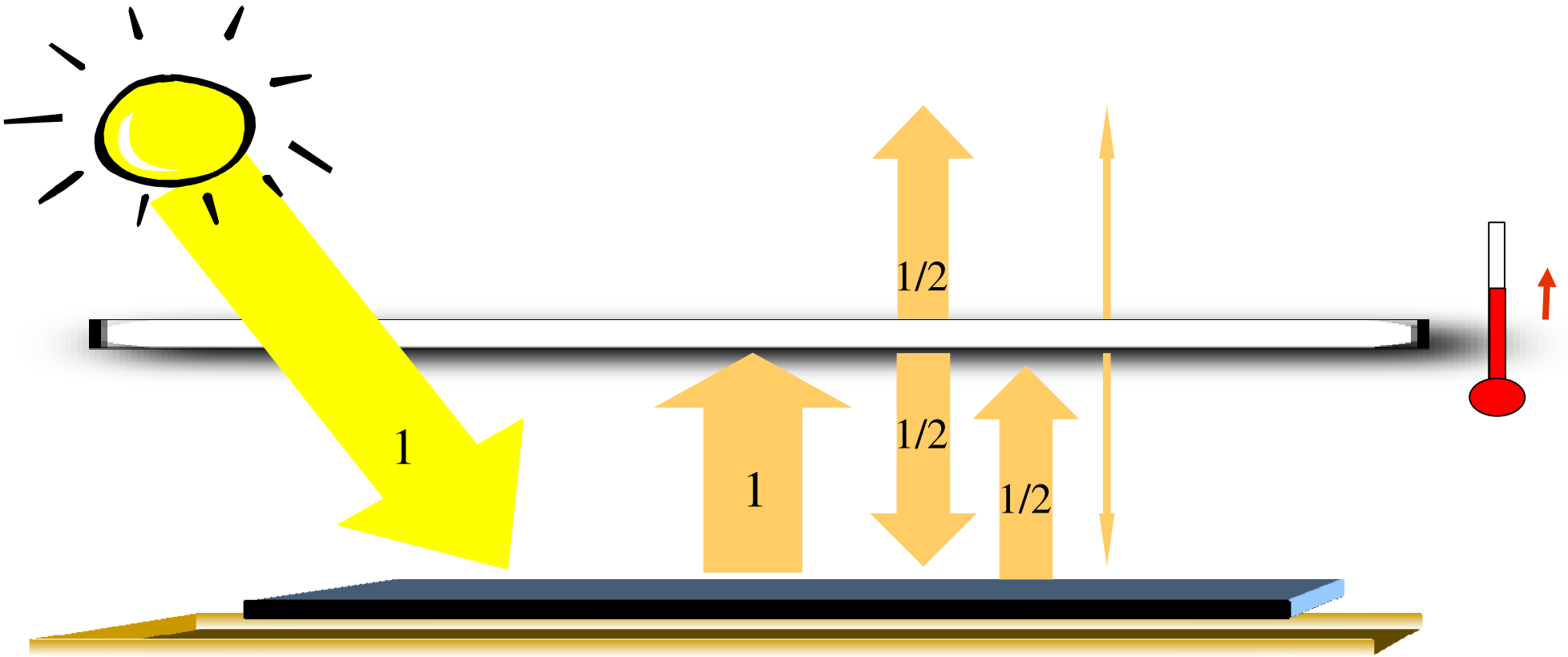
... until a new equilibrium is reached.

