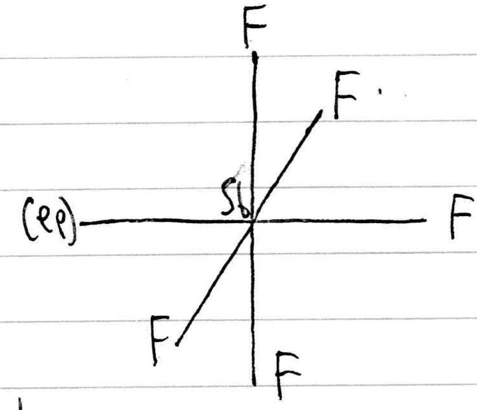
Example: VSEPR SbF_5

Q: Answer the following questions about the compound antimony penta-fluoride dianion: Construct the structure of SbF_5^{-2}. ~~Begin by selecting a n option~~

A:



Octahedral.

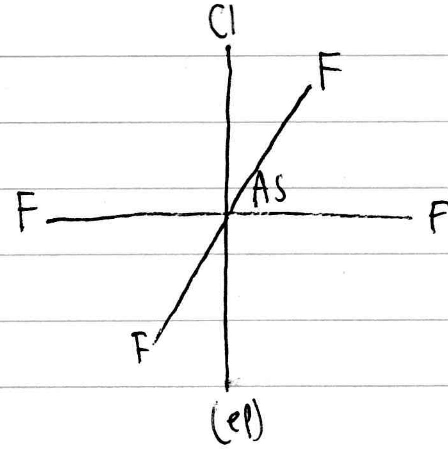
Q:
- Name the electron distribution about the central atom.
- Name the type of hybrid orbitals the central atom forms.
- Name the molecular geometry of the ~~atom~~ compound.
- State whether the molecule is polar or non-polar

A:
- Octahedral
- sp^3d^2
- Square Pyramidal
- Polar

Example: VSEPR $AsClF_4^{2-}$

Q: Construct the correct structure for $AsClF_4^{2-}$. Construct the molecule is oriented ~~vertically~~ up or vertically down.

A:



Q: • Name the type of hybrid orbitals the central atom forms.
• Name the molecular geometry of the compound.
• State whether the molecule is polar or non-polar.
• Which of the following provides the best estimate of the Cl-As-F ~~Bond Angle~~ bond angle in this molecule.

A: • sp^3d^2
• Square pyramidal
• Polar
• Slightly less than 90°.

Q: Calculate the maximum wavelength, in meters, of EM radiation capable of breaking the weakest bond in $AsClF_4^{2-}$.

$$\sqrt{E_{As-As}E_{F-F}} + 96.5(2.18-3.98)^2 = E_{As-F}$$

$$481.718 \frac{kJ}{mol} = \qquad \Rightarrow \lambda = 248.306 \text{ nm}$$

$$8 \cdot 10^{-19} \frac{J}{bond} = h\frac{c}{\lambda} \qquad = 2.48 \cdot 10^{-7} \text{ m}$$

Example: Dichloroallene

Q: 1,1 - Dichloro allene has the chemical formula

$$CH_2 = C = CCl_2$$

What are the hybridizations of the left, middle, and right carbons as seen in the formula?

A: Left: sp^2

Middle: sp

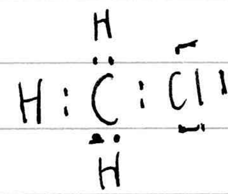
Right: sp^2

Example: Structure of CH_3Cl

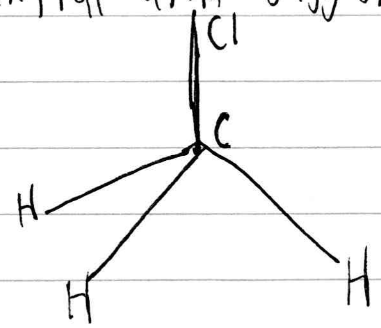
Q: Carbon reacts with chlorine and hydrogen to form the compound CH_3Cl.

