

Quantum numbers

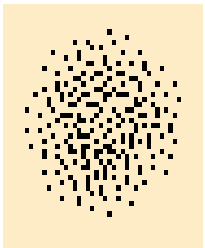
$$n = 1$$

$$\ell = 0$$

$$m_\ell = 0$$

$$m_s = \pm \frac{1}{2}$$

Maximum  
**2**  
Electrons



s

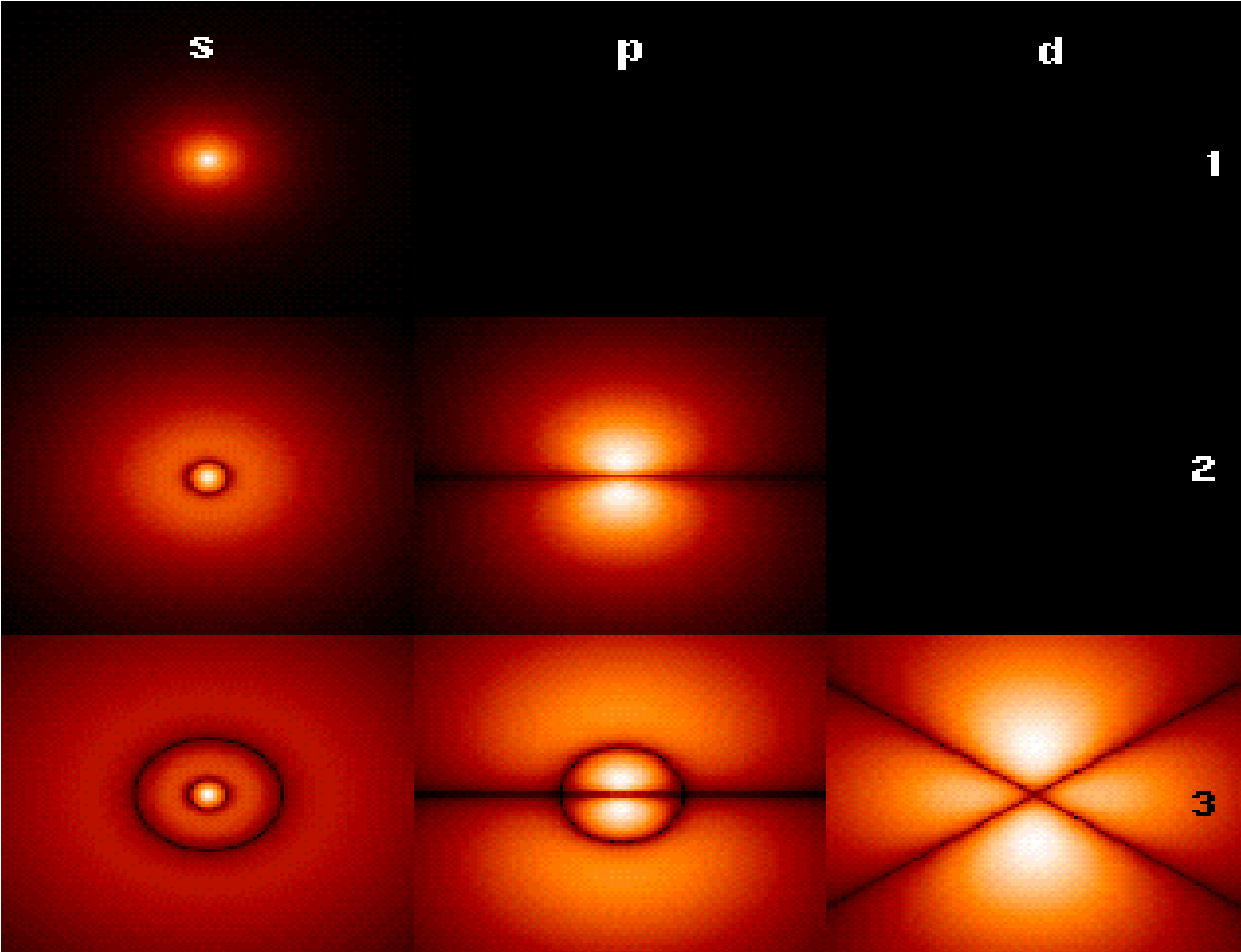
p

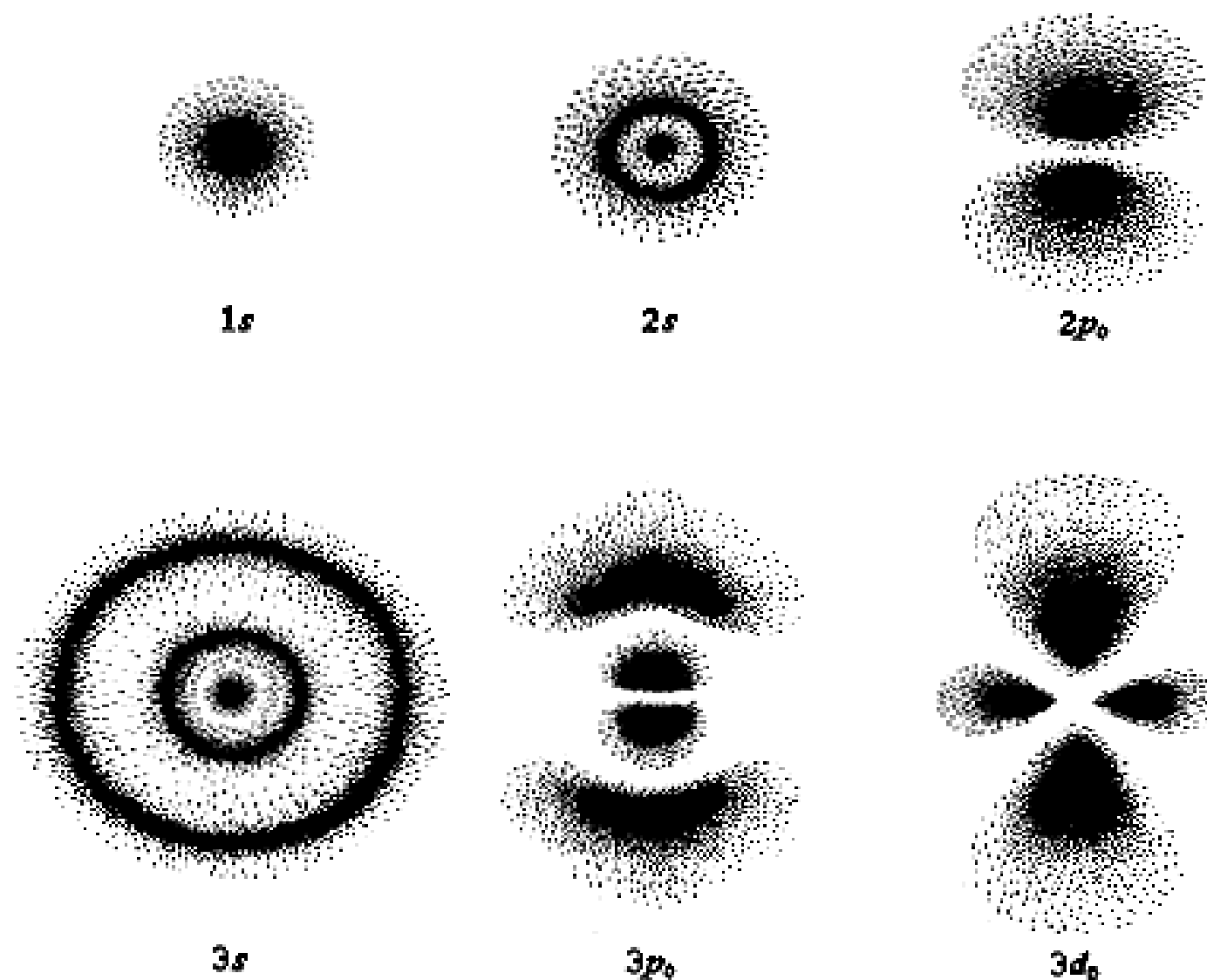
d

1

2

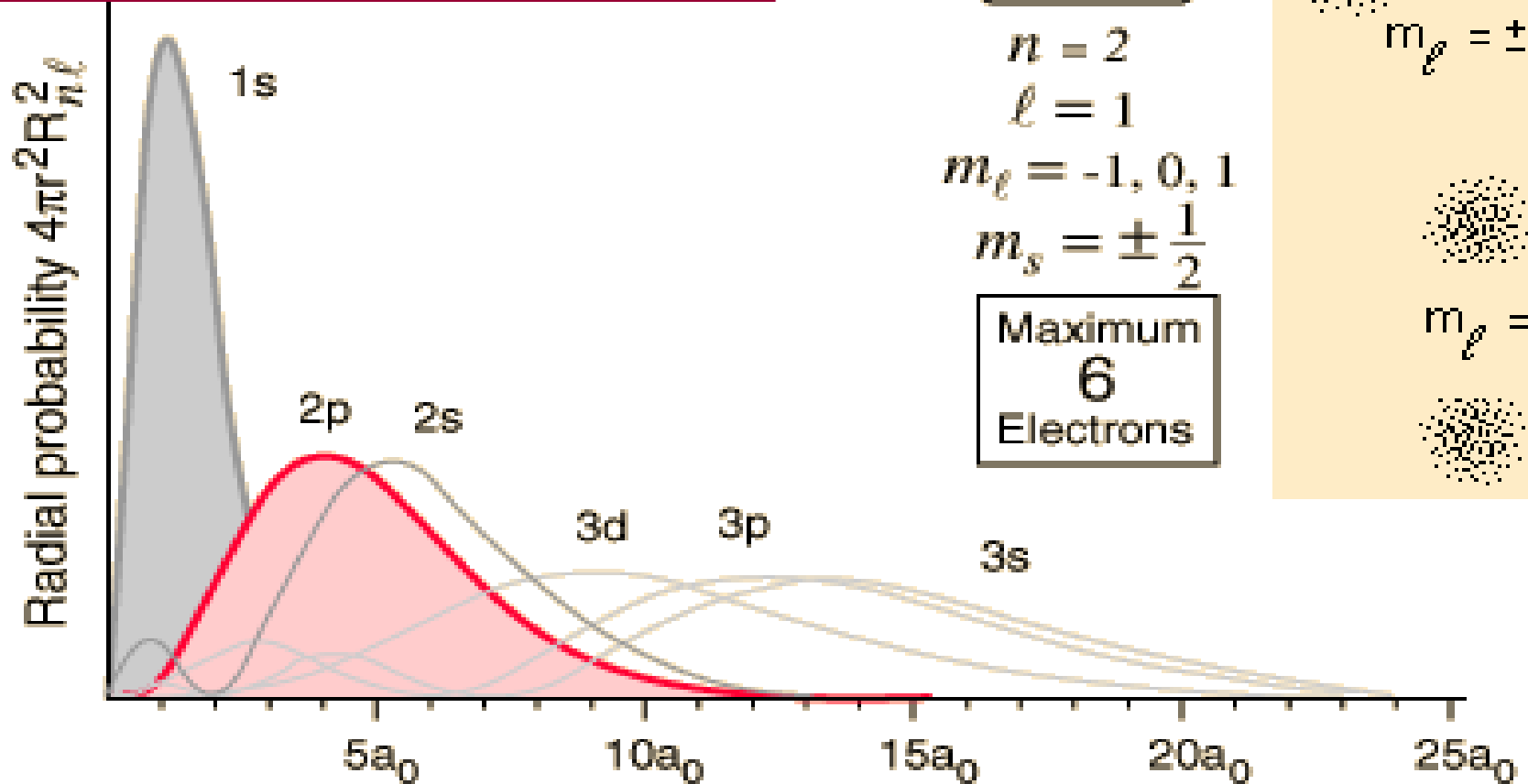
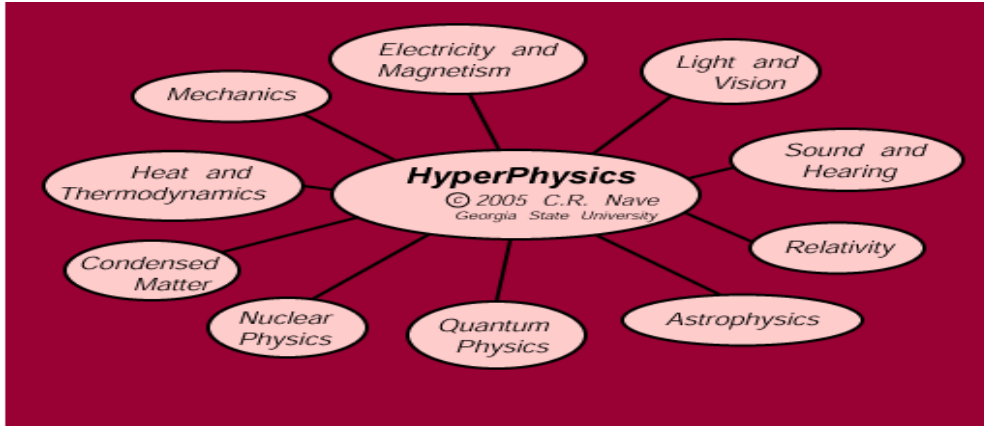
3





