

COVALENT BONDING

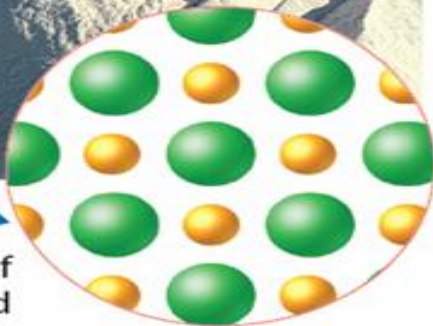
Chapter 8

IONIC COMPOUNDS VS. MOLECULAR COMPOUNDS

Ionic compound – Table Salt



Array of
sodium ions and
chloride ions



Formula unit of
sodium chloride:



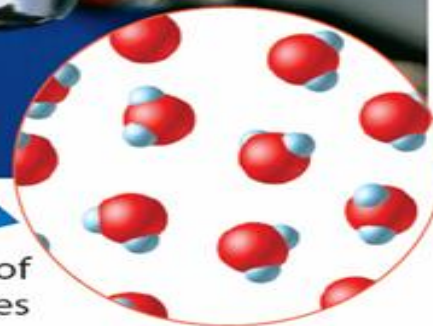
Chemical formula:



Molecular compound – Water



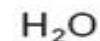
Collection of
water molecules



Molecule of water:



Chemical formula:



MOLECULAR COMPOUND CHARACTERISTICS

- ◉ **do not conduct electric current in solution**
- ◉ **have low solubilities (may or may not dissolve)**
- ◉ **have lower melting points**
- ◉ **Many are liquids or gases at room temperature**

COVALENT COMPOUNDS

- ◉ Covalent bonds formed between nonmetals.
- ◉ Covalent compounds form so that each atom, by sharing electrons, has an octet of electrons in its highest occupied energy level.
- ◉ The term “molecule” is used exclusively for covalent bonding.
 - ◉ Ionic compounds sometimes get the term formula unit.

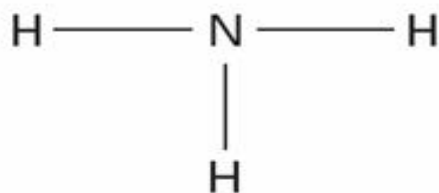
MOLECULAR FORMULA

- Shows how many atoms of each element a molecule contains.

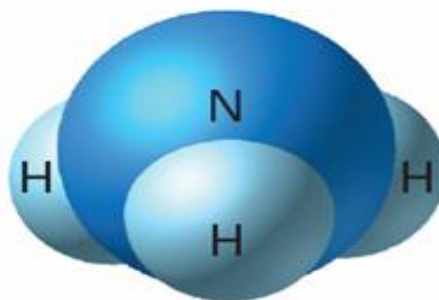
Ammonia



Molecular formula



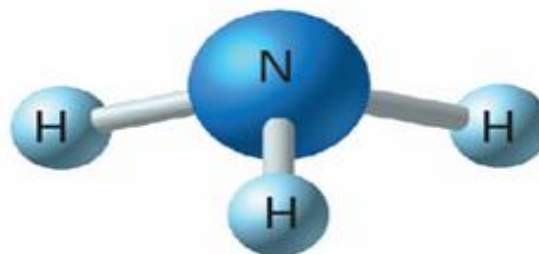
Structural formula



Space-filling molecular model



Perspective drawing



Ball-and-stick molecular model

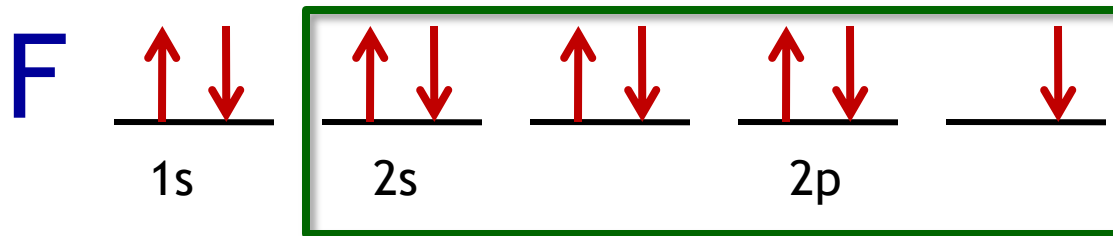
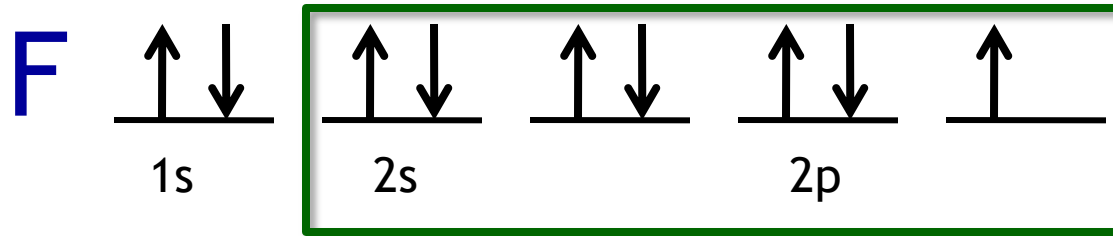
DIATOMIC MOLECULES

- ⦿ Diatomic Molecule - a molecule with 2 atoms
- ⦿ Gases that exist as diatomic molecules:
 - “Super 7”
 - H_2 , N_2 , O_2 , F_2 , Cl_2 , Br_2 , I_2

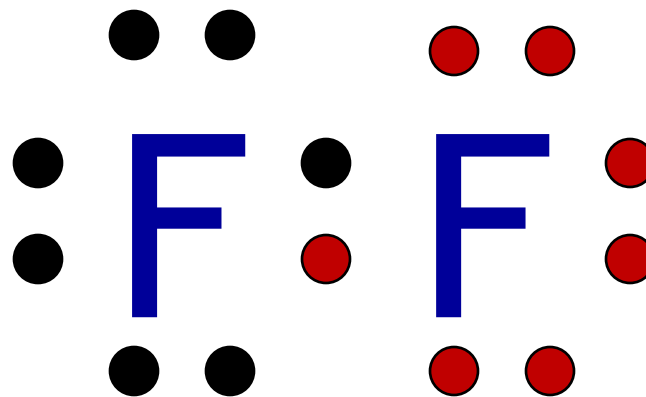
THE “HONC” RULE

- Hydrogen (and Halogens) form one covalent bond
- Oxygen (and sulfur) form two covalent bonds
 - One double bond, or two single bonds
- Nitrogen (and phosphorus) form three covalent bonds
 - One triple bond, or three single bonds, or one double bond and a single bond
- Carbon (and silicon) form four covalent bonds.
 - Two double bonds, or four single bonds, or a triple and a single, or a double and two singles