5) The greenhouse effect



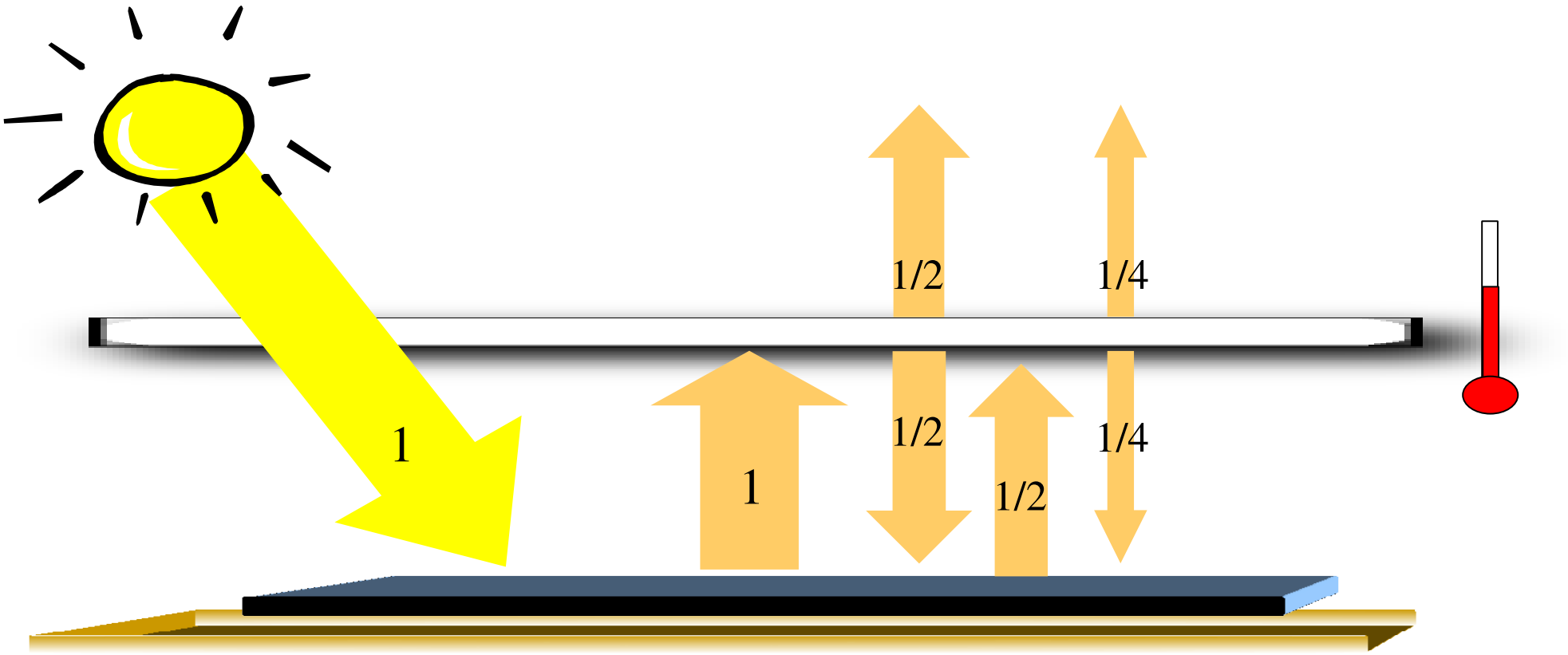
This infra-red radiation emitted by the surface is absorbed by the glass, which temperature increases.

