Using X-Ray Fluorescence Spectrometry for the Application of Moseley's Law

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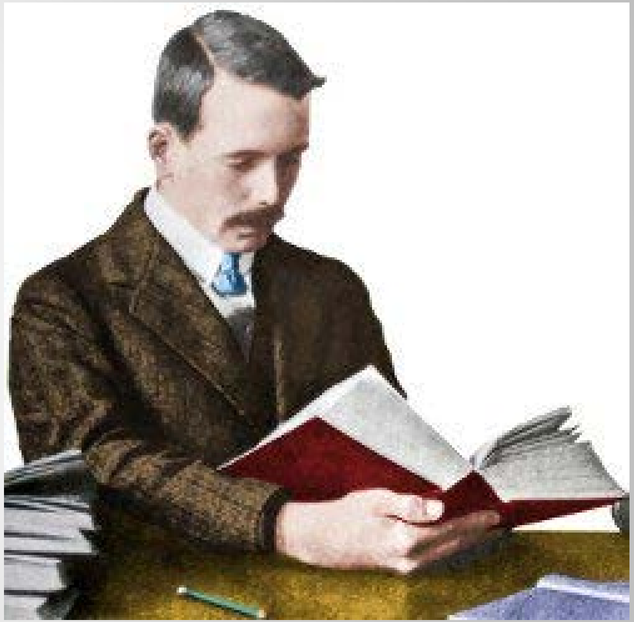
Henry Moseley

- 1887-1915
- 1906: Admitted to University of Oxford’s Trinity College
- 1910: Joined Ernest Rutherford’s research group
- 1911: Studied Antonius van den Broek’s hypothesis of the atomic number
- 1912: Developed X-ray spectrum analysis to study atomic structure
- 1913: He published experimental results known as “Moseley’s Law”



Moseley’s law

Empirical law that shows a linear relationship between the square root of an x-ray emission frequency and the atomic number of an element

$$\sqrt{\boldsymbol{\nu}} = a\,(Z-b)$$

- Z = atomic number of element
- a = constant depending on spectral line
- b = screening effect constant that depends on the spectral line
  - b= 1 for Kα
  - b= 7.4 for Lα

Moseley's law: Understanding constants

- Moseley's law supports and expands previous laws and concepts
- Various scientists such as Rutherford, Rydberg and Bohr were also working on atomic structure at the time
- Rydberg's formula

$$\frac{\nu}{c} = \frac{1}{\lambda} = \frac{Z^2 e^4 m}{8\epsilon_0^2 h^3 c}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda \equiv \text{Wavelength}$$
$$R \equiv \text{Rydberg constant}$$
$$Z \equiv \text{Atomic number}$$
$$n \equiv \text{Integers} : n_1 < n_2$$

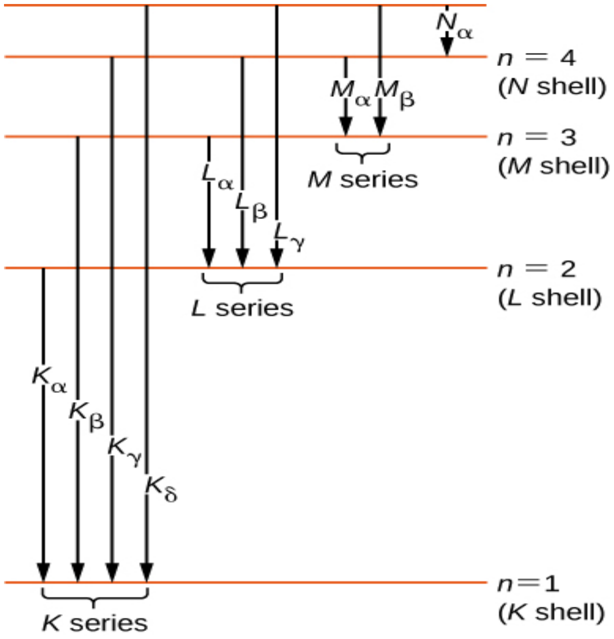
$$R = \frac{-E_0}{hc} = \frac{m_e e^4}{(4\pi)^3 \epsilon_0^2 \hbar^3 c} = 1.097 \times 10^7 \text{ m}^{-1}.$$

