

# Appendix III\*

## A. Character Tables for Chemically Important Symmetry Groups

### 1. The Nonaxial Groups

$C_1$	$E$
$A$	1

$C_3$	$E$	$\sigma_h$		$C_2$	$E$	$i$	
$A'$	1	1	$x, y, R_z$	$x^2, y^2, z^2, xy$	$A_g$	1	$R_x, R_y, R_z$
$A''$	1	-1	$z, R_x, R_y$	$yz, xz$	$A_u$	1	$x, y, z$

### 2. The $C_n$ Groups

$C_2$	$E$	$C_2$	
$A$	1	1	$z, R_z$
$B$	1	-1	$x, y, R_x, R_y$

$C_3$	$E$	$C_3$	$C_3^2$	$\epsilon = \exp(2\pi i/3)$
$A$	1	1	1	$x^2 + y^2, z^2$
$E$	$\begin{pmatrix} 1 & \epsilon \\ 1 & \epsilon^* \end{pmatrix}$	$\epsilon^*$	$\epsilon$	$(x^2 - y^2, xy)(yz, xz)$

\* Appendix IIIA is presented in two places: (1) here, in its proper location in the sequence of appendices, and (2) as a separate section in a pocket inside the back cover.

The  $C_n$  Groups (continued)

$C_4$	$E$	$C_4$	$C_2$	$C_4^3$					
$A$	1	1	1	1	$z, R_z$	$x^2 + y^2, z^2$			
$B$	1	-1	1	-1		$x^2 - y^2, xy$			
$E$	$\begin{Bmatrix} 1 & i \\ 1 & -i \end{Bmatrix}$	$\begin{Bmatrix} -1 & -i \\ -1 & i \end{Bmatrix}$		$i$	$(x, y)(R_x, R_y)$	$(yz, xz)$			
$C_5$	$E$	$C_5$	$C_5^2$	$C_5^3$	$C_5^4$		$\varepsilon = \exp(2\pi i/5)$		
$A$	1	1	1	1	1	$z, R_z$	$x^2 + y^2, z^2$		
$E_1$	$\begin{Bmatrix} \varepsilon & \varepsilon^2 & \varepsilon^{2*} & \varepsilon^* \\ \varepsilon^* & \varepsilon^{2*} & \varepsilon^2 & \varepsilon \end{Bmatrix}$					$(x, y)(R_x, R_y)$	$(yz, xz)$		
$E_2$	$\begin{Bmatrix} 1 & \varepsilon^2 & \varepsilon^* & \varepsilon \\ 1 & \varepsilon^{2*} & \varepsilon & \varepsilon^{2*} \end{Bmatrix}$						$(x^2 - y^2, xy)$		
$C_6$	$E$	$C_6$	$C_3$	$C_2$	$C_3^2$	$C_6^5$		$\varepsilon = \exp(2\pi i/6)$	
$A$	1	1	1	1	1	1	$z, R_z$	$x^2 + y^2, z^2$	
$B$	1	-1	1	-1	1	-1			
$E_1$	$\begin{Bmatrix} \varepsilon & -\varepsilon^* & -1 & -\varepsilon \\ \varepsilon^* & -\varepsilon & -1 & -\varepsilon^* \end{Bmatrix}$					$\varepsilon$	$(x, y)$	$(xz, yz)$	
$E_2$	$\begin{Bmatrix} 1 & -\varepsilon^* & -\varepsilon & 1 \\ 1 & -\varepsilon & -\varepsilon^* & 1 \end{Bmatrix}$					$\varepsilon$	$(R_x, R_y)$	$(x^2 - y^2, xy)$	
$C_7$	$E$	$C_7$	$C_7^2$	$C_7^3$	$C_7^4$	$C_7^5$	$C_7^6$	$\varepsilon = \exp(2\pi i/7)$	
$A$	1	1	1	1	1	1	1	$z, R_z$	
$E_1$	$\begin{Bmatrix} \varepsilon & \varepsilon^2 & \varepsilon^3 & \varepsilon^{3*} & \varepsilon^{2*} & \varepsilon^* \\ \varepsilon^* & \varepsilon^{2*} & \varepsilon^{3*} & \varepsilon^3 & \varepsilon^2 & \varepsilon \end{Bmatrix}$							$(x, y)$	
$E_2$	$\begin{Bmatrix} \varepsilon^2 & \varepsilon^{3*} & \varepsilon^* & \varepsilon & \varepsilon^3 & \varepsilon^{2*} \\ \varepsilon^{2*} & \varepsilon^3 & \varepsilon & \varepsilon^* & \varepsilon^{3*} & \varepsilon^2 \end{Bmatrix}$							$(R_x, R_y)$	
$E_3$	$\begin{Bmatrix} 1 & \varepsilon^3 & \varepsilon^* & \varepsilon^2 & \varepsilon^{2*} & \varepsilon & \varepsilon^{3*} \\ 1 & \varepsilon^{3*} & \varepsilon & \varepsilon^{2*} & \varepsilon^2 & \varepsilon^* & \varepsilon^3 \end{Bmatrix}$							$(x^2 - y^2, xy)$	
$C_8$	$E$	$C_8$	$C_4$	$C_2$	$C_4^3$	$C_8^3$	$C_8^5$	$C_8^7$	$\varepsilon = \exp(2\pi i/8)$
$A$	1	1	1	1	1	1	1	1	$z, R_z$
$B$	1	-1	1	1	-1	-1	-1	-1	$x^2 + y^2, z^2$
$E_1$	$\begin{Bmatrix} \varepsilon & i & -1 & -i & -\varepsilon^* & -\varepsilon \\ \varepsilon^* & -i & -1 & i & -\varepsilon & -\varepsilon^* \end{Bmatrix}$								$(x, y)$
$E_2$	$\begin{Bmatrix} 1 & i & -1 & 1 & -1 & -i \\ 1 & -i & -1 & 1 & -1 & i \end{Bmatrix}$								$(xz, yz)$
$E_3$	$\begin{Bmatrix} 1 & -\varepsilon & i & -1 & -i & \varepsilon^* & \varepsilon & -\varepsilon^* \\ 1 & -\varepsilon^* & -i & -1 & i & \varepsilon & \varepsilon^* & -\varepsilon \end{Bmatrix}$								$(x^2 - y^2, xy)$

