3] Sketch the normal modes of Vibration of a) H_2O and b) CO_2 molecule. (1)

A normal mode vibration is defined as a molecular motion in which all the atoms in the molecule vibrate with same frequency and all the atoms pass through their eqm positions ~~simultaneously~~ simultaneously.

Normal mode of vibration for a linear molecule $= (3N-5)$

Normal mode of vibration for a non-linear molecule $= (3N-6)$ internal degrees of freedom

Condition

For a molecule to be Infrared active, it must either possess a permanent dipole moment (or) the dipole moment must change during a ~~vibrati~~ vibration.

$$\frac{d\mu}{dr} \neq 0$$

a) H_2O molecule:

It is a triatomic non-linear molecule.

∴ Normal mode of vibration $= (3N-6)$ internal degrees of freedom

$= (3\times3) - 6$

$= 3$

Three fundamental vibration

... are all IR-active since each of them is accompanied by a change in dipole moment

→ The Symmetric Stretching frequency is labelled as $\bar{\nu}_1$
The Symmetric bending frequency is labelled as $\bar{\nu}_2$
The asymmetric Stretching frequency is labelled as $\bar{\nu}_3$.

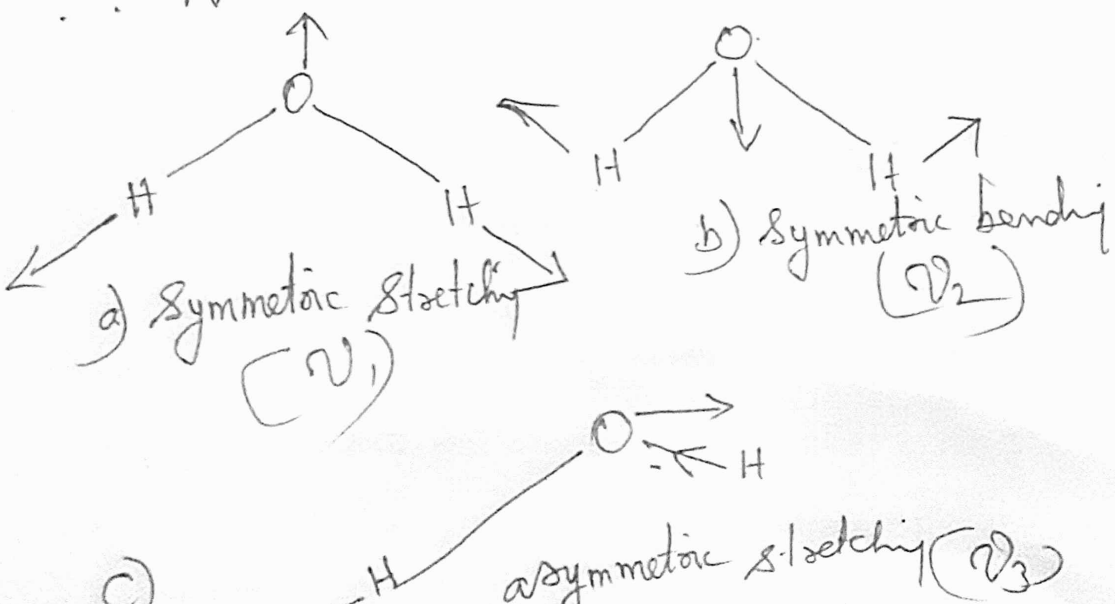
→ The ~~the~~ three vibrations are denoted as
$\bar{\nu}_1 = 3651\ cm^{-1}$, $\bar{\nu}_2 = 1595\ cm^{-1}$ and
$\bar{\nu}_3 = 3755\ cm^{-1}$.

→ It is easier to bend a molecule than to stretch it. Hence, the bending frequency is generally lower than Stretching frequency

→ Also, it is easier to Stretch a molecule Symmetrically than asymmetrically.

(*) Hence, Symmetric Stretching frequency is lower than asymmetric Stretching frequency

∴ Normal modes of vibration of Water is



* It is a linear polyatomic molecule.

∴ Normal modes of vibration $= 3N-5$

$= 3\times 3-5 = 4$

$= 4$ internal degrees of freedom

→ Of the four fundamental vibrations of CO_2 molecule, two have the same frequency and are said to be degenerate

→ The Symmetric Stretching frequency $\bar{\nu}_1$ is not observed in CO_2 since there is no change in dipole moment.