**Figure 6-12. Probability density plots of some hydrogen atomic orbitals. The density of the dots represents the probability of finding the electron in that region.**

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Quantum numbers

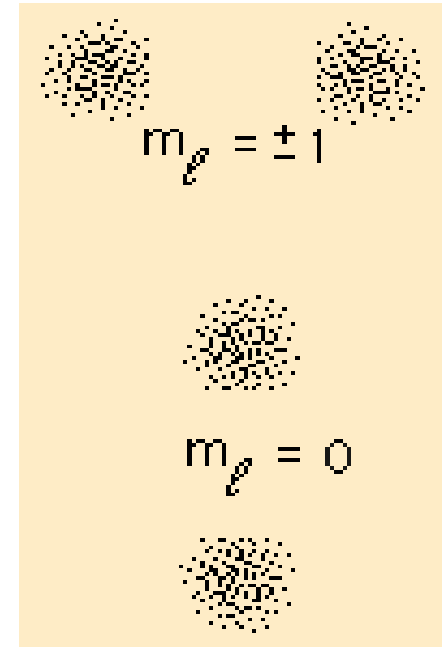
$$n = 2$$

$$\ell = 1$$

$$m_\ell = -1, 0, 1$$

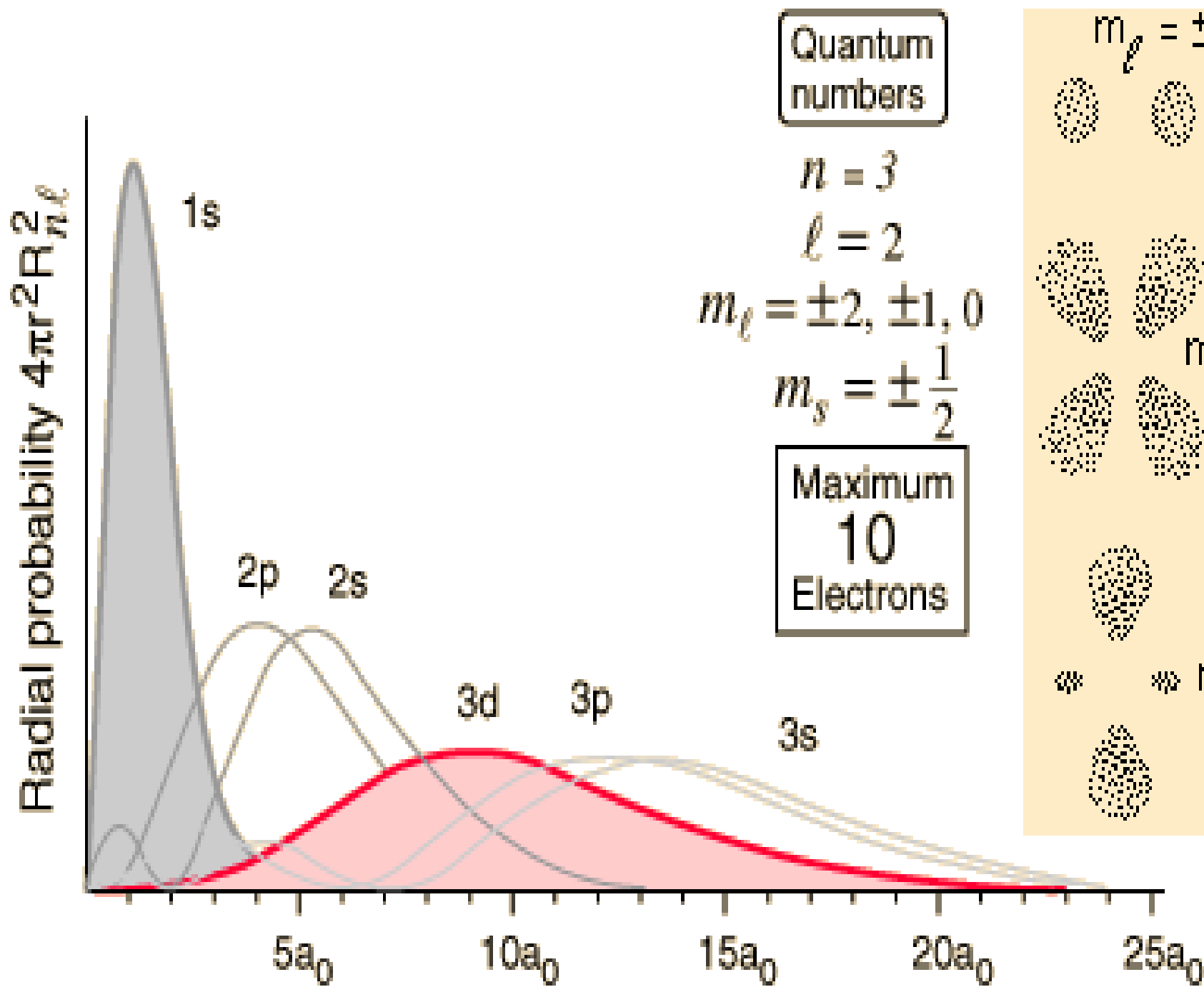
$$m_s = \pm \frac{1}{2}$$

Maximum  
6  
Electrons



$$m_\ell = \pm 1$$

$$m_\ell = 0$$



Quantum numbers

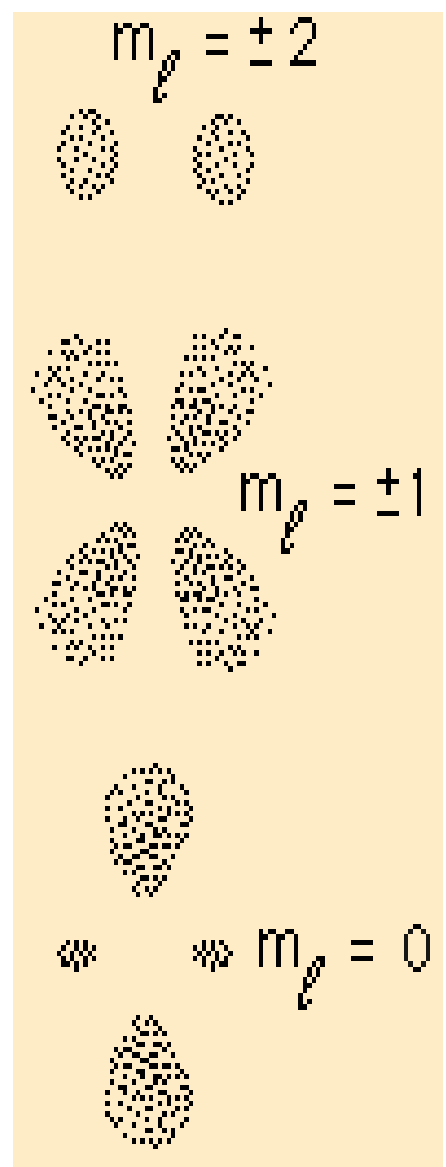
$$n = 3$$

$$\ell = 2$$

$$m_\ell = \pm 2, \pm 1, 0$$

$$m_s = \pm \frac{1}{2}$$

Maximum  
10  
Electrons





|                  |         |                                 | <u>n=1</u> | <u>n=2</u> | <u>n=3</u> | <u>n=4</u> |
|------------------|---------|---------------------------------|------------|------------|------------|------------|
| s -- sharp       | $l = 0$ | 1s                              | 2s         | 3s         | 4s         |            |
| p -- principal   | $l = 1$ |                                 | 2p         | 3p         | 4p         |            |
| d -- diffuse     | $l = 2$ |                                 |            | 3d         | 4d         |            |
| f -- fundamental | $l = 3$ |                                 |            |            | 4f         |            |
| g                | $l = 4$ | beyond this point, the notation |            |            |            |            |