11. The Icosahedral Groups\*

$I_h$	$E$	$12C_5$	$12C_5^2$	$20C_3$	$15C_2$	$i$	$12S_{10}$	$12S_{10}^3$	$20S_6$	$15\sigma$		
$A_g$	1	1	1	1	1	1	1	1	1	1	$(R_x, R_y, R_z)$	$x^2 + y^2 + z^2$
$T_{1g}$	3	$\frac{1}{2}(1 + \sqrt{5})$	$\frac{1}{2}(1 - \sqrt{5})$	0	-1	3	$\frac{1}{2}(1 - \sqrt{5})$	$\frac{1}{2}(1 + \sqrt{5})$	0	-1		$(2z^2 - x^2 - y^2, x^2 - y^2, xy, yz, zx)$
$T_{2g}$	3	$\frac{1}{2}(1 - \sqrt{5})$	$\frac{1}{2}(1 + \sqrt{5})$	0	-1	3	$\frac{1}{2}(1 + \sqrt{5})$	$\frac{1}{2}(1 - \sqrt{5})$	0	-1		
$G_g$	4	-1	-1	1	0	4	-1	-1	1	0		
$H_g$	5	0	0	-1	1	5	0	0	-1	1		
$A_u$	1	1	1	1	1	-1	-1	-1	-1	-1	$(x, y, z)$	
$T_{1u}$	3	$\frac{1}{2}(1 + \sqrt{5})$	$\frac{1}{2}(1 - \sqrt{5})$	0	-1	-3	$-\frac{1}{2}(1 - \sqrt{5})$	$-\frac{1}{2}(1 + \sqrt{5})$	0	1		
$T_{2u}$	3	$\frac{1}{2}(1 - \sqrt{5})$	$\frac{1}{2}(1 + \sqrt{5})$	0	-1	-3	$-\frac{1}{2}(1 + \sqrt{5})$	$-\frac{1}{2}(1 - \sqrt{5})$	0	1		
$G_u$	4	-1	-1	1	0	-4	1	1	-1	0		
$H_u$	5	0	0	-1	1	-5	0	0	1	-1		

\* For the pure rotation group I, the outlined section in the upper left is the character table; the  $g$  subscripts should, of course, be dropped and  $(x, y, z)$  assigned to the  $T_1$  representation.

