

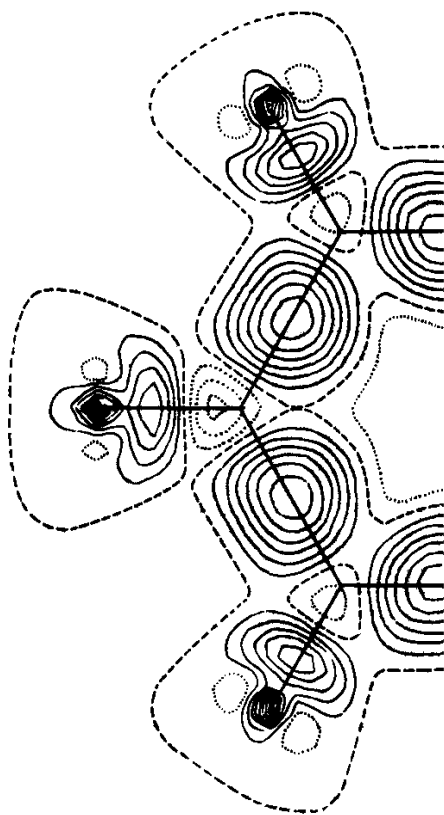
Here are some questions on Lewis Structures, Resonance, SPM, and X-ray from previous Chem 125 hour exams. They would all be fair game (after Monday, Sept 15) this year:

1. (5 minutes) **Add** pairs of **dots** and necessary **formal charges** below to complete **two** different plausible Lewis structures for cyanic acid (HNCO). **Underline** the one you think is a better structure and say **why** you think so.

H N C O

H N C O

3. (4 min) Explain why X-ray scattering [in 2 dimensions] by an evenly spaced row of atoms gives tiny dots at specific angles, rather than broad peaks spread over a range of angles.
4. (6 min) **How** did scientists create the following diagram for half of an aromatic benzene ring? (i.e. what **experiment** and **calculation** was necessary?) What does the diagram show in general about the **nature of bonds**?

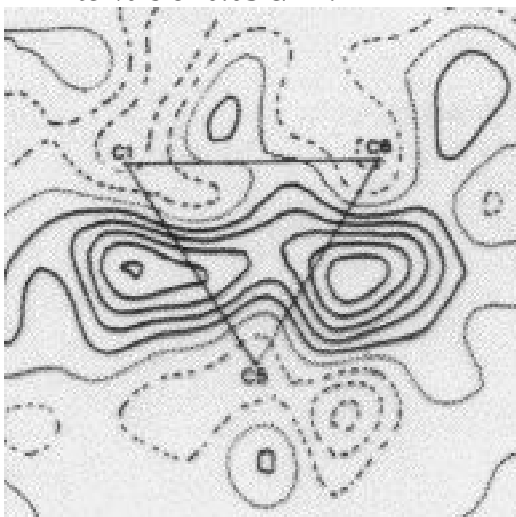


2. (8.4 / 10) Add dots below to give valid **Lewis** formulae of the two resonance structures of the **cation** HCNH^+ . Show the location of **formal charge**. Beneath **each** structure indicate one of its good features (e.g. complete octets) and one of its bad features (four features in all).

H C N H

H C N H

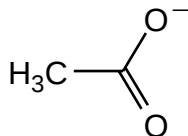
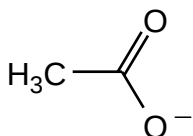
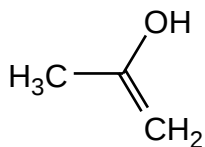
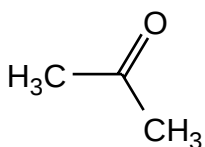
1. (3 minutes) Write a valid Lewis dot structure for the *anion* NO^- . Show the location of the formal charge.
4. (9.0 / 12) Why is it difficult or impossible to do each of the following?
 - A. Use a superpowerful visible-light microscope to locate individual atoms.
 - B. Use an atomic force microscope to locate individual atoms on the surface of an organic solid.
 - C. Use x-ray diffraction to locate atomic nuclei directly (rather than inferring their position).
5. Below left is an electron deformation density (or difference density) map in the plane of a bonded triangle consisting of three carbons atoms (C1, C5, C6). Other atoms to which they are attached do not lie in this plane. The contours are drawn at intervals of $0.05 \text{ e}/\text{\AA}^3$.



