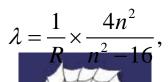
## 752.

## Problem 51.22 (RHK)

In stars the Pickering series is found in the  $He^+$ spectrum. It is emitted when the electron in  $He^+$  jumps from higher levels to the level with n = 4. We have to show that (a) the wavelengths of the lines in this series are given by



in which n = 5, 6, 7.. We have to calculate the wavelength of the first line in this series and of the series limit. (c) We have to find the region of the electromagnetic spectrum in which this series occurs.

## **Solution:**

(a)

In the Bohr' model the energies of hydrogen like atom are given by

$$E_n = -\frac{hcR}{n^2}, n = 1, 2, 3...$$

The Rydberg constant *R* can be expressed in terms of the fundamental constants as

$$R_{\rm He^+} = \frac{2\alpha^2}{(h/mc)} = 4R$$

where Z is the charge of the nucleus and  $\alpha$  is the fine structure constant,

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 hc} = \frac{1}{137}.$$

For  $\text{He}^+$  atom Z = 2 and

$$R = \frac{2\alpha^2}{(h/mc)}.$$
Pickering series corresponds to transitions from

Pickering series corresponds to transitions from states with n = 5, 6, 7... to the state with n = 4. Thus the wavelengths of radiation which form Pickering series will be given by

$$\lambda_{n} = \frac{c}{v_{n}} = \frac{ch}{\left(\frac{hcR_{He}^{+}}{4^{2}} + \frac{hcR_{He}^{+}}{n^{2}}\right)} = \frac{4n^{2}}{R(n^{2} - 16)}.$$
(b)

The wavelength of the first line in the Pickering series will correspond to transition from the state with n = 5 to n = 4. We find

$$\lambda_5 = \frac{4 \times 25}{R(25 - 16)} = \frac{100}{9R}.$$

We next calculate the value of R for

Therefore,

$$\lambda_5 = \frac{100}{9} \times \frac{2 \times 2.418 \times 10^{-12}}{(1/137)^2} \text{m} = 1008 \text{ nm.}$$

Wavelength of the series limit will correspond to  $n \rightarrow \infty$ . We get

$$\lambda_{\text{series limit}} = \frac{4}{R} = 2 \times 4 \times (137)^2 \times 2.418 \times 10^{-12} \text{ m}$$

$$= 36.28 \text{ nm.}$$
(c)
The spectrum of wavelengths in the Pickering series,

therefore, occurs in the ultraviolet region extending to visible region.