| h                | $l = 5$ | just follows the alphabet       |            |            |            |            |
| ...              |         |                                 |            |            |            |            |

| n | $\ell$ | $m_\ell$ | F( $\phi$ )                           | P( $\theta$ )                    | R(r)   | <input checked="" type="checkbox"/> n=1,2 <input type="checkbox"/> n=3 |
|---|--------|----------|---------------------------------------|----------------------------------|--|--|
| 1 | 0      | 0        | $\frac{1}{\sqrt{2\pi}}$               | $\frac{1}{\sqrt{2}}$             | $\frac{2}{a_0^{3/2}} e^{-r/a_0}$   | <input checked="" type="checkbox"/> Separated                          |
| 2 | 0      | 0        | $\frac{1}{\sqrt{2\pi}}$               | $\frac{1}{\sqrt{2}}$             | $\frac{1}{2\sqrt{2} a_0^{3/2}} \left[2 - \frac{r}{a_0}\right] e^{-r/2a_0}$ | <input type="checkbox"/> Combined                                      |
| 2 | 1      | 0        | $\frac{1}{\sqrt{2\pi}}$               | $\frac{\sqrt{6}}{2} \cos \theta$ | $\frac{1}{2\sqrt{6} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$                  |  |
| 2 | 1      | $\pm 1$  | $\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$ | $\frac{\sqrt{3}}{2} \sin \theta$ | $\frac{1}{2\sqrt{6} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$                  |  |

