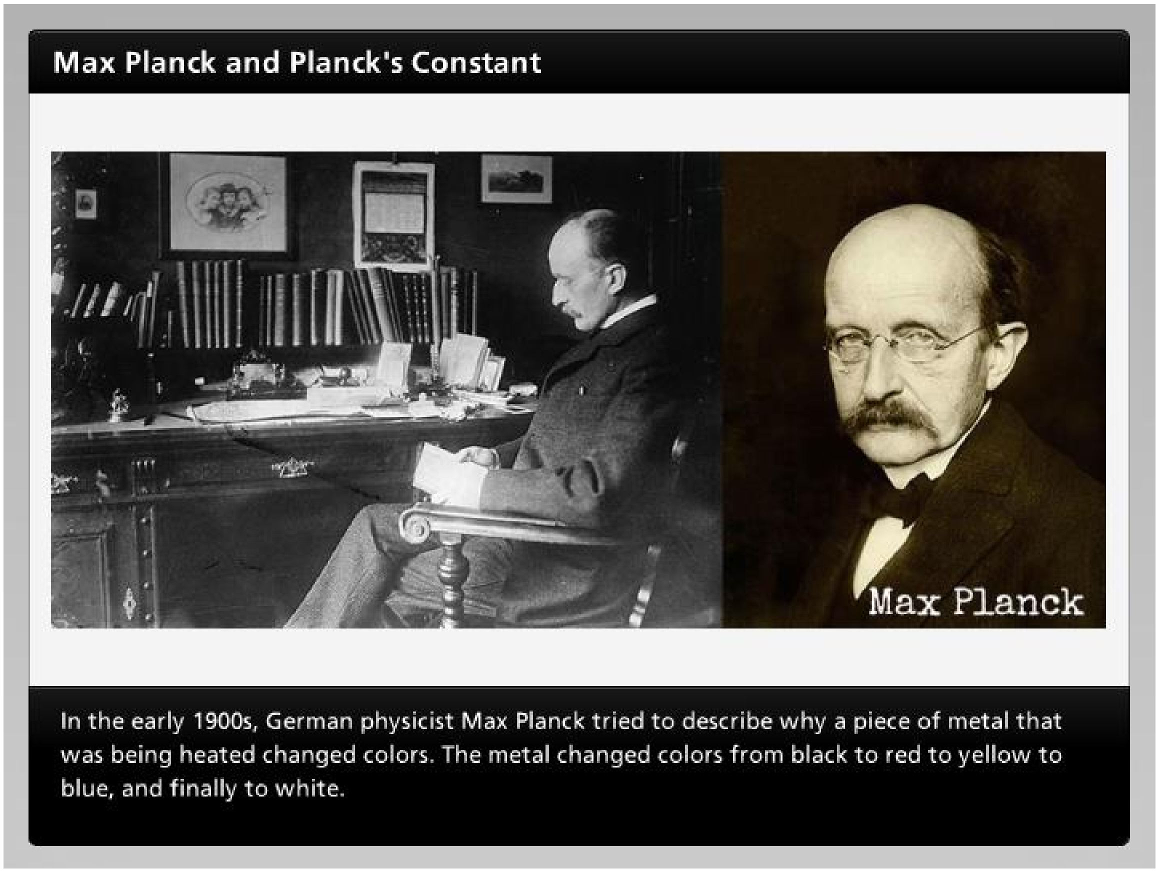
Module 3: Modern Atomic Theory, Electron Structure, and Periodicity

