



Ch. 8. Molecules



Linus Carl Pauling
(1901 - 1994)

The Nobel Prize in Chemistry 1954
The Nobel Prize in Peace 1963



Covalent Bond

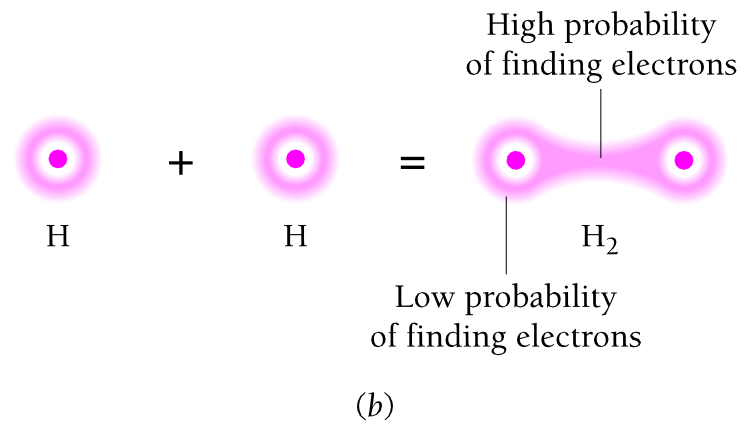
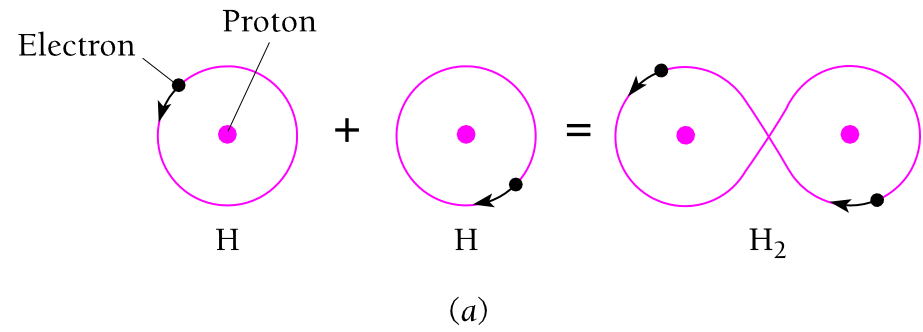


그림 8.1 (a) 수소 분자의 궤도 모델 (b) 수소 분자의 양자 역학적인 모델, 두 모델 모두에서 공유 전자는 핵 사이에서 평균적으로 좀더 많은 시간을 보내게 되고, 이에 의해 원자끼리 끌어당기는 힘이 생긴다. 그러한 결합을 공유 결합이라고 한다.



Ionic Bond

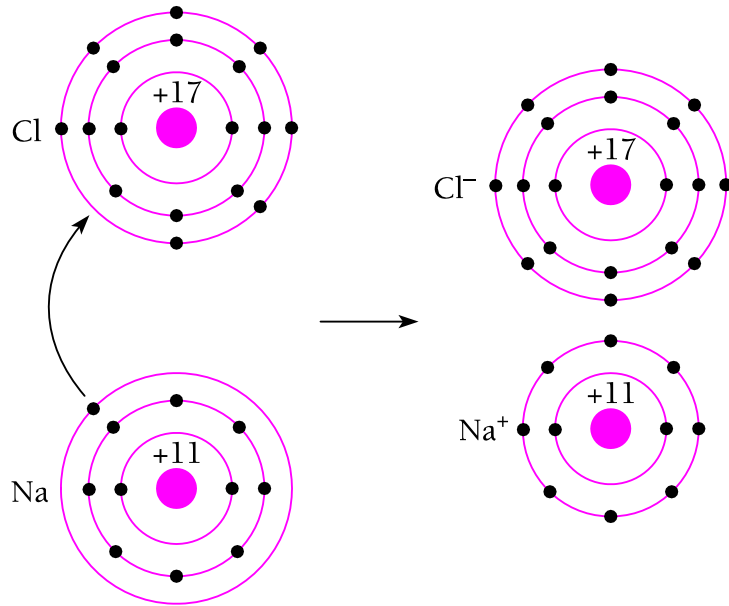


그림 8.2 이온 결합의 한 예. 전자를 나트륨 원자에서 염소 원자로 전달함으로써 나트륨과 염소는 화학적으로 결합한다. 결과적으로 형성된 두 이온은 전기적인 힘으로 서로를 이끈다.

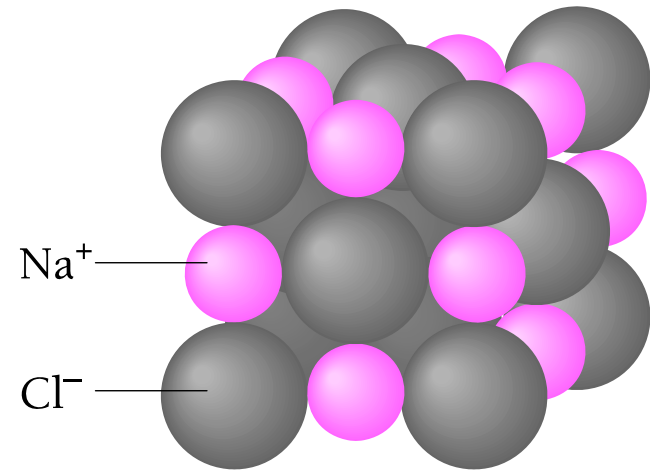
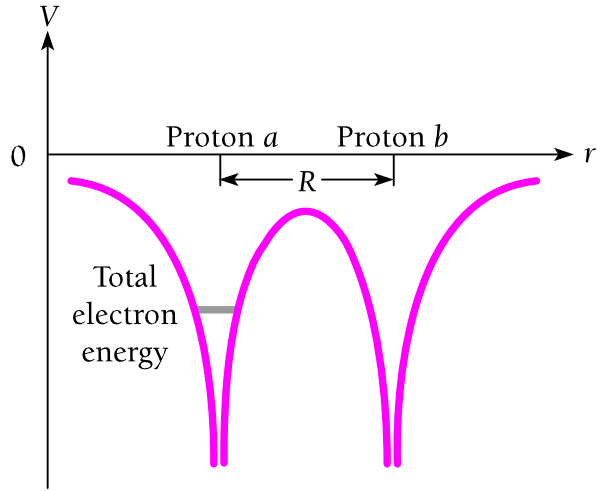


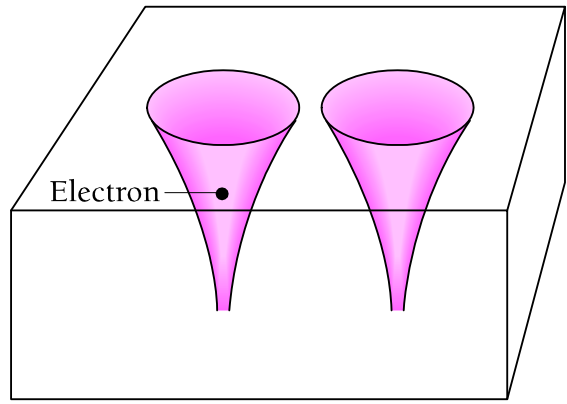
그림 8.3 소금(NaCl) 결정의 모델.



Covalent Bond – Electron Sharing

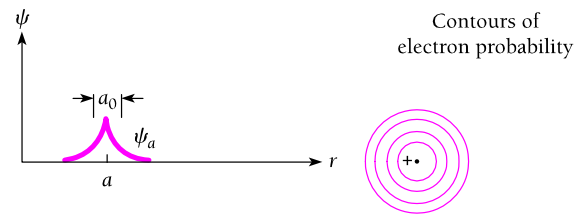


(a)

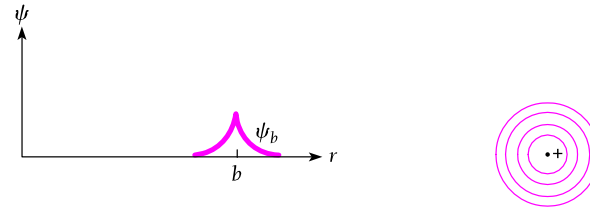


(b)

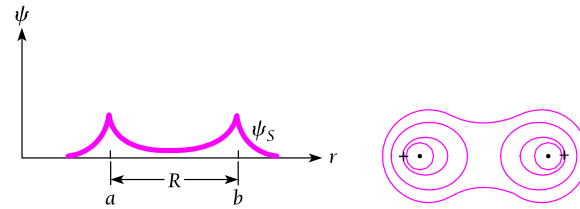
그림 8.4 (a) 두 이웃한 양성자 전기장에 의한 어떤 전자의 퍼텐셜 에너지. 수소 원자에 있는 바닥 상태 전자의 총 에너지를 나타내었다. (b) 두 이웃한 양성자는 양자 역학적으로 장벽에 의해 분리된 상자 쌍에 대응된다.