Moseley's law: Understanding constants

- Calculate the change in energy, which is proportional to $\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$
- Multiply c on both sides of the equation to derive the general equations
- Calculating $\boldsymbol{\nu}$ for Kα and Lα lines:

$$f\,(K_\alpha) = \left(3.29 \times 10^{15}\right) \times 3/4 \times (Z-1)^2 \ \text{Hz}$$

$$f\,(L_\alpha) = \left(3.29 \times 10^{15}\right) \times 5/36 \times (Z-7.4)^2 \ \text{Hz}$$



Moseley’s law: Proof of a linear relation

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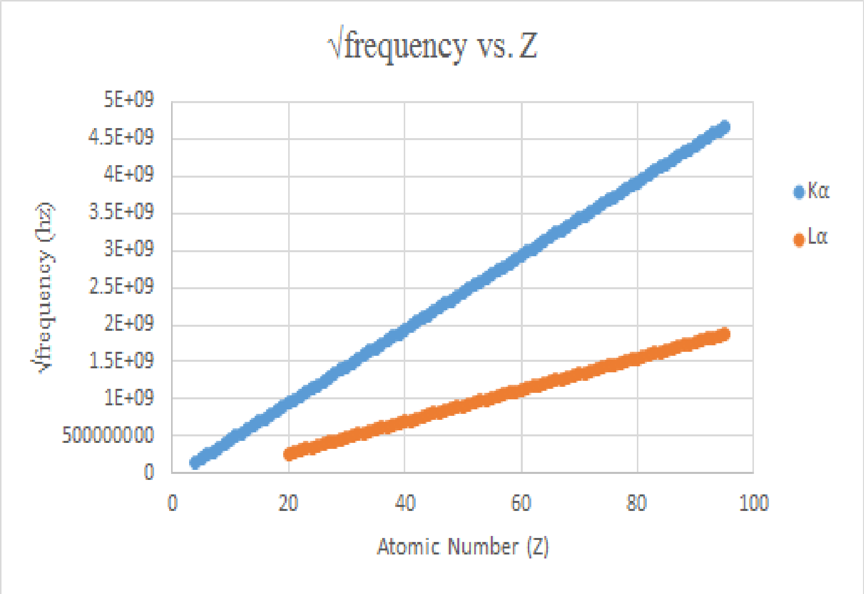
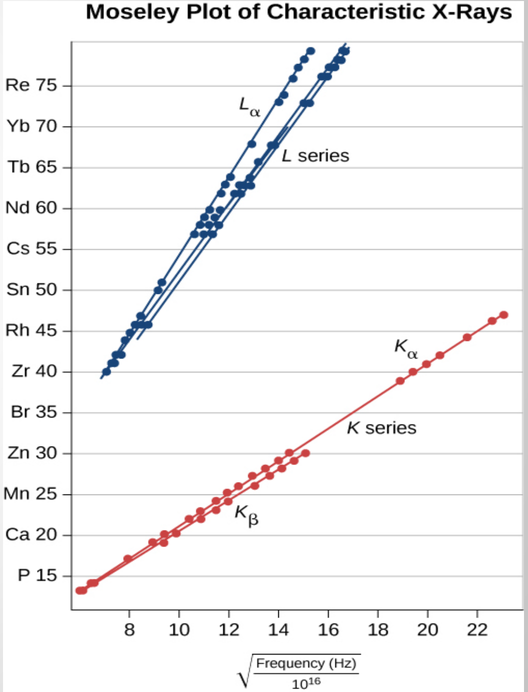
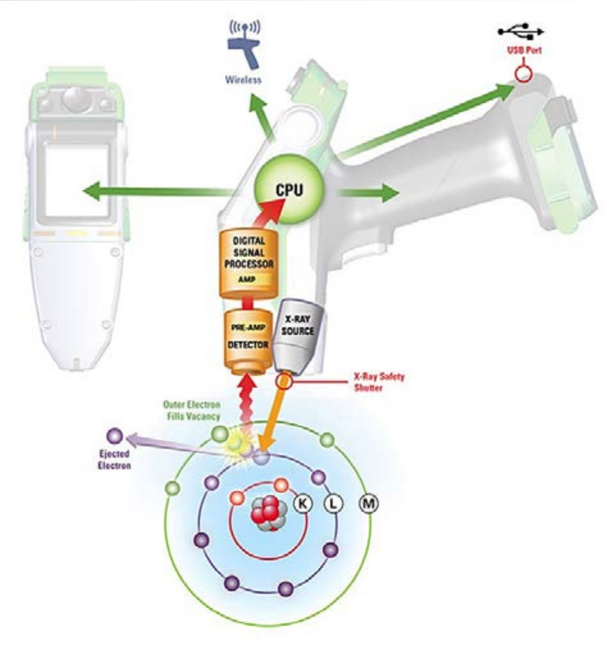