3. The  $D_n$  Groups

$D_2$	$E$	$C_2(z)$	$C_2(y)$	$C_2(x)$		
$A$	1	1	1	1	1	$x^2, y^2, z^2$
$B_1$	1	1	-1	-1	-1	$xy$
$B_2$	1	-1	1	-1	-1	$xz$
$B_3$	1	-1	-1	1	1	$yz$

  

$D_3$	$E$	$2C_3$	$3C_2$		
$A_1$	1	1	1	$z, R_z$	$x^2 + y^2, z^2$
$A_2$	1	1	-1	$(x, y)(R_x, R_y)$	$(x^2 - y^2, xy)(xz, yz)$
$E$	2	-1	0		

  

$D_4$	$E$	$2C_4$	$C_2(=C_4^2)$	$2C_2'$	$2C_2''$	
$A_1$	1	1	1	1	1	$x^2 + y^2, z^2$
$A_2$	1	1	1	-1	-1	$z, R_z$
$B_1$	1	-1	1	1	-1	$x^2 - y^2$
$B_2$	1	-1	1	-1	1	$xy$
$E$	2	0	-2	0	0	$(xz, yz)$

  

$D_5$	$E$	$2C_5$	$2C_5^2$	$5C_2$	
$A_1$	1	1	1	1	$x^2 + y^2, z^2$
$A_2$	1	1	1	-1	$z, R_z$
$E_1$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	$(xz, yz)$
$E_2$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	$(x^2 - y^2, xy)$

  

$D_6$	$E$	$2C_6$	$2C_3$	$C_2$	$3C_2'$	$3C_2''$	
$A_1$	1	1	1	1	1	1	$x^2 + y^2, z^2$
$A_2$	1	1	1	1	-1	-1	$z, R_z$
$B_1$	1	-1	1	-1	1	-1	$(xz, yz)$
$B_2$	1	-1	1	-1	-1	1	$(x^2 - y^2, xy)$
$E_1$	2	1	-1	-2	0	0	
$E_2$	2	-1	-1	2	0	0	

4. The  $C_{nv}$  Groups

$C_{2v}$	$E$	$C_2$	$\sigma_v(xz)$	$\sigma'_v(yz)$		
$A_1$	1	1	1	1	$z$	$x^2, y^2, z^2$
$A_2$	1	1	-1	-1	$R_z$	$xy$
$B_1$	1	-1	1	-1	$x, R_y$	$xz$
$B_2$	1	-1	-1	1	$y, R_x$	$yz$

$C_{3v}$	$E$	$2C_3$	$3\sigma_v$		
$A_1$	1	1	1	$z$	$x^2 + y^2, z^2$
$A_2$	1	1	-1	$R_z$	
$E$	2	-1	0	$(x, y)(R_x, R_y)$	$(x^2 - y^2, xy)(xz, yz)$

$C_{4v}$	$E$	$2C_4$	$C_2$	$2\sigma_v$	$2\sigma_d$		
$A_1$	1	1	1	1	1	$z$	$x^2 + y^2, z^2$
$A_2$	1	1	1	-1	-1	$R_z$	
$B_1$	1	-1	1	1	-1		$x^2 - y^2$
$B_2$	1	-1	1	-1	1		$xy$
$E$	2	0	-2	0	0	$(x, y)(R_x, R_y)$	$(xz, yz)$

$C_{5v}$	$E$	$2C_5$	$2C_5^2$	$5\sigma_v$		
$A_1$	1	1	1	1	$z$	$x^2 + y^2, z^2$
$A_2$	1	1	1	-1	$R_z$	
$E_1$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	$(x, y)(R_x, R_y)$	$(xz, yz)$
$E_2$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0		$(x^2 - y^2, xy)$