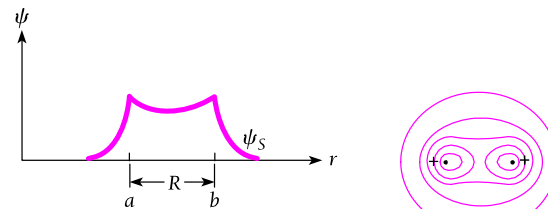
(a)



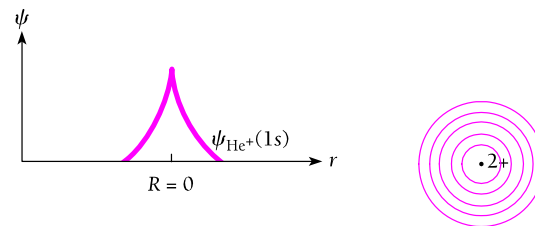
(b)



(c)



(d)



(e)

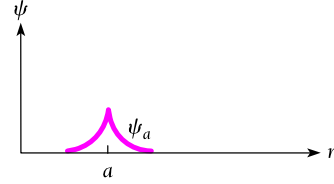
H_2^+ Molecular Ion



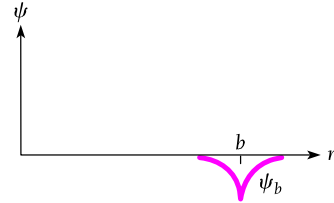
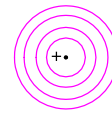


Contours of
electron probability

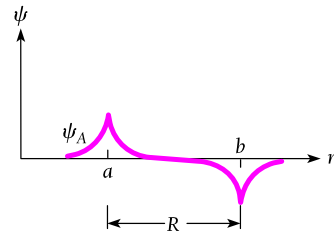
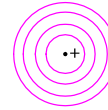
H₂⁺ Molecular Ion



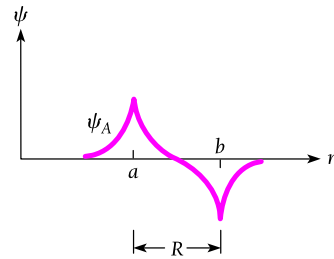
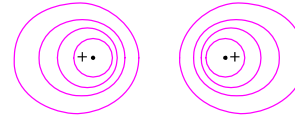
(a)



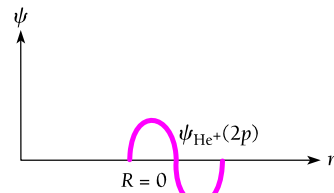
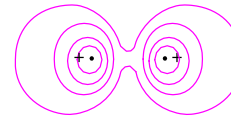
(b)



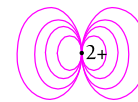
(c)



(d)

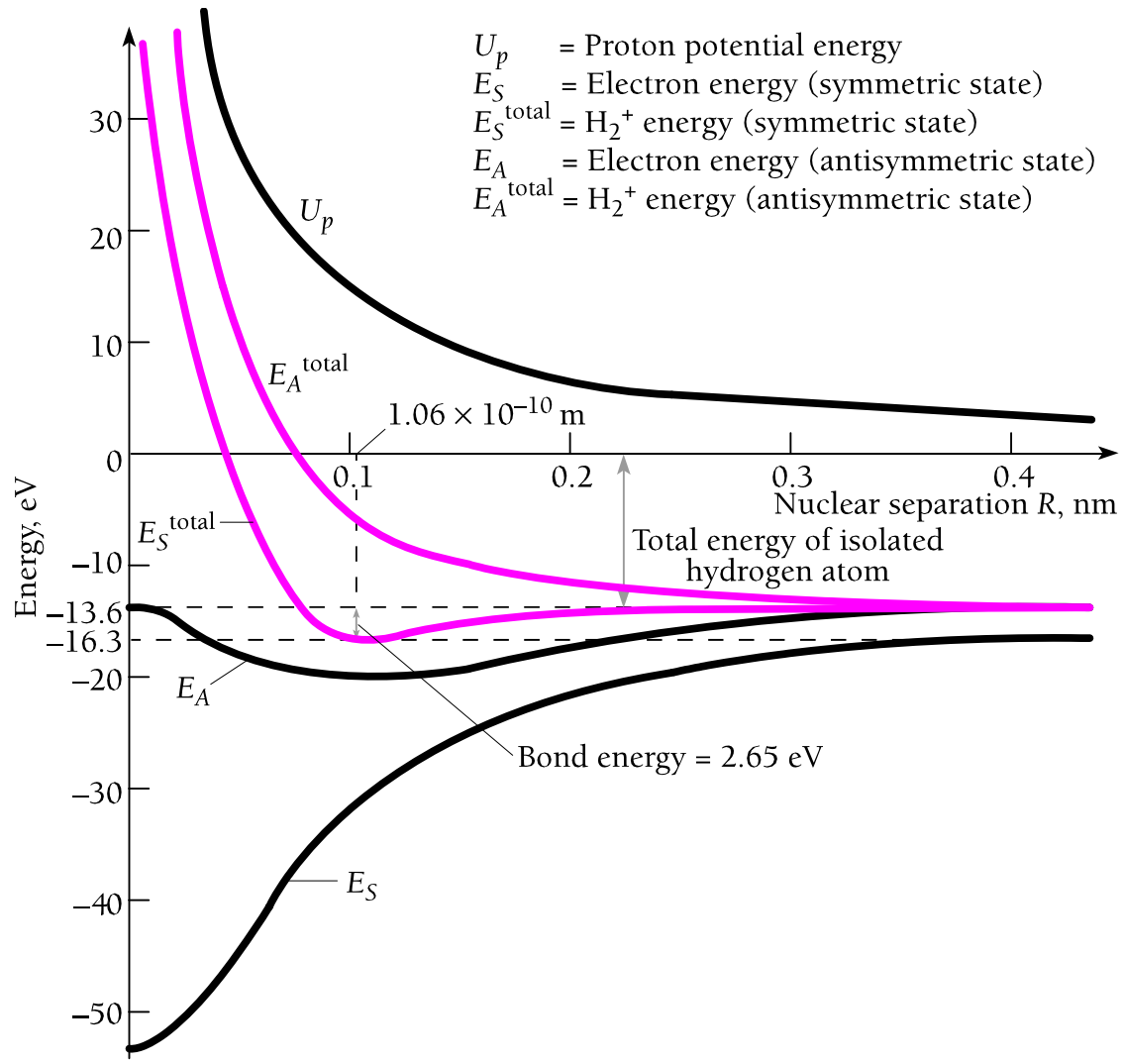


(e)





H₂⁺ Molecular Ion





H₂ Molecule

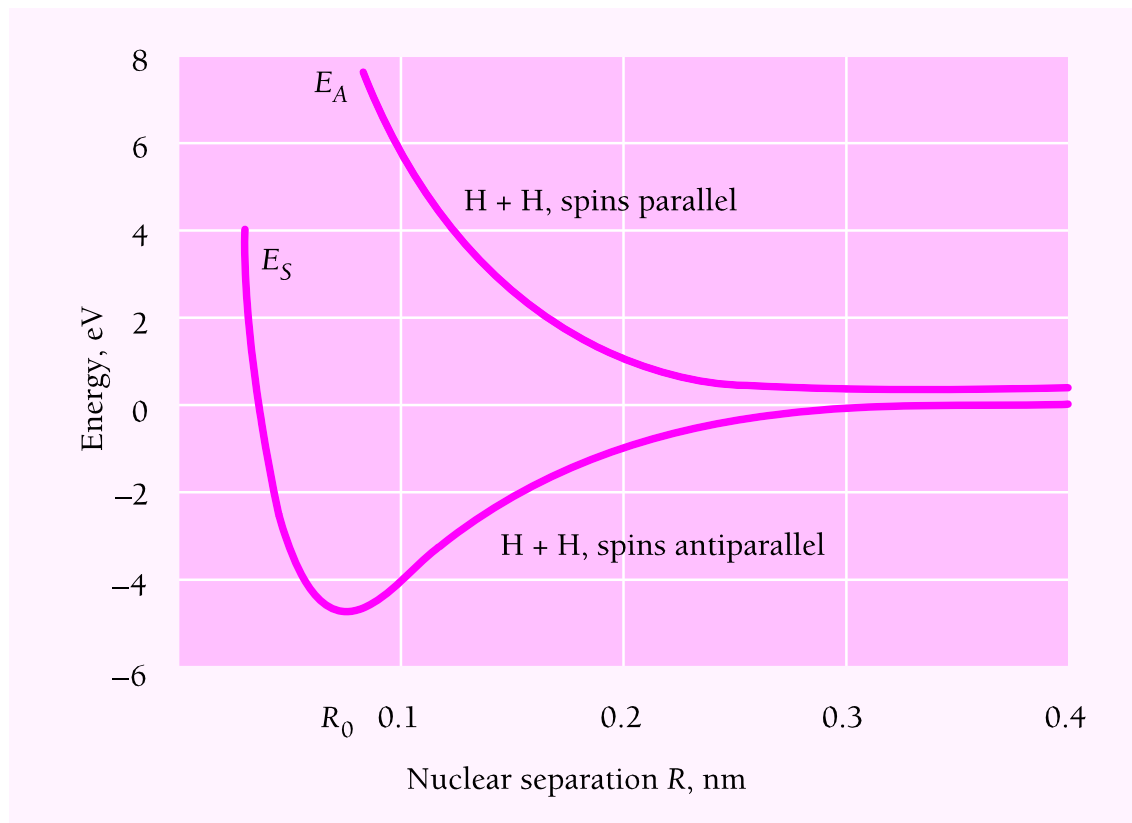
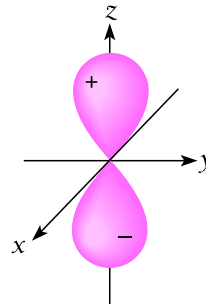
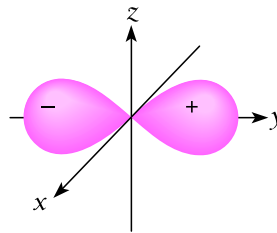
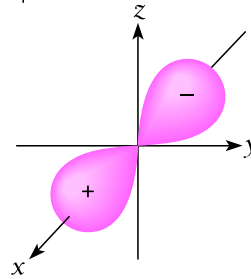
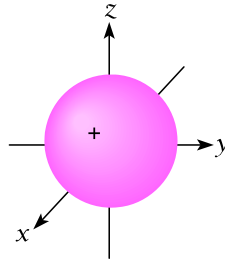


그림 8.8 전자의 스핀이 평행할 때와 반평행할 때, 핵간 거리의 함수로서 H+H의 에너지 변화.