5) The greenhouse effect



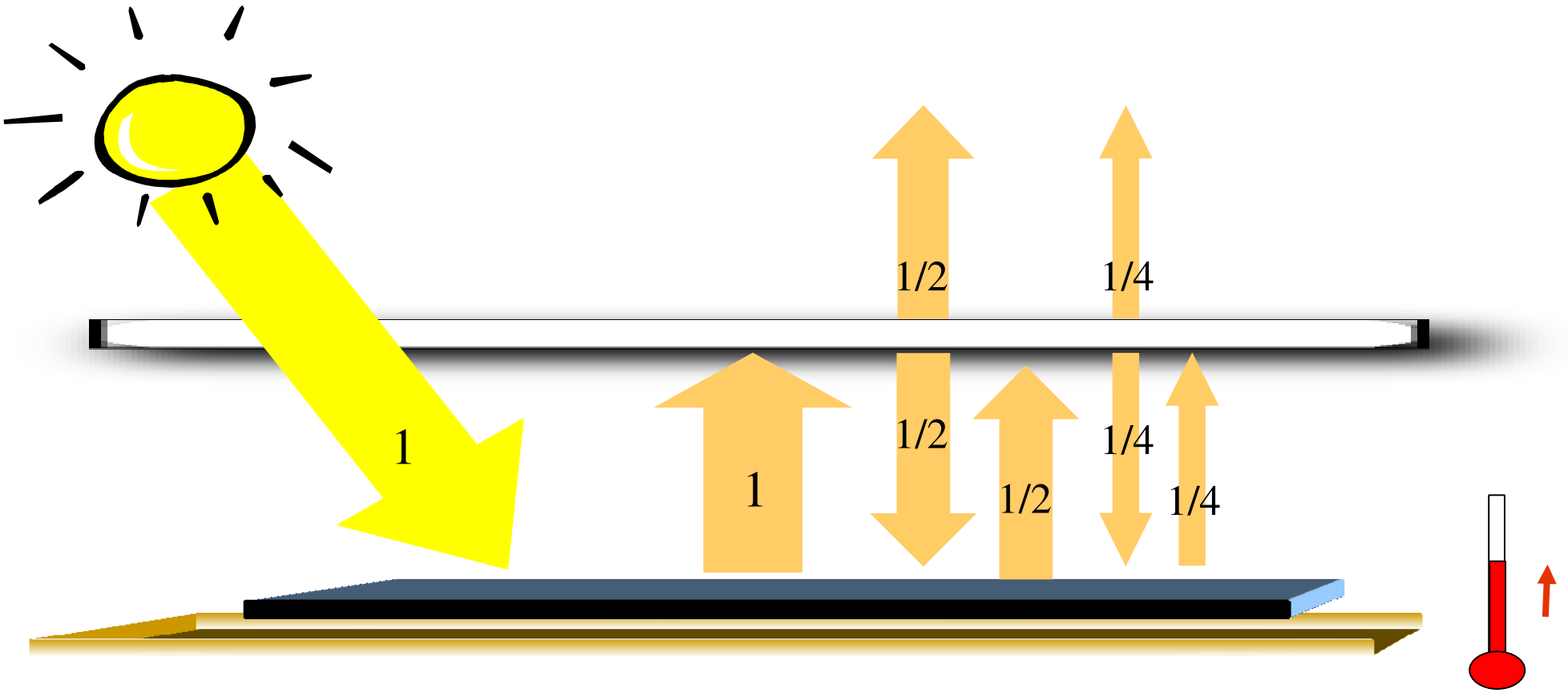
The temperature of the glass increases, it emits more radiation, half above and half below the glass.