$C_{6v}$	$E$	$2C_6$	$2C_3$	$C_2$	$3\sigma_v$	$3\sigma_d$		
$A_1$	1	1	1	1	1	1	$z$	$x^2 + y^2, z^2$
$A_2$	1	1	1	1	-1	-1	$R_z$	
$B_1$	1	-1	1	-1	1	-1		
$B_2$	1	-1	1	-1	-1	1		
$E_1$	2	1	-1	-2	0	0	$(x, y)(R_x, R_y)$	$(xz, yz)$
$E_2$	2	-1	-1	2	0	0		$(x^2 - y^2, xy)$

9. The Cubic Groups (Continued).

$T_h$	$E$	$4C_3$	$4C_3^2$	$3C_2$	$i$	$4S_6$	$4S_6^5$	$3\sigma_h$		
$A_g$	1	1	1	1	1	1	1	1	$z$	$x^2 + y^2 + z^2$
$A_u$	1	1	1	1	1	-1	-1	-1		
$E_g$	1	$\epsilon$	$\epsilon^*$	1	1	$\epsilon$	$\epsilon^*$	$\epsilon$	$(R_x, R_y, R_z)$	$(2z^2 - x^2 - y^2, x^2 - y^2)$
$E_u$	1	$\epsilon$	$\epsilon^*$	1	1	$\epsilon$	$\epsilon^*$	$\epsilon$		
$T_g$	1	$\epsilon$	$\epsilon^*$	1	1	$\epsilon$	$\epsilon^*$	$\epsilon$		
$T_u$	3	0	0	0	0	-1	-1	0	$(R_x, R_y, R_z)$	$(xz, yz, xy)$
$T_h$	3	0	0	0	0	-1	-1	0		

$T_d$	$E$	$8C_3$	$3C_2$	$6S_4$	$6\sigma_d$		
$A_1$	1	1	1	1	1	$(R_x, R_y, R_z)$	$x^2 + y^2 + z^2$
$A_2$	1	1	1	-1	-1		$(2z^2 - x^2 - y^2, x^2 - y^2)$
$E$	2	-1	2	0	0	$(x, y, z)$	$(xy, xz, yz)$

$O_h$	$E$	$6C_4$	$3C_2(=C_4^2)$	$8C_3$	$6C_2$		
$A_1$	1	1	1	1	1	$(R_x, R_y, R_z)$	$x^2 + y^2 + z^2$
$A_2$	1	-1	1	1	-1		$(2z^2 - x^2 - y^2, x^2 - y^2)$
$E$	2	0	2	-1	0	$(x, y, z)$	$(xy, xz, yz)$

$O_h$	$E$	$8C_3$	$6C_2$	$6C_4$	$3C_2(=C_4^2)$	$i$	$6S_4$	$8S_6$	$3\sigma_h$	$6\sigma_d$		
$A_{1g}$	1	1	1	1	1	1	1	1	1	1	$z$	$x^2 + y^2 + z^2$
$A_{2g}$	1	1	-1	-1	1	1	1	-1	-1	-1	$R_z$	$(2z^2 - x^2 - y^2, x^2 - y^2)$
$E_g$	2	-1	0	0	2	2	0	-1	2	0	$(x, y, z)$	$(xz, yz, xy)$
$T_{1g}$	3	0	-1	1	-1	-1	3	1	0	-1		
$T_{2g}$	3	0	1	-1	-1	-1	3	-1	0	-1		
$A_{1u}$	1	1	1	1	1	1	-1	-1	-1	-1		
$A_{2u}$	1	1	-1	-1	1	1	-1	-1	-1	-1		
$E_u$	2	-1	0	0	-2	-2	0	1	-2	0		
$T_{1u}$	3	0	-1	1	-1	-1	-3	-1	0	1		
$T_{2u}$	3	0	1	-1	-1	-1	-3	1	0	-1		

10. The Groups  $C_{\infty v}$  and  $D_{\infty h}$  for Linear Molecules

$C_{\infty v}$	$E$	$2C_{\infty}^\phi$	$\dots$	$\infty\sigma_v$		
$A_1 \equiv \Sigma^+$	1	1	1	1	$z$	$x^2 + y^2, z^2$
$A_2 \equiv \Sigma^-$	1	1	1	-1	$R_z$	
$E_1 \equiv \Pi$	2	$2 \cos \Phi$	$\dots$	0	$(x, y), (R_x, R_y)$	$(xz, yz)$
$E_2 \equiv \Delta$	2	$2 \cos 2\Phi$	$\dots$	0		$(x^2 - y^2, xy)$
$E_3 \equiv \Phi$	2	$2 \cos 3\Phi$	$\dots$	0		

