PHY2505S
Atmospheric Radiative Transfer and Remote Sounding

Lecture 8

- Molecular Absorption and Emission
- Vibration-Rotation Spectra

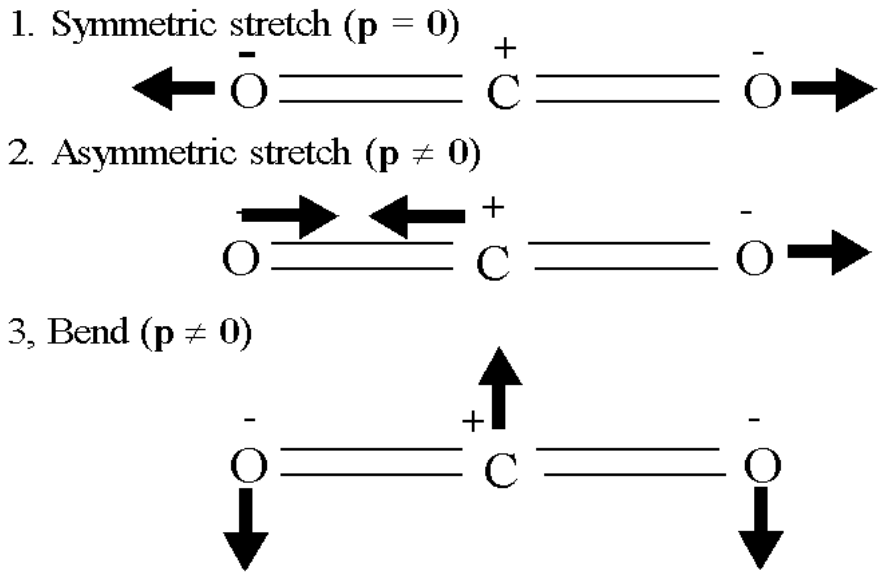
Greenhouse Gases

- **Water vapour (H_2O)**
  - → most common greenhouse gas
  - → increases as surface temperature rises
- **Carbon dioxide (CO_2)**
  - → released by plant and animal life, decay, and burning of fuels
  - → removed by plant photosynthesis and absorption by the oceans
- **Methane (CH_4)**
  - → not as common in volume as H_2O or CO_2
  - → very effective at trapping heat - powerful greenhouse gas
  - → wetlands, rice paddies, animal digestion, fossil fuel extraction, decaying garbage
- **Nitrous oxide (N_2O)**
  - → soils and the oceans, some from burning fossil fuels and fertilizer use
- **Ozone (O_3)**
  - → most ground level ozone is from chemical reactions involving pollutants
- **Halocarbons**
  - → anthropogenic chemicals containing bromine, chlorine, or fluorine, and carbon
  - → extremely powerful greenhouse gases

Greenhouse Gases (GHGs)

Greenhouse gases = gases with vib-rot absorption features at ~5-50 μm

VIBRATIONAL MODES OF CO_2



IR inactive – no change in the dipole moment

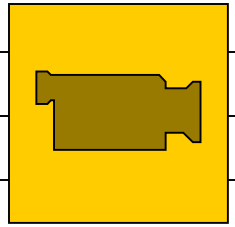
IR active

IR active

- Major greenhouse gases: H_2O, CO_2, CH_4, O_3, N_2O, CFCs,…
- Not greenhouse gases: N_2, O_2, Ar, …

Adapted from D. Jacob

Molecular Absorption and Emission



Rotational Energy Levels

Figures are from C.N. Banwell, Fundamentals of Molecular Spectroscopy, 3rd Edition, 1983.

These diagrams are relevant to material on pages 2-3 of the notes.

Figure 2.2 shows the energy levels:

$E = BJ(J+1)$ in cm^{-1}

$= 0, 2B, 6B, 12B, 20B$, etc.