THE OCTET RULE: THE DIATOMIC FLUORINE MOLECULE

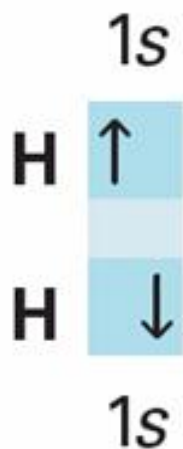
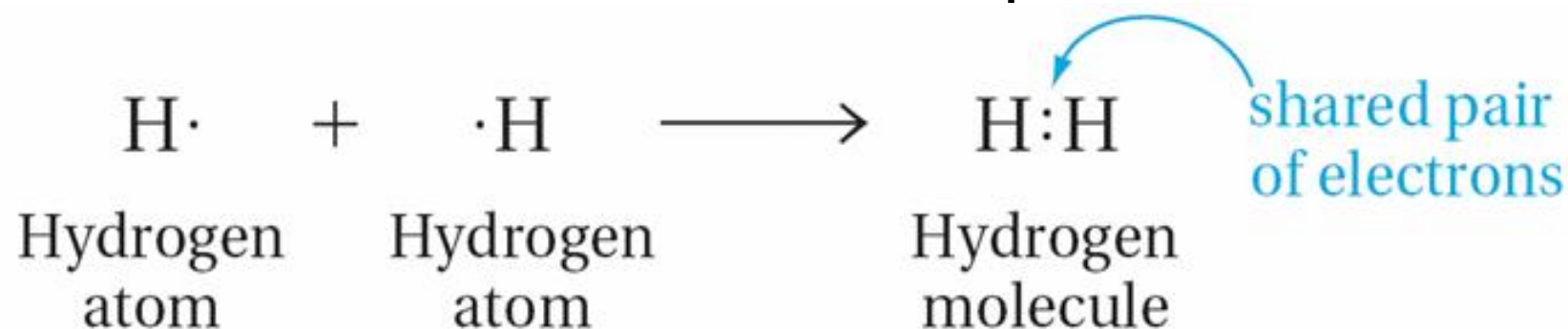


Each has seven
valence
electrons



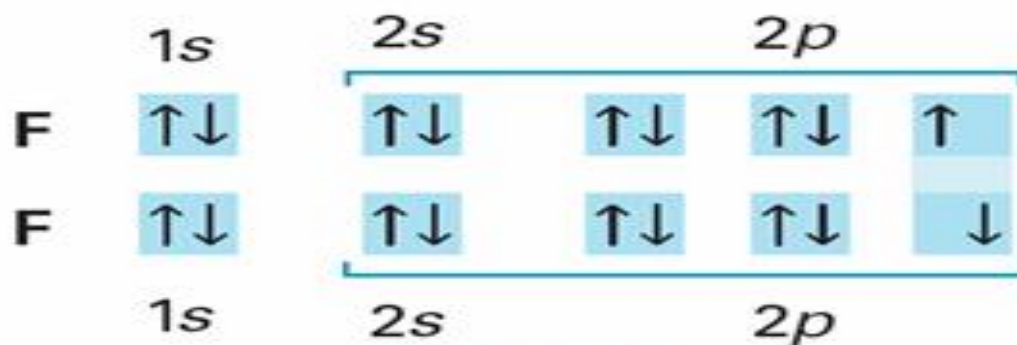
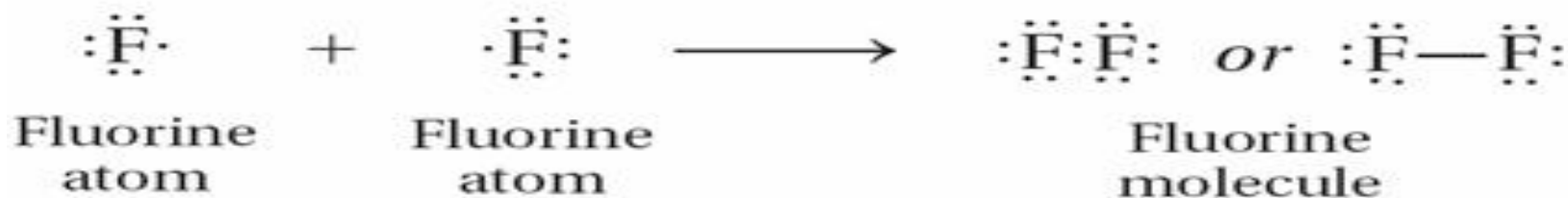
SINGLE COVALENT BONDS

- Two atoms are held together by sharing a pair of electrons
- 1 covalent bond = 1 “shared pair” of electrons



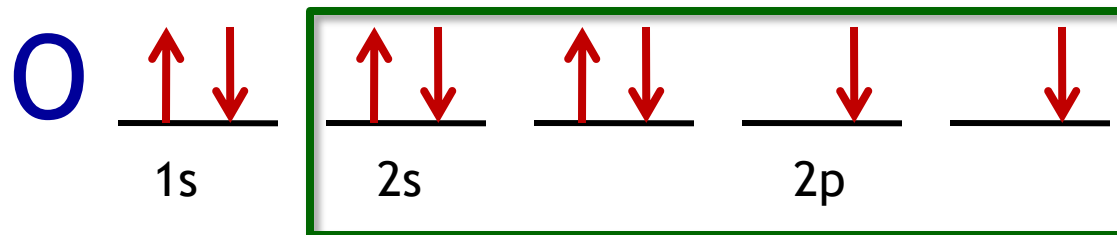
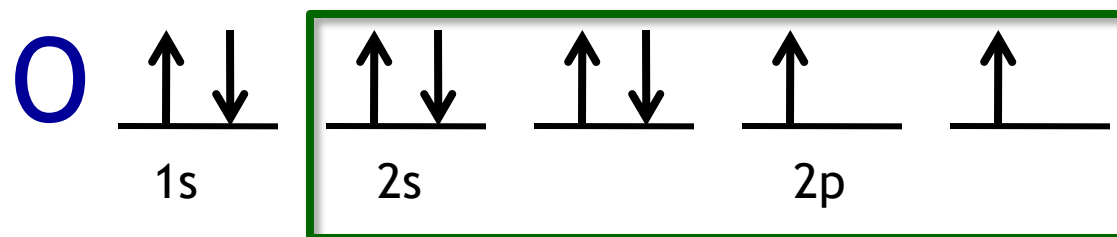
SINGLE COVALENT BONDS

- ◉ The halogens form single covalent bonds in their diatomic molecules. Fluorine is one example.

