Table 1.8. Commonly-observed lines from molecular clouds

Molecule	Transition	Frequency ν: GHz	Wavelength λ: mm	$E_{\rm upper}/k_B$ K	[a]Typical $n(H_2)$ cm^{-3}
H_2	v=1–0, S(1)	140 THz	2.128 μm		
H_2 ortho	v=0–0, S(0)	11 THz	28.2 μm	510	
	v=0–0, S(2)	24 THz	12.3 μm	1 682	
H_2 para	v=0–0, S(1)	18 THz	17.1 μm	1 015	
CO	$J = 1 \rightarrow 0$	115.3	2.6	5.5	~ 100
	$J = 2 \rightarrow 1$	230.5	1.3	17	$\sim 1\,000$
	$J = 3 \rightarrow 2$	345.8	0.87	34	$10^3 - 10^4$
CS	$J = 1 \rightarrow 0$	49	6.1	2.4	$> 5\,000$
	$J = 5 \rightarrow 4$	244	1.2	35	10^6
SiO	$J = 2 \rightarrow 1$	86.8	3.5	6.3	[c]shocks
	$J = 5 \rightarrow 4$	217.1	1.4	31.3	[c]shocks
	$J = 8 \rightarrow 7$	347.3	0.86	75	[c]shocks
HCO^+	$J = 1 \rightarrow 0$	89	3.4	4.3	$> 3\,000$
	$J = 3 \rightarrow 2$	268	1.1	26	$> 30\,000$
HCN	$J = 1 \rightarrow 0$	89	3.4	4.3	$> 10\,000$
	$J = 3 \rightarrow 2$	266	1.1	26	$> 10^5$
HNC	$J = 1 \rightarrow 0$	91	3.3	4.3	$> 10\,000$
	$J = 3 \rightarrow 2$	272	1.1	26	$> 10^5$
NH_3 para	$(J, K) = (1, 1) - (1, 1)$	23.69	12.7	23	2×10^3
	$(J, K) = (2, 2) - (2, 2)$	23.72	12.6	64	2×10^3
NH_3 ortho	$(J, K) = (3, 3) - (3, 3)$	23.87	12.6	122	
H_2CO ortho	$2_{12} \rightarrow 1_{11}$	140.8	2.1	21.9	10^5
	$3_{12} \rightarrow 2_{11}$	225.7	1.3	33.5	5×10^5
	$5_{33} \rightarrow 4_{32}$	364.3	0.82	158.4	10^6
H_2CO para	$2_{02} \rightarrow 1_{01}$	145.6	2.1	10.5	2×10^5
	$3_{22} \rightarrow 2_{21}$	218.5	1.4	68.1	2×10^5
	$5_{23} \rightarrow 4_{22}$	365.4	0.82	99.7	2×10^6
[b]OH	$^2\Pi_{3/2}, J = 3/2$	1.7	176	0.1	$10^4 - 10^6$
[b]H_2O ortho	$6_{16} \rightarrow 5_{23}$	22.2	13.5	640	$10^7 - 10^9$

[a]This density depends on cloud size, temperature, radiation field, etc.

[b]This line is often seen as a maser.

[c]This line indicates that shocks at speeds of $10 - 40\,\mathrm{km\,s^{-1}}$ have disrupted dust grains.