PHY 251 SPR 02
HW #10

8.3 Z_{eff} for Na, K

[Ne]3s' [Ar]4s'

Ionization energies

$$E^{(ion)}_{Na} = 5.14\text{ eV}$$

$$E^{(ion)}_{K} = 4.34\text{ eV}$$

Forms: Bohr atom expectation is always Z_{eff}
Use Bohr radius $(a_0 n^2)$ →

$$E^{(ion)} = + \frac{e^2}{4\pi\varepsilon_0}\frac{1}{a_0 n^2} Z_{eff}$$ = energy added to free an electron

$$Z_{eff} = \frac{E^{(ion)}}{(e^2/4\pi\varepsilon_0)} n^2 a_0$$

Na

$$Z^{(Na)}_{eff} = \frac{5.14\ \cancel{eV}}{1.44\ \cancel{eV\,nm}}\ 3^2 \times 5.29 \times 10^{-2}\text{ nm}$$

$$= 1.7$$

$$Z^{(K)}_{eff} = \frac{4.34\text{ eV}}{1.44\text{ eV nm}} \cdot 4^2 \cdot 5.29 \times 10^{-2}\text{ nm}$$

$$= 2.6$$

Both are 'large' ⇒ electron penetrates to lower orbitals in previous set

[8.2 a) P $Z = 15$ see p. 240 periodic table & Table p. 241 for an exampl

$\underbrace{[1s^2 2s^2 2p^6]}_{[Ne]} 3s^2 3p^3$

b) V $Z = 23$

$\underbrace{[1s^2 2s^2 2p^6 3s^2 3p^6]}_{[Ar]} 4s^2 3d^3$

c) Sb $Z = 51$ [Kr]

$[1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6]$
$5s^2 4d^{10} 5p^3$

d) Pb $Z = 82$ etc.

$[Xe]\, 6s^2 4f^{14} 5d^{10} 6p^2$

8.4 Eq (8.1) $\nu = \frac{3cR_\infty}{4}(Z-1)^2$ p. 249

Text refers to Eqs 6.36, 6.42

$$(6.36): H: \nu_H = \frac{me^4}{64\pi^3\epsilon_0^2\hbar^3}\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right) = \frac{E_{n_1}^H - E_{n_2}^H}{h}$$

see p. 249 (6.35)

$$\longrightarrow (Z-1): E_n^Z = (Z-1)^2 E_n^H$$

so

$$\nu_H = (Z-1)^2 \frac{me^4}{64\pi^3\epsilon_0^2\hbar^3}\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$$

from (6.38)

$$K_\alpha: = (Z-1)^2 R_\infty c\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3cR_\infty}{4}(Z-1)^2$$

8.6

Ca $(Z = 20)$

$$\nu = \frac{3cR_\infty}{4}(19)^2$$

p. 638

$$= \frac{3}{4}(3\times10^8 \tfrac{m}{s})(1.1\times10^7 m^{-1})(19)^2$$

$$= 8.9\times10^2 \times 10^{15} s^{-1}$$

$$= 8.9\times10^{17} s^{-1}$$

$$h\nu_{Ca} = 4.1\times10^{-15} eV\, s \cdot 8.9\times10^{17} s^{-1}$$
$$= 3.6\times10\times10^2 eV$$
$$= 3.65\, keV$$

not bad compared to 3.69

Zr $(Z = 40)$

$$h\nu_{Zr} = h\nu_{Ca}\times\frac{(39)^2}{(19)^2} = 15.4\, keV$$

compared to 15.8

Hg $(Z = 80)$

$$h\nu_{Hg} = h\nu_{Ca}\frac{(79)^2}{(19)^2} = 63.1\, keV$$

compared to 70.8