Orbital	n	l	m_l
s	1,2,3, ...	0	0
p_x	2,3,4, ...	1	± 1
p_y	2,3,4, ...	1	± 1
p_z	2,3,4, ...	1	0

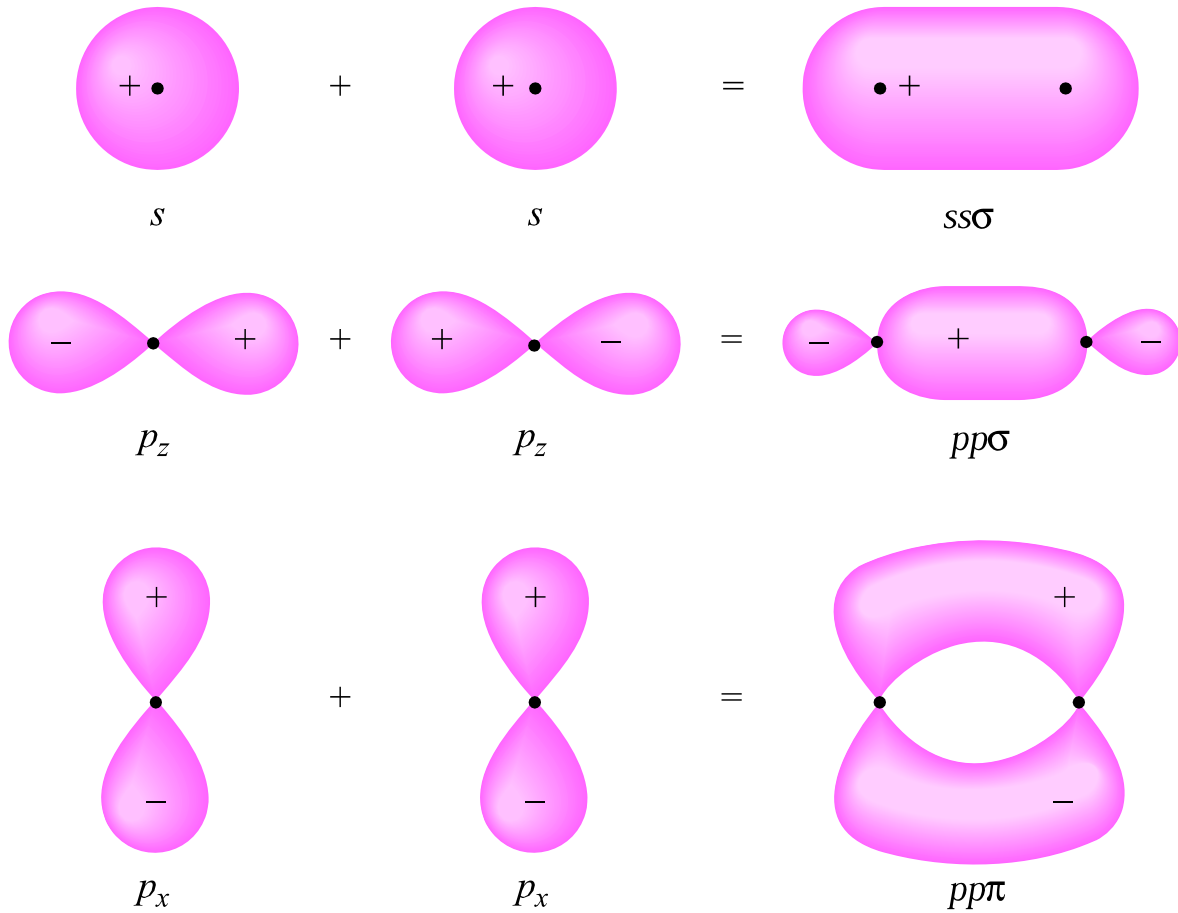
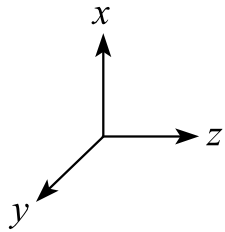


$$\psi_{p_x} = \frac{1}{\sqrt{2}} (\psi_{+1} + \psi_{-1})$$

$$\psi_{p_y} = \frac{1}{\sqrt{2}} (\psi_{+1} - \psi_{-1})$$

그림 8.9 s와 p궤도의 경계면 그림. 각각의 궤도들은 두 개의 전자를 포함할 수 있다. 음영 부분에서 전자를 발견 할 확률이 높다. 각 돌출부에 파동함수의 부호를 표시하였다.





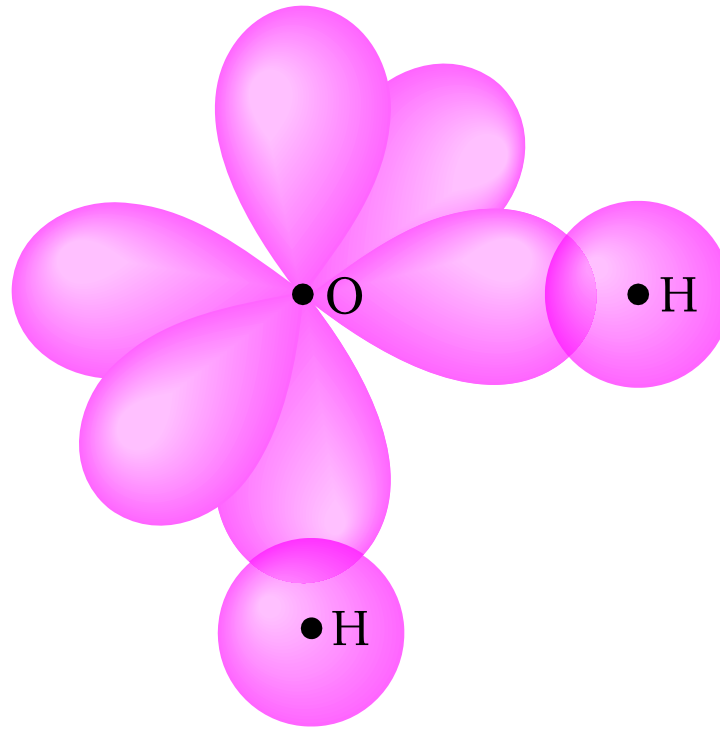
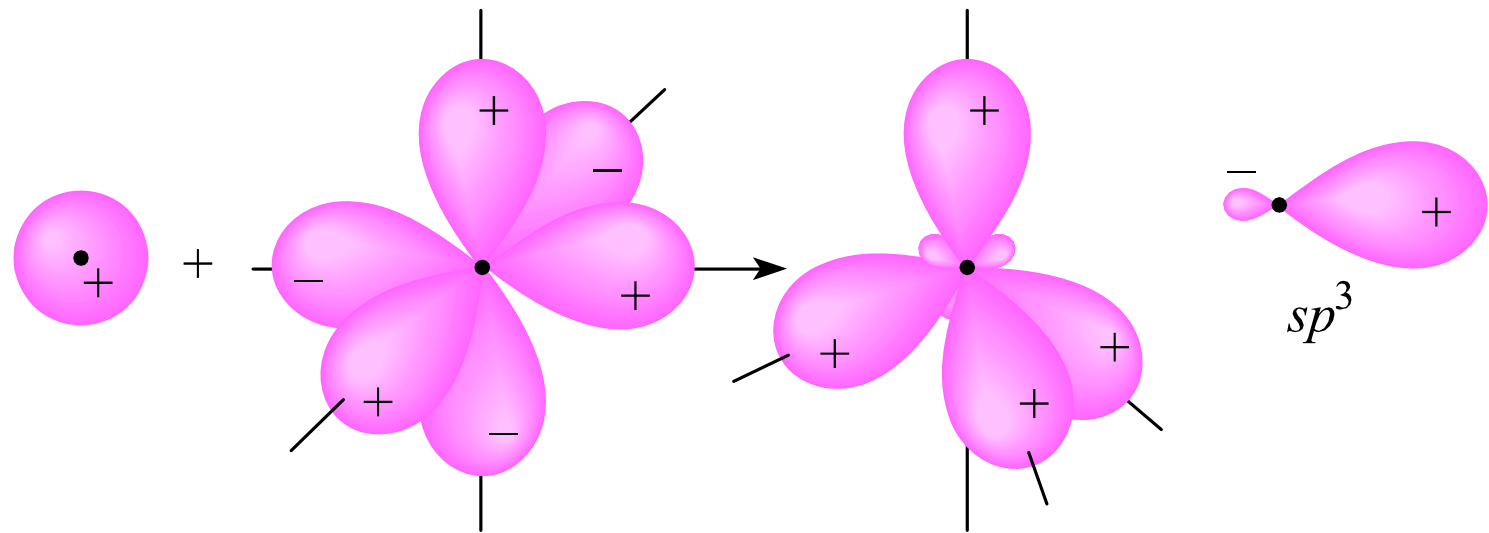


그림 8.11 물분자의 형성.