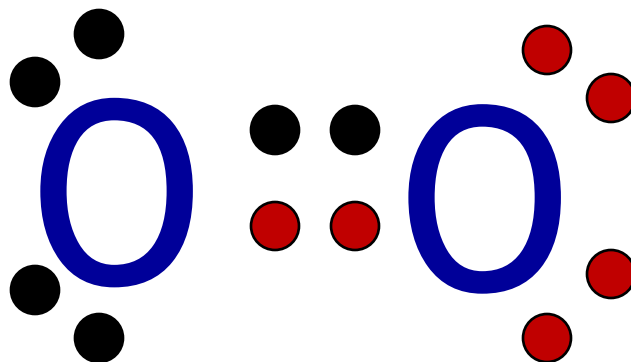


Fluorine molecule

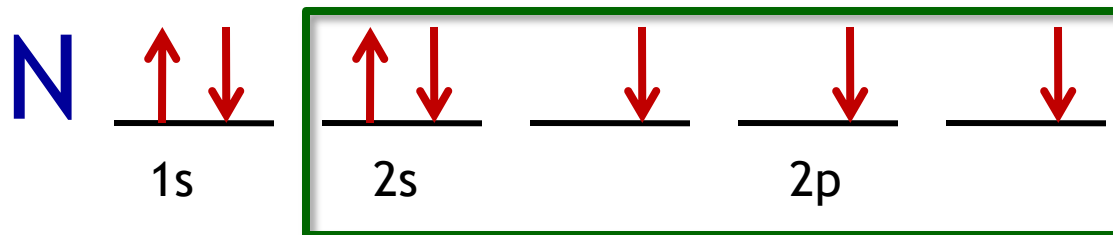
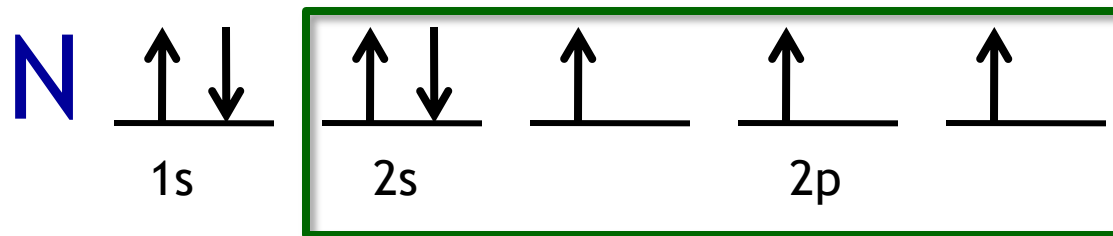
THE OCTET RULE: THE DIATOMIC OXYGEN MOLECULE



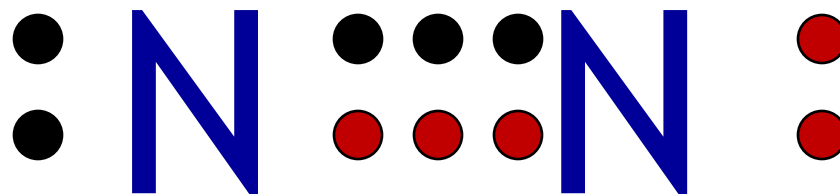
Each has six
valence
electrons



THE OCTET RULE: THE DIATOMIC NITROGEN MOLECULE



Each has five
valence
electrons



DOUBLE AND TRIPLE BONDS

◉ Double bond

- Involves **2 shared pairs** of electrons
- Oxygen gas (O_2)

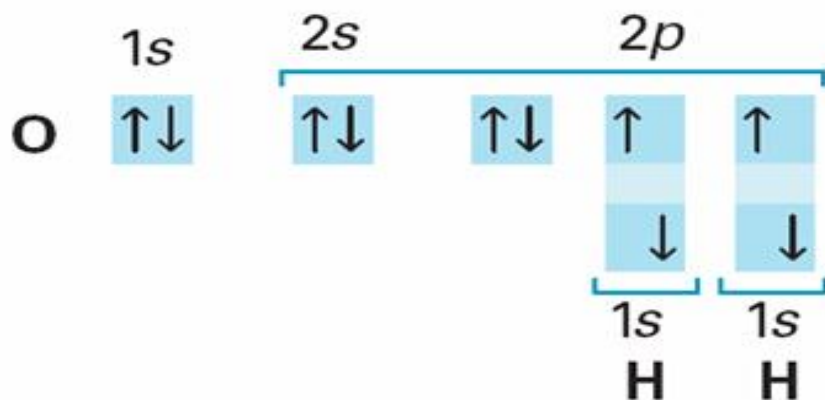
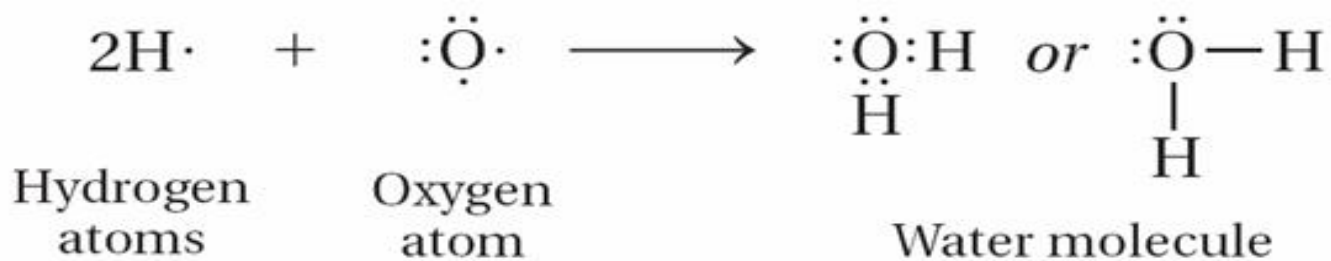
◉ Triple bond

