# Welcome to 3.091

## Lecture 17

## October 20, 2004

## September 22: Lecture 7.

Octet stability by electron transfer: ionic bonding. Properties of ionic compounds: crystal lattice energy. Reading: Ch. 5.1-5.7, 5.10 (text); LN 2, pp. 1-12 (archives).

## September 24: Lecture 8.

Born-Haber cycle. Octet stability by electron sharing: covalent bonding. Lewis structures. Hybridization. Reading: Ch. 4.1-4.7, 4.10-4.12, 4.17 (text).

## September 27: Lecture 9.

Electronegativity, partial charge, polar bonds and polar molecules. Ionic character of covalent bonds, Pauling's calculation of heteronuclear bond energies. Reading: Ch. 5.7, 5.10, 4A.1, 4A.3 (text).

## October 1: Lecture 10.

LCAO MO, Energy Level Diagrams for $H_2$, $He_2$, $Li_2$. Hybridization, double bonds and triple bonds, paramagnetism and diamagetism. Reading: Ch. 4A.1-4A.4, 14-4-14.6, 8.2, 8.9 (text); LN 2, pp.12- end (archives).

## October 4: Lecture 11.

The Shapes of Molecules, Electron Domain Theory, Secondary Bonding. Reading: Ch. 4.14, 4.15 (text).

## October 6: Lecture 12.

Metallic Bonding, Band Theory of Solids (Heitler and London), Band Gaps in Metals, Semiconductors, and Insulators, Absorption Edge of a Semiconductor. Reading: Ch. 5.9-5.11, 9.4 (text); M.12 (modules); LN 2, pp. 25-26, LN 3 (archives).

## October 8: Lecture 13.

Intrinsic and Extrinsic Semiconductors, Doping, Compound Semiconductors, Molten Semiconductors. Reading: M.12 (modules); LN 3 (archives).

## October 13: Lecture 14.

Introduction to the Solid State, the 7 Crystal Systems, the 14 Bravais Lattices. Reading: 9.6-9.12 (text), M.1-M.4, M.8 (modules); pp. 3-11 (supplement); LN 4 (archives).

## October 15: Lecture 15.

Properties of Cubic Crystals: simple cubic, face-centered cubic, body-centered cubic, diamond cubic. Crystal coordinate systems, Miller indices. Reading: 9.6-9.12 (text); M.1-M.6 (modules); pp. 3-23; 150-155; 167-174 (supplement); LN 4 (archives).

## October 18: Lecture 16.

Characterization of atomic structure: the generation of x-rays and Moseley's Law. Reading: pp. 139-141; 144-149; 175-181 (supplement); LN 5, pp. 1-9 (archives).

## October 20: Lecture 17.

X-ray spectra, Bragg's Law. Reading: pp. 26-31; 186-191 (supplement); LN 5 (archives).

effect in the case of many metals and alloys are subject to variations as great as an octave and more. This difficulty is all the more real in that as yet we are not in a position to determine what influences on and in the extremely thin bounding surface of the metal in which the light absorption takes place are the determining factors in this displacement.

Berlin, Physikalisches Institut
der Universität, July 1913.

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## XCIII. *The High-Frequency Spectra of the Elements.* By H. G. J. MOSELEY, *M.A.*[*]

[Plate XXIII.]

IN the absence of any available method of spectrum analysis, the characteristic types of X radiation, which an atom emits when suitably excited, have hitherto been described in terms of their absorption in aluminium[†]. The interference phenomena exhibited by X rays when scattered by a crystal have now, however, made possible the accurate determination of the frequencies of the various types of radiation. This was shown by W. H. and W. L. Bragg[‡], who by this method analysed the line spectrum emitted by the platinum target of an X-ray tube. C. G. Darwin and the author[§] extended this analysis and also examined the continuous spectrum, which in this case constitutes the greater part of the radiation. Recently Prof. Bragg[||] has also determined the wave-lengths of the strongest lines in the spectra of nickel, tungsten, and rhodium. The electrical methods which have hitherto been employed are, however, only successful where a constant source of radiation is available. The present paper contains a description of a method of photographing these spectra, which makes the analysis of the X rays as simple as any other branch of spectroscopy. The author intends first to make a general survey of the principal types of high-frequency radiation, and then to examine the spectra of a few elements in greater detail and with greater accuracy. The results already obtained show that such data have an important bearing on the question of

