SAMPLE PROBLEM A

Quantum Energy

PROBLEM

At the peak of the sun's radiation spectrum, each photon carries an energy of about 2.7 eV. What is the frequency of this light?

SOLUTION

Given: $E = 2.7 \text{ eV}$ $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$

Unknown: $f = ?$

Use the equation for the energy of a light quantum, and isolate frequency.

$$E = hf \quad \text{or} \quad f = \frac{E}{h}$$

$$f = \frac{E}{h} = \frac{(2.7 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{6.63 \times 10^{-34} \text{ J} \cdot \text{s}}$$

$$\boxed{f = 6.5 \times 10^{14} \text{ Hz}}$$

TIP

Always be sure that your units cancel properly. In this problem, you need to convert energy from electron volts to joules. For this reason, 2.7 eV is multiplied by the conversion factor of 1.60×10^{-19} J/eV.

PRACTICE A

Quantum Energy

1. Assume that the pendulum of a grandfather clock acts as one of Planck's resonators. If it carries away an energy of 8.1×10^{-15} eV in a one-quantum change, what is the frequency of the pendulum? (Note that an energy this small would not be measurable. For this reason, we do not notice quantum effects in the large-scale world.)
2. A vibrating mass-spring system has a frequency of 0.56 Hz. How much energy of this vibration is carried away in a one-quantum change?
3. A photon in a laboratory experiment has an energy of 5.0 eV. What is the frequency of this photon?
4. Radiation emitted from human skin reaches its peak at $\lambda = 940$ μm.
   - **a.** What is the frequency of this radiation?
   - **b.** What type of electromagnetic waves are these?
   - **c.** How much energy (in electron volts) is carried by one quantum of this radiation?