Answer on Question #40615-Chemistry-Inorganic Chemistry

Question

An X-ray photon of wavelength 0.989 nm strikes a surface. The emitted electron has a kinetic energy of 969eV. What is the binding energy of the electron in kJ/mol?

Solution

The electron binding energy of each of the emitted electrons can be determined by using an equation that is based on the work of Ernest Rutherford:

$$E_{binding} = E_{photon} - (E_{kinetic} + \varphi)$$

where $E_{binding}$ is the binding energy of the electron, E_{photon} is the energy of the X-ray photons being used, $E_{kinetic}$ is the kinetic energy of the electron as measured by the instrument and φ is the work function of the spectrometer.

It is given that $E_{kinetic}$ = 969 eV = $969 \cdot 1.60 \cdot 10^{-19} = 1.55 \cdot 10^{-16}$ J

Since the work function φ is not specified in the task it can be neglected ($\varphi = 0$).

Energy of the photon is

$$E_{photon} = h\nu = \frac{hc}{\lambda},$$

where h – Plank constant ($h = 6.63 \cdot 10^{-34}$ J·s), c – speed of light ($c = 3.00 \cdot 10^{8}$ m·s^{-1}), λ – wave length of the photon. In given case λ = 0.989 nm = $9.89 \cdot 10^{-10}$ m

$$E_{photon} = \frac{hc}{\lambda} = \frac{6.63 \cdot 10^{-34} \cdot 3.00 \cdot 10^{8}}{9.89 \cdot 10^{-10}} = 2.01 \cdot 10^{-16} J$$

The binding energy:

$$E_{binding} = E_{photon} - E_{kinetic} = 2.01 \cdot 10^{-16} - 1.55 \cdot 10^{-16} = 4.60 \cdot 10^{-17} J = 4.60 \cdot 10^{-20} kJ$$

To convert the value to kJ/mol we should multiply it by Avogadro constant ($N_A = 6.02 \cdot 10^{23}$ mol^{-1})

$$E_{binding} = 4.60 \cdot 10^{-20} kJ \cdot 6.02 \cdot 10^{23} mol^{-1} = 27692\ kJ/mol$$

Answer: 27692 kJ/mol