$D_{\infty h}$	$E$	$2C_{\infty}^\phi$	$\dots$	$\infty\sigma_v$	$i$	$2S_{\infty}^\phi$	$\dots$	$\infty C_2$		
$\Sigma_g^+$	1	1	1	1	1	1	1	1	$z$	$x^2 + y^2, z^2$
$\Sigma_g^-$	1	1	1	1	-1	-1	-1	-1		
$\Pi_g$	2	$2 \cos \Phi$	$\dots$	0	2	$-2 \cos \Phi$	$\dots$	0	$(R_x, R_y)$	$(xz, yz)$
$\Delta_g$	2	$2 \cos 2\Phi$	$\dots$	0	2	$2 \cos 2\Phi$	$\dots$	0		$(x^2 - y^2, xy)$
$\Sigma_u^+$	1	1	1	-1	-1	-1	-1	-1		
$\Sigma_u^-$	1	1	1	-1	1	1	1	1	$z$	
$\Pi_u$	2	$2 \cos \Phi$	$\dots$	0	-2	$-2 \cos \Phi$	$\dots$	0		
$\Delta_u$	2	$2 \cos 2\Phi$	$\dots$	0	-2	$-2 \cos 2\Phi$	$\dots$	0		

7. The  $D_{nd}$  Groups (Continued).

$D_{6d}$	E	$2S_{12}$	$2C_6$	$2S_6$	$2C_3$	$2S_{12}^2$	$C_2$	$6C_2'$	$6\sigma_d$
$A_1$	1	1	1	1	1	1	1	1	1
$A_2$	1	1	1	1	1	1	1	-1	-1
$B_1$	1	-1	1	-1	1	1	1	-1	-1
$B_2$	1	-1	1	-1	1	1	1	1	1
$E_1$	2	$\sqrt{3}$	1	0	-1	$-\sqrt{3}$	-2	0	0
$E_2$	2	0	-1	-2	-1	1	2	0	0
$E_3$	2	0	-2	0	2	0	-2	0	0
$E_4$	2	-1	-1	2	-1	-1	2	0	0
$E_5$	2	$-\sqrt{3}$	1	0	-1	$\sqrt{3}$	-2	0	0

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2$	$x^2 + y^2, z^2$
	$z$	$z$
	$(x, y)$	$(x^2 - y^2, xy)$

  

	$(R_{xx}, R_y)$	$(xz, yz)$
	$(xz, yz)$	$(xz, yz)$

8. The  $S_n$  Groups

$S_4$	E	$S_4$	$C_2$	$S_4^3$
$A$	1	1	1	1
$B$	1	-1	1	-1
$E$	1	$i$	-1	$-i$

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2$	$x^2 + y^2, z^2$
	$z$	$z$
	$(x, y)$	$(R_{xx}, R_y)$
	$(xz, yz)$	$(xz, yz)$

5. The  $C_{nh}$  Groups

$C_{2h}$	E	$C_2$	$i$	$\sigma_h$
$A_g$	1	1	1	1
$B_g$	1	-1	-1	1
$A_u$	1	-1	1	-1
$B_u$	1	1	-1	-1

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2, xy$	$x^2 + y^2, z^2, xy$
	$z$	$z$
	$(x, y)$	$(R_{xx}, R_y)$

$C_{3h}$	E	$C_3$	$C_3^2$	$\sigma_h$	$S_3$	$S_3^5$
$A'$	1	1	1	1	1	1
$E'$	1	$e^*$	$e^{2*}$	$e$	$e^*$	$e^{2*}$
$A''$	1	1	1	-1	-1	-1
$E''$	1	$e^*$	$e^{2*}$	-1	$-e^*$	$-e^{2*}$