[*] Communicated by Prof. E. Rutherford, F.R.S.
[†] *Cf.* Barkla, Phil. Mag. xxii. p. 396 (1911).
[‡] Proc. Roy. Soc. A. lxxxviii. p. 428 (1913).
[§] Phil. Mag. xxvi. p. 210 (1913).
[||] Proc. Roy. Soc. A. lxxxix. p. 246 (1913).

The reason for introducing this particular constant will be given later. It is at once evident that Q increases by a constant amount as we pass from one element to the next, using the chemical order of the elements in the periodic system. Except in the case of nickel and cobalt *, this is also the order of the atomic weights. While, however, Q increases uniformly the atomic weights vary in an apparently arbitrary manner, so that an exception in their order does not come as a surprise. We have here a proof that there is in the atom a fundamental quantity, which increases by regular steps as we pass from one element to the next. This quantity can only be the charge on the central positive nucleus, of the existence of which we already have definite proof. Rutherford has shown, from the magnitude of the scattering of $\alpha$ particles by matter, that this nucleus carries a $+$ charge approximately equal to that of $\frac{A}{2}$ electrons, where A is the atomic weight. Barkla, from the scattering of X rays by matter, has shown that the number of electrons in an atom is roughly $\frac{A}{2}$, which for an electrically neutral atom comes to the same thing. Now atomic weights increase on the average by about 2 units at a time, and this strongly suggests the view that N increases from atom to atom always by a single electronic unit. We are therefore led by experiment to the view that N is the same as the number of the place occupied by the element in the periodic system. This atomic number is then for H 1 for He 2 for Li 3 ... for Ca 20 ... for Zn 30, &c. This theory was originated by Broek † and since used by Bohr ‡. We can confidently predict that in the few cases in which the order of the atomic weights A clashes with the chemical order of the periodic system, the chemical properties are governed by N ; while A is itself probably a complicated function of N. The very close similarity between the X-ray spectra of the different elements shows that these radiations originate inside the atom, and have no direct connexion with the complicated light-spectra and chemical properties which are governed by the structure of its surface.
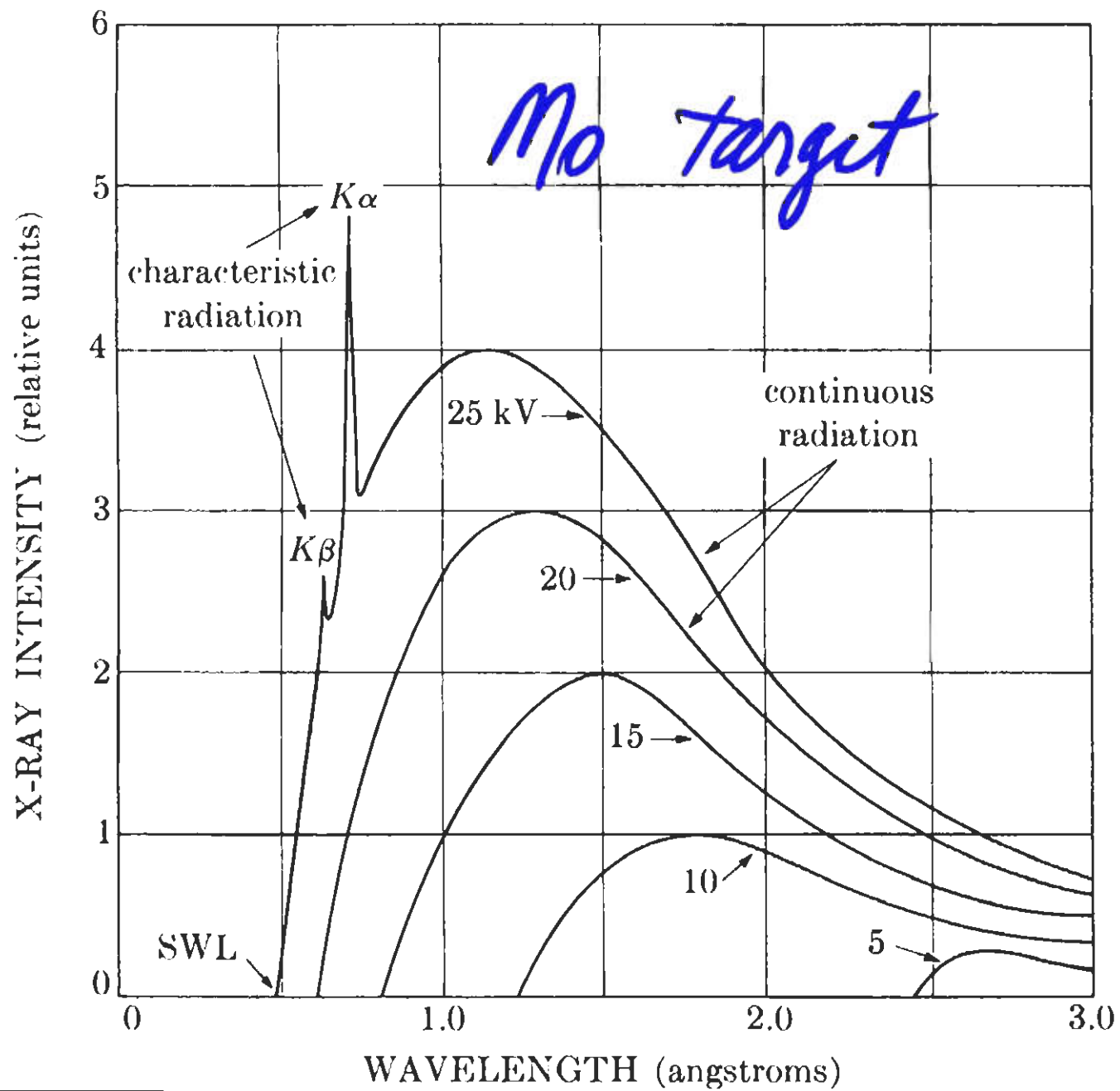
We will now examine the relation
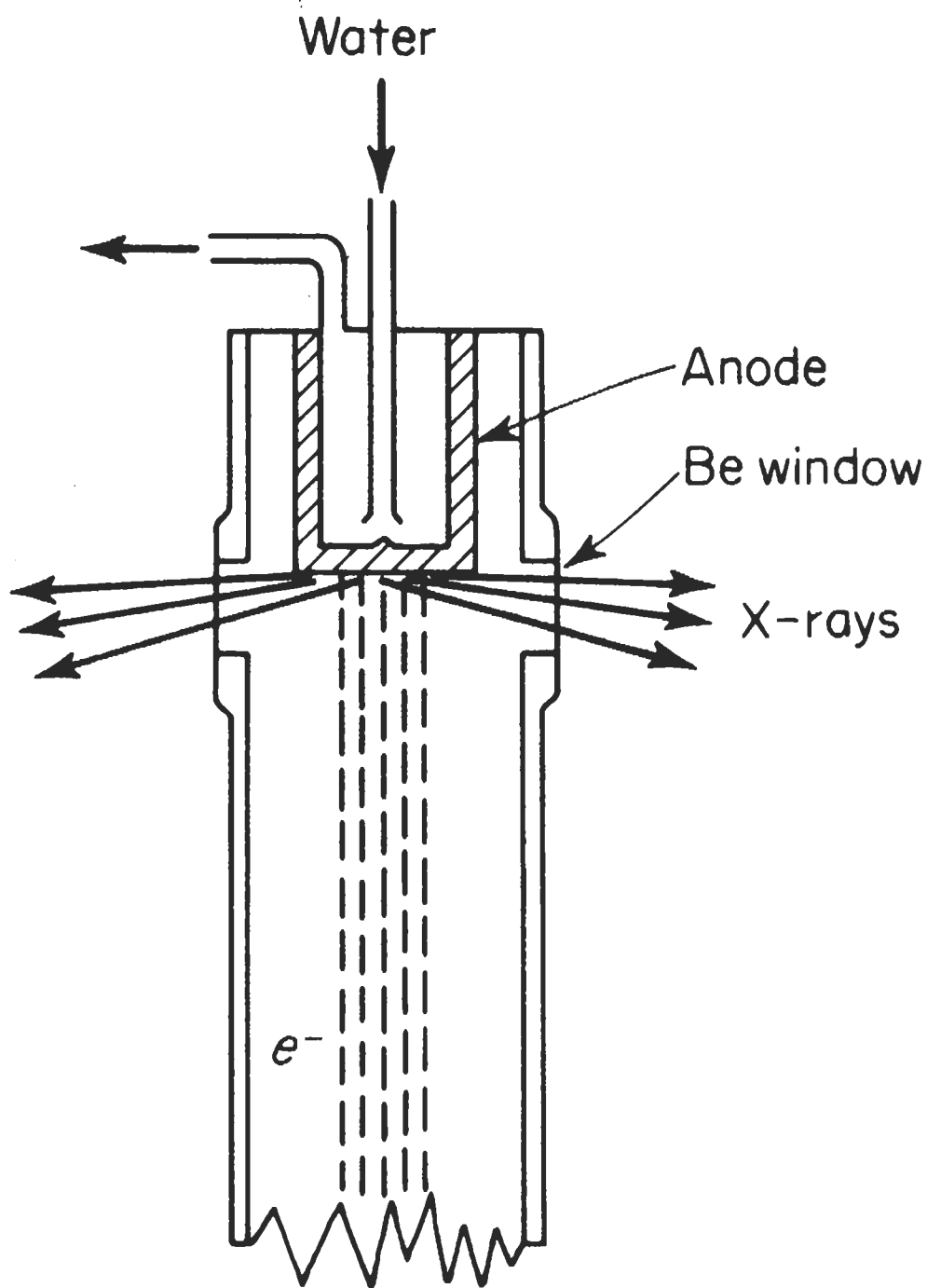
$$Q = \sqrt{\frac{\nu}{\frac{3}{4}\nu_0}}$$