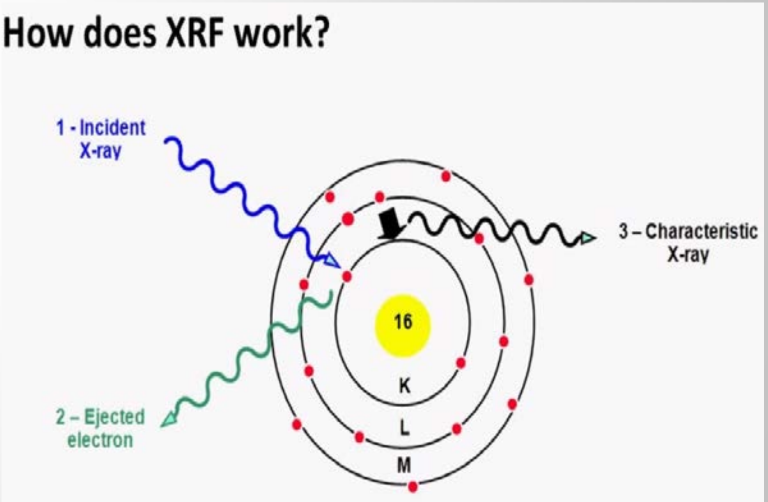


Importance of Moseley's work

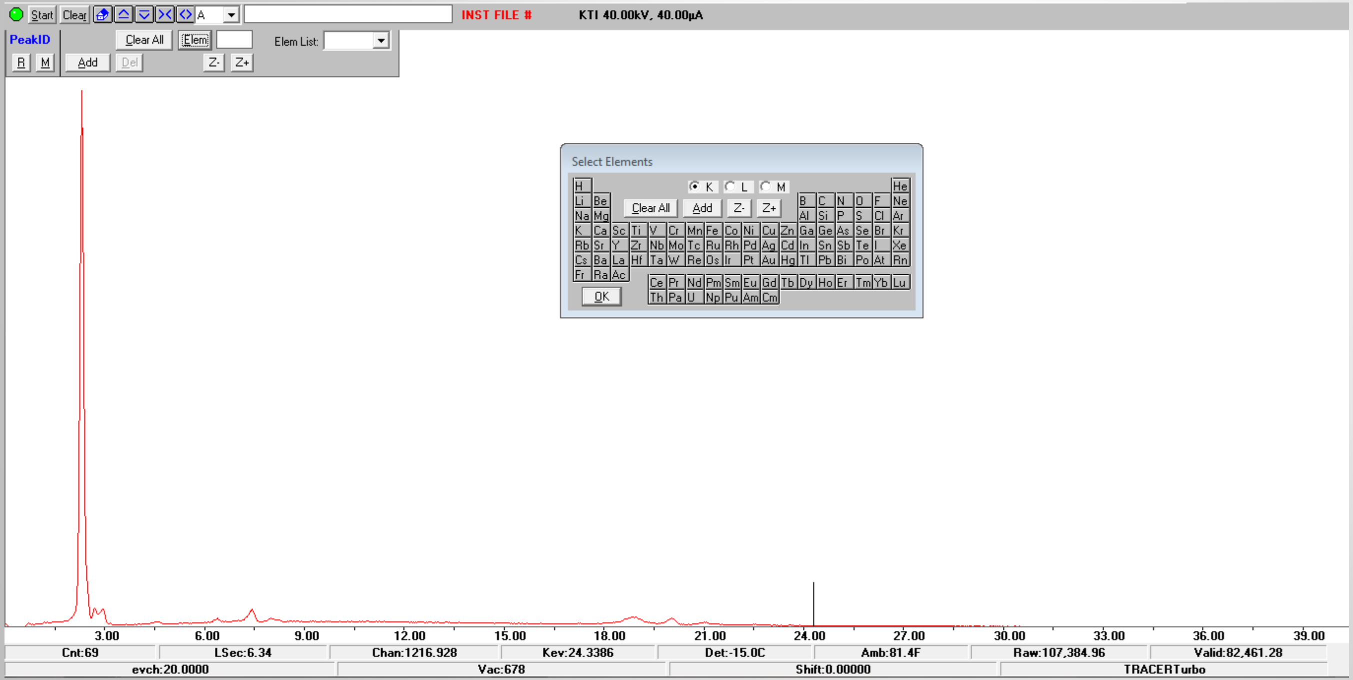
- Improving the Periodic Table
- Better organization of the elements in order of their atomic number
- Difference between Ni, Co, I and Te based on their atomic numbers
- Modern definition of atomic number
- Linear relationship between atomic number and x-ray emissions.

