**EXERCISE 1**

A surface of 2 cm² radiates as a black body at a temperature of 1500°C.

Calculate:

1. The total power radiated into space;
2. Its radiance;
3. The wavelength at which the radiation is maximal.

**EXERCISE 2**

To heat a room in an apartment, a cylindrical radiator with a diameter of 2.5 cm and a length of 60 cm is used. This radiator radiates as a black body and emits a power of 1.5 kW:

1. Calculâtes its temperature;
2. Calculate the wavelength at which its radiance is maximal;
3. What should its temperature be for this wavelength to be 2.3 m?
4. What would its emitted power be in that case?

**EXERCISE 3**

The positronium is an atom composed of a positron (antielectron) and an electron; its lifetime is on the order of 10−7s, which is relatively long on an atomic scale. Electron-positron annihilation ends the life of this atom.

1. What are the energy levels of positronium?
2. What are the extreme wavelengths of the Balmer series of positronium?

**EXERCISE 4**

Consider a hydrogen-like ion with atomic number Z, treated using Bohr's model.

1. Derive the ratio between the kinetic and potential energies in the energy state En
2. What is its energy in the state n?
3. Find the Z value beyond which the ratio v1/c exceeds 3%.
4. By how much does the hydrogen atom (Z=1) expand when it absorbs a 12 eV photon?

**EXERCISE 5**

We are interested in the Pickering series (transitions between level n=4 and other levels n) in the spectrum of singly ionized helium.

1. Assuming the nucleus has infinite mass, determine the wavelengths of the spectral lines whose values lie between 4000 Å and 5000 Å.
2. Now assuming the nucleus has a finite mass (the nucleus consists of two protons and two neutrons), determine the corrected wavelengths of the observed spectral lines.

**EXERCISE 6**

hydrogen-like ion is an atom consisting of an electron (mass mmm and charge −e) and a nucleus of mass M≫m and charge +Ze. We assume that the electron moves in a circular orbit of radius r around the fixed nucleus.

**1)**  
a) Show that the total energy of the hydrogen-like ion is given by:

E

b) What is the physical meaning of a total energy equal to zero?

**2)**  
What result is obtained by applying classical theory?

**)** We consider the following two hypotheses (Bohr's hypotheses):

* The only allowed orbits for the electron are those for which the angular momentum σ\sigmaσ satisfies the relation: ∣σ⃗∣=nℏ where n is an integer ≥1 .
* The electron radiates energy only when it jumps from an orbit characterized by energy En to another orbit of lower energy Ep​. The emission frequency νnp\nu\_{np}νnp​ is given by: hνnp=En−Eph\nu\_{np} = E\_n - E\_phνnp​=En​−Ep​

**a)** Derive the expression for the radius of the allowed orbits and their corresponding energies.

**b)** Show that the emission wavelengths λnm​ satisfy the following relation:

1λnp=Z2RH(1p2−1n2)\frac{1}{\lambda\_{np}} = Z^2 R\_H \left( \frac{1}{p^2} - \frac{1}{n^2} \right)λnp​1​=Z2RH​(p21​−n21​)

where RH is a constant, known as the Rydberg constant.  
Express the Rydberg constant RH both symbolically and numerically.

**c)** Identify the spectral series associated with the values of p and n.