Figure 2.3 shows the locations of spectral lines based on energy transitions:

$\Delta E = 2B(J+1)$ in cm^{-1}

$= 2B, 4B, 6B, 8B$, etc.

so they are equally spaced

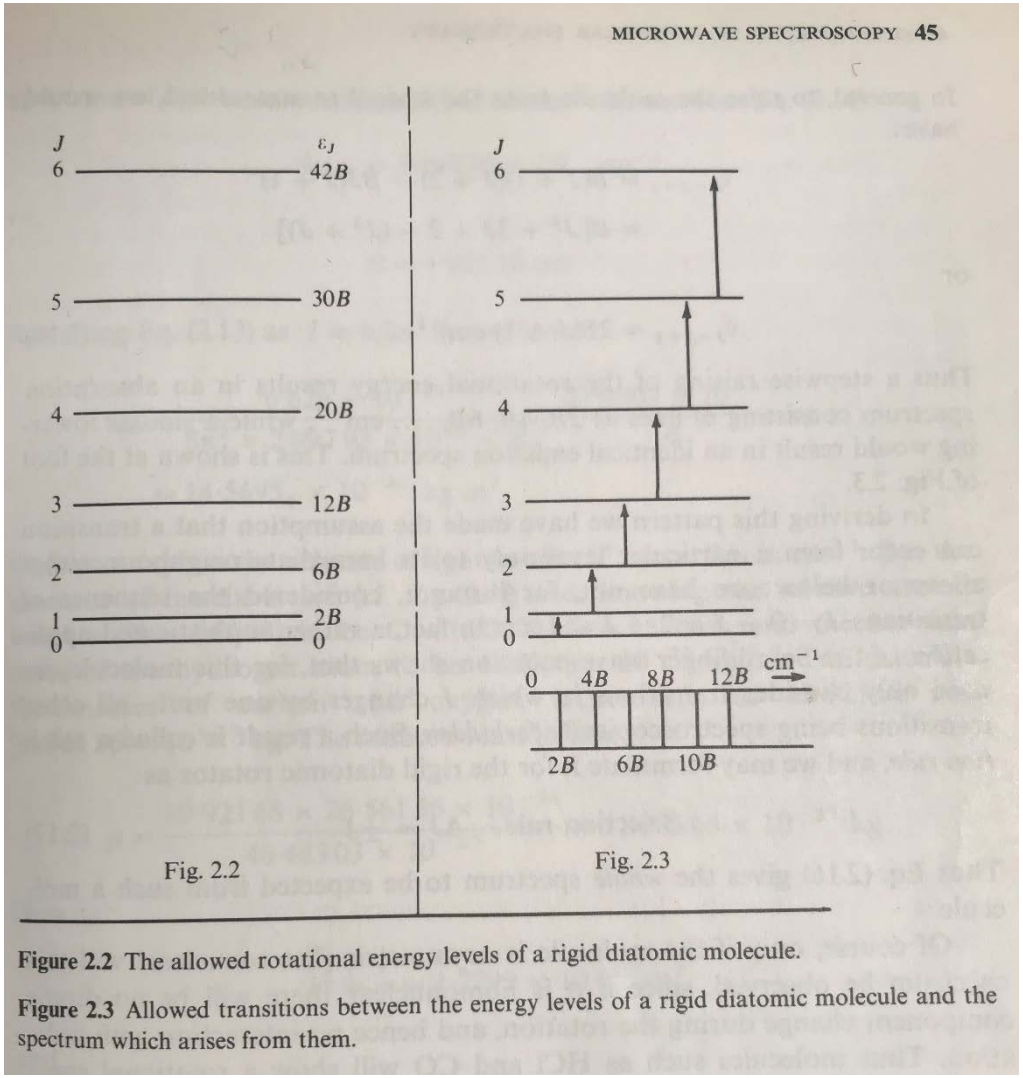


Figure 2.2 The allowed rotational energy levels of a rigid diatomic molecule.

Figure 2.3 Allowed transitions between the energy levels of a rigid diatomic molecule and the spectrum which arises from them.

Vibration-Rotation Spectra