- Involves **3 shared pairs** of electrons
- Nitrogen gas (N_2)

UNSHARED PAIR OF ELECTRONS

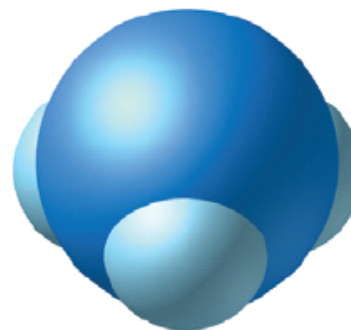
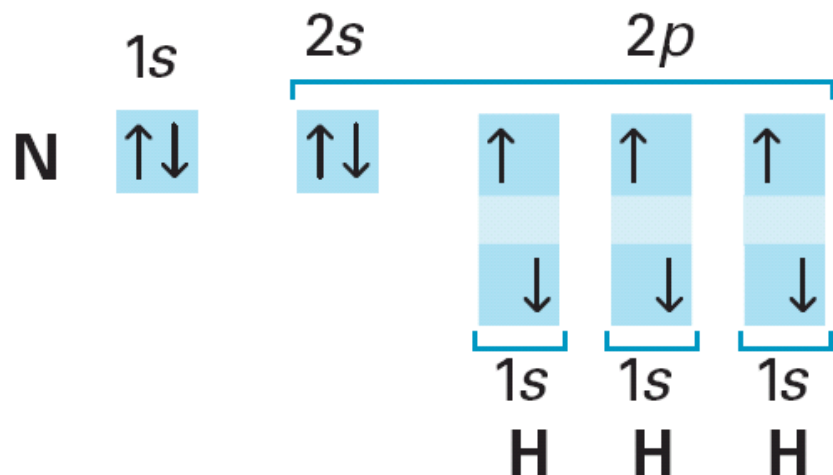
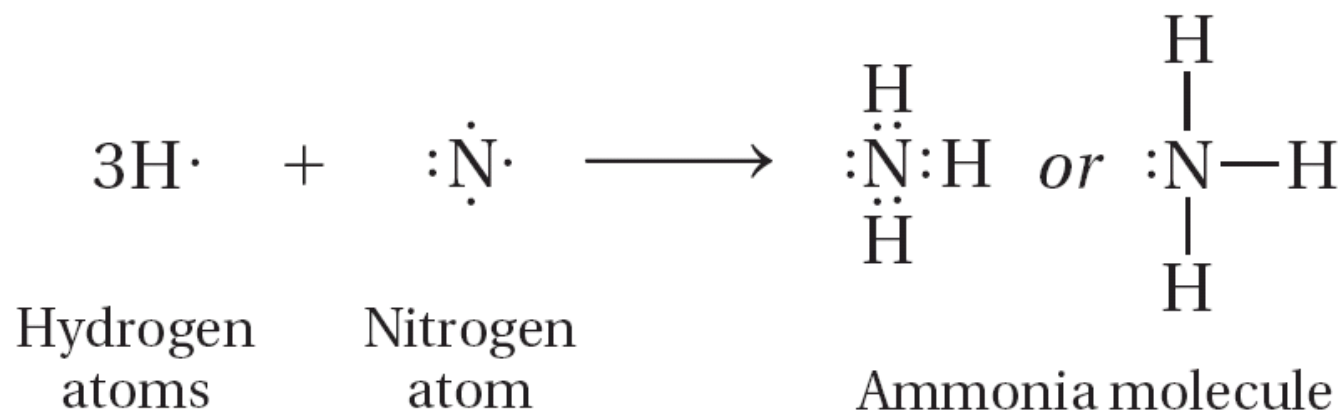
◉ **Unshared pair** - a pair of valence electrons that is not shared between atoms

- Do not connect two atoms together
- Also known as a **lone pair of electrons** or a **nonbonding pair**.



UNSHARED PAIR OF ELECTRONS

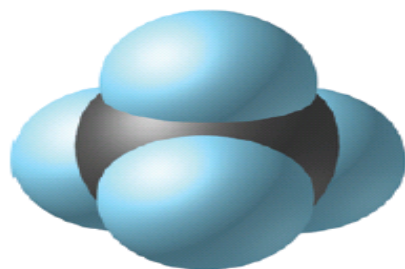
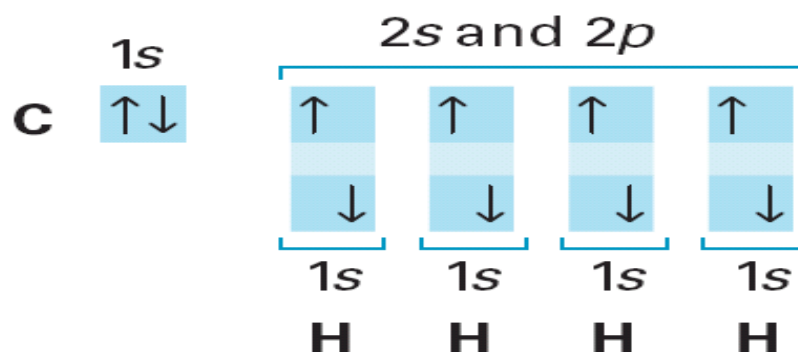
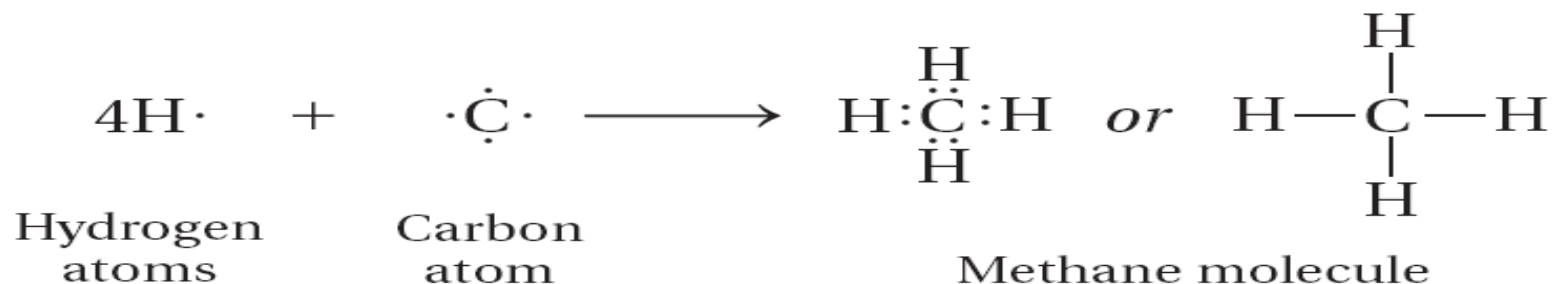
- The ammonia molecule has one unshared pair of electrons.