5) The greenhouse effect



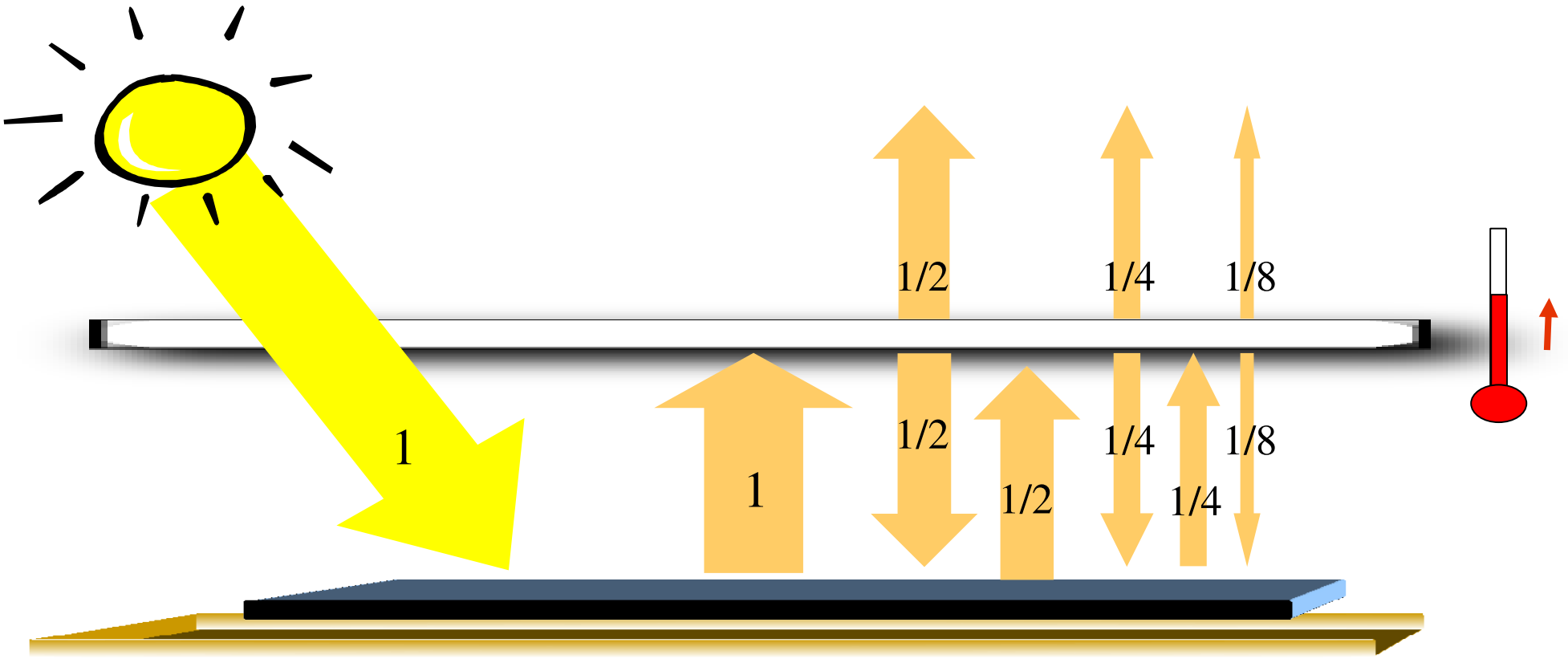
... until a new equilibrium is reached.

5) The greenhouse effect



... and so on.

5) The greenhouse effect



... and so on.