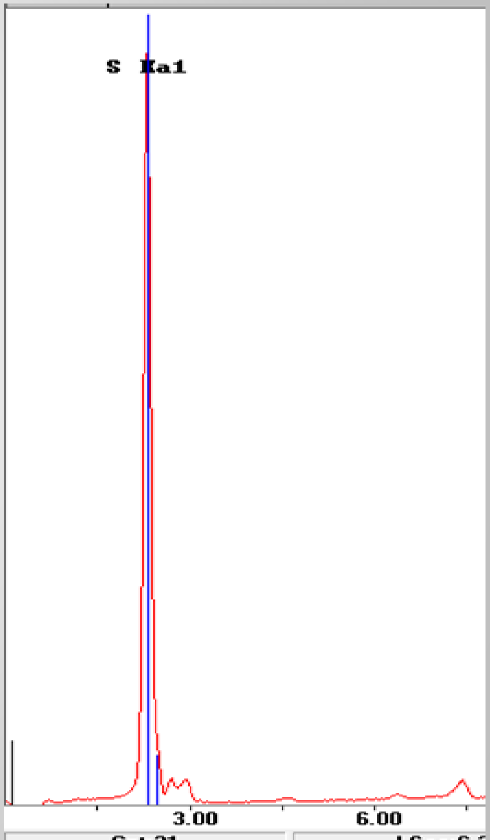
X- Ray Fluorescence Spectrometer





X- Ray Fluorescence Spectrometer





Physics Experiment using Moseley’s Law & XRF

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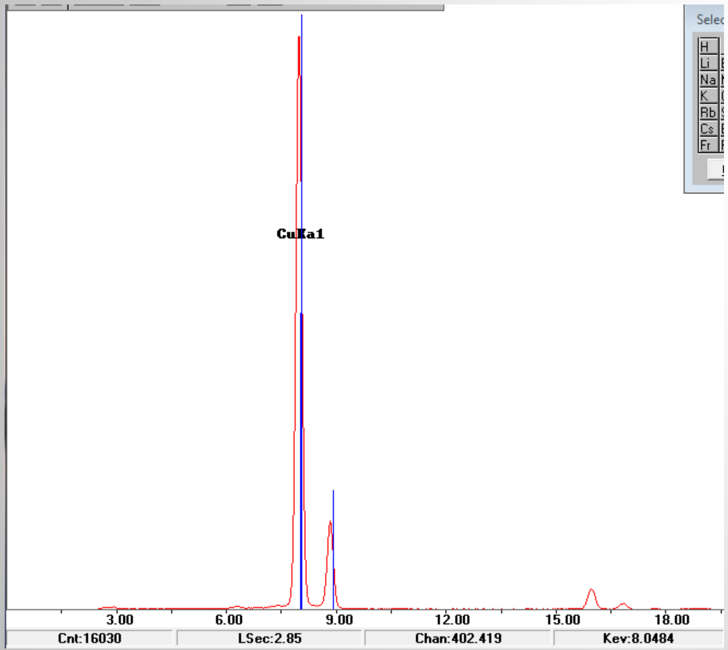
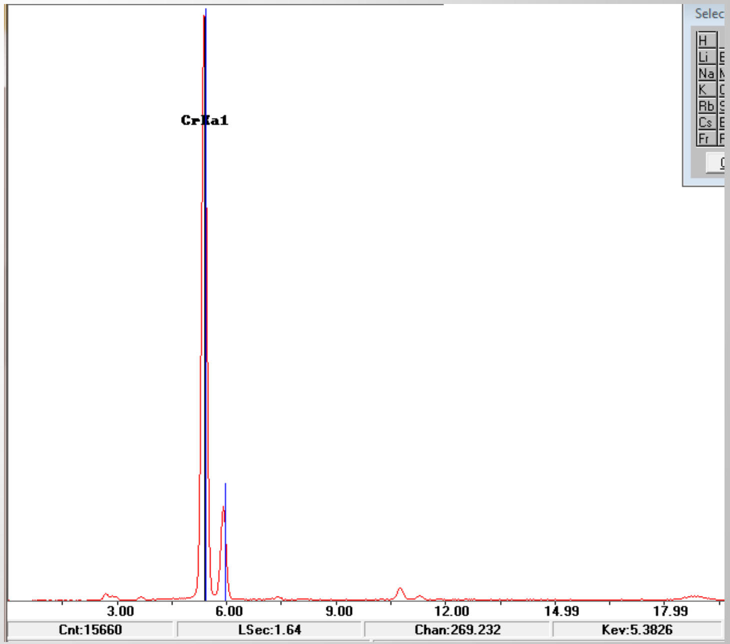
- Physics 205
  - General physics III; Continues sequence PY 203-204, with emphasis on modern physics. Includes atomic and nuclear physics.
- Purpose:
  - Prove of Rydberg constant
  - Prove linear relation of x- ray emission frequencies and atomic number
  - Identifying an unknown