Ammonia molecule

UNSHARED PAIR OF ELECTRONS

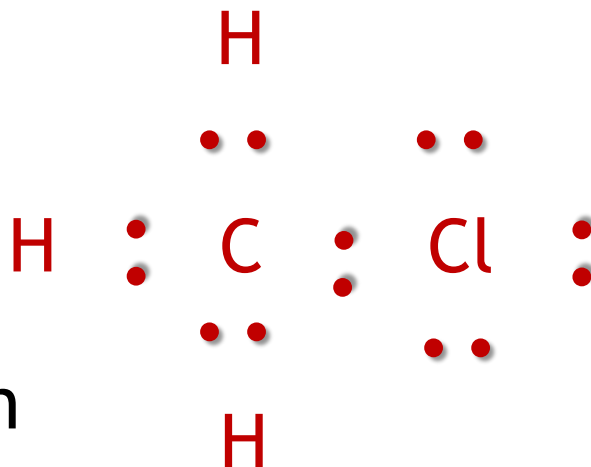
- Methane has no unshared pairs of electrons.



Methane molecule

COMPLETING A LEWIS STRUCTURE -CH₃Cl

- Make carbon the central atom
(it wants the most bonds, 4)
- Add up available valence electrons:
 - C = 4, H = (3)(1), Cl = 7 Total = 14
- Join peripheral atoms to the central atom with electron pairs.
- Complete octets on atoms other than hydrogen with remaining electrons



POLAR BONDS - *NOT ALL SHARING IS EQUAL*

◉ **Polar Bonds**

- **Nonpolar covalent** - equal sharing of electrons
 - “Super 7” diatomics
- **Polar covalent** - unequal sharing of electrons
 - The more EN atoms attracts electrons more strongly and gains a slightly negative charge.
 - The less EN atom has a slightly positive charge