| n | $\ell$ | $m_\ell$ |    | $\Psi_{n \ell m_\ell}(r, \theta, \phi)$   | <input checked="" type="checkbox"/> n=1,2 <input type="checkbox"/> n=3 |
|---|--------|----------|----|---|--|
| 1 | 0      | 0        | 1s | $\frac{1}{\sqrt{\pi} a_0^{3/2}} e^{-r/a_0}$   | <input type="checkbox"/> Separated                                     |
| 2 | 0      | 0        | 2s | $\frac{1}{4\sqrt{2\pi} a_0^{3/2}} \left[2 - \frac{r}{a_0}\right] e^{-r/2a_0}$         | <input checked="" type="checkbox"/> Combined                           |
| 2 | 1      | 0        | 2p | $\frac{1}{4\sqrt{2\pi} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0} \cos \theta$              |  |
| 2 | 1      | $\pm 1$  | 2p | $\frac{1}{8\sqrt{\pi} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0} \sin \theta e^{\pm i\phi}$ |  |

$$a_0 = \frac{\hbar^2}{me^2} = .0529 \text{ nm} = \text{first Bohr radius}$$

# Konfiguracja elektronów dla pierwszych pierwiastków: elektrony walencyjne

|   | 1A  | 2A    | 3A    | 4A    | 5A   | 6A   | 7A    | 8A  |
|---|---|-------|-------|-------|------|------|-------|---|
| n | H 1   |       |       |       |      |      |       | He 2  |
| 1 |  |       |       |       |      |      |       |  |
| 2 | Li 3  | Be 4  | B 5   | C 6   | N 7  | O 8  | F 9   | Ne 10   |
| 3 | Na 11   | Mg 12 | Al 13 | Si 14 | P 15 | S 16 | Cl 17 | Ar 18   |



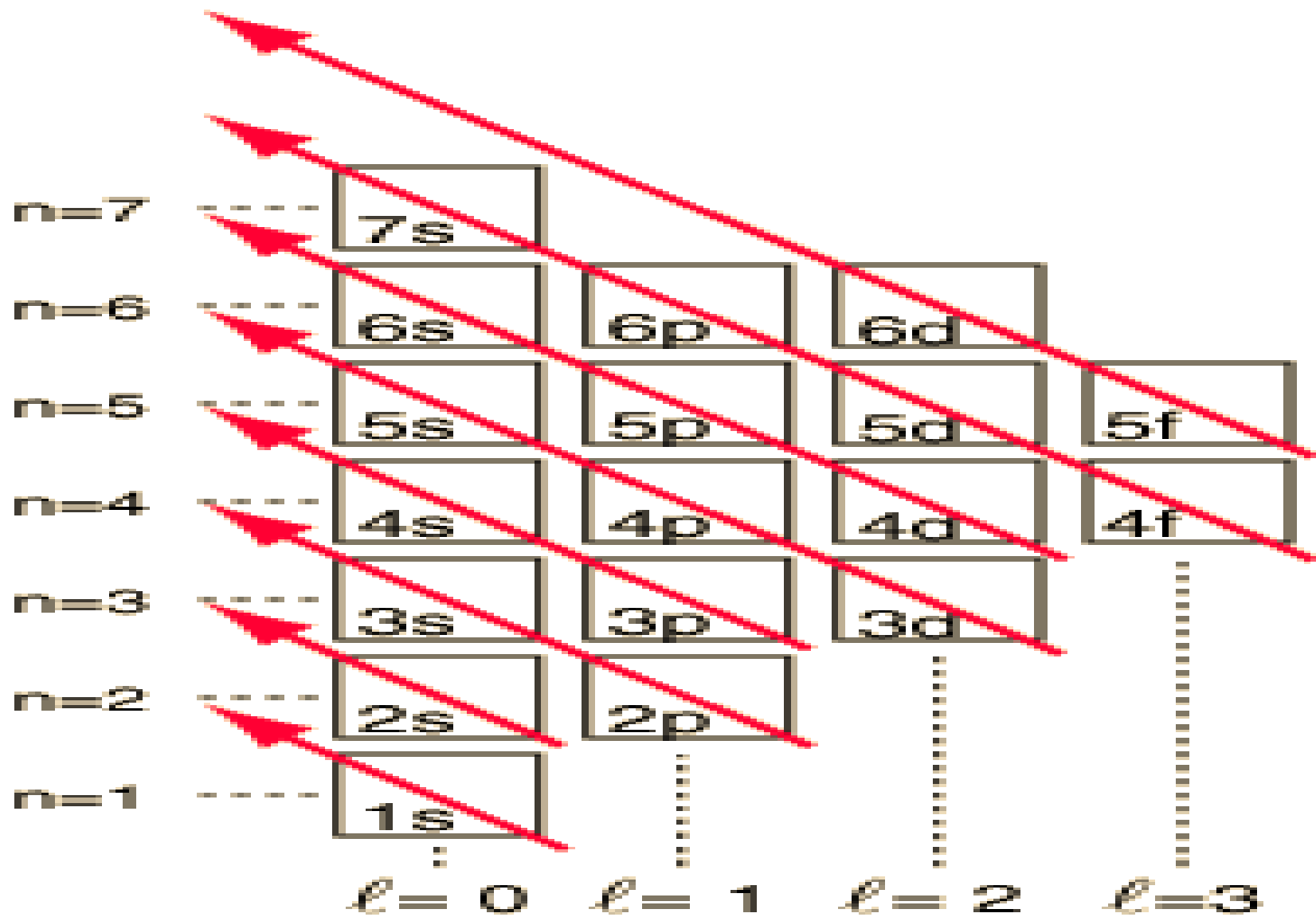
# Elektrony walencyjne oraz glowna liczba n a okresy (kolumny)