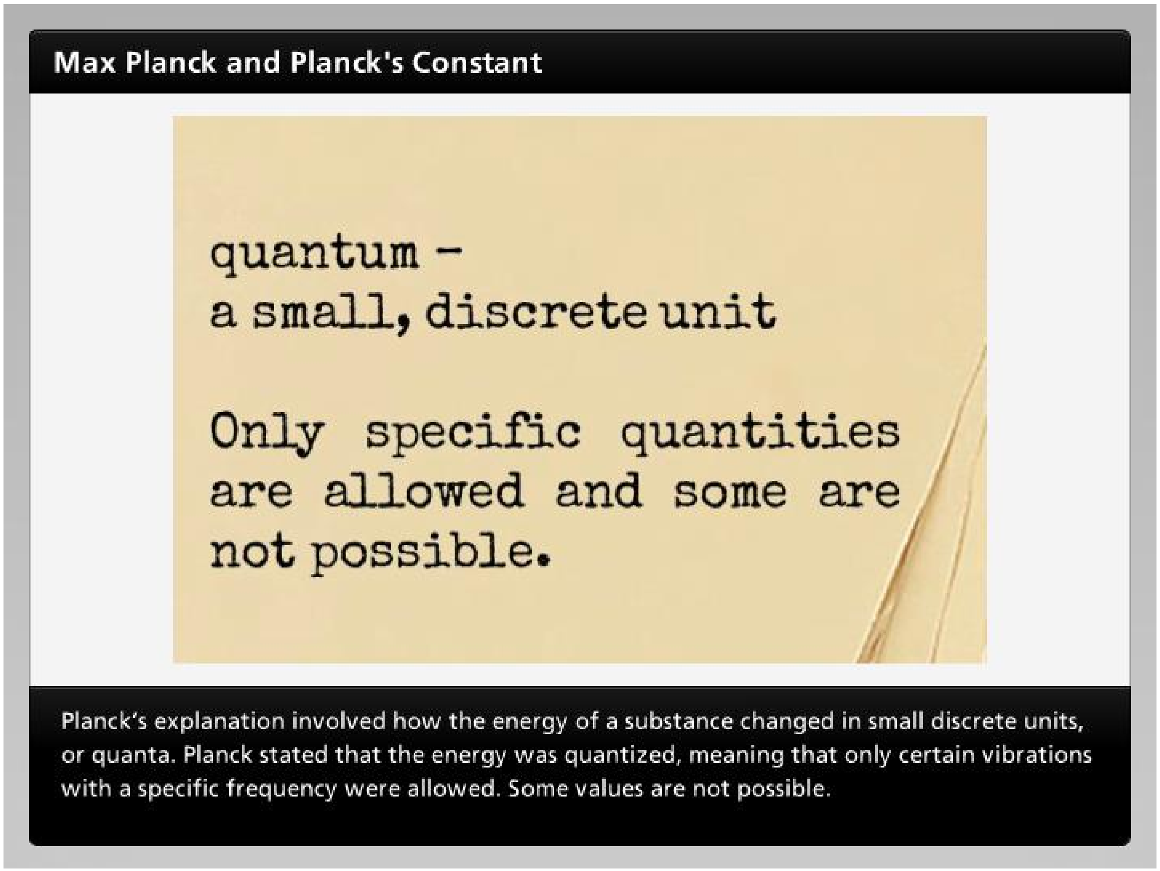
Topic 1 Content: Max Planck and Planck's Constant Presentation Notes



Max Planck and Planck's Constant

In the early 1900s, German physicist Max Planck tried to describe why a piece of metal that was being heated changed colors. The metal changed colors from black to red to yellow to blue, and finally to white.

In the early 1900s, German physicist Max Planck tried to describe why a piece of metal that was being heated changed colors. The metal changed colors from black to red to yellow to blue, and finally to white.