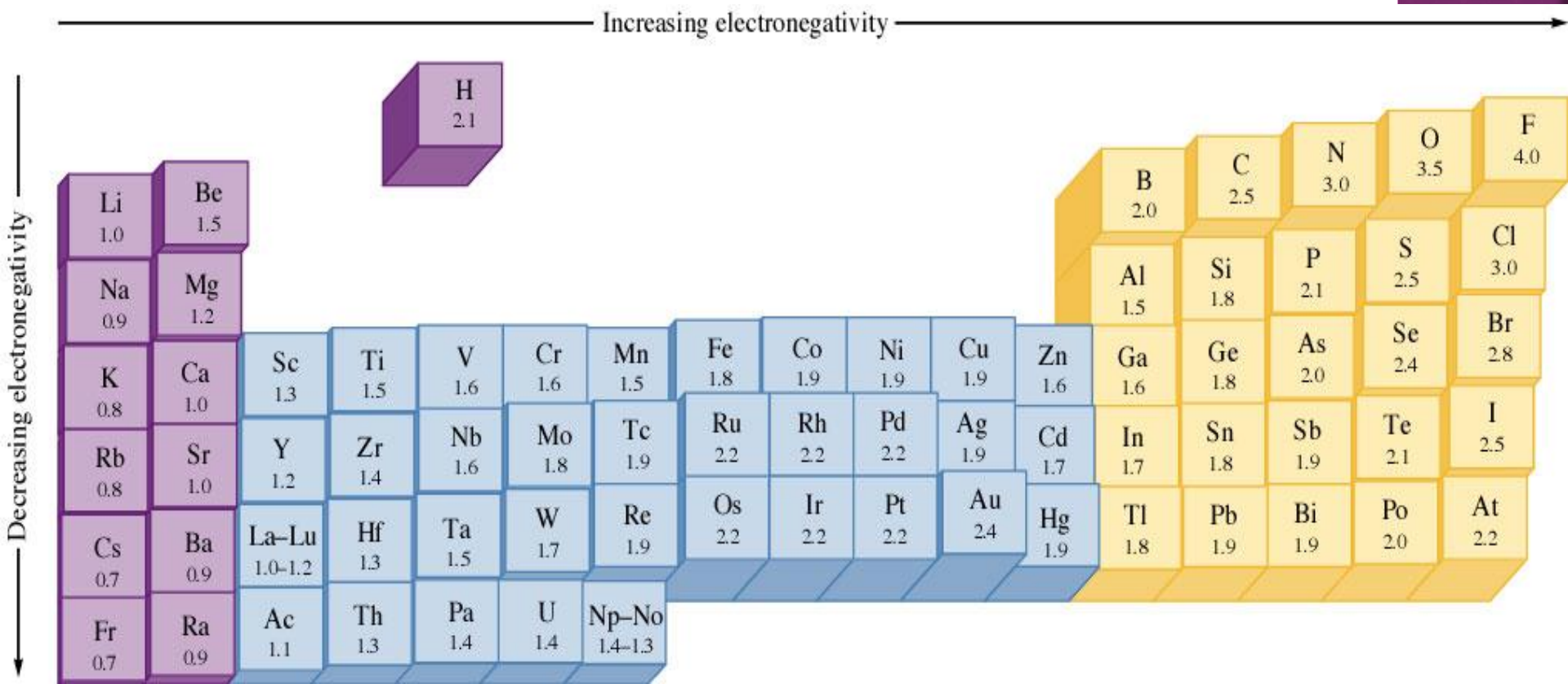
◉ **Electronegativity Differences**

- 0.0-0.4 nonpolar covalent
- 0.4-1.7 polar covalent
- 1.7-4.0 ionic

POLAR BONDS - *NOT ALL SHARING IS EQUAL*

Examples

- HCl
- Cl₂
- H₂O



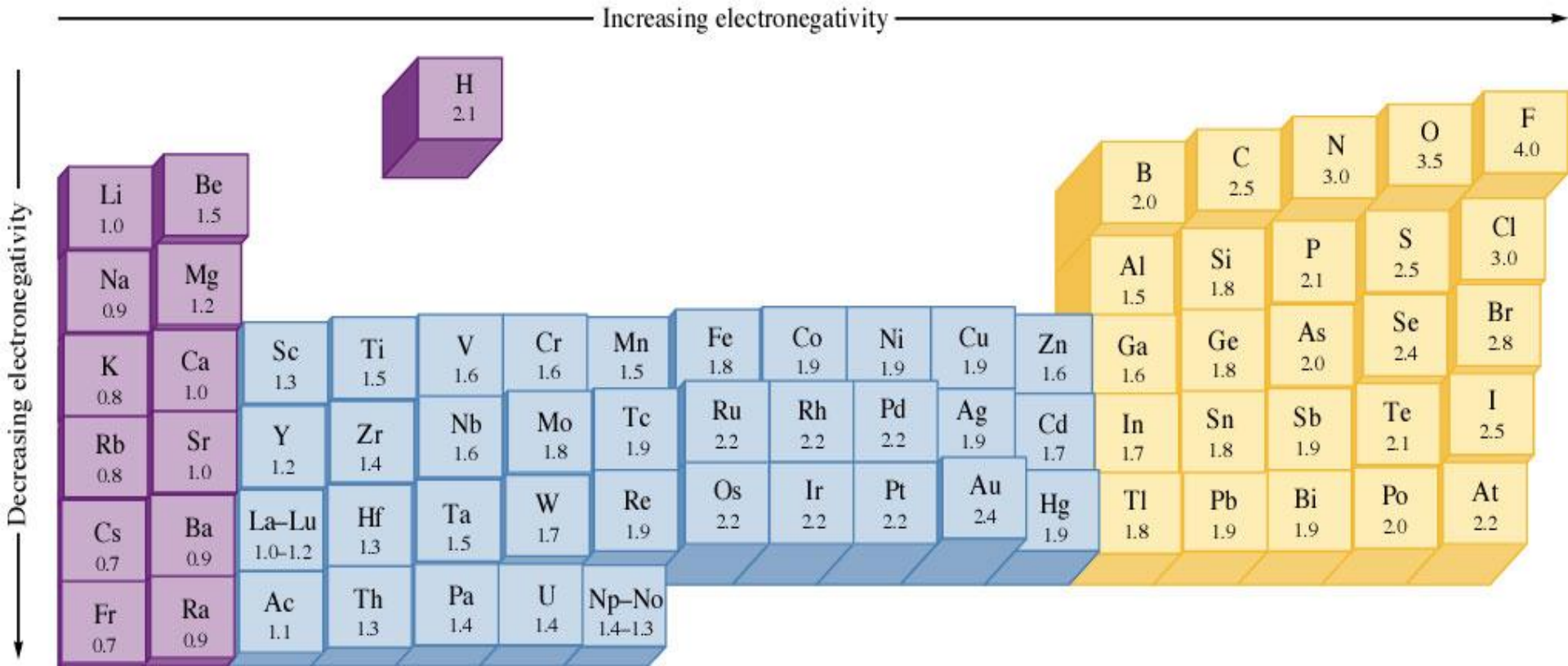
POLAR MOLECULES

- ◉ The presence of a polar bond in a molecule often, but not always, makes the entire molecule polar.
- ◉ One end of the molecule is slightly negative, the other slightly positive.
 - Dipole - a molecule that has 2 poles
- ◉ Look at the overall shape of the molecule and all the individual bonds.
 - SYMMETRY usually results in a nonpolar molecule!

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 2679, 26

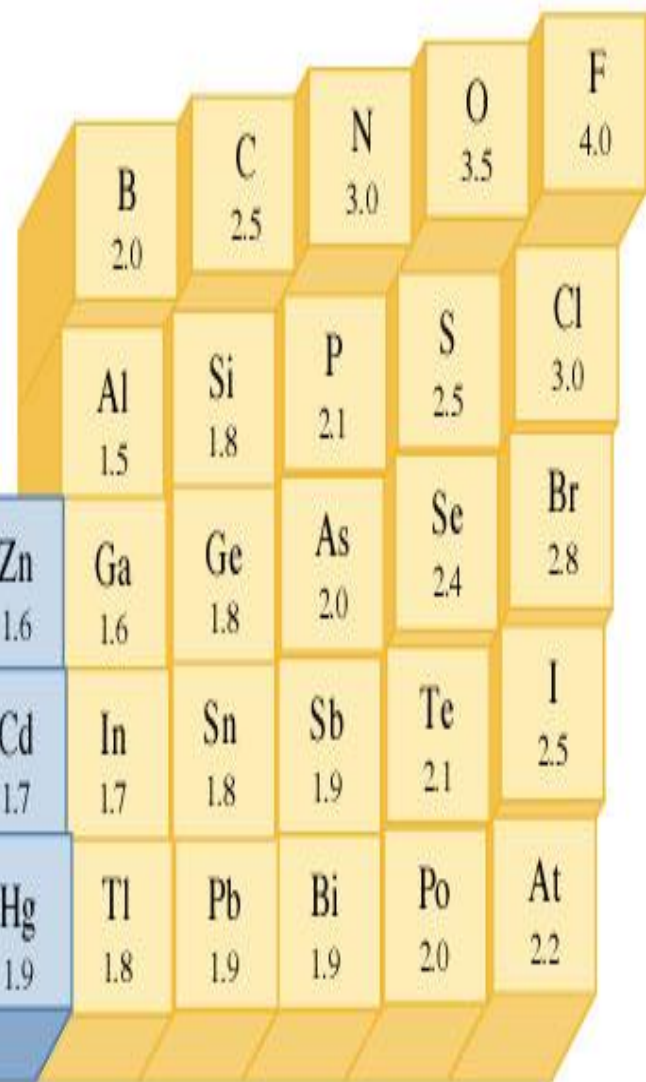
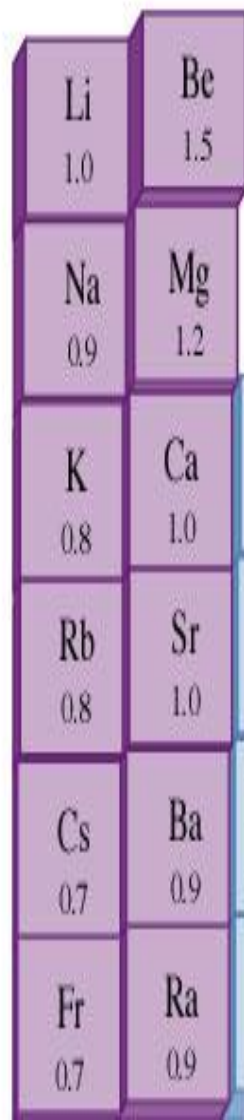
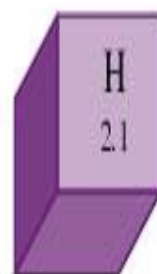
Examples