Construct the structure of CH_3Cl:

A: Consider its Lewis structure



4 ligands on a central atom suggests tetrahedral,



Q: What is the dominant form of secondary bonding for CH_3Cl?

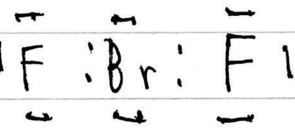
A: X | Dipole - Dipole interactions
| London dispersion forces
| Covalent bonding
| Ionic Bonding

Secondary bonding is defined as ~~the bond a universe conside~~ → the bonds where no electrons are shared or transferred. Dipole - Dipole follows, as it is the only attractive force remaining.

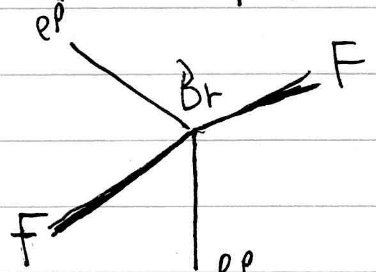
Example: VSEPR BrF_2^+

Q: Construct the structure of BrF_2^+, ~~beginning by selecting an~~

A: BrF_2^+ has the lewis structure



where of course the positive charge was attained by pulling an electron off the Br; then in 3d we have



, tetrahedral ~~and~~ due to the electron pairs on the Br.

Q: • Name the electron distribution about the central atom.
• Name the type of hybrid orbitals the central atom forms.
• Name the molecular geometry of the compound.
• State whether the molecule is polar or non-polar.

A: • Tetrahedral
• sp^3
• Bent
• Polar

Example: Boiling point comparison between Ar and HCl

Q: Identify the compound with the lower boiling point:

A: X | Ar
HCl

Example: Secondary Bonding Comparison

Q: For each molecule listed below, identify the dominant form of secondary bonding:

- NH_3
- CCl_4
- HCl

A:

- Hydrogen Bonding
- London Dispersion Forces
- Dipole interactions.

Example: Rankings of boiling points

Q: • Rank the following 3 compounds interms of increasing boiling point: CH_4, CH_2Cl_2, CCl_4.

• Rank the following 3 compounds in terms of increasing boiling point: CF_4, CH_4, CH_2F_2

• Water is a liquid at room temperature and H_2Se is a homologue compound. At room temperature what state is it in?

A: • CH_4, CH_2Cl_2, CCl_4
• CH_4, CF_4, CH_2F_2
• Gas; due to no hydrogen bonding holding it liquid.

Example: Rate of reaction of arrhenium fluoride

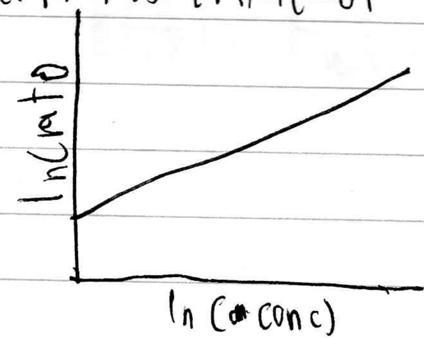
A: $R = (9.591 \cdot 10^{-3}\ M^{-1}\ s^{-1}) \cdot (2.5^2\ M^2)$

$\boxed{R = 0.0599\ M \cdot s^{-1}}$

Q: The fictitious compound, AhF reacts with itself to form a dimer Ah_2F_2. The reaction is second order in AhF. The value of the rate constant is $9.591 \cdot 10^{-3}$ $M^{-1}\ s^{-1}$. What is the initial rate of reaction ~~of~~ in a reactor filled with AhF to a concentration of 2.5 M?

Example: Rate of reaction of Administratium Bromide

Q: Administratium Bromide decomposes readily at temperatures exceeding 37° C. The figure below shows how the rate of reaction varies with the concentration of AdBr. The rate r has units of $M \cdot s^{-1}$ and the concentration C in units of M (moles L^{-1}). The slope has a value of a 1.67 and the intercept has a value of 0.49.