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2$	$x^2 + y^2, z^2$
	$(x, y)$	$(x^2 - y^2, xy)$
	$z$	$z$
	$(R_{xx}, R_y)$	$(xz, yz)$

$C_{4h}$	E	$C_4$	$C_2$	$C_4^3$	$i$	$S_4^3$	$\sigma_h$	$S_4$
$A_g$	1	1	1	1	1	1	1	1
$B_g$	1	-1	1	-1	1	1	1	-1
$E_g$	1	$i$	-1	$-i$	1	1	1	$i$
$A_u$	1	1	1	1	-1	-1	-1	-1
$B_u$	1	-1	1	-1	-1	-1	-1	1
$E_u$	1	$i$	-1	$-i$	-1	-1	-1	$i$

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2$	$x^2 + y^2, z^2$
	$z$	$z$
	$(x, y)$	$(R_{xx}, R_y)$
	$(xz, yz)$	$(xz, yz)$

$C_{6h}$	E	$C_6$	$C_3$	$C_2$	$C_3^2$	$C_6^5$	$i$	$S_3^5$	$S_6^5$	$S_6^3$	$S_6^1$
$A'$	1	1	1	1	1	1	1	1	1	1	1
$E_1'$	1	$e$	$e^2$	$e^2*$	$e^*$	$e$	$e$	$e^*$	$e^{2*}$	$e^*$	$e$
$E_2'$	1	$e^2$	$e^4$	$e^4*$	$e^2*$	$e^2$	$e^2$	$e^{2*}$	$e^4*$	$e^2*$	$e^4$
$A''$	1	1	1	1	1	1	-1	-1	-1	-1	-1
$E_1''$	1	$e$	$e^2$	$e^2*$	$e^*$	$e$	-1	$-e$	$-e^*$	$-e^{2*}$	$-e$
$E_2''$	1	$e^2$	$e^4$	$e^4*$	$e^2*$	$e^2$	-1	$-e^2$	$-e^{2*}$	$-e^4*$	$-e^2*$

  

	$R_2$	$R_2$
	$x^2 + y^2, z^2$	$x^2 + y^2, z^2$
	$(x, y)$	$(x^2 - y^2, xy)$
	$z$	$z$
	$(R_{xx}, R_y)$	$(xz, yz)$

9. The Cubic Groups

T	E	$4C_3$	$4C_3^2$	$3C_2$
$A$	1	1	1	1
$E$	1	$e$	$e^*$	1
$T$	3	0	0	-1

  

	$e = \exp(2\pi i/3)$
	$x^2 + y^2, z^2$
	$(2z^2 - x^2 - y^2)$
	$(x, y)$
	$(R_{xx}, R_y, R_z); (x, y, z)$

6. The  $D_{nh}$  Groups

$D_{2h}$	$E$	$C_2(z)$	$C_2(y)$	$C_2(x)$	$i$	$\sigma(xy)$	$\sigma(xz)$	$\sigma(yz)$	
$A_g$	1	1	1	1	1	1	1	1	$R_z$
$B_{1g}$	1	1	-1	-1	1	1	-1	-1	$R_y$
$B_{2g}$	1	-1	1	-1	1	-1	1	-1	$R_x$
$B_{3g}$	1	-1	-1	1	1	-1	-1	1	$R_z$
$A_u$	1	1	1	1	-1	-1	-1	-1	$z$
$B_{1u}$	1	1	-1	-1	-1	-1	1	1	$y$
$B_{2u}$	1	-1	1	-1	-1	1	-1	-1	$x$
$B_{3u}$	1	-1	-1	1	-1	1	1	-1	$x$

$D_{3h}$	$E$	$2C_3$	$3C_2$	$\sigma_h$	$2S_6$	$3\sigma_v$		
$A_1'$	1	1	1	1	1	1	$R_z$	$x^2+y^2, z^2$
$A_2'$	1	1	-1	1	1	-1	$R_z$	$x^2-y^2$
$E_2'$	2	-1	0	2	-1	0	$(R_x, R_y)$	$(x^2-y^2, xy)$
$A_1''$	1	1	1	-1	-1	-1	$z$	$(xz, yz)$
$A_2''$	1	1	-1	-1	-1	1	$z$	$(xz, yz)$
$E_2''$	2	-1	0	-2	1	0	$(R_x, R_y)$	$(xz, yz)$