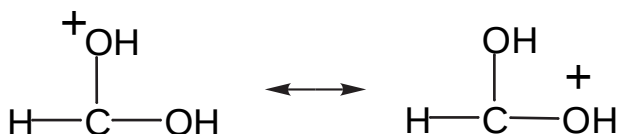
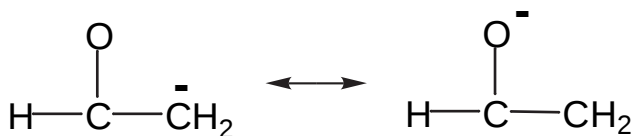
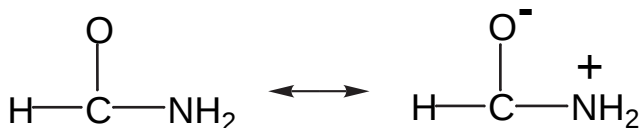
- A. (3 min) In the right frame sketch a plausible map of the total electron density in this same plane.

B. (6 min) What does the electron deformation density map show about this molecule, and in what ways is what it shows curious?

- (3 minutes) Write a valid Lewis dot structure for H_2NCN (cyanamide).
- (7 minutes) At the top and bottom of Rosalind Franklin's X-ray diffraction pattern from double-helical DNA are large dark spots. In terms of the molecular structure, explain the source of these two spots and why they are further from the center of the pattern than the other dark spots. (If you draw a blank on this question, you can describe another feature of the pattern for half credit.)
- (7 minutes) Draw appropriate horizontal arrows to denote the relationship between the members of the following two pairs of structures. Explain briefly the meaning of the arrows.



- (4.5 minutes) **Draw a bond in each formula** below to complete a reasonable resonance structure. Then in each pair of resonance structures **circle the more important one**. (In case of a tie, circle both.) Write a few words **explaining** your choices.



2. (4.5 min) The ribosome is a pretty big structure containing some 300,000-400,000 atoms (including water molecules inside the ribosome and hydrogen atoms). Pretending that these atoms are packed in a cube, which of the values below gives a reasonable estimate for the **length of an edge** of the cube (**circle** one value):

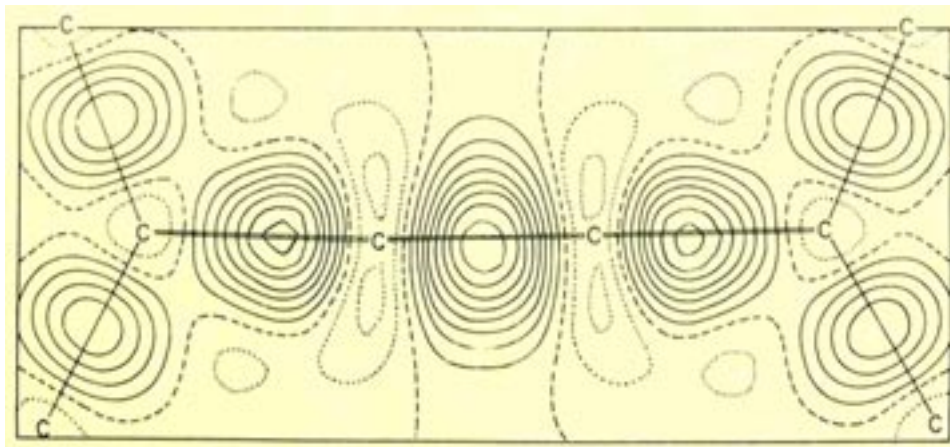
15 atoms 70 atoms 500 atoms 1500 atoms 5000 atoms

Assuming that the distance between neighboring atoms is on average 1.5 bond distances, **circle** the approximate **length of an edge** of this ribosome box:

30 Å 16 nm 160 nm 0.75 μm 11 μm 0.3 mm

If a bunch of ribosomes were lying next to one another on a glass slide, would a high-powered **optical microscope** be able to see them as separate structures? **Explain** your thinking, being sure to mention how scattered light incorporates information on the distance between such particles.