- What is the order of the reaction?
- Calculate the instant rate of decomposition of AdBr when its concentration is 0.03091 M.

A:
- The graph follows the equation
  $\ln(R) = 1.67 \ln(\text{conc}) + 0.49.$ (1)
  Consider the equation
  $R = [A]^a$.
  then,
  $\log(r) = a \ln([A])$
  if we let $a = 1.67$, then there is a perfect match and the order is 1.67.
- Plug given values into (1); exp the right side and find $R = 4.912 \cdot 10^{-3}\ M\, s^{-1}$

Example: Activation energy of a reaction

A: • $\ln(K) = \ln(A) - \frac{E_a}{R \cdot 298.15\,K}$

$\ln(2K) = \ln(a) - \frac{E_a}{R\ 308.15\,K}$

$\ln(K) - \ln(2K) = \frac{E_a}{R\,308.15\,K} - \frac{E_a}{R\ 298.15\,K}$

$\ln\left(\frac{K}{2K}\right) = E_a\left(\frac{1}{8.315 \cdot 308.15} - \frac{1}{8.315 \cdot 298.15}\right)$

$\ln\left(\frac{1}{2}\right) =$

$\boxed{E_a = 52952{,}284\ J/mol}$

• Recall the formula

$\ln\left(\frac{K'}{K}\right) = \frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T'}\right)$

Insert the known temperatures (converted to Kelvin) and the known rate constant, and E_a:

$\ln\left(\frac{K'}{5 \cdot 10^{-4}}\right) = \frac{3091}{8.315}\left(\frac{1}{25} - \frac{1}{100}\right)$

$\ln(K') = \cancel{18.753} = \cancel{3.551} = -7.589$

$\cancel{K' = 34.856}$

$\boxed{K' = 5.056 \cdot 10^{-4}\ s^{-1}}$

Q: • Calculate the activation energy of a reaction whose rate at 35°C is twice its rate at 25°C.

• The activation energy of a decomposition reaction is known to be 3,091 KJ/mol. At 25°C, the rate constant $K = 5 \cdot 10^{-4}\ s^{-1}$. What is the rate constant at 100°C?

Example: CO_2 Reaction Rate

Q: A professor at MIT has recently developed a device ~~that~~ which chemically removes the CO_2 from carbonated drinks. This device takes advantage of a reaction in which CO_2 is a reactant. The reaction is second order in CO_2. Laboratory tests have shown that the device is capable of removing CO_2 at a rate of 10^{-4} M/s when there is 0.2 M of CO_2 in solution, and the solution is at 50° C.

- What is the rate constant at 50° C?
- To what temperature should the device be heated to remove $1.1 \cdot 10^{-4}$ M/s of CO_2? Assume an activation energy of 1.1 kJ/mol and an initial concentration of 0.2 M.

A:
- $R = K [A]^2$

$$10^{-4}\ M\ s^{-1} = K\ 0.04\ M^2$$

$$K = 0.0025\ M^{-1}\ s^{-1}$$

- $\cancel{R = \quad = K_0 e^{-E_a/kT} \cdot 0.2}$

$$\cancel{\ln\left(\frac{K'}{K}\right) = \frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T'}\right)}$$

$$\cancel{\ln\left(\frac{K'}{0.}\right.} \quad K' = \frac{R}{[A]^2} = \frac{1.1 \cdot 10^{-4}}{0.04\ M^2 s} = 2.75 \cdot 10^{-3}\ M^{-1}\ s^{-1}$$

$$\ln\left(\frac{2.75 \cdot 10^{-3}\ M^{-1}\ s^{-1}}{2.5 \cdot 10^{-3}\ M^{-1}\ s^{-1}}\right) = \frac{1100\ J \cdot K \cdot mol}{8.314\ J}\left(\frac{1}{\cancel{50}K} - \frac{1}{tK}\right)$$

$$0.0953 = \ldots \rightarrow \cancel{t = 51.868°C}$$

$$\boxed{t = 421.2\ K = 148.05°C}$$