$D_{4h}$	$E$	$2C_4$	$C_2$	$2C_2'$	$2C_2''$	$i$	$2S_4$	$\sigma_h$	$2\sigma_v$	$2\sigma_d$	
$A_{1g}$	1	1	1	1	1	1	1	1	1	1	$R_z$
$A_{2g}$	1	1	1	-1	-1	1	1	1	1	1	$R_z$
$B_{1g}$	1	1	-1	1	1	1	1	1	-1	-1	$R_z$
$B_{2g}$	1	1	-1	-1	-1	1	1	1	-1	1	$(R_x, R_y)$
$E_g$	2	0	-2	0	0	2	0	-2	0	0	$(R_x, R_y)$
$A_{1u}$	1	1	1	1	1	-1	-1	-1	-1	-1	$z$
$A_{2u}$	1	1	1	-1	-1	-1	-1	-1	-1	-1	$z$
$B_{1u}$	1	1	-1	1	1	-1	-1	-1	1	1	$z$
$B_{2u}$	1	1	-1	-1	-1	-1	-1	-1	1	-1	$z$
$E_u$	2	0	-2	0	0	-2	0	2	0	0	$(x, y)$

$D_{5h}$	$E$	$2C_5$	$2C_5^2$	$5C_2$	$\sigma_h$	$2S_5$	$2S_5^3$	$5\sigma_v$	
$A_1'$	1	1	1	1	1	1	1	1	$R_z$
$A_2'$	1	1	1	-1	1	1	1	-1	$R_z$
$E_1'$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	$(x, y)$
$E_2'$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	$(x^2-y^2, xy)$
$A_1''$	1	1	1	1	-1	-1	-1	-1	$z$
$A_2''$	1	1	1	-1	-1	-1	-1	1	$z$
$E_1''$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	-2	$-2 \cos 72^\circ$	$-2 \cos 144^\circ$	0	$(R_x, R_y)$
$E_2''$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	-2	$-2 \cos 144^\circ$	$-2 \cos 72^\circ$	0	$(R_x, R_y)$

$D_{6h}$	$E$	$2C_6$	$2C_3$	$C_2$	$3C_2'$	$3C_2''$	$i$	$2S_6$	$2S_6^5$	$\sigma_h$	$3\sigma_d$	$3\sigma_v$	
$A_{1g}$	1	1	1	1	1	1	1	1	1	1	1	1	$R_z$
$A_{2g}$	1	1	1	1	-1	-1	1	1	1	1	1	1	$R_z$
$B_{1g}$	1	1	1	-1	1	1	1	1	1	1	-1	-1	$R_z$
$B_{2g}$	1	1	1	-1	-1	-1	1	1	1	1	-1	1	$(R_x, R_y)$
$E_{1g}$	2	-1	-1	2	0	0	2	-1	-1	-2	0	0	$(R_x, R_y)$
$E_{2g}$	2	-1	-1	2	0	0	-2	1	1	2	0	0	$(R_x, R_y)$
$A_{1u}$	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	$z$
$A_{2u}$	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	$z$
$B_{1u}$	1	1	1	-1	1	1	-1	-1	-1	-1	1	1	$z$
$B_{2u}$	1	1	1	-1	-1	-1	-1	-1	-1	-1	1	-1	$z$
$E_{1u}$	2	-1	-1	2	0	0	-2	1	1	-2	0	0	$(x, y)$
$E_{2u}$	2	-1	-1	2	0	0	2	-1	-1	2	0	0	$(x, y)$

