University of Batna 2 **2025-2026**
Faculty of Technology
Department of Science and Technology LMD
Module: Chemistry 1

Tutorial Series Nº 4

Exercise 1 (Crookes Tube)

If the potential difference between the two electrodes is U, in a tube that emits electrons, the distance between the anode and the cathode is (L).

1. Show that the expression for the kinetic energy of electrons emitted from the cathode toward the anode does not depend on L.

2. Calculate the velocity acquired by the electrons when the applied potential difference is $U=5\times10^{4}$ V.

Given data for numerical calculations:

$e=1.6\times10^{-19}$ C, $m=9.1\times10^{-31}$ kg

Exercise 2

An iron atom and an electron have respective masses close to: $m_{Fe}=9.1\times10^{-28}$ g, $m_{e}=9.3\times10^{-23}$ g

An iron atom contains 26 electrons.

1. What is the ratio of the total mass of electrons to the mass of the atom?

2. Based on this result, by what approximation can we compare the mass of the nucleus to the mass of the atom?

3. The volumetric mass of iron is $\rho=7.68$ g/cm^3. If the diameter of the nucleus is 10,000 times smaller than that of the atom, what is the approximate density of the nucleus in tonnes/mm^3?

Exercise 3 (Millikan's Experiment)

Between the plates of a capacitor (assumed horizontal), there is a small oil droplet with a radius $r=9.57\times10^{-4}$ cm, and the volumetric mass of the oil is $\rho=0.9604$ g/cm^3. A uniform electric field of $E=9.37\times10^{5}$ V/m is applied between the plates. At a certain moment, the droplet appears to be stationary.

Determine the number of elementary charges q carried by the droplet,
given that Stokes' forces are negligible.

Exercise 4

Among the following atoms: $^{29}_{14}Si$ ،$^{35}_{17}Cl$ ،$^{35}_{16}S$ ،$^{35}_{18}Ar$ ،$^{30}_{14}Si$،$^{37}_{17}Cl$ ،$^{35}_{15}P$ ،$^{28}_{14}Si$،$^{33}_{17}Cl$ ،$^{33}_{16}S$ ،$^{34}_{17}Cl$

Identify: the isotopes, the isobars, and the isotones, and define each term.

Exercise 5

1. Define the natural isotopic abundance, usually denoted x_i.

2. Define the atomic molar mass of an element.

3- The element tellurium (Te) has four natural isotopes:

^{126}Te: 33.333%, ^{128}Te: 33.333%, ^{129}Te: 16.666%, ^{131}Te: 16.666%.

Compute the atomic molar mass of tellurium.

Exercise 6 (The Cambridge Mass Spectrometer)

Natural magnesium (^{124}Mg, ^{125}Mg, and ^{126}Mg) consists of three isotopes with mass numbers 24, 25, and 26, having respective abundances n_1, n_2, n_3. In a mass spectrometer, the Mg^{2+} ions are accelerated by a potential difference U between the slits f_1 and f_2. Afterwards, these ions enter through slit f_3 into a region where a magnetic field (B) is applied perpendicular to their trajectories, allowing the detection of the following ions.

1. Calculate the potential difference U that allows the detection of the ions $^{24}Mg^{2+}$, $^{25}Mg^{2+}$, $^{26}Mg^{2+}$ successively in slit f_3.

2. Behind the analyzer, the discharge currents have respective intensities i_1, i_2, i_3 proportional to n_1, n_2, n_3. It is found that: $i_3/i_2 = 1.5$, and $i_1/i_2 = 10$.

Determine the natural isotopic abundances n_1, n_2, n_3 and the approximate atomic mass of natural magnesium.

Notes: - The two questions are independent.

- There is no magnetic field in the velocity selector.

Given data: B = 0.5 T, $f_2f_3 = D = 40$ cm, $f_1f_2 = d = 4$ cm.

Exercise 7

The radius R of a nucleus with mass number A is given empirically by: $R = R_0 \times A^{1/3}$

where $R_0 = 1.3 \times 10^{-15}$ m. For the aluminum nucleus $^{27}_{13}$Al:

1. Compute its mass (in kg).

2. Compute its volume (in m^3).

3. Compute its volumetric mass (in kg/m^3 and $tonnes/cm^3$).

4. The volumetric mass of metallic aluminum is $\rho_{Al} = 2.7$ g/cm³. Determine the volume occupied by the nuclei in 1 cm^3 of aluminum metal.

5. Are these results consistent with Thomson's model or with Rutherford's model of the atom?