## Periodic Table of the Elements

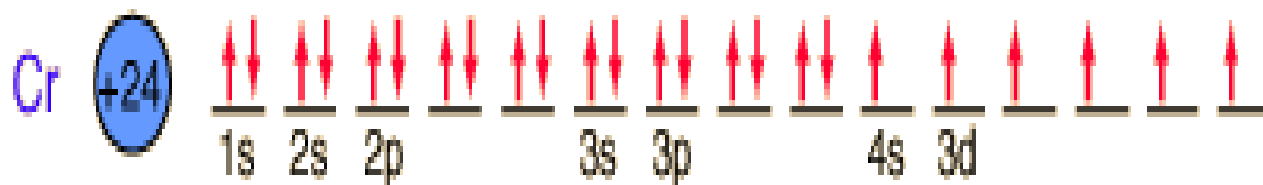
| I                | II               | Transition Metals  |                   |                   |                  |                  |                  |                  |                  |                  |                  | III              | IV               | V                | VI               | VII              | 0                |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|------------------|------------------|--|-------------------|-------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| H <sup>1</sup>   |                  |  |                   |                   |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | He <sup>2</sup>  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Li <sup>3</sup>  | Be <sup>4</sup>  |  |                   |                   |                  |                  |                  |                  |                  |                  |                  | B <sup>5</sup>   | C <sup>6</sup>   | N <sup>7</sup>   | O <sup>8</sup>   | F <sup>9</sup>   | Ne <sup>10</sup> |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Na <sup>11</sup> | Mg <sup>12</sup> | IIIB   | IVB               | VB                | VIB              | VII B            | VIII B           |                  |                  | IB               | IIB              | Al <sup>13</sup> | Si <sup>14</sup> | P <sup>15</sup>  | S <sup>16</sup>  | Cl <sup>17</sup> | Ar <sup>18</sup> |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| K <sup>19</sup>  | Ca <sup>20</sup> | Sc <sup>21</sup>   | Ti <sup>22</sup>  | V <sup>23</sup>   | Cr <sup>24</sup> | Mn <sup>25</sup> | Fe <sup>26</sup> | Co <sup>27</sup> | Ni <sup>28</sup> | Cu <sup>29</sup> | Zn <sup>30</sup> | Ga <sup>31</sup> | Ge <sup>32</sup> | As <sup>33</sup> | Se <sup>34</sup> | Br <sup>35</sup> | Kr <sup>36</sup> |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Rb <sup>37</sup> | Sr <sup>38</sup> | Y <sup>39</sup>  | Zr <sup>40</sup>  | Nb <sup>41</sup>  | Mo <sup>42</sup> | Tc <sup>43</sup> | Ru <sup>44</sup> | Rh <sup>45</sup> | Pd <sup>46</sup> | Ag <sup>47</sup> | Cd <sup>48</sup> | In <sup>49</sup> | Sn <sup>50</sup> | Sb <sup>51</sup> | Te <sup>52</sup> | I <sup>53</sup>  | Xe <sup>54</sup> |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Cs <sup>55</sup> | Ba <sup>56</sup> | 57-71  | Hf <sup>72</sup>  | Ta <sup>73</sup>  | W <sup>74</sup>  | Re <sup>75</sup> | Os <sup>76</sup> | Ir <sup>77</sup> | Pt <sup>78</sup> | Au <sup>79</sup> | Hg <sup>80</sup> | Tl <sup>81</sup> | Pb <sup>82</sup> | Bi <sup>83</sup> | Po <sup>84</sup> | At <sup>85</sup> | Rn <sup>86</sup> |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Fr <sup>87</sup> | Ra <sup>88</sup> | 89-103   | Rf <sup>104</sup> | Ha <sup>105</sup> | 106              | 107              | 108              | 109              |                  |                  |                  |                  |                  |                  |                  |                  |                  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Lanthanides      |                  | <table border="1"> <tr> <td>57</td><td>58</td><td>59</td><td>60</td><td>61</td><td>62</td><td>63</td><td>64</td><td>65</td><td>66</td><td>67</td><td>68</td><td>69</td><td>70</td><td>71</td> </tr> <tr> <td>La</td><td>Ce</td><td>Pr</td><td>Nd</td><td>Pm</td><td>Sm</td><td>Eu</td><td>Gd</td><td>Tb</td><td>Dy</td><td>Ho</td><td>Er</td><td>Tm</td><td>Yb</td><td>Lu</td> </tr> </table>    |                   |                   |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 57               | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68  | 69  | 70  | 71  | La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| 57               | 58               | 59   | 60                | 61                | 62               | 63               | 64               | 65               | 66               | 67               | 68               | 69               | 70               | 71               |                  |                  |                  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| La               | Ce               | Pr   | Nd                | Pm                | Sm               | Eu               | Gd               | Tb               | Dy               | Ho               | Er               | Tm               | Yb               | Lu               |                  |                  |                  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Actinides        |                  | <table border="1"> <tr> <td>89</td><td>90</td><td>91</td><td>92</td><td>93</td><td>94</td><td>95</td><td>96</td><td>97</td><td>98</td><td>99</td><td>100</td><td>101</td><td>102</td><td>103</td> </tr> <tr> <td>Ac</td><td>Th</td><td>Pa</td><td>U</td><td>Np</td><td>Pu</td><td>Am</td><td>Cm</td><td>Bk</td><td>Cf</td><td>Es</td><td>Fm</td><td>Md</td><td>No</td><td>Lr</td> </tr> </table> |                   |                   |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 89               | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | Ac | Th | Pa | U  | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |
| 89               | 90               | 91   | 92                | 93                | 94               | 95               | 96               | 97               | 98               | 99               | 100              | 101              | 102              | 103              |                  |                  |                  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Ac               | Th               | Pa   | U                 | Np                | Pu               | Am               | Cm               | Bk               | Cf               | Es               | Fm               | Md               | No               | Lr               |                  |                  |                  |    |    |    |    |    |    |    |    |    |    |     |     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