6. The  $D_{nh}$  Groups (Continued).

$D_{8h}$	$E$	$2C_8$	$2C_4^3$	$2C_4$	$C_2$	$4C_2'$	$4C_2''$	$i$	$2S_8$	$2S_8^3$	$2S_8^5$	$2S_8^7$	$\sigma_h$	$4\sigma_d$	$4\sigma_v$	
$A_{1g}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$R_z$
$A_{2g}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$R_z$
$B_{1g}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$R_z$
$B_{2g}$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	$R_z$
$E_{1g}$	2	$\sqrt{2}$	$-\sqrt{2}$	0	2	0	0	2	$\sqrt{2}$	$\sqrt{2}$	0	2	0	0	0	$(R_x, R_y)$
$E_{2g}$	2	0	0	-2	2	0	0	2	0	0	2	2	0	0	0	$(R_x, R_y)$
$E_{3g}$	2	$-\sqrt{2}$	$\sqrt{2}$	0	-2	0	0	-2	$\sqrt{2}$	$\sqrt{2}$	0	2	0	0	0	$(R_x, R_y)$
$A_{1u}$	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	$z$
$A_{2u}$	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	$z$
$B_{1u}$	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	$z$
$B_{2u}$	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	$z$
$E_{1u}$	2	$\sqrt{2}$	$-\sqrt{2}$	0	2	0	0	-2	$-\sqrt{2}$	$-\sqrt{2}$	0	-2	0	0	0	$(x, y)$
$E_{2u}$	2	0	0	-2	2	0	0	-2	0	0	-2	2	0	0	0	$(x, y)$
$E_{3u}$	2	$-\sqrt{2}$	$\sqrt{2}$	0	-2	0	0	-2	$\sqrt{2}$	$\sqrt{2}$	0	-2	0	0	0	$(x, y)$

7. The  $D_{nd}$  Groups

$D_{2d}$	$E$	$2C_2$	$C_2$	$2C_2'$	$2\sigma_d$		
$A_1$	1	1	1	1	1	$R_z$	$x^2+y^2, z^2$
$A_2$	1	1	1	-1	-1	$R_z$	$x^2-y^2$
$B_1$	1	-1	1	1	-1	$z$	$xy$
$B_2$	1	-1	1	-1	1	$z$	$(xz, yz)$
$E$	2	0	-2	0	0	$(R_x, R_y)$	$(xz, yz)$

$D_{3d}$	$E$	$2C_3$	$3C_2$	$i$	$2S_6$	$3\sigma_d$	
$A_{1g}$	1	1	1	1	1	1	$R_z$
$A_{2g}$	1	1	1	1	1	-1	$R_z$
$E_g$	2	-1	0	2	-1	0	$(R_x, R_y)$
$A_{1u}$	1	1	1	-1	-1	-1	$z$
$A_{2u}$	1	1	1	-1	-1	1	$z$
$E_u$	2	-1	0	-2	1	0	$(x, y)$

$D_{4d}$	$E$	$2S_8$	$2C_4$	$2S_8^3$	$C_2$	$4C_2'$	$4\sigma_d$	
$A_1$	1	1	1	1	1	1	1	$R_z$
$A_2$	1	1	1	1	1	1	1	$R_z$
$B_1$	1	1	1	1	1	1	1	$z$
$B_2$	1	1	1	1	1	1	1	$z$
$E_1$	2	$\sqrt{2}$	0	$-\sqrt{2}$	2	0	0	$(x, y)$
$E_2$	2	0	-2	0	2	0	0	$(x, y)$
$E_3$	2	$-\sqrt{2}$	0	$\sqrt{2}$	-2	0	0	$(R_x, R_y)$

$D_{5d}$	$E$	$2C_5$	$2C_5^2$	$5C_2$	$i$	$2S_{10}^3$	$2S_{10}^7$	$5\sigma_d$	
$A_{1g}$	1	1	1	1	1	1	1	1	$R_z$
$A_{2g}$	1	1	1	1	1	1	1	1	$R_z$
$E_{1g}$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	$(R_x, R_y)$
$E_{2g}$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	$(R_x, R_y)$
$A_{1u}$	1	1	1	1	-1	-1	-1	-1	$z$
$A_{2u}$	1	1	1	1	-1	-1	-1	-1	$z$
$E_{1u}$	2	$2 \cos 72^\circ$	$2 \cos 144^\circ$	0	-2	$-2 \cos 72^\circ$	$-2 \cos 144^\circ$	0	$(x, y)$
$E_{2u}$	2	$2 \cos 144^\circ$	$2 \cos 72^\circ$	0	-2	$-2 \cos 144^\circ$	$-2 \cos 72^\circ$	0	$(x, y)$