Physics Experiment using Moseley's Law & XRF

1. First part:

   1-Using XRF to get the data for keV of several element.





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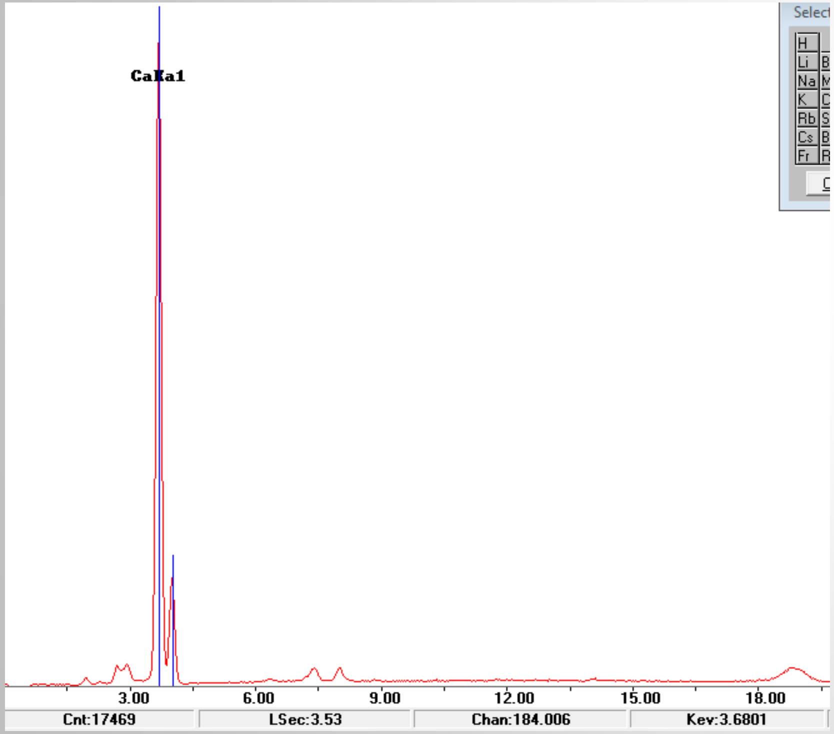