more closely. So far the argument has relied on the fact that Q is a quantity which increases from atom to atom by equal steps. Now Q has been obtained by multiplying $\nu^{\frac{1}{2}}$ by a constant factor so chosen as to make the steps equal to unity. We have, therefore,
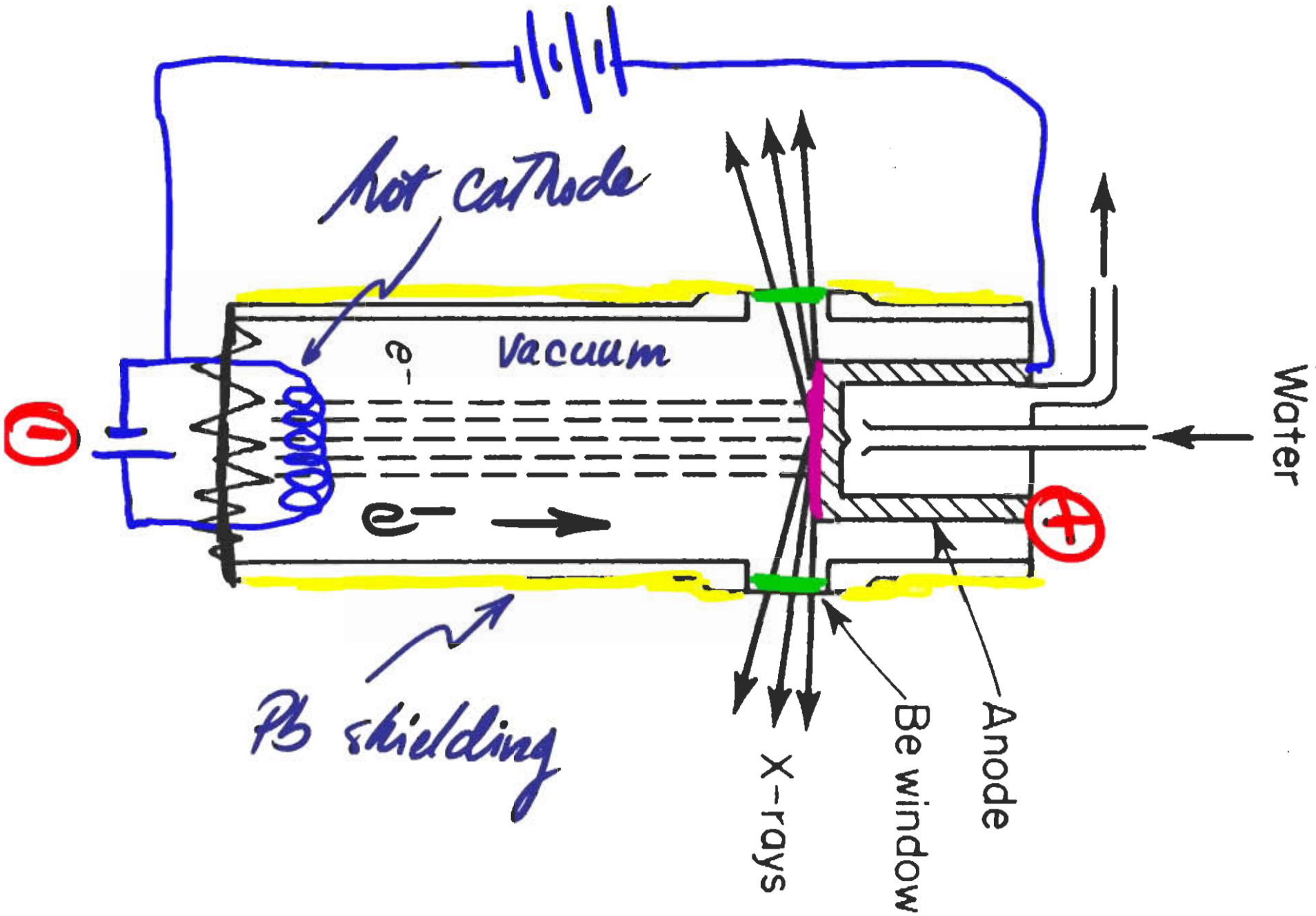
$$Q = N - k,$$