- H_2O
- SiO_2
- CF_4
- CH_2Cl_2



Increasing electronegativity →

↓ Decreasing electronegativity



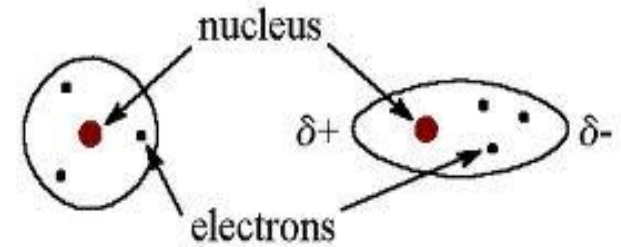
INTERMOLECULAR ATTRACTIONS

- ⦿ Attractions between molecules, not physical bonds.
- ⦿ These attractions are weaker than either ionic or covalent bonds.

TYPES

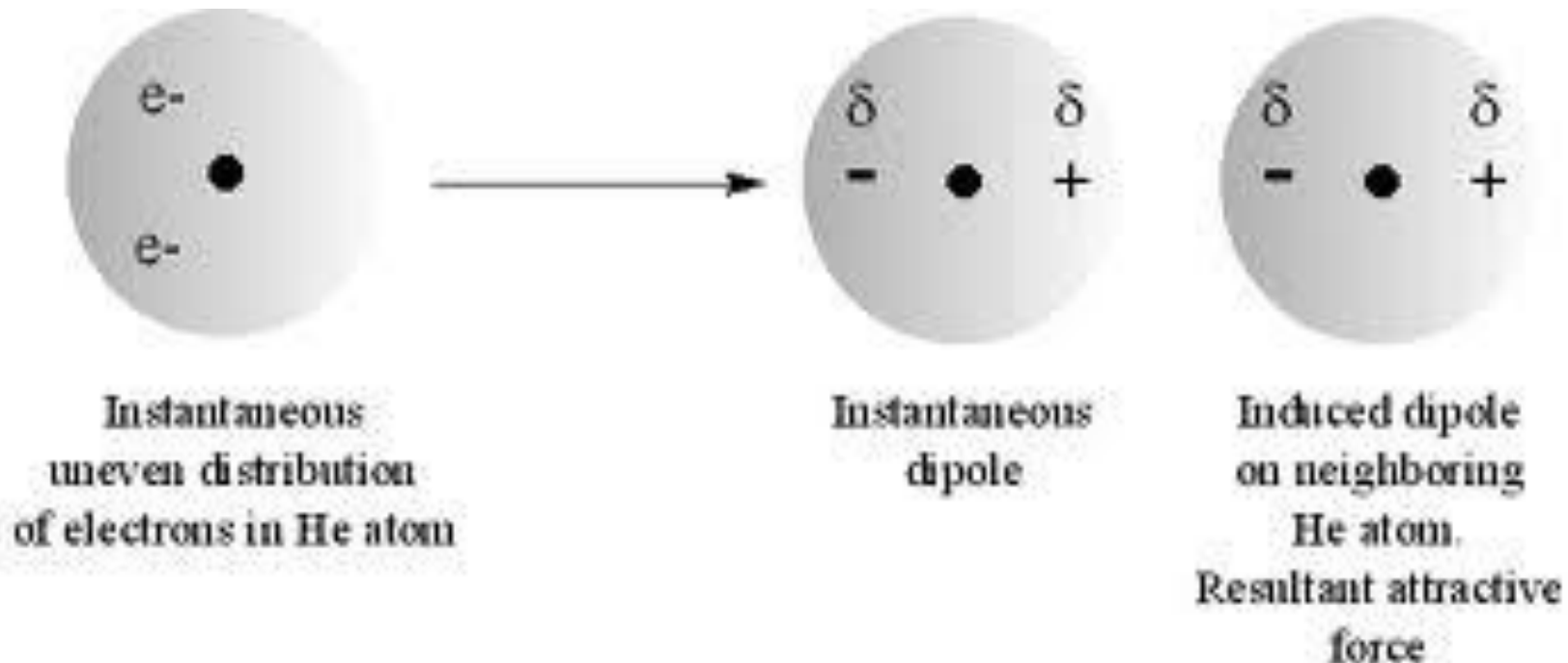
⊙ (London) Dispersion forces (Van d

- Weakest
- Caused by static attraction
- **ALL PAIRS OF MOLECULES EXPERIENCE THIS FORCE!**
(even nonpolar molecules)