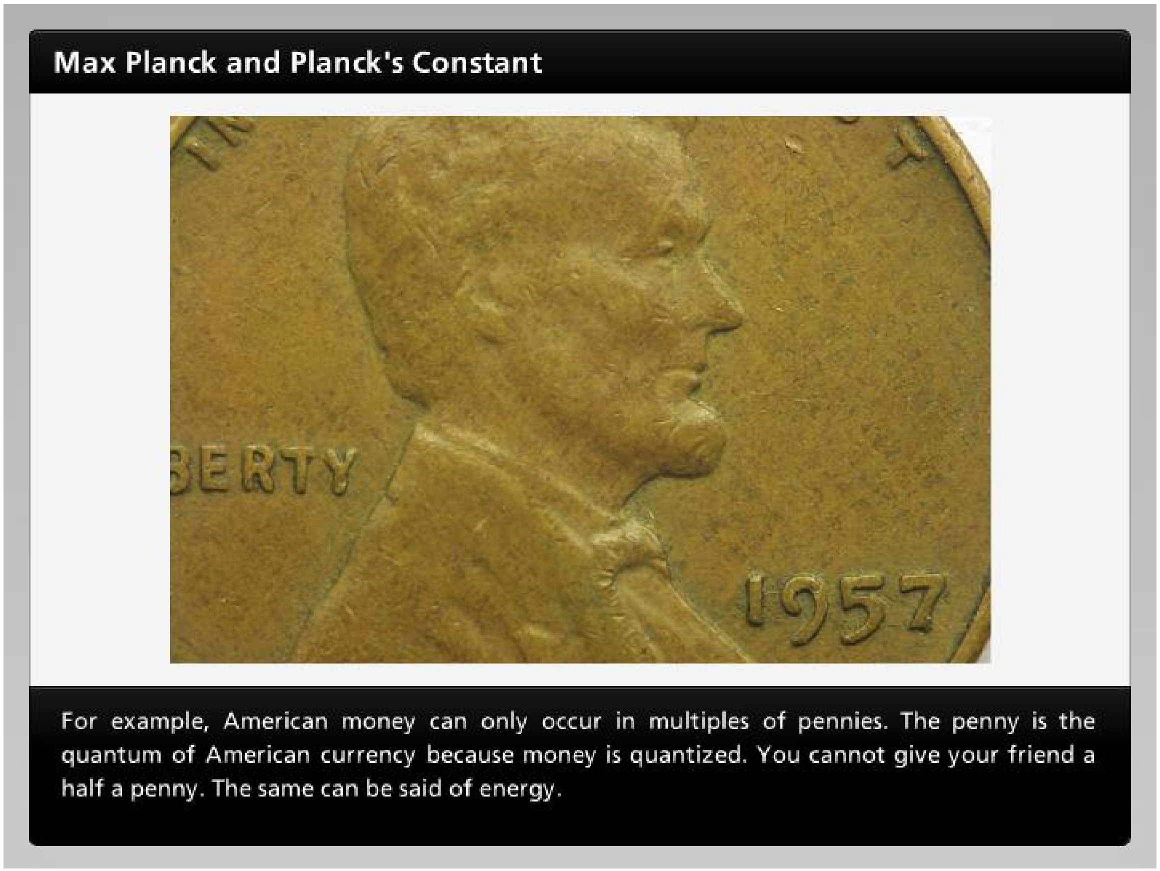
Max Planck and Planck's Constant

quantum -
a small, discrete unit

Only specific quantities are allowed and some are not possible.

Planck's explanation involved how the energy of a substance changed in small discrete units, or quanta. Planck stated that the energy was quantized, meaning that only certain vibrations with a specific frequency were allowed. Some values are not possible.