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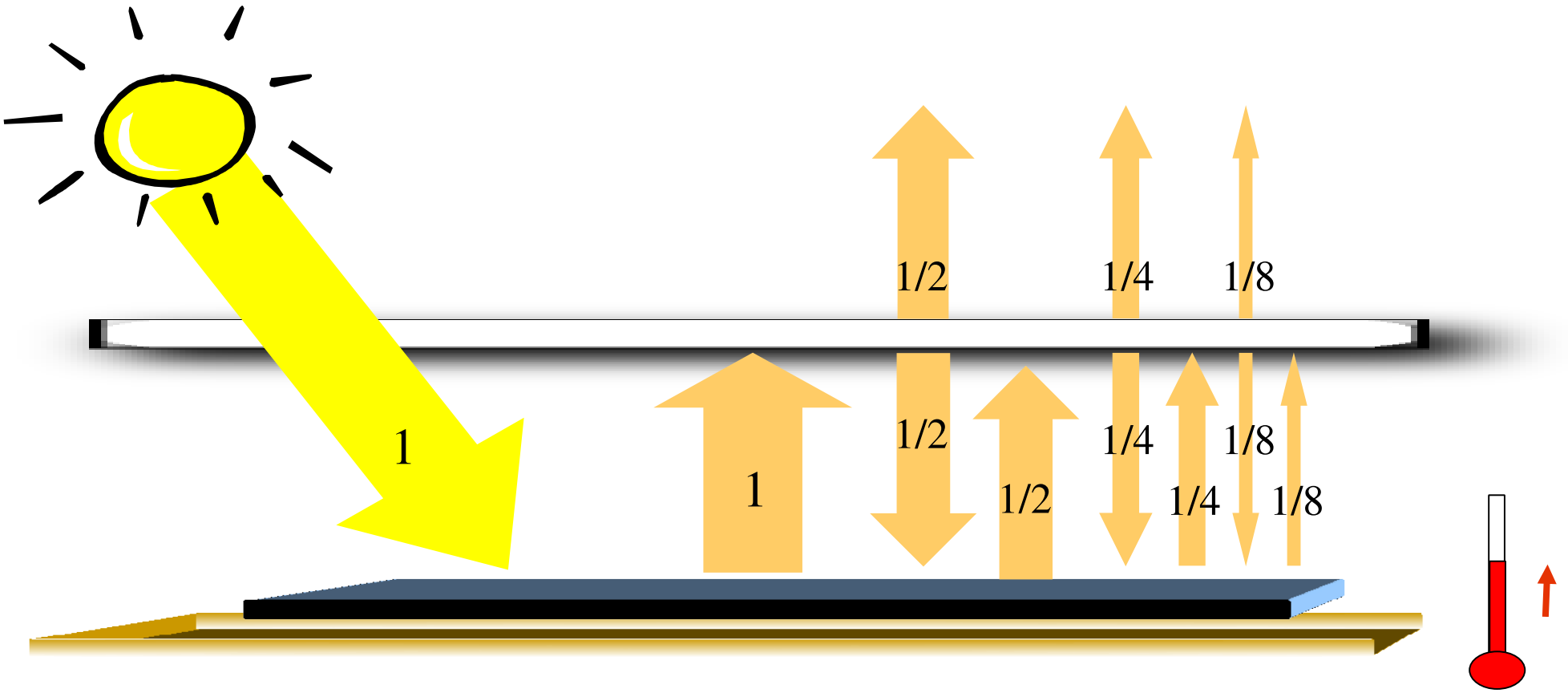
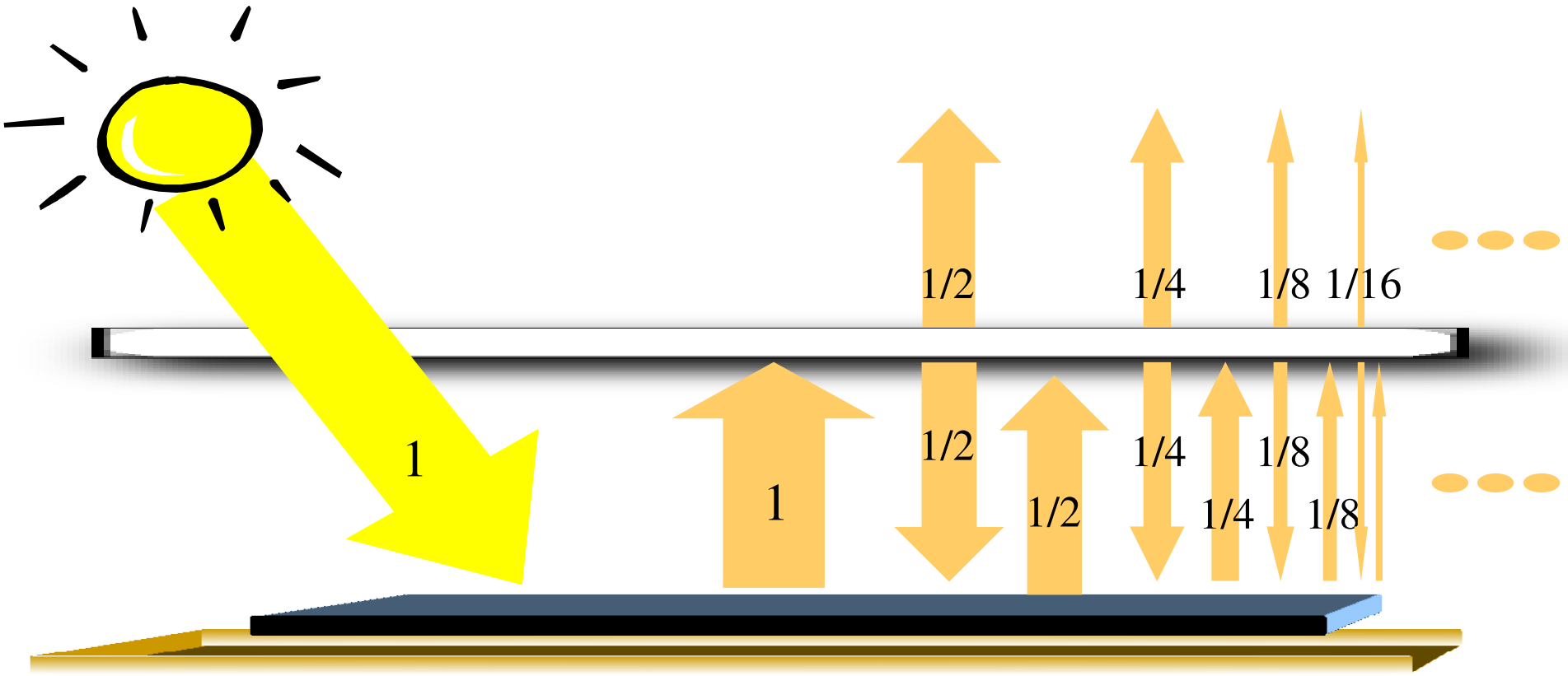