symmetrical
distribution

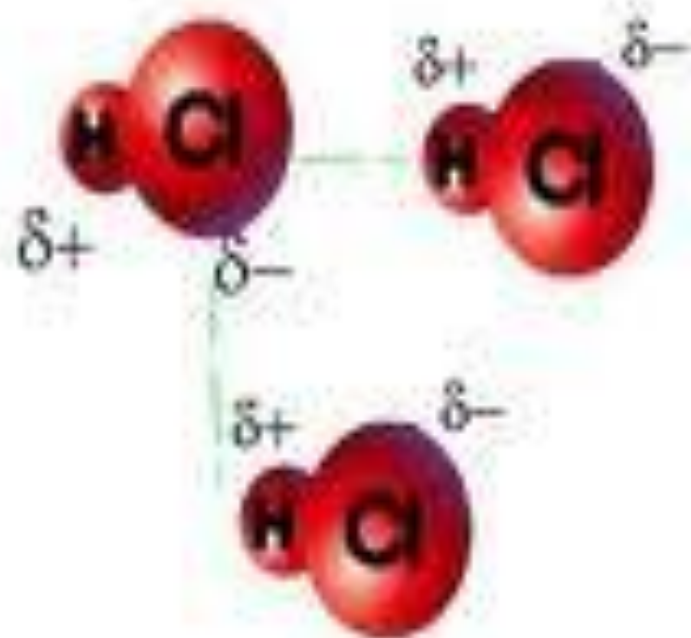
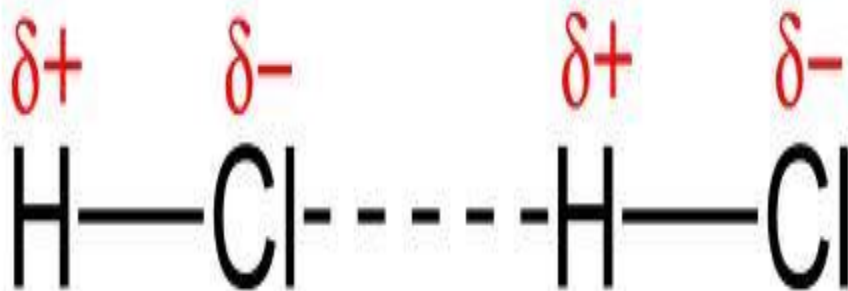
unsymmetrical
distribution



TYPES

◉ Dipole interactions (Van der Waals)

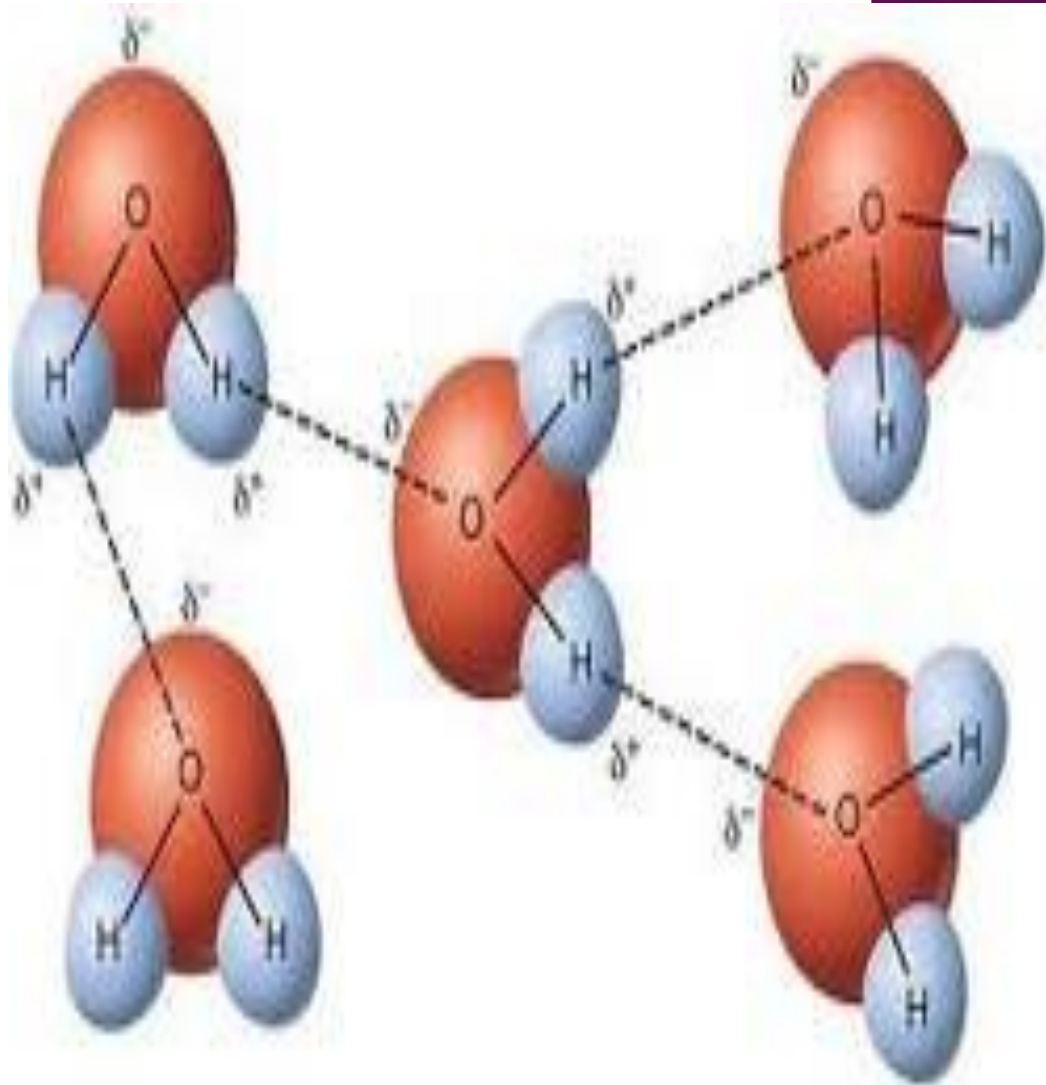
- Attraction between 2 **POLAR MOLECULES**
- The slightly negative region of a polar molecule is weakly attracted to the slightly positive region of another polar molecule



TYPES

○ Hydrogen bonding

- Strongest
- Must be **POLAR MOLECULES**
 - 1 atom must be H
 - 1 atom of O, N, Cl or F (highly EN elements)



EXAMPLES

- Draw the following molecules and state the type(s) of intermolecular forces found between the molecules

- HBr and HBr

- CH₄ and CH₄

- H₂O and HCl

- N₂ and F₂

BOND DISSOCIATION ENERGY

⦿ Energy (units: kilojoules/mole or kJ/mol) required to break a bond.



HOW MUCH ENERGY DOES IT TAKE TO MELT THE WICKED WITCH?

- Styrofoam - polystyrene, C_8H_8 - has the following structure. Calculate the total bond dissociation energy.