Hybrid Orbitals

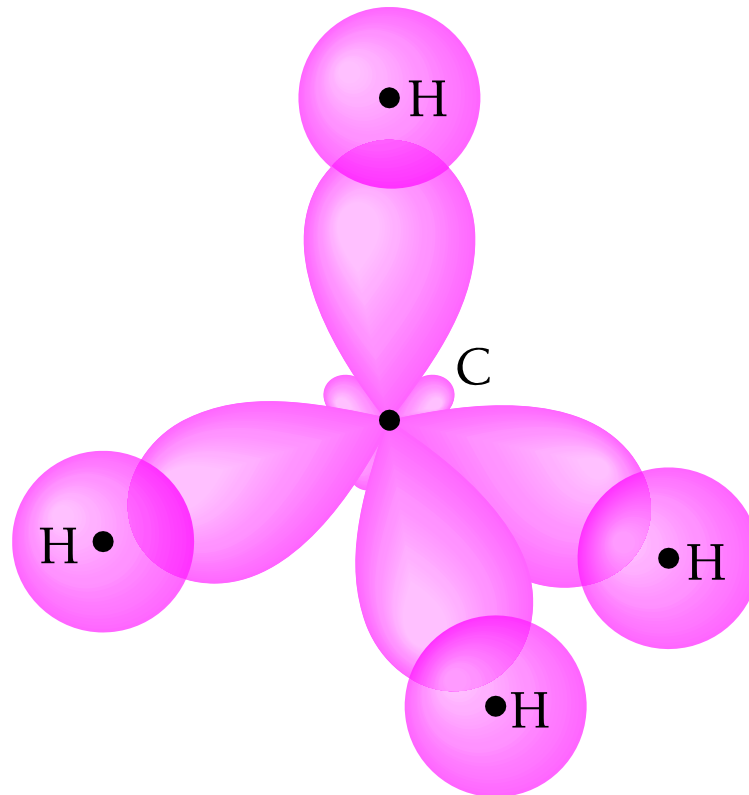


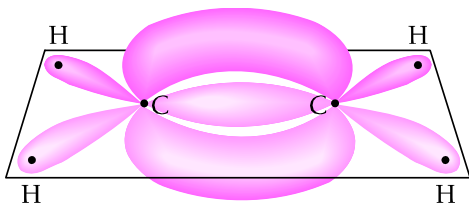
$$\psi_1 = \frac{1}{2} (\psi_s + \psi_{p_x} + \psi_{p_y} + \psi_{p_z})$$

$$\psi_2 = \frac{1}{2} (\psi_s - \psi_{p_x} - \psi_{p_y} + \psi_{p_z})$$

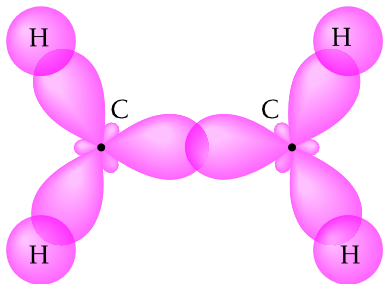
$$\psi_3 = \frac{1}{2} (\psi_s + \psi_{p_x} - \psi_{p_y} - \psi_{p_z})$$

$$\psi_4 = \frac{1}{2} (\psi_s - \psi_{p_x} + \psi_{p_y} - \psi_{p_z})$$

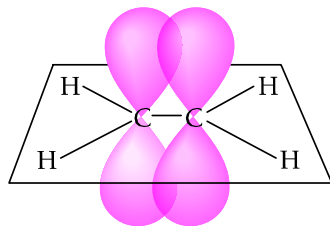




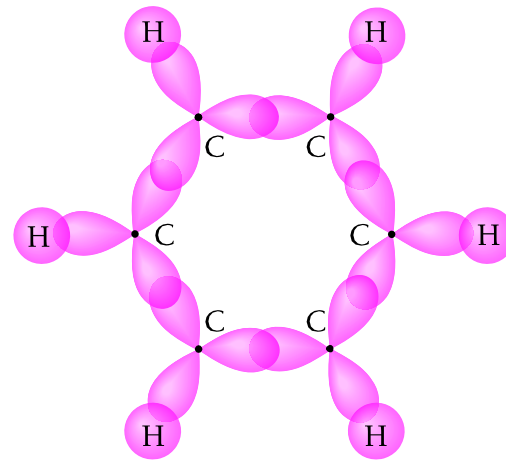
(a)



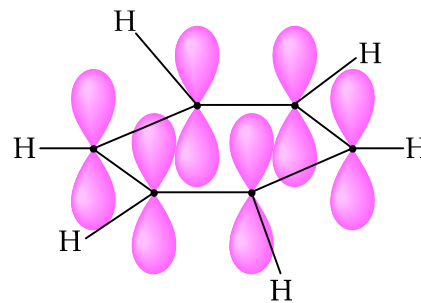
(b)



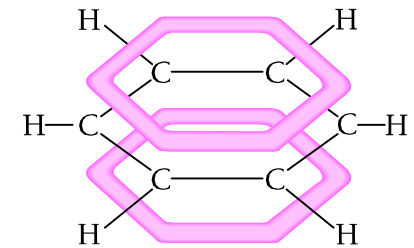
(c)



(a)



(b)



(c)





Molecular Rotation

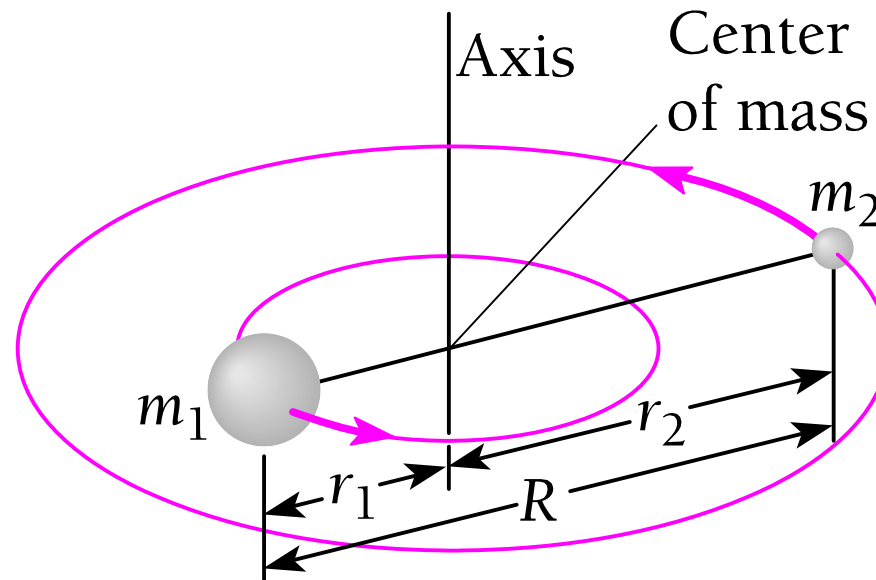


그림 8.16 이원자 분자는 질량중심에 대해 회전할 수 있다.