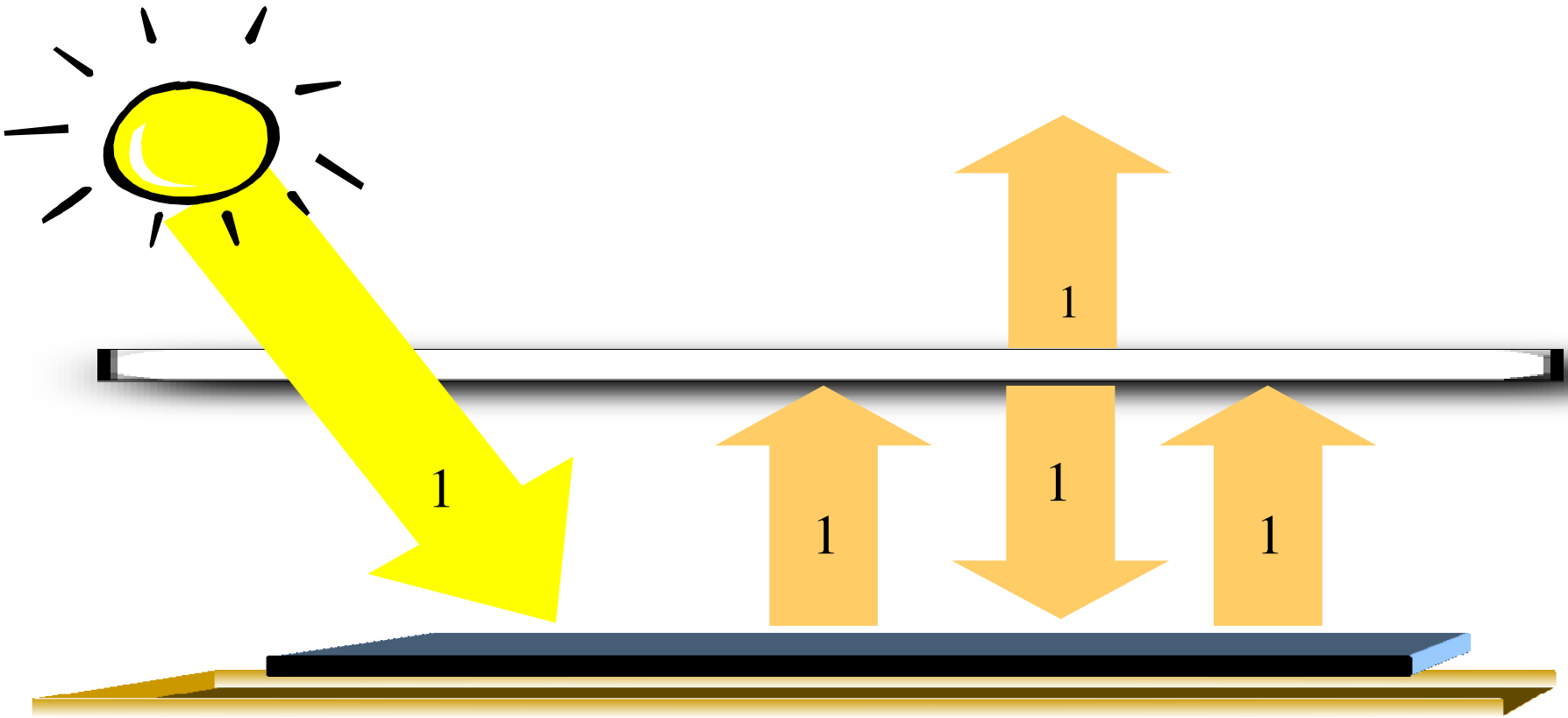
... and so on.