where $k$ is a constant. Hence the frequency $\nu$ varies as $(N-k)^2$. If N for calcium is really 20 then $k=1$.

There is good reason to believe that the X-ray spectra with which we are now dealing come from the innermost ring of electrons [*].

Window

Shielding

Figure by MIT OCW.

| | | |
|---|---|---|
| 1.00794 | | |
| -259.34 | | **1** |
| -252.87 | | 1 |
| 0.0899 | | |
| 2.20 | **H** | |
| 13.598 | | |
| $1s^1$ | | |
| Hydrogen | | |

≈7 !!! →

| | | | | |
|---|---|---|---|---|
| **6.941** | | **3** | 9.012182 | **4** |
| 180.5 | | 1 | 1287 | 2 |
| 1342 | | | 2471 | |
| 0.534 | **Li** | | 1.8477 | **Be** |
| 0.98 | | | 1.57 | |
| 5.392 | | | 9.322 | |
| $[He]2s^1$ | | | $[He]2s^2$ | |
| Lithium | | | Beryllium | |
| 22.989768 | | **11** | 24.3050 | **12** |
| 97.72 | | 1 | 650 | 2 |
| 883 | | | 1090 | |
| 0.97 | **Na** | | 1.74 | **Mg** |
| 0.93 | | | 1.31 | |
| 5.139 | | | 7.646 | |
| $[Ne]3s^1$ | | | $[Ne]3s^2$ | |
| Sodium | | | Magnesium | |

Figure by MIT OCW.