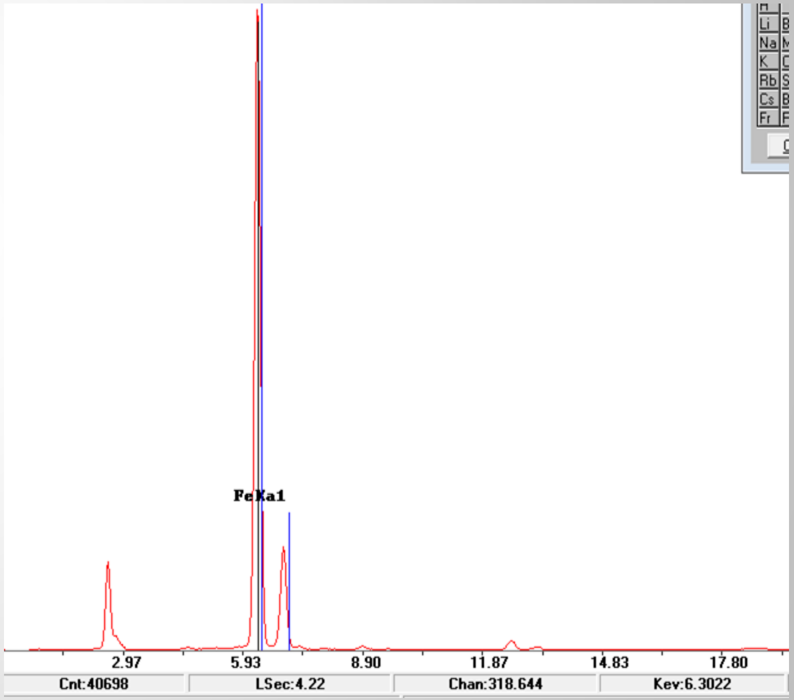

Physics Experiment using Moseley's Law & XRF

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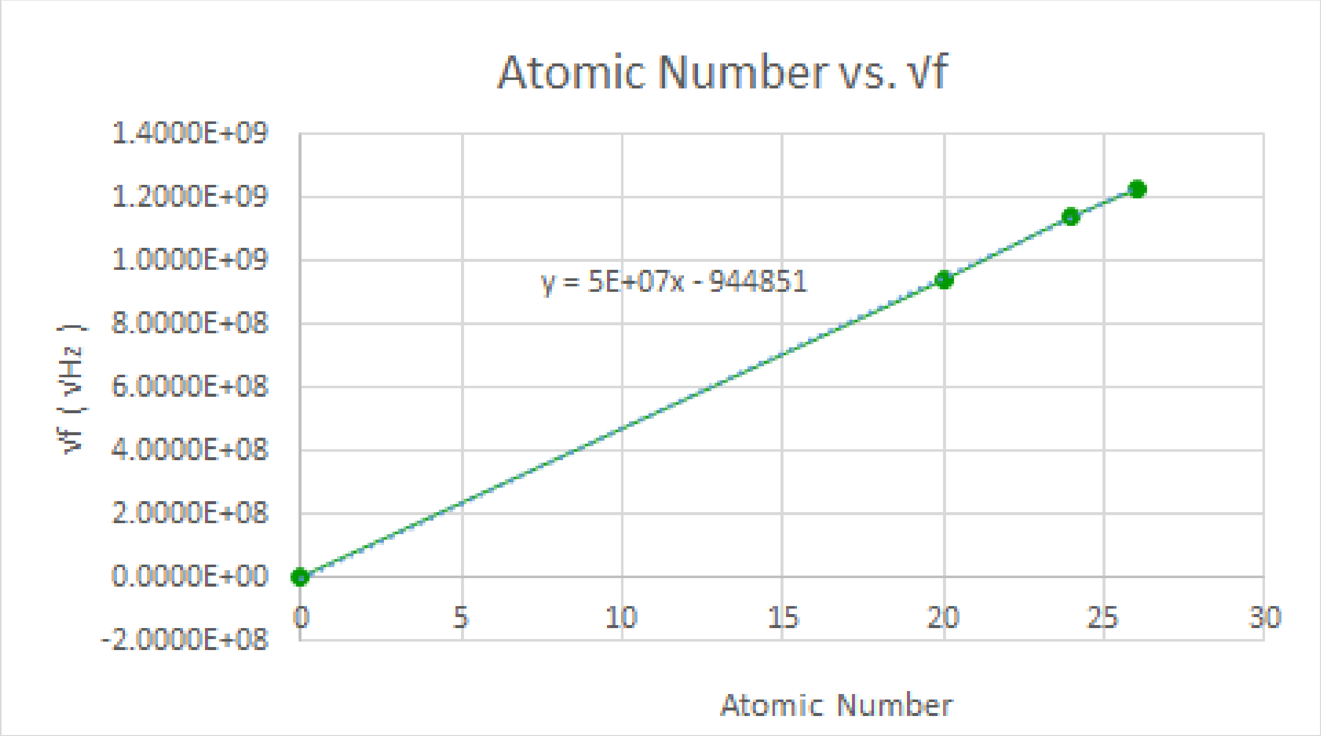
2-Calculate the frequency based on the Kev and atomic number.

