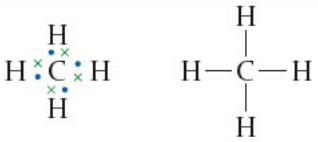
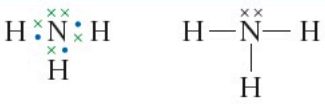
Topic 4.3 Covalent Structures
4.5 Metallic Bonding

I. Lewis Structure

A. How to draw?

1. 数最外层电子数的总数
2. 画出skeletal structure
3. 用两个×/两个点/一条线来标注一对电子 （都可以用，但是最好要保持一致…）
4. Octet Rule("The tendency of atoms to gain a valence shell with a total of 8 electrons"): 确保每个原子（其他情况见III）外都有8个电子
5. ↑如果上面没满就用double/triple bond
6. 检验最外层电子总数是否和第一步算出来的相同

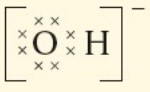
B. Example:

Molecule	Total number of valence electrons	Lewis structure
CH_4	4 + (1 × 4) = 8	
NH_3	5 + (1 × 3) = 8	
H_2O	(1 × 2) + 6 = 8	
CO_2	4 + (6 × 2) = 16	
HCN	1 + 4 +5 = 10	

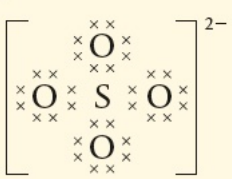
C. 注意：

1. 画Ion的时候在结构外打中括号并标注 example:
2. 正离子减去电子，负离子加上电子

(i) valence electrons = 6 + 1 + 1 = 8



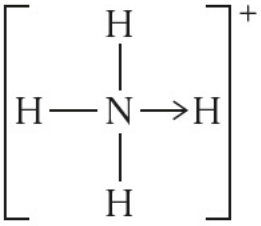
(ii) valence electrons = 6 + (6 × 4) + 2 = 32



II. Coordinate Bonds

A. Definition: Bond forms by both the electrons in the pair originating from the same atom.
（想象一下你和你划水的队友，你贡献了coordinate bond)

B. Sometimes shown by an arrow on the head of the bond

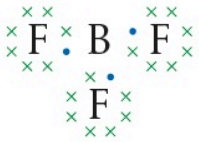


III. "Outliers" for Octet rule

A. Beryllium (Be) and Boron (B); => Incomplete octet

$BeCl_2$ valence electrons = 2 + (7 × 2) = 16

BF_3 valence electrons = 3 + (7 × 3) = 24



B. "electron deficient" -> tend to accept an electron pair from a molecule with a lone pair

C. 很显然，Hydrogen 没法成为central atom （只能出现在边缘）

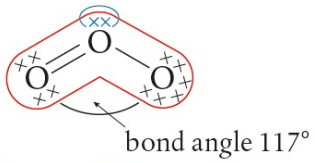
IV. VSEPR theory

A. Electron Domain: All electron locations in the valence shell

B. Non-bonding pairs (lone pairs) have a higher concentration of charge than a bonding pair (because they are not shared between two atoms, causing more repulsion)

C. Shapes （记住！越多的lone pair角度就越小！可以从标准角度推！）

1. **Linear** (180°): 2 Electron Domain (ED)
2. **Triangular Planar** (120°): 3 ED, bonding.
3. **Bent**/V-shaped (117°): O_3
4. **Tetrahedral**: 4 ED; 4 bonding (109.5°); 1 lone pair (lp) (107°); 2 lp (105°)



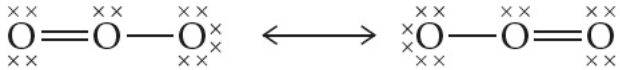
bent or V-shaped

D. Polarity *(SKIP for midterm)*

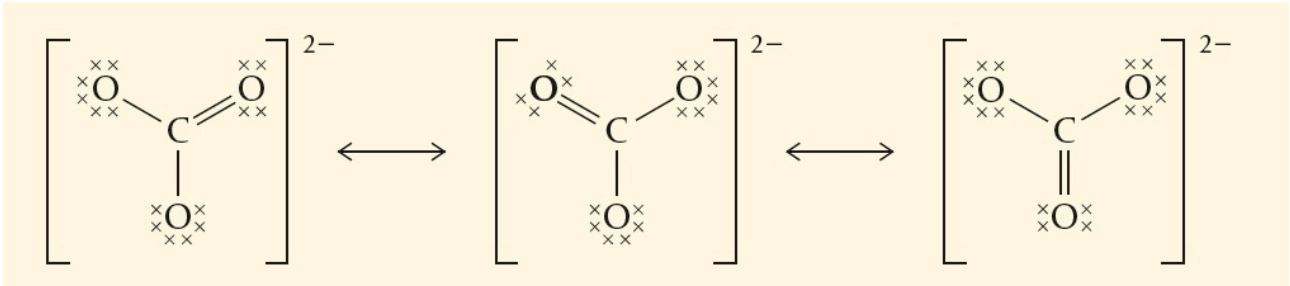
1. The polar bonds that it contains
2. Shape (polar bonds or not?)
   a) If bonds are of equal polarity - non-polar, the dipoles cancel out
   b) Dipole moment - polar bonds are formed.