Metal
  Metalloid
  Nonmetal

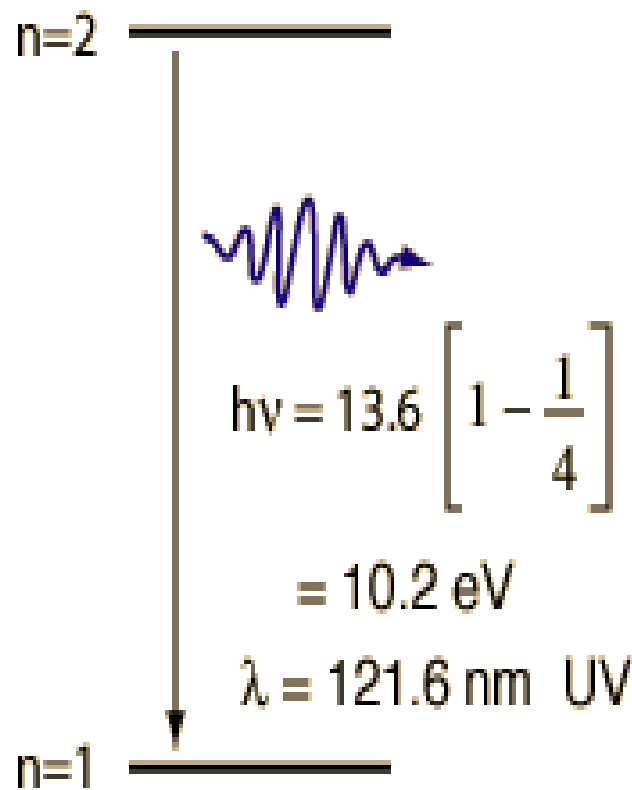
# Kolejność wypełniania powłok



## Kolejność wypełniania orbit przez elektrony

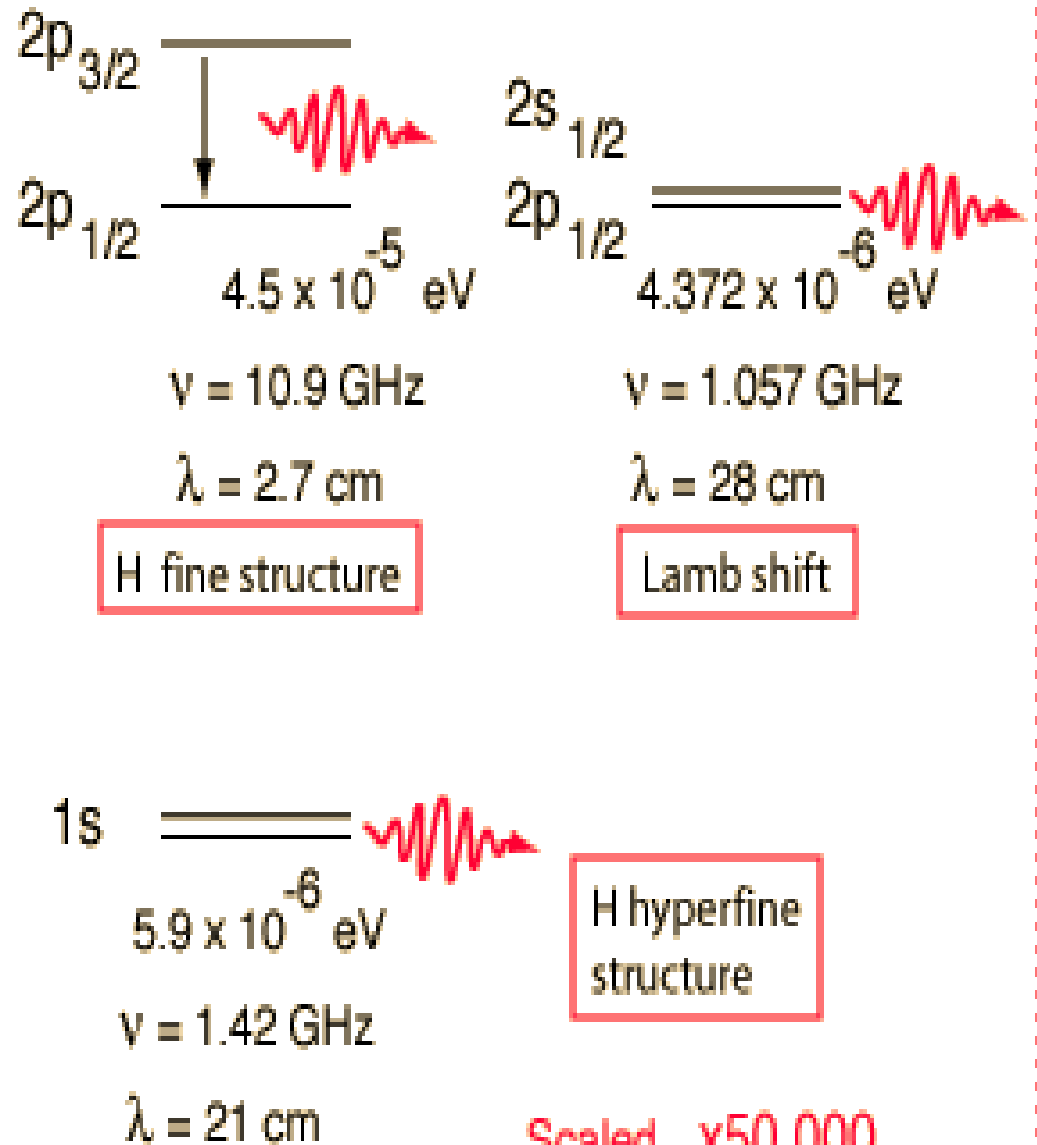


Chrom jest pierwszym wyjątkiem: wpierw wypełniane są stany 3d (pieć elektronów), później 4s