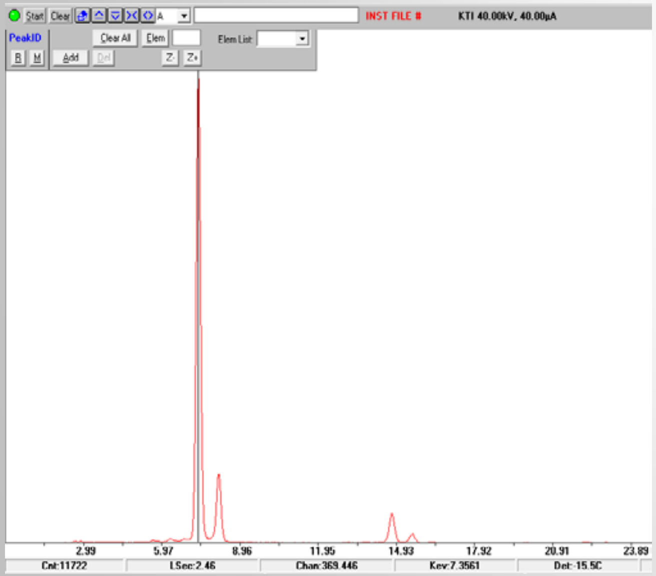
	A	B	C	D	E	F
1	KeV	Z	E (J)	f (Hz)	√f (√Hz)	
2	0	0	0.0000E+00	0.0000E+00	0.0000E+00	
3	3.6801	20	5.8882E-16	8.8811E+17	9.4240E+08	
4	5.3826	24	8.6122E-16	1.2990E+18	1.1397E+09	
5	6.3022	26	1.0084E-15	1.5209E+18	1.2332E+09	
6	8.0484	29	1.2877E-15	1.9423E+18	1.3937E+09	
7						

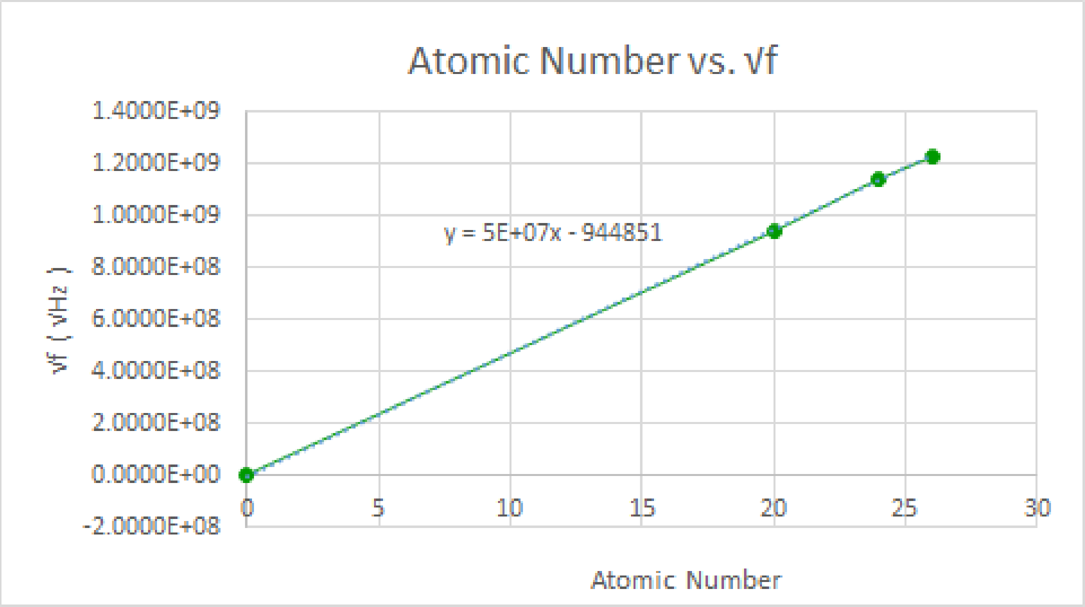
Physics Experiment using Moseley’s Law & XRF



Physics Experiment using Moseley's Law & XRF

Second part: Identifying Unknown





Experimental challenges

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- The difference between Lα or Kα.
- Unclear and messy spectrums
- Lα contains several marker lines
- X Ray emission
- Working with toxic compounds
- XRF could not recognize elements below Ne.

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