5) The greenhouse effect



If we do the sum...

5) The greenhouse effect



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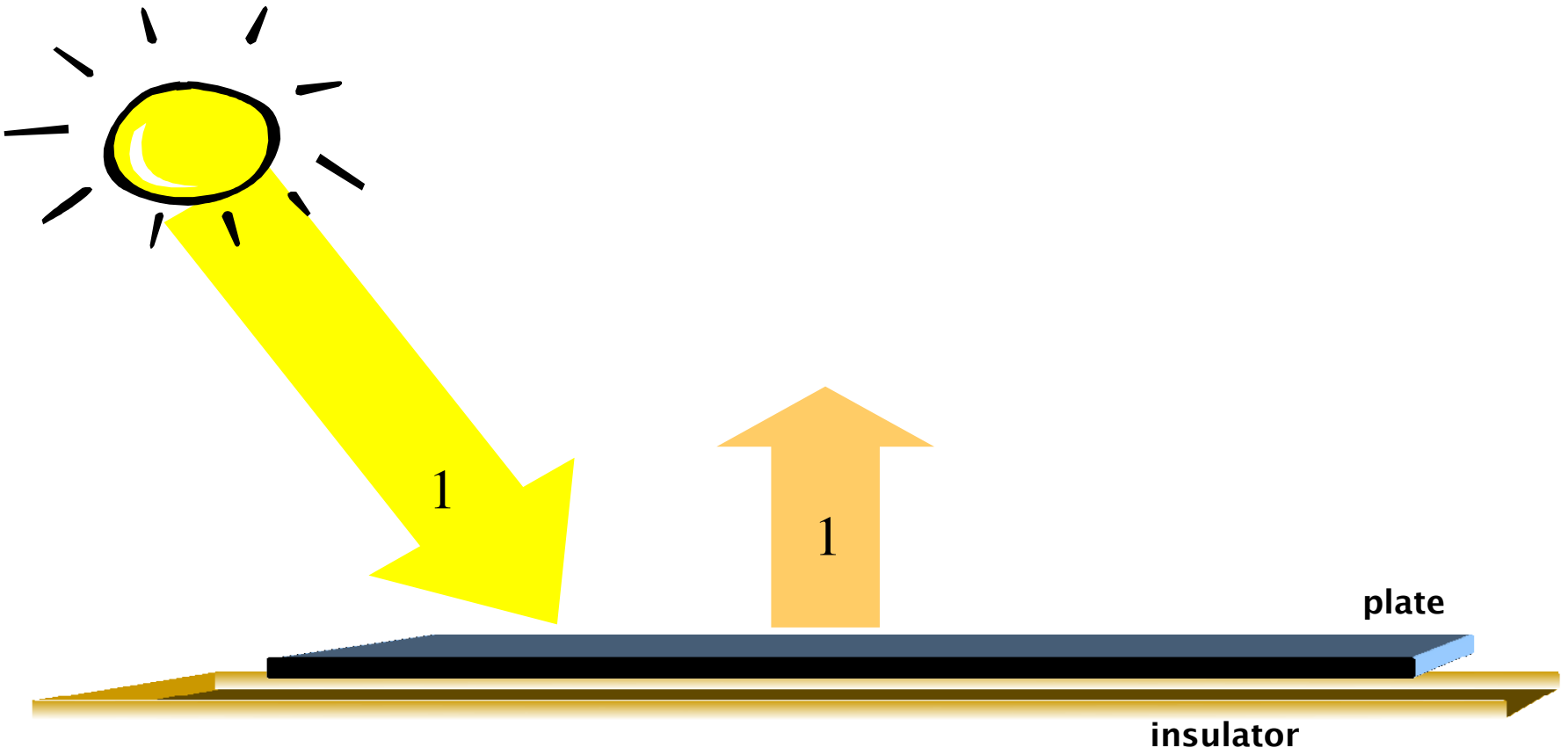
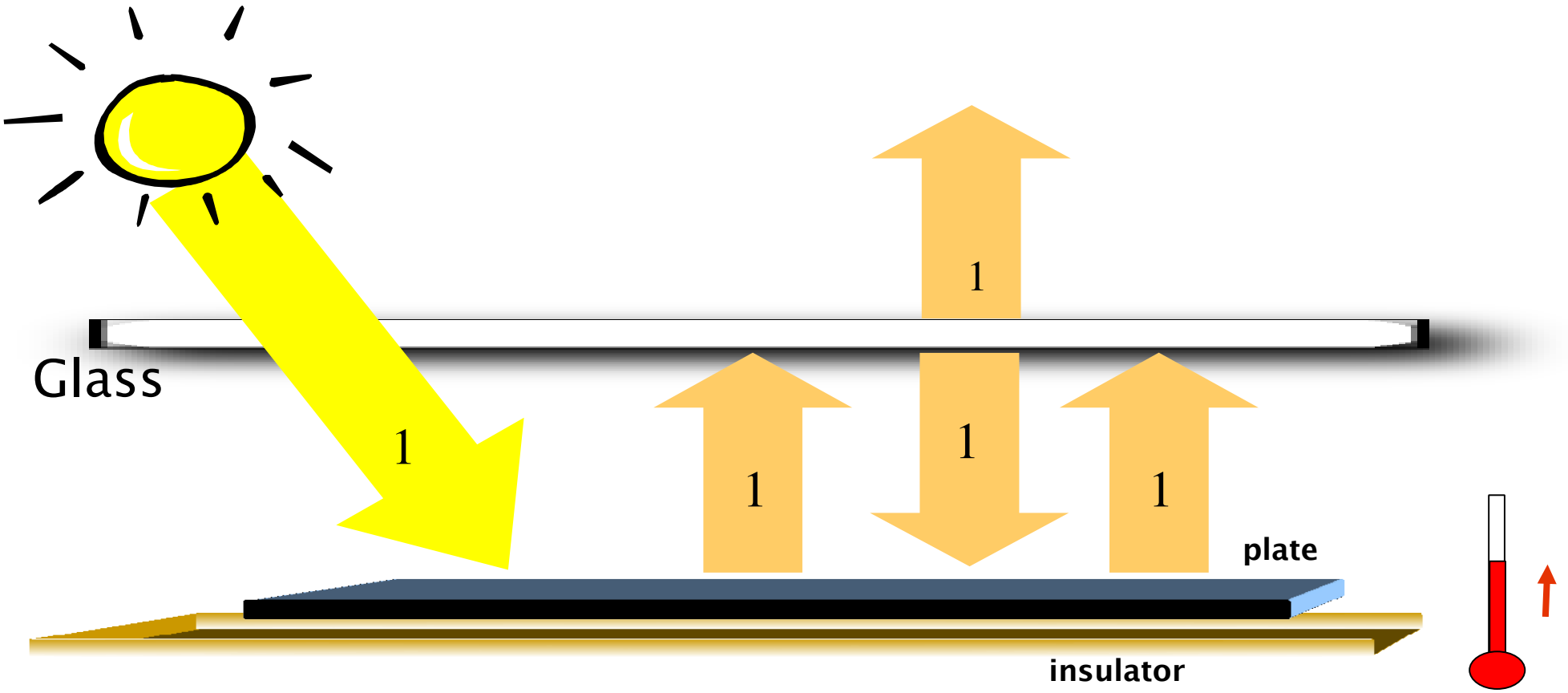


If we summarize:

5) The greenhouse effect



If we summarize: the infra-red radiation absorbed by the glass increases its temperature, it emits more radiation which is absorbed by the surface, which temperature increases.