Molecular Rotation

$$L = m_1 v_1 r_1 + m_2 v_2 r_2 = (m_1 r_1^2 + m_2 r_2^2) \omega = I \omega$$

$$E_{rot} = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} I \omega^2 = \frac{L^2}{2I}$$

$$I_{CM} = \frac{m_1 m_2}{m_1 + m_2} (r_1 + r_2)^2 = \mu R_o^2$$

$$L^2 = l(l+1)\hbar^2 \quad l = 0, 1, 2, \dots$$

$$E_{rot} = \frac{\hbar^2}{2I_{CM}} l(l+1)$$



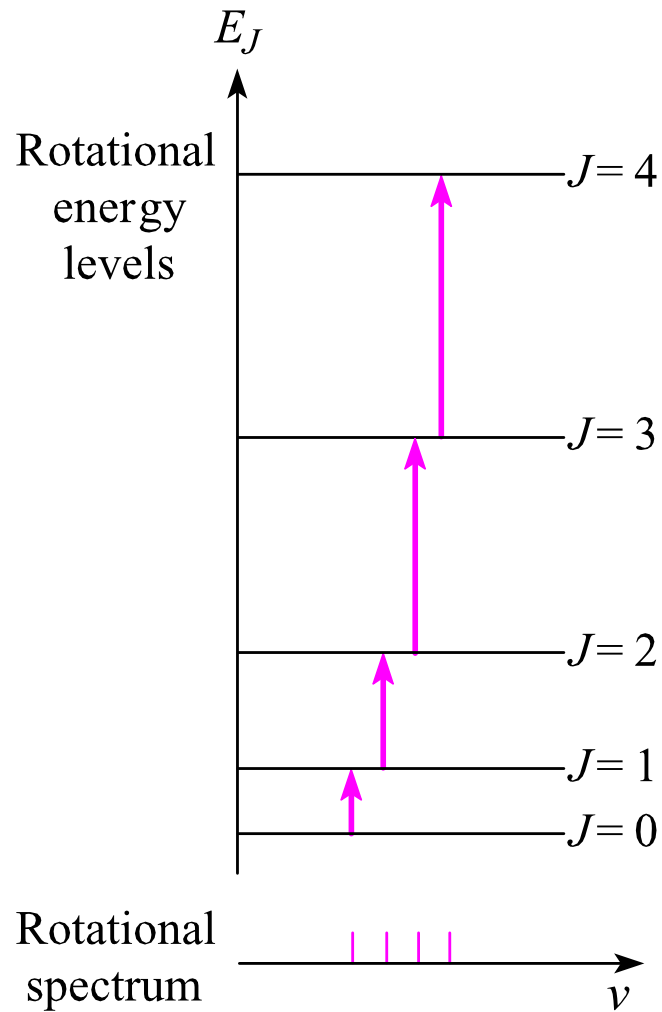


그림 8.17 분자 회전의 에너지 준위와 스펙트럼.



Molecular Vibration

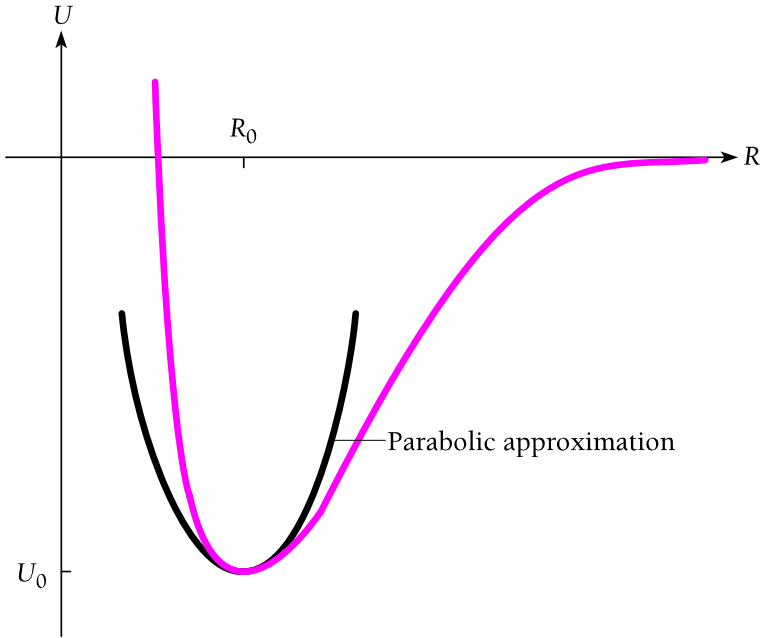
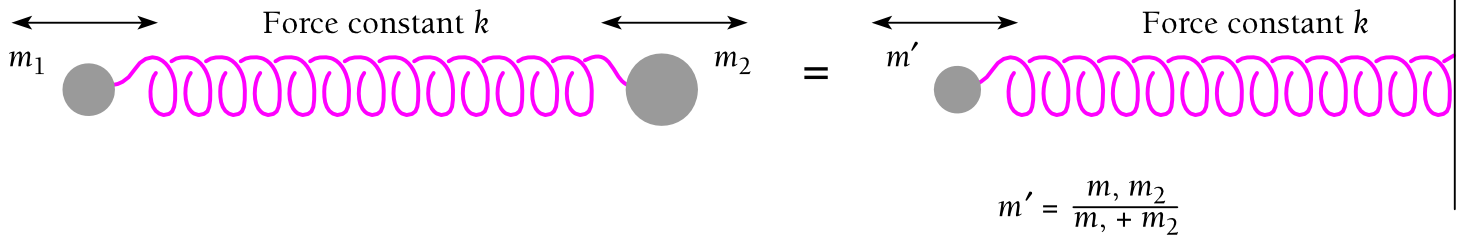


그림 8.18 핵간 거리의 함수로서 이원자 분자의 퍼텐셜 에너지.



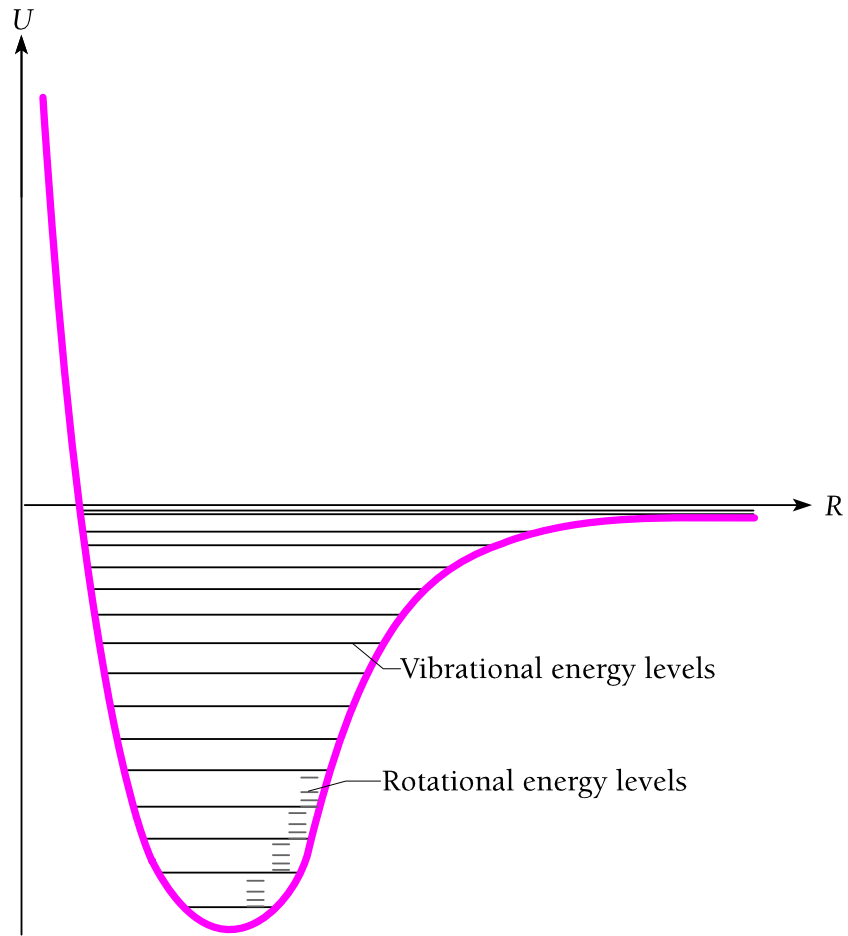


그림 8.20 핵간 거리의 함수로서 이원자 분자의 퍼텐셜 에너지. 진동 에너지 준위와 회전 에너지 준위도 같이 보여주고 있다.

