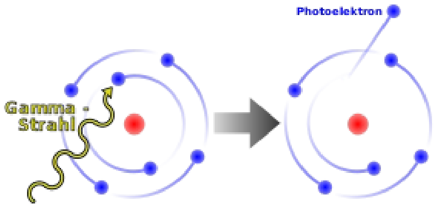
Radiant ionization

Radiant ionization (or **photoionization**) is a type of ionization in which an atom, ion, or molecule absorbs a quantum of electromagnetic radiation from an incident photon, releasing an electron (called a *photoelectron*) from the atom, ion, or molecule.

Ionizing electromagnetic radiation typically includes UV radiation , X-rays, and gamma radiation.



Principle of photoionization

This is essentially the same process that occurs in the photoelectric effect. Upon impact, electromagnetic radiation transfers energy to electrons on the surface of the substance under investigation. If the frequency of the incident radiation is high enough (wavelength low enough), the electron can reach a sufficient energy value to be released from the bond in the shell of the atom. In radiant ionization, the energy of electromagnetic radiation is used to release an electron, in contrast to collisional ionization, where part of the kinetic energy of the collision of two atoms is used to release an electron from an atom.

Ionization work

The ionization (output) work W is the energy required to remove an electron from an atomic shell. This work is equal to the binding energy of a given electron. If the photon energy of the incident radiation is less than the ionization work, ionization does not occur, regardless of the intensity of the incident radiation. In that case, the radiation can be absorbed and the electron is then "only" excited to higher energy levels.

If the energy of the incident radiation is higher than the ionization work of the atom, ionization occurs . The excess energy of the incident radiation is manifested by an increase in the kinetic energy of the released electron. This energy does not depend on the intensity of the incident radiation, but only on its frequency (in particle physics, frequency is denoted ν).

$$h\nu = W + \frac{mv^2}{2}$$

where *h* is Planck's constant (h = 6.6·10 -34 J·s), ν frequency of the photon, *W* ionization work and the expression $mv^2/2$ expresses the kinetic energy of the emitted electron.

In photoionization, the ionization energy is often expressed using the radiation wavelength λ :

$$h.\frac{c}{\lambda} = W + \frac{mv^2}{2}$$

where *c* is the speed of light ($c \doteq 3 \cdot 10^8$ m·s^{-1}).

This explains why only UV, X-rays and gamma rays ionize. The rest of the spectrum of electromagnetic radiation in the vast majority of cases does not cause ionization, as it does not have a sufficient frequency (i.e. a sufficiently small wavelength).

Ionization of hydrogen

For example, in order to ionize hydrogen, a photon must have an energy greater than 13.6 eV, which corresponds to a wavelength of 91.2 nm. For photons with higher energy than this, the relation for calculating the energy of the emitted photoelectron applies:

$$\frac{mv^2}{2} = h\nu - 13.6eV$$

Primary and secondary ionization

Ionizing particles form an ion pair (an ion pair consists of a positive ion and an electron). Primary ionization expresses the number of ion pairs created by an ionizing particle. Electrons released by primary ionization can have such a high kinetic energy that they are able to cause further, so-called secondary ionization of the environment (this ionization is therefore collisional ionization).

Links

Related articles

- The concept of ionization
- Interaction of ionizing radiation
- Collision ionization

External links

- https://en.wikipedia.org/wiki/Ionizing_radiation
- https://en.wikipedia.org/wiki/Photoionisation
- http://hyperphysics.phy-astr.gsu.edu/hbase/mod4.html

References

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- CARROLL, Bradley W – OSTLIE, Dale A. *An introduction to modern astrophysics.* 2. edition. San Francisco : Pearson Addison-Wesley, 2007. ISBN 0-321-44284-9.