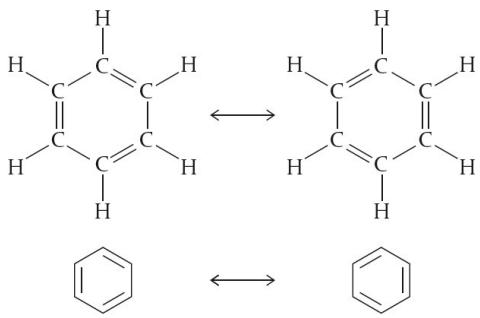
E. Resonance (hybrid) *(SKIP for midterm)*

1. More than one valid Lewis structure can be drawn for a particular molecule (an average of these)



2. 不要慌！主要是这3个！ C_6H_6, CO_3^{2-}, and O_3.
3. 具体长这样： （P.S Benzene主要是第10章…）





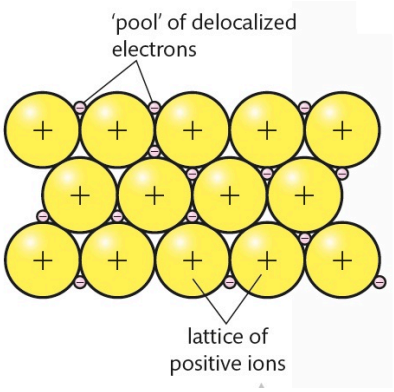
4. 有几个resonance structures主要看有几个可能的double bond的位置.....

V. Metallic Bonding

A. Definition: A metallic bond is the electrostatic attraction between a lattice of positive ions and delocalized electrons.

B. Determinants on metallic bond strength:

1. **Number of delocalized electrons**
2. **Charge on the cation (metal ion)**
3. **Radius of the cation (metal ion)**



由此可以判断Metallic Bonding Strength的Trend：

- Down the Group的情况
  Metals all have same charge→radius will dominate trend
  As radius increases --> metallic bonds strength decreases

- Across the Period的情况 (L-->R)
  The radius decreases and charge increases
  在这里 charge 影响更大，smaller radius也会增加strength
  1. Greater charge density of metal ions (More free electrons)
  2. Smaller Radius
  --> metallic bonds strength increases

C. Reflected by Physical Properties *(Skip for Midterm)*

Metallic property	Explanation	Application
good electrical conductivity	delocalized electrons are highly mobile, and so can move through the metal structure in response to an applied voltage	electrical circuits use copper
good thermal conductivity	delocalized electrons and close packed ions enable efficient transfer of heat energy	cooking utensils
malleable, can be shaped under pressure	movement of delocalized electrons is non-directional and essentially random through the cation lattice, so the metallic bond remains intact while the conformation changes under applied pressure	moulded into many forms including machinery and structural components of buildings and vehicles
ductile, can be drawn out into threads		electric wires and cables
high melting points	a lot of energy is required to break the strong metallic bonds and separate the atoms	high speed tools and turbine engines; tungsten has the highest melting point
shiny, lustrous appearance	delocalized electrons in metal crystal structure reflect light	ornamental structures

Time for PAST PAPERS!!!

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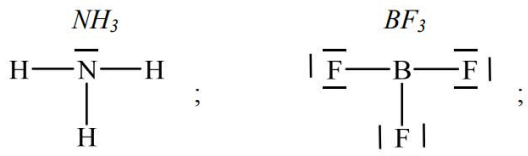
(c) (i) Deduce the Lewis structures of NH_3 and BF_3.

(i) *NH_3* *BF_3*



这里要注意的是B是一个exception
6个即为full orbit了

Accept any combination of lines, dots or crosses to represent electron pairs.

(iii) Compare the shapes of the two molecules and explain the difference using valence shell electron pair repulsion theory (VSEPR). *[4]*

(iii) *NH_3:* (trigonal/triangular) pyramidal;
BF_3: trigonal/triangular planar;
NH_3 has 4 negative centres of charge/three bonding pairs and one lone pair **and**
BF_3 has 3 negative centres of charge/three bonding pairs / *OWTTE*;
(bond angles) 107° in NH_3 **and** 120° in BF_3; ***[4]***
Accept 107.5° for NH_3.

本质上就是描述一下有几个bonding pair和lone pair

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(b) (ii) Outline the nature of the metallic bonding present in potassium.

(b) (ii) (electrostatic) attraction between lattice of cations/positive ions and delocalized electrons;

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Which metal has the strongest metallic bond?

A. Li

B. Na

C. K

D. Rb

答案选A，这四个金属都来自于Group1 ,也就是down the group的trend，最上面的radius最小，所以metallic bond strength最强