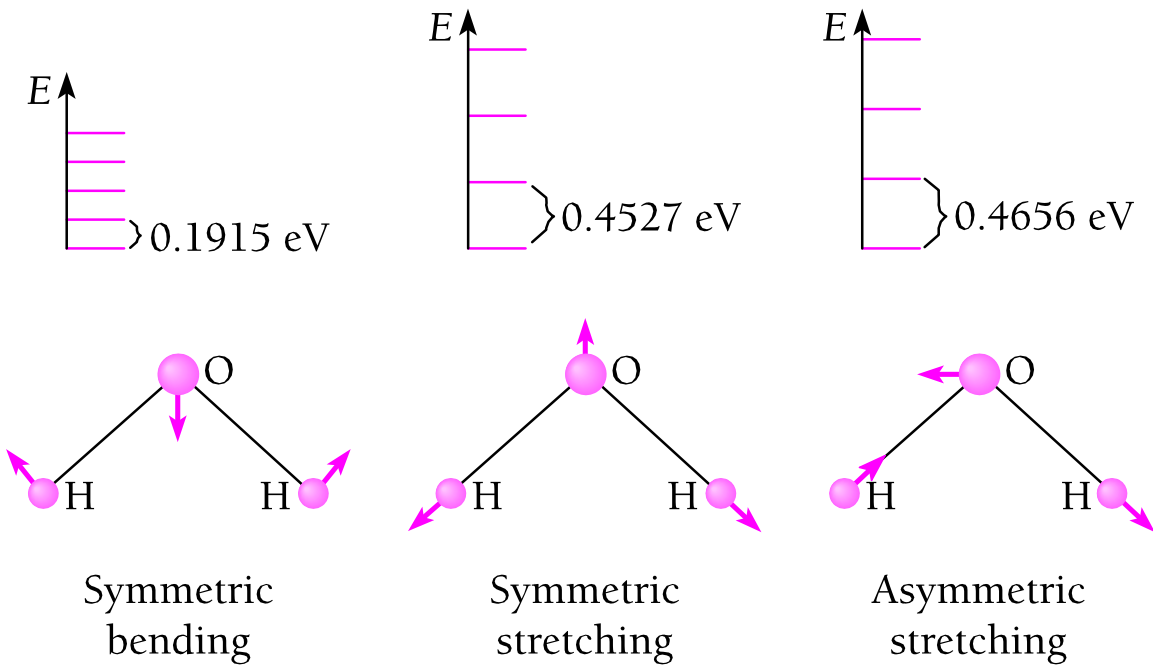
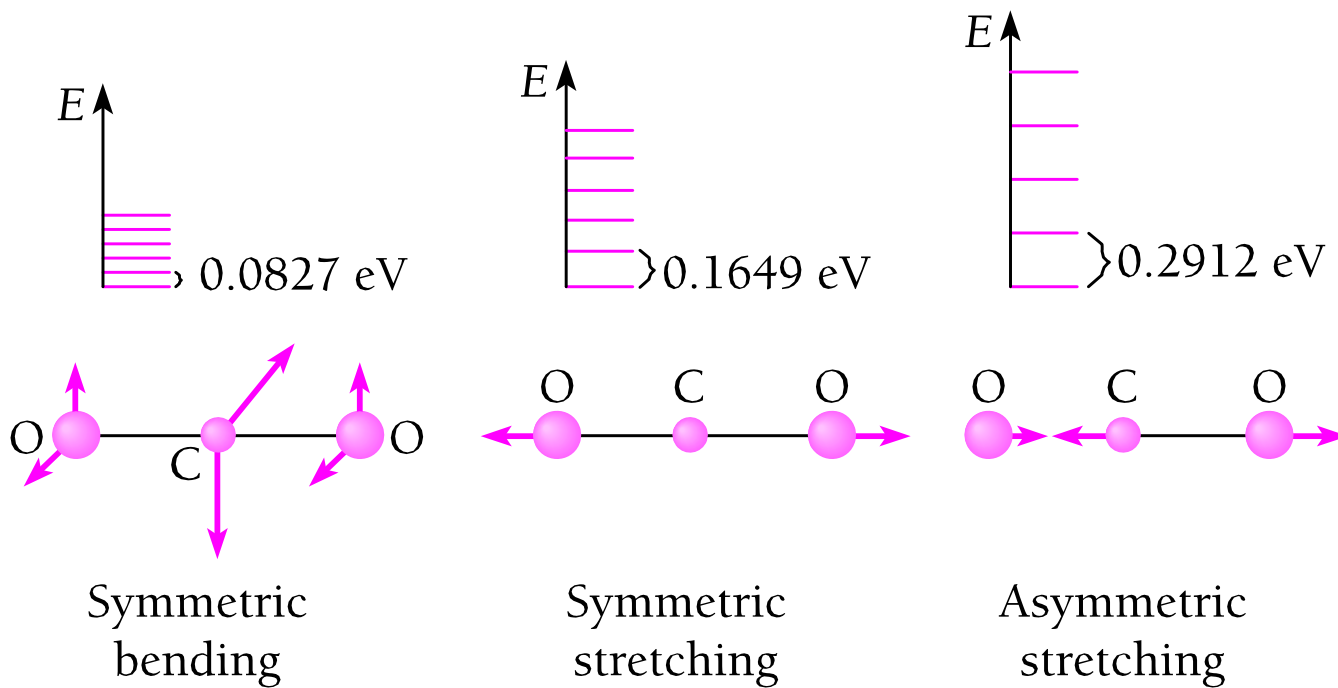
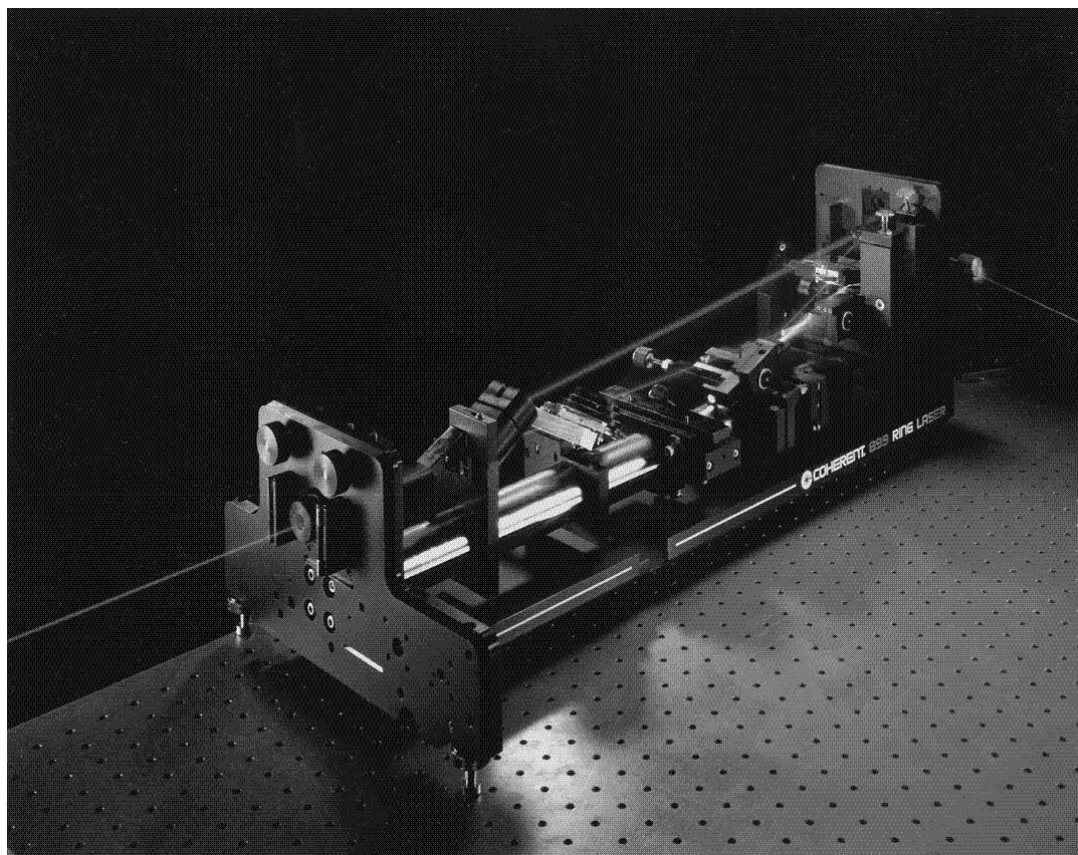


그림 8.21 물분자의 기준진동모드와 각 모드에서의 에너지준위들. 물분자를 휘게 하는 것 보다 잡아당기는데 더 많은 에너지가 필요하고, 일반적으로도 그렇다.





이 진동수 가변 색소레이저는 전 가시 광 스펙트럼 영역인 370nm에서 900nm까지의 빛을 방출한다. 500kHz 정도까지의 매우 좁은 진동수 띠 폭을 가지고 있다.