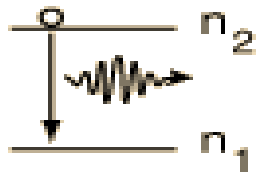


$$E = \frac{-13.6 \text{ eV}}{n^2}$$

Hydrogen Shrodinger  
(confirms Bohr model)

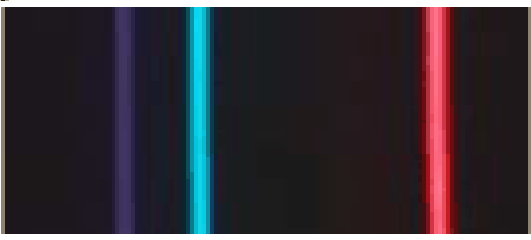
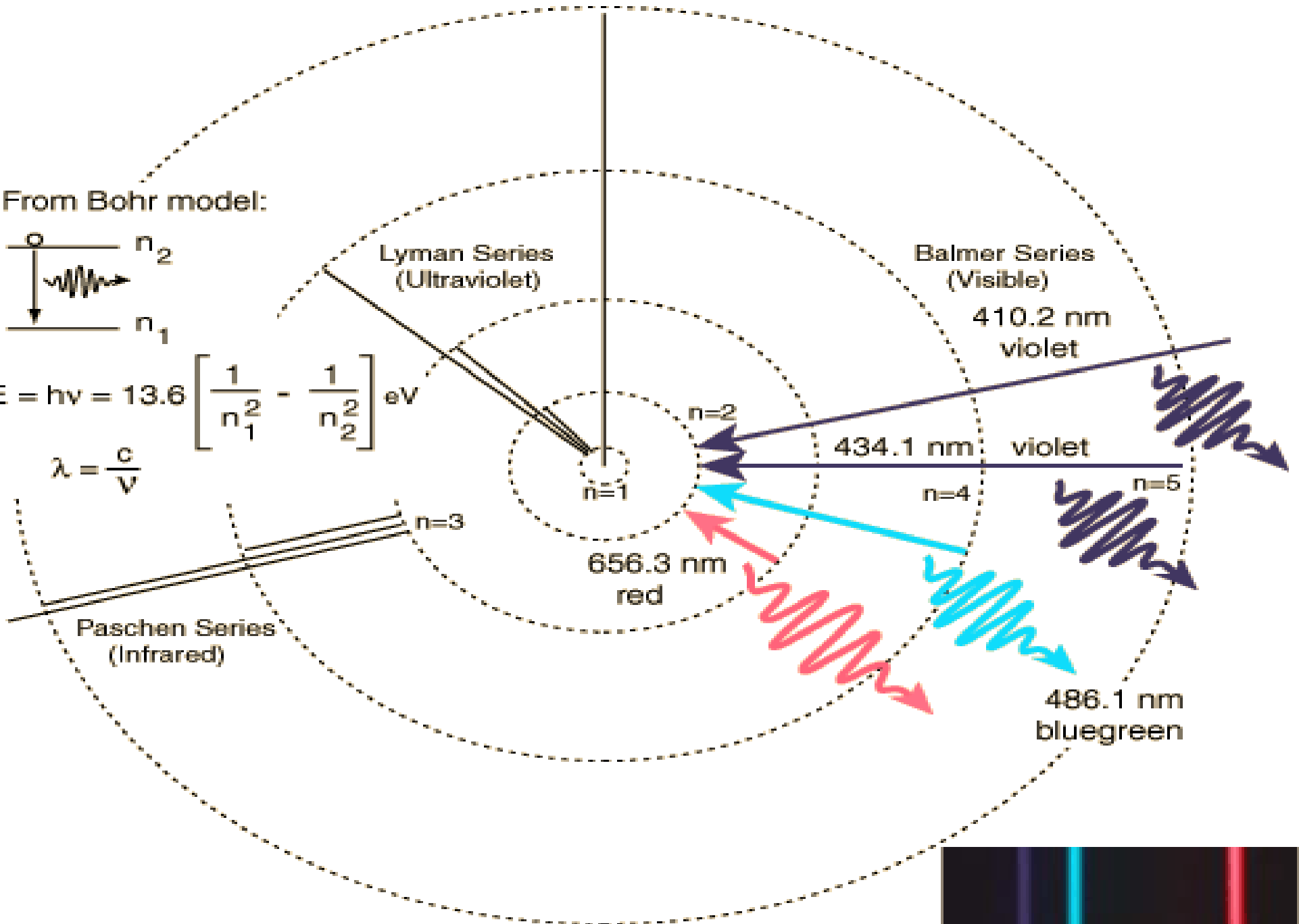


From Bohr model:



$$\Delta E = h\nu = 13.6 \left[ \frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \text{ eV}$$

$$\lambda = \frac{c}{\nu}$$



Linie emisyjne wodoru (u dołu) dla siatki o stałej 600 szczelin/mm  
(podobnie cdrom)

