(b) \( \bar{\nu} \) (wavenumber) = \( \frac{1}{\lambda} = \frac{1}{408 \times 10^{-9} \text{m}} = 2.45 \times 10^6 \text{m}^{-1} \)

(c) \( \lambda = 408 \times 10^{-9} \text{m} \times \frac{10^{10} \text{Å}}{\text{m}} = 4080 \text{Å} \)

(d) \( E = h\nu \times N_A = 6.63 \times 10^{-34} \times 7.353 \times 10^{14} \times 6.02 \times 10^{23} \text{ J/mole} \)

\[ = 2.93 \times 10^5 \text{ J/mole} = 293 \text{ kJ/mole} \]

(e) visible spectrum: violet (500 nm) red (800 nm) 408 nm = UV

Problem #3

For "yellow radiation" (frequency, \( \nu \), = \( 5.09 \times 10^{14} \text{ s}^{-1} \)) emitted by activated sodium, determine:

(a) the wavelength (\( \lambda \)) in [m]

(b) the wave number (\( \bar{\nu} \)) in [cm\(^{-1}\)]

(c) the total energy (in kJ) associated with 1 mole of photons

Solution

(a) The equation relating \( \lambda \) and \( \nu \) is \( c = \lambda \nu \) where \( c \) is the speed of light = \( 3.00 \times 10^8 \text{ m} \).

\[ \lambda = \frac{3.00 \times 10^8 \text{ m/s}}{5.09 \times 10^{14} \text{ s}^{-1}} = 5.89 \times 10^{-7} \text{m} \]

(b) The wave number is \( 1/\text{wavelength} \), but since the wavelength is in m, and the wave number should be in cm\(^{-1}\), we first change the wavelength into cm:

\[ \lambda = 5.89 \times 10^{-7} \text{m} \times 100\text{cm/m} = 5.89 \times 10^{-5} \text{ cm} \]

Now we take the reciprocal of the wavelength to obtain the wave number:

\[ \bar{\nu} = \frac{1}{\lambda} = \frac{1}{5.89 \times 10^{-5} \text{ cm}} = 1.70 \times 10^4 \text{ cm}^{-1} \]

(c) The Einstein equation, \( E = h\nu \), will give the energy associated with one photon since we know \( h \), Planck's constant, and \( \nu \). We need to multiply the energy obtained by Avogadro's number to get the energy per mole of photons.

\[ h = 6.62 \times 10^{-34} \text{ J.s} \]

\[ \nu = 5.09 \times 10^{14} \text{ s}^{-1} \]

\[ E = h\nu = (6.62 \times 10^{-34} \text{ J.s}) \times (5.09 \times 10^{14} \text{ s}^{-1}) = 3.37 \times 10^{-19} \text{ J per photon} \]