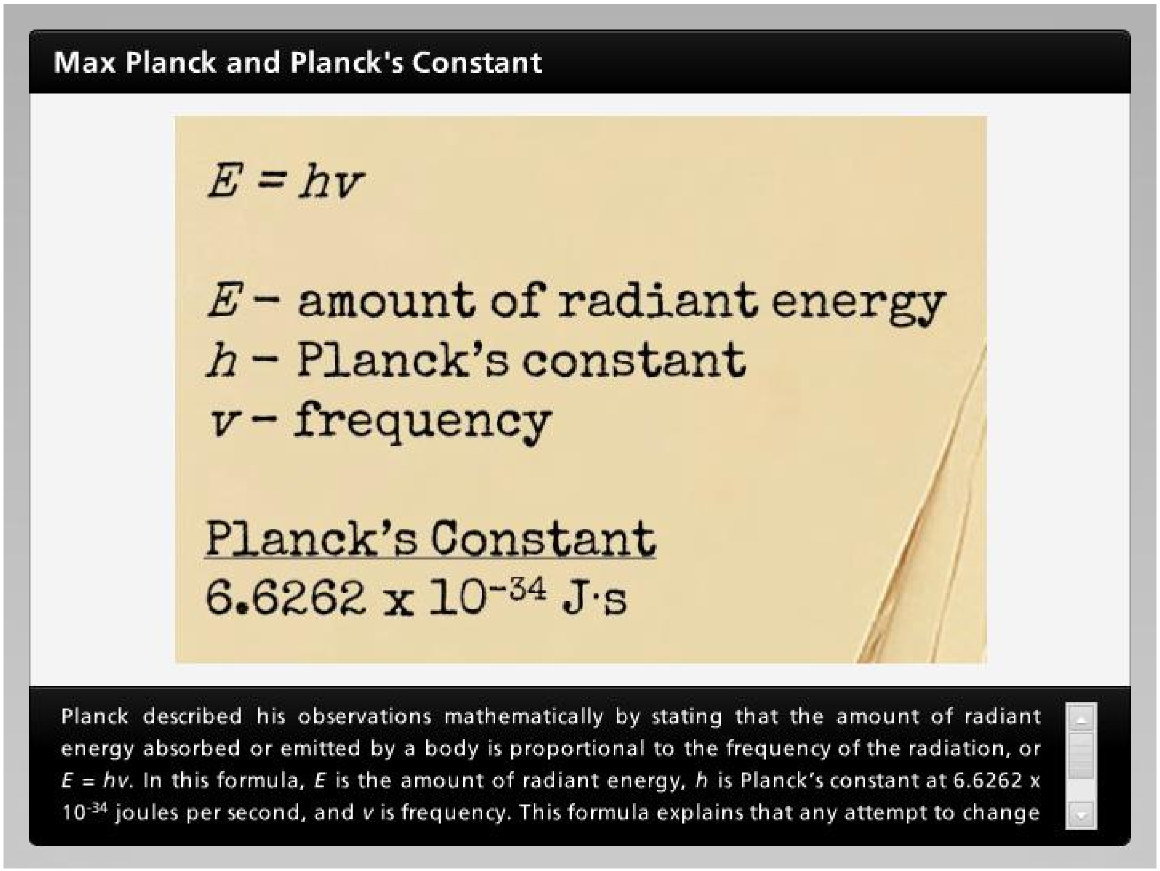
Planck's explanation involved how the energy of a substance changed in small discrete units, or quanta. Planck stated that the energy was quantized, meaning that only certain vibrations with a specific frequency were allowed. Some values were not possible.



Max Planck and Planck's Constant

For example, American money can only occur in multiples of pennies. The penny is the quantum of American currency because money is quantized. You cannot give your friend a half a penny. The same can be said of energy.

For example, American money can only occur in multiples of pennies. The penny is the quantum of American currency because money is quantized. You cannot give your friend a half a penny. The same can be said of energy.