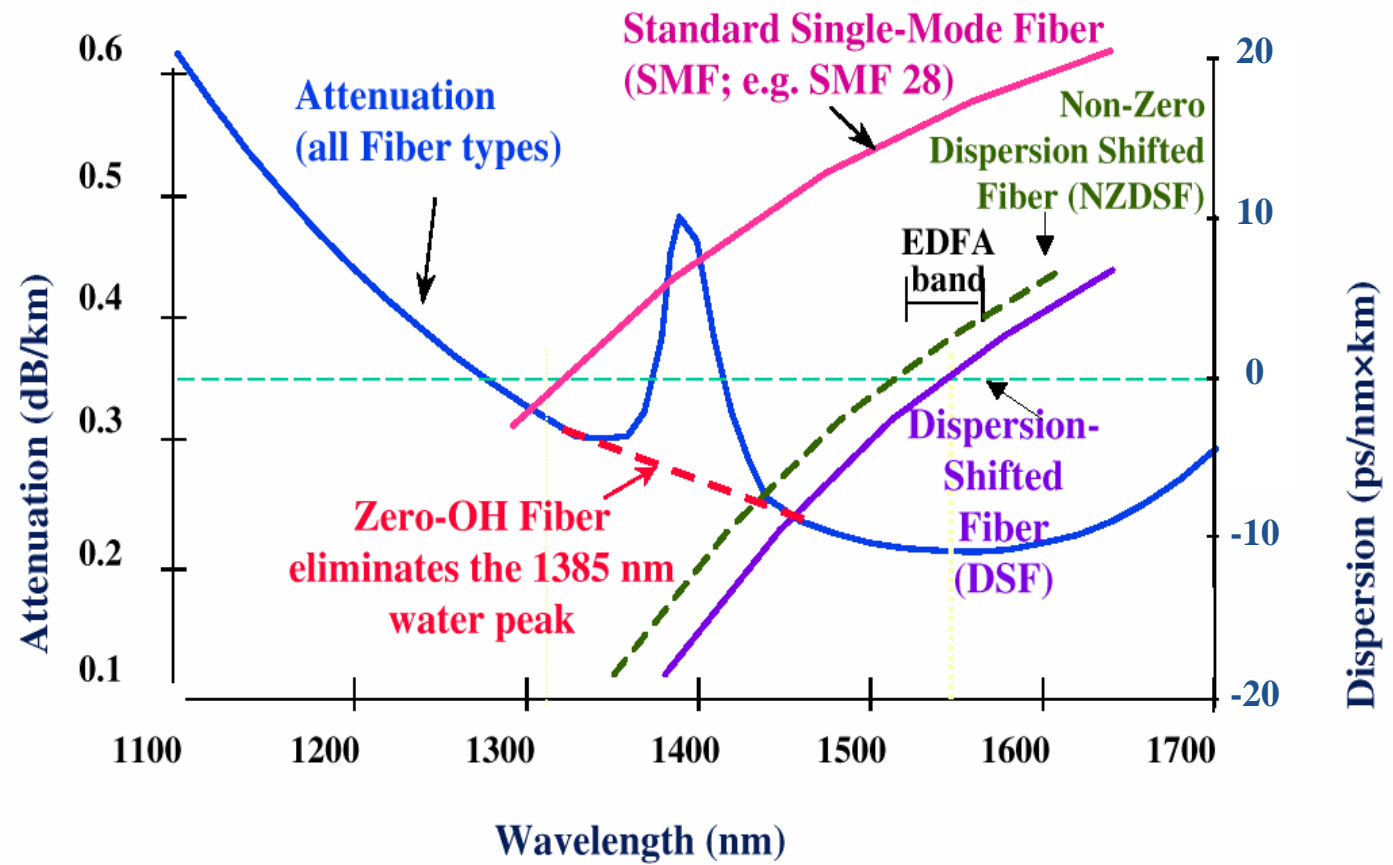
Rayleigh



Lord Rayleigh
(John William Strutt)
(1842 - 1919)



광섬유의 특성

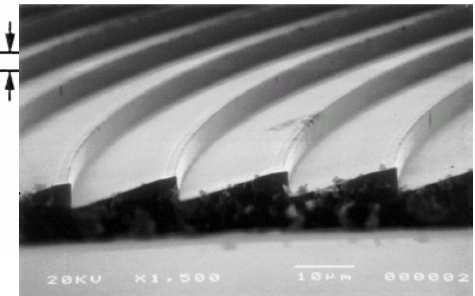
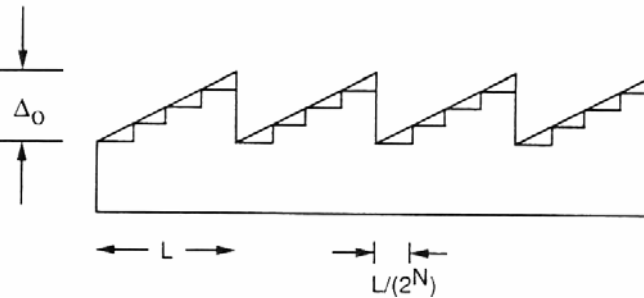




Rayleigh



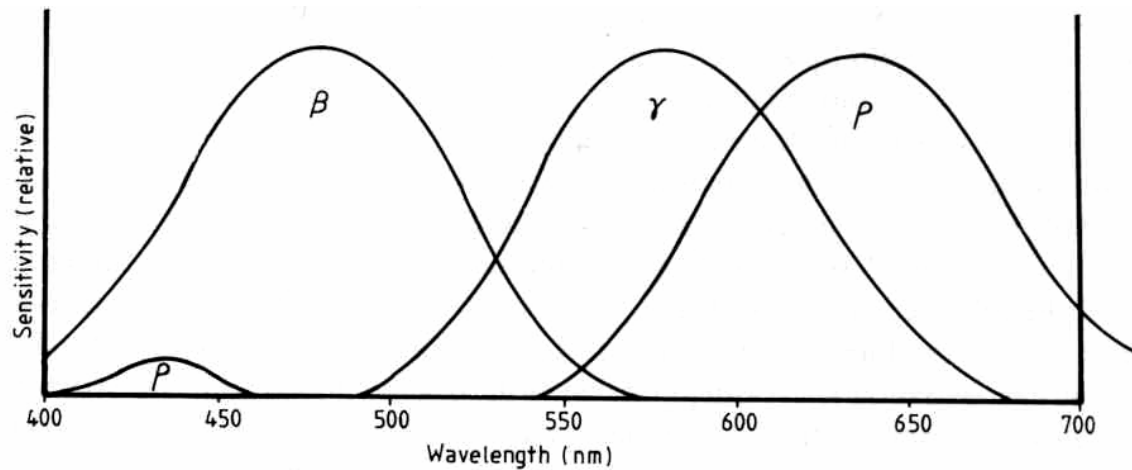
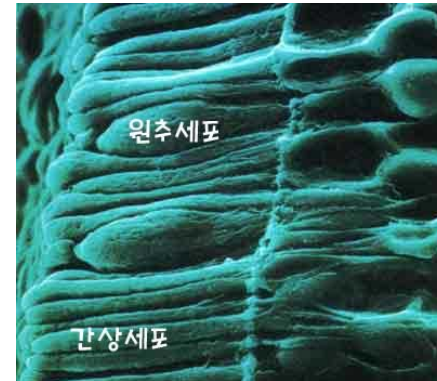
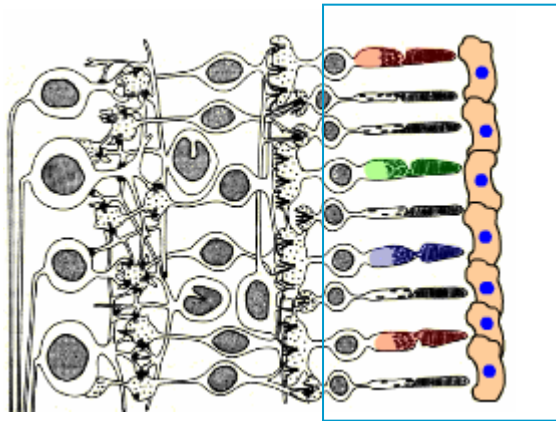
Never say 'Never'!



“...그렇지만, 이런 구조를 실제 만들 수 있게 될 것 같지는 않다.”

Encyclopaedia Britannica, 9th ed., Vol. 24, “Wave Theory of Light” (New York, Charles Schribner’s Sons, 1888), p. 437.

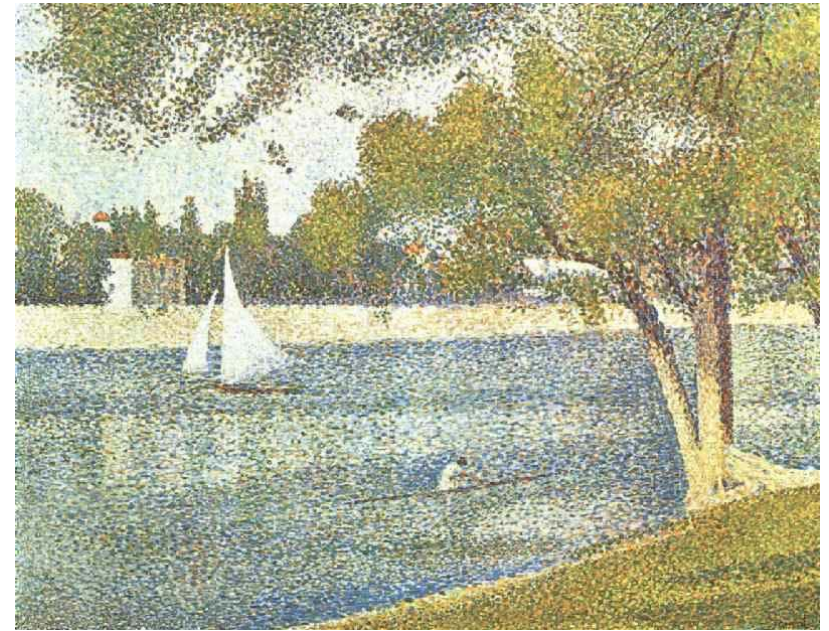
빛의 파장에 따른 사람 눈의 원추세포의 반응도





Georges Seurat

(1859~1891)