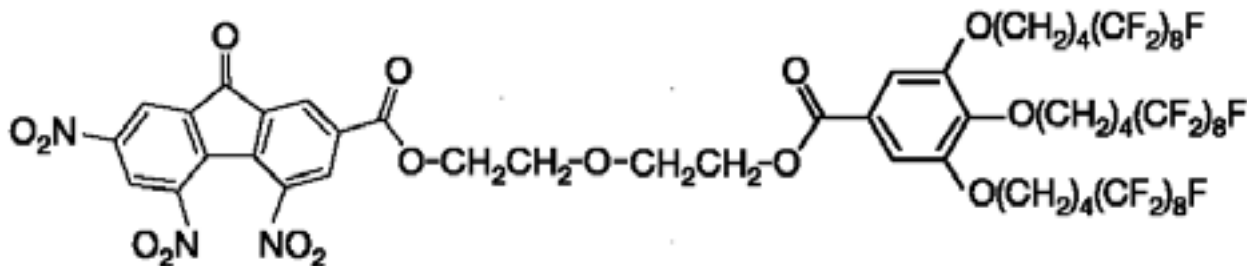
3. (16 minutes) Consider the following figure in which the four terminal C atoms are parts of benzene rings not shown.



- A. Explain the procedure that was used to generate data plotted in this figure (mention both experiments and calculations).
 - B. Explain exactly what the straight and curved lines show (and how dotted and solid curves differ).
 - C. What qualitative and quantitative insight does one gain about the nature of carbon-carbon bonds from this figure?
 - D. Explain a way in which this plot supports the Lewis theory of bonding and a way in which it refutes the theory.
1. (4 min) **Explain** which of the following techniques would be best for measuring the distance between two copper atoms about 5Å apart on a graphite surface: AFM, STM, high-powered optical microscopy.

Note: Question 3 relates to memorizing the functional groups in Table 3.1 pp. 38-39 of the Text, which you will be responsible for on the first exam.

3. (4 minutes) In yesterday's issue of the journal *Nature* [vol. 419, p. 384] is a description of "helical dendrimers" that show promise as electronic materials. The formula below shows one of the molecules discussed. **Neglecting** the three $(\text{CH}_2)_4(\text{CF}_2)_8\text{F}$ groups on the far right, **circle FOUR DIFFERENT functional groups** in this molecule and **give their names**. Make sure the groups have different names.:

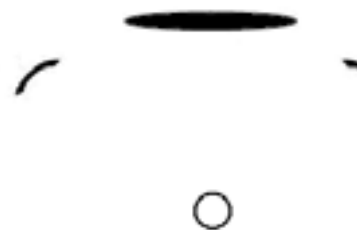
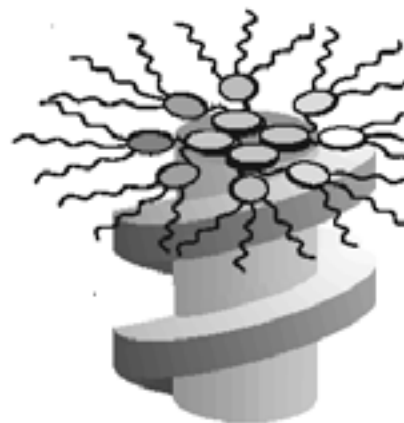


4. (6 min) The authors of the *Nature* paper suggests that molecules of the type shown in Question 3 pack together with the flat portion on the left (the part with all the NO_2 s) stacked in the middle to form a cylinder and the "hairy" part on the right arranged as a helical wrapping around the cylinder, denoted by the spiral around their rough figure shown on the right

As evidence to support the stacking and the helical wrapping of this material they show a fiber's x-ray scattering pattern, six spots of which are shown below right.

(The open circle in the middle shows where the undeflected x-ray beam would hit the film.)

Explain how the **six spots** support the existence of **stacking and helix**, and explain how the pattern shows the **spacing** of the stacking and the **pitch** (steepness) of the helix. **Is the pattern consistent** with the rough figure showing the packing?



8. (12 minutes) For **ONE** of the following two cases **draw** a schematic **x-ray difference density** plot, **explain** how it would be generated experimentally, **and** use it to **discuss** the curious nature of the bonding:

The C-F bond from a benzene ring **OR** The C-C bonds in a ring of three bonded carbons.

9. (Extra Credit) As a university science student, what is the most important trait you should have in common with Joseph Nathan Kane, who died last Sunday at the age of 103? [See obituary in today's New York Times]