Max Planck and Planck's Constant

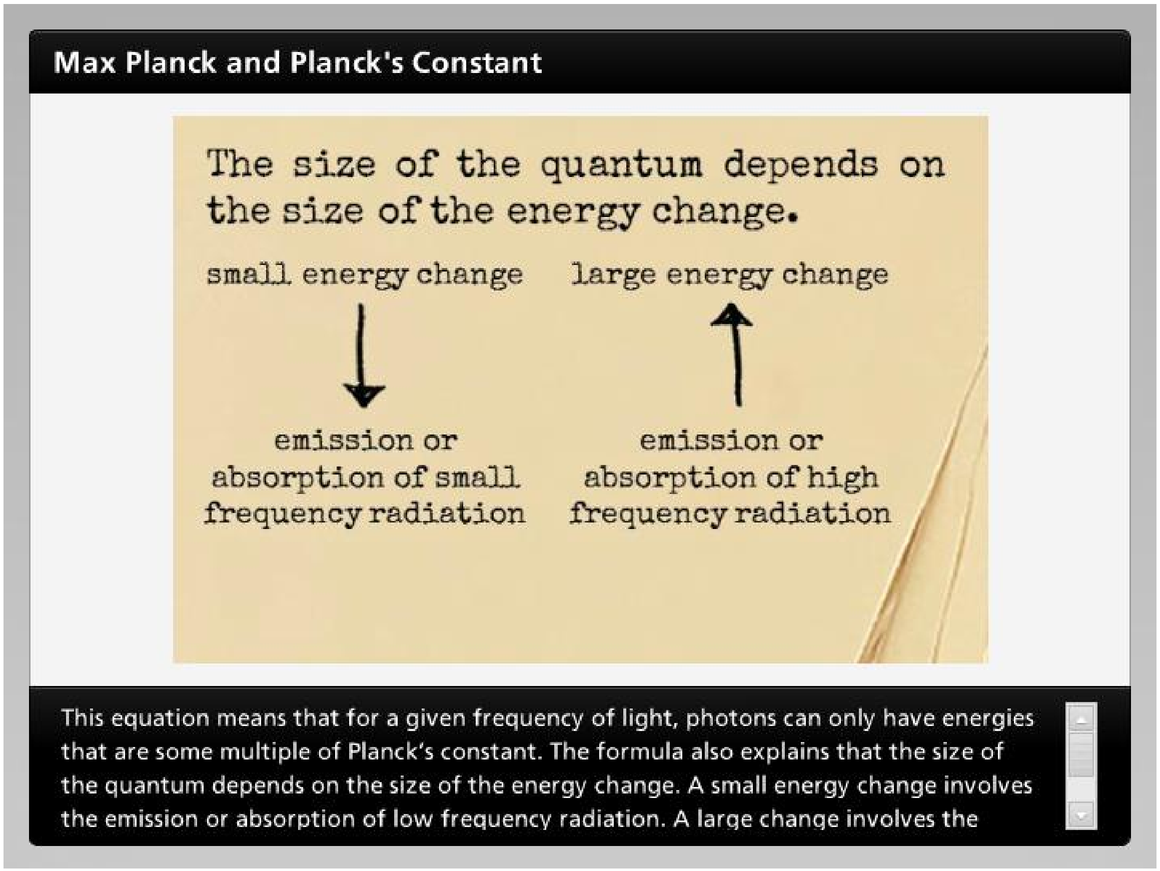
$E = hv$

E – amount of radiant energy
h – Planck's constant
v – frequency

Planck's Constant
6.6262×10^{-34} J·s

Planck described his observations mathematically by stating that the amount of radiant energy absorbed or emitted by a body is proportional to the frequency of the radiation, or $E = hv$. In this formula, E is the amount of radiant energy, h is Planck's constant at 6.6262 x 10^{-34} joules per second, and v is frequency. This formula explains that any attempt to change

Planck described his observations mathematically by stating that the amount of radiant energy absorbed or emitted by a body is proportional to the frequency of the radiation, or $E = hv$. In this formula, E is the amount of radiant energy, h is Planck's constant at 6.6262 x 10^{-34} joules per second, and v is frequency. This formula explains that any attempt to change the energy of a quantum by less than hv will fail.