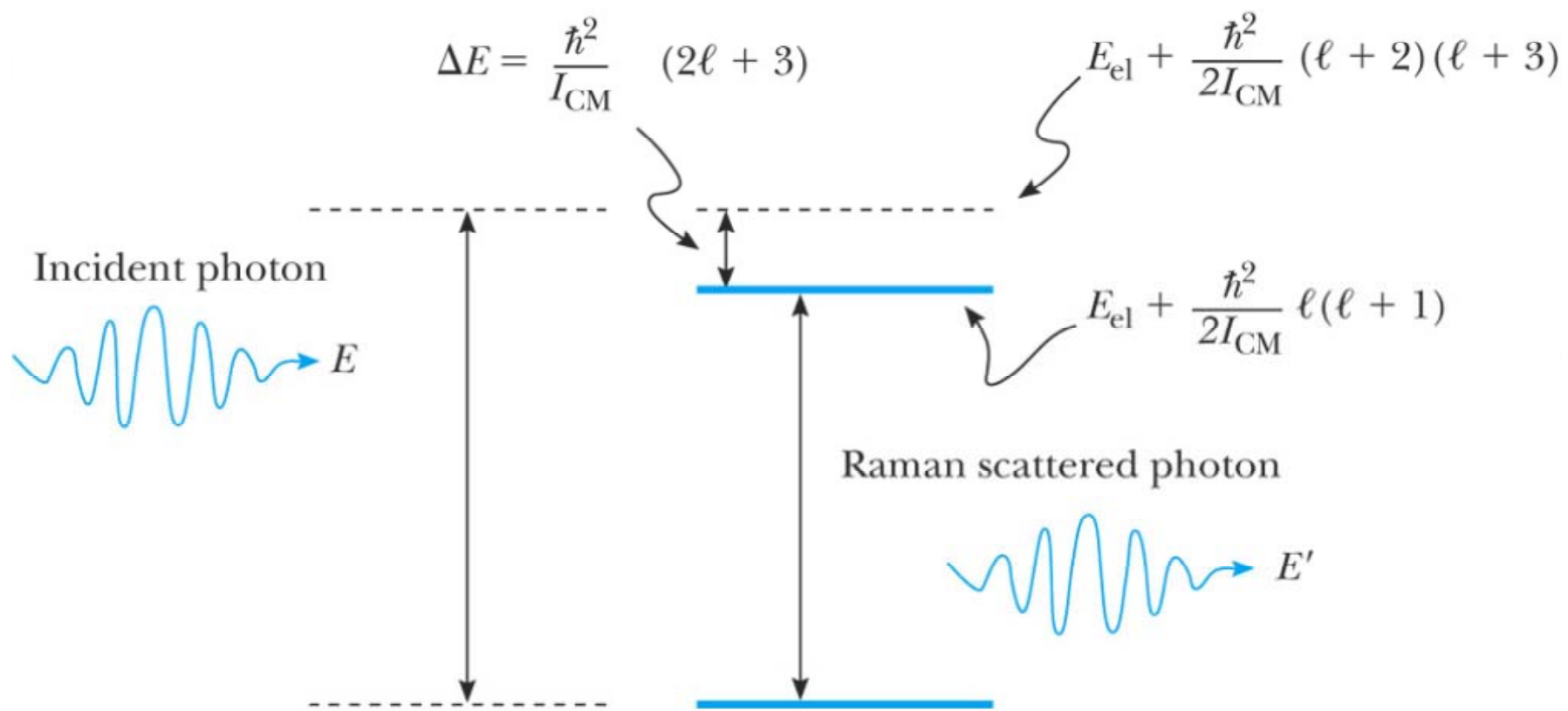




Raman



Venkata Raman
(1888 - 1970)



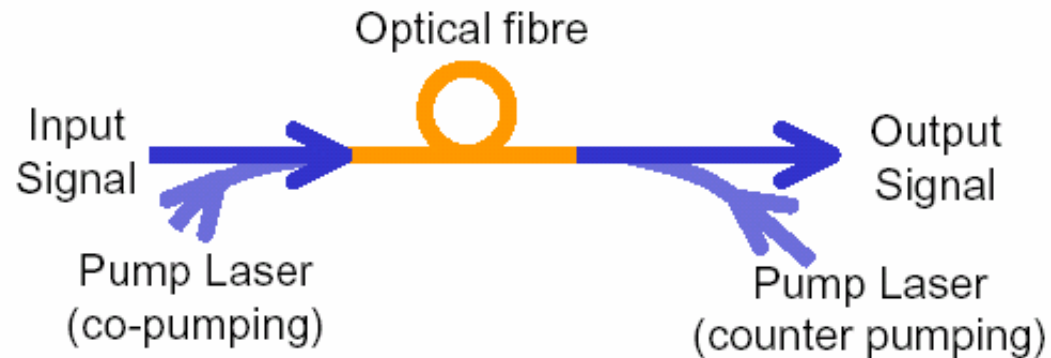
© 2005 Brooks/Cole - Thomson





Fiber Raman Amplifier

Raman Amplification



Raman amplification requires no special doping in the optical fiber. It is usually accomplished as “distributed amplification” - that is, it happens throughout the length of the actual transmission fiber, rather than all in one place in a small box.



Fluorescence

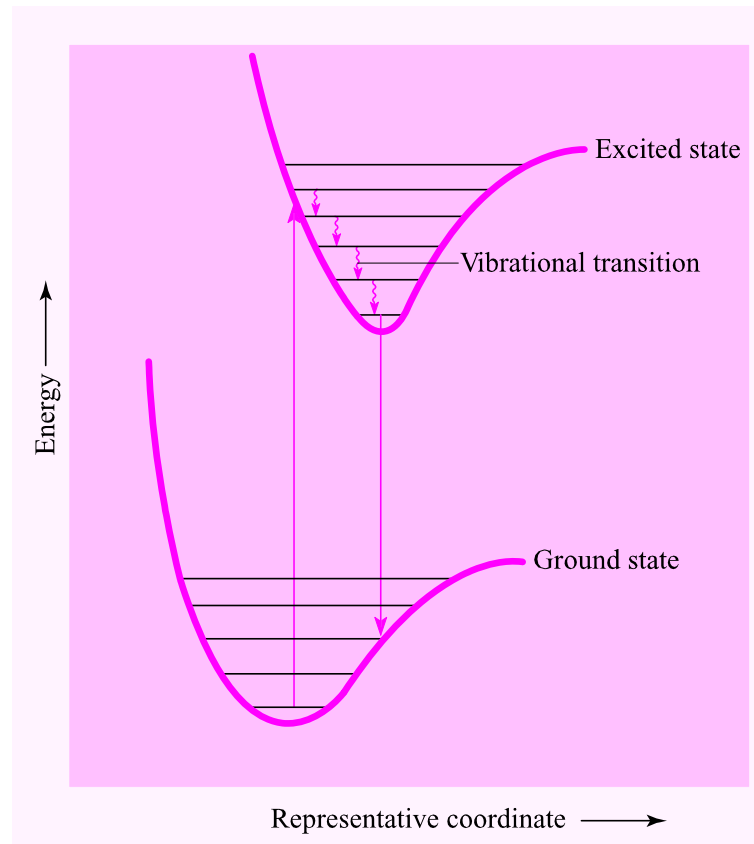


그림 8.24 형광의 기원. 방출되는 빛의 진동수는 흡수된 빛의 진동수보다 작다.





Phosphorescence

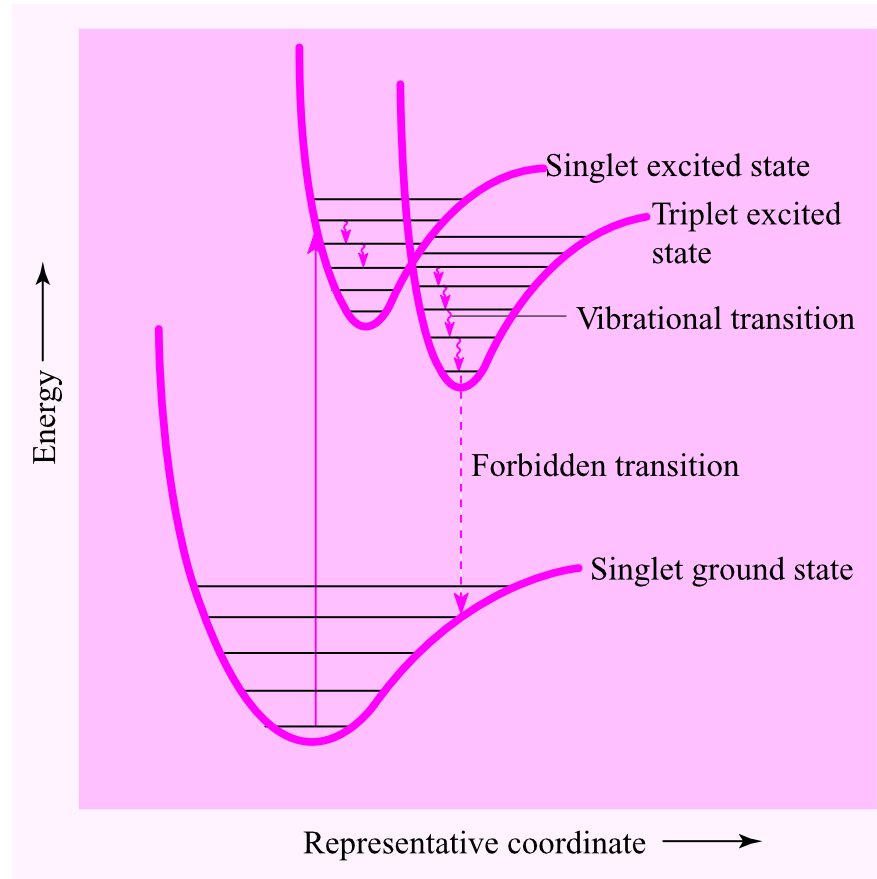


그림 8.25 인광의 기원. 마지막 전이는-전자 전이의 선택 규칙을 어기기 때문에 지연되어서 일어난다.