

## Ground state term symbols

The procedure is to, from the spectroscopic notation of an element (i) determine the possible term symbols using the Russel-Saunders coupling scheme ( $J = L + S$ ), (ii) determine which of these term symbols is consistent with the fact that the electron wave function must be anti-symmetric (Pauli principle), then (iii) apply Hund's rules to identify the ground-state term symbol.

a) Na ( $Z=11$ );  $3s^1$ ;  $S = \frac{1}{2}$ ;  $l=0$ ;  $^{2S+1}L_J = \boxed{{}^2S_{1/2}}$   
 $j_{\max} = \frac{1}{2} + 0$ ;  $j_{\min} = \frac{1}{2} - 0$ ;  $j = \frac{1}{2}$

b) Mg ( $Z=12$ );  $3s^2$ ;  $S_{\max} = \frac{1}{2} + \frac{1}{2}$ ;  $S_{\min} = \frac{1}{2} - \frac{1}{2}$ ;

$S = 1, 0$ ;  $l=0$ ;  $j_{\max} = 1+0$ ;  $j_{\min} = 1-0$ , for  $S=1$

$j_{\max} = 0+0$ ;  $j_{\min} = 0-0$ , for  $S=0$

term symbols:  ~~${}^3S_1$~~ ;  ${}^1S_0$

forbidden by

Pauli Principle.

Therefore

$\boxed{{}^1S_0}$

c) Al ( $Z=13$ ) ;  $3s^2 3p^1$  ;  $l=1$  ;

adding 2 spins:  $S_{max} = \frac{1}{2} + \frac{1}{2} = 1$ ,  $S_{min} = \frac{1}{2} - \frac{1}{2} = 0 \Rightarrow S=1$  or  $0$

adding third spin:  $S=1: S_{max} = 1 + \frac{1}{2}$ ,  $S_{min} = 1 - \frac{1}{2} \Rightarrow \frac{3}{2}, \frac{1}{2}$  } allowed  
 $S=0: S_{max} = 0 + \frac{1}{2}$ ,  $S_{min} = |0 - \frac{1}{2}| \Rightarrow \frac{1}{2}$  } S

finding  $j$ :  $S = \frac{3}{2} \Rightarrow j_{max} = \frac{3}{2} + 1$ ,  $\frac{3}{2} - 1 \Rightarrow j = \frac{5}{2}, \frac{3}{2}, \frac{1}{2}$

$S = \frac{1}{2} \Rightarrow j_{max} = \frac{1}{2} + 1$ ,  $|\frac{1}{2} - 1| \Rightarrow j = \frac{3}{2}, \frac{1}{2}$   
 allowed  $j$

term symbols:

$S = \frac{3}{2}, L=1: {}^1P_{\frac{5}{2}, \frac{3}{2}, \frac{1}{2}}$

← These are forbidden by Pauli Principle

$S = \frac{1}{2}, L=1: {}^2P_{\frac{3}{2}, \frac{1}{2}}$



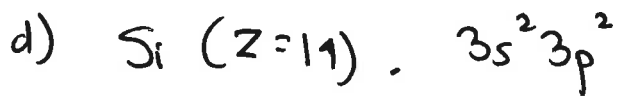
Allowed term symbols. Now use Hund's

rules: 1<sup>st</sup> two rules don't distinguish

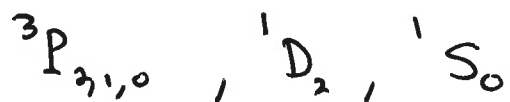
these term symbols. Last Hund rule

requires smallest  $j$ . Thus

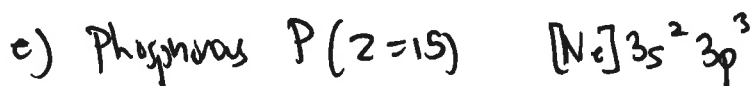
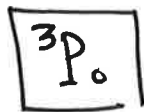
${}^2P_{\frac{1}{2}}$



- I'll just look up the term symbols that are consistent w/ Pauli Principle:



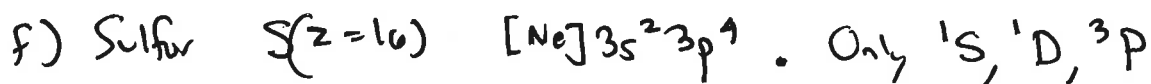
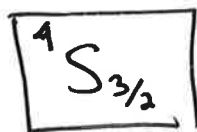
- Now Hund's rules require (i) highest multiplicity ( $2S+1=3$ ) and then (ii) smallest  $j$  ( $j=0$ ) . So



- Allowed symbols: only S (not P, D or F)

So  $L=0$ , Maximize multiplicity:  $S = \frac{3}{2}, \frac{1}{2}$

Thus  $j = \frac{3}{2}$ .



allowed by symmetry / Pauli principle.

(i) maximum multiplicity:  ${}^3P$

(ii) largest  $j$ : must have  $S=1$  and  $L=1$ ,  $j_{max} = 1+1=2$



g) Chlorine Cl ( $Z=17$ )  $[\text{Ne}] 3s^2 3p^5$

Allowed term symbols:  ~~$2P$~~   $2P$

Therefore since  $2s+1 = 2$ ,  $s = \frac{1}{2}$ ,

since  $\ell = P$ ,  $L = 1$

Need to maximize  $j$ :  $j = \frac{3}{2}$



h) Argon Ar ( $Z=18$ )  $[\text{Ne}] 3s^2 3p^6$

$S=0$ ,  $L=0$ ,  $j_{\text{max}}=0$