Max Planck and Planck's Constant

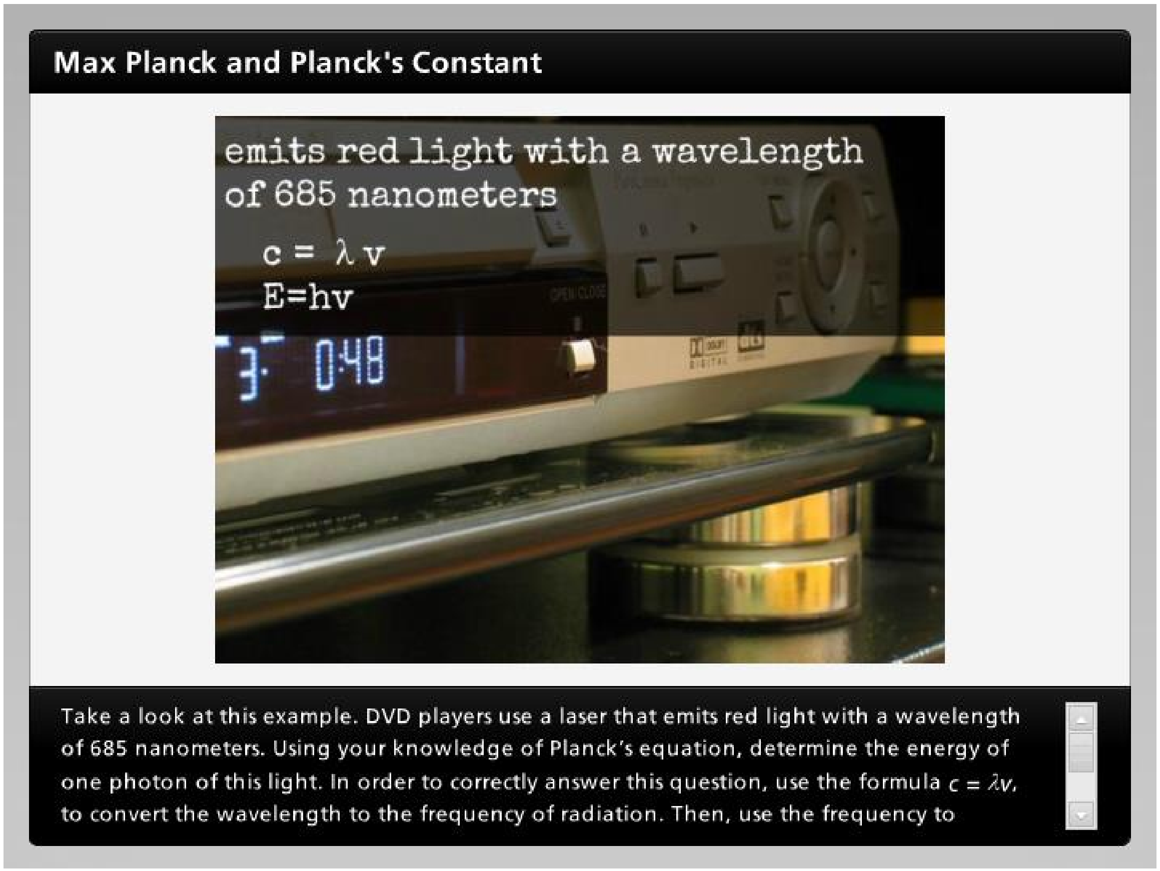
The size of the quantum depends on the size of the energy change.

small energy change → emission or absorption of small frequency radiation

large energy change → emission or absorption of high frequency radiation

This equation means that for a given frequency of light, photons can only have energies that are some multiple of Planck's constant. The formula also explains that the size of the quantum depends on the size of the energy change. A small energy change involves the emission or absorption of low frequency radiation. A large change involves the

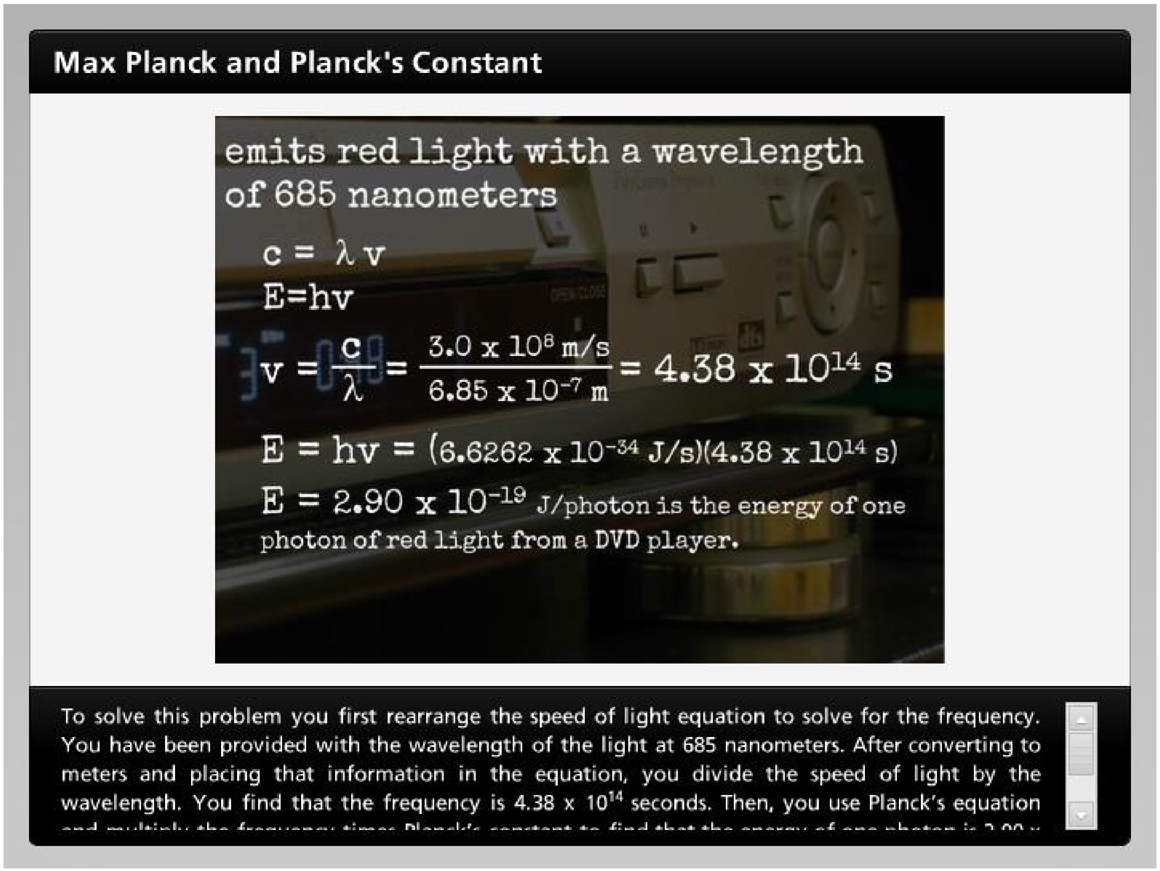
This equation means that for a given frequency of light, photons can only have energies that are some multiple of Planck's constant. The formula also explains that the size of the quantum depends on the size of the energy change. A small energy change involves the emission or absorption of low frequency radiation. A large change involves the emission or absorption of high energy radiation.



Max Planck and Planck's Constant

Take a look at this example. DVD players use a laser that emits red light with a wavelength of 685 nanometers. Using your knowledge of Planck's equation, determine the energy of one photon of this light. In order to correctly answer this question, use the formula $c = \lambda v$, to convert the wavelength to the frequency of radiation. Then, use the frequency to

Take a look at this example. DVD players use a laser that emits red light with a wavelength of 685 nanometers. Using your knowledge of Planck's equation, determine the energy of one photon of this light. In order to correctly answer this question, use the formula $c = \lambda v$, to convert the wavelength to the frequency of radiation. Then, use the frequency to calculate the energy per photon using the equation $E=hv$. Once you have calculated your answer, click ***NEXT*** to check your response.



Max Planck and Planck's Constant

emits red light with a wavelength of 685 nanometers

$c = \lambda v$

$E = hv$

$$v = \frac{c}{\lambda} = \frac{3.0 \times 10^{8}\ m/s}{6.85 \times 10^{-7}\ m} = 4.38 \times 10^{14}\ s$$

$$E = hv = (6.6262 \times 10^{-34}\ J/s)(4.38 \times 10^{14}\ s)$$

$E = 2.90 \times 10^{-19}$ J/photon is the energy of one photon of red light from a DVD player.

To solve this problem you first rearrange the speed of light equation to solve for the frequency. You have been provided with the wavelength of the light at 685 nanometers. After converting to meters and placing that information in the equation, you divide the speed of light by the wavelength. You find that the frequency is 4.38 x 10^{14} seconds. Then, you use Planck's equation

To solve this problem you first rearrange the speed of light equation to solve for the frequency. You have been provided with the wavelength of the light at 685 nanometers. After converting to meters and placing that information in the equation, you divide the speed of light by the wavelength. You find that the frequency is 4.38 x 10^{14} seconds. Then, you use Planck's equation and multiply the frequency times Planck's constant to find that the energy of one photon is 2.90 x 10^{-19} joules.