1. (5 min) A former Chem 125 student sent along a screen capture from last Monday’s Season 3 premiere of *Heroes*. The character Hiro finds a paper in his father’s safe containing chemical formulae, including one related to the structure of the antiviral *Tamiflu* shown below. Apparently Hiro says, “I knew I should’ve paid more attention in Chemistry class.”

To help Hiro out CIRCLE five functional groups in *Tamiflu* and NAME THEM.

2. (3 min) **Draw a pair** of plausible resonance structures for a **functional group that appears in Tamiflu**. You may show only the functional group and use “R”s to denote other stuff. Use a proper **arrow(s)** to connect the pair.
3. (4 min) **DESCRIBE** the nodal pattern in this atomic orbital **AND CIRCLE** its nickname: 1p 2p 3p 4p 5p 6p

4. (4 min) **HOW** did J. J. Thomson propose to modify Coulomb’s Law in 1923, and **WHY**?

5. (3 minutes) What is remarkable about the electron difference density map of the C=C=C=C group?

6. (4 minutes) **Explain briefly** how combining perpendicular 2p orbitals generates a new 2p orbital.
   
   (Pictures would help.)
7. (3 minutes) How does each of the following properties of the 2s state of an H-like atom scale with the nuclear charge $Z$?

No explanation required, just give the dependence on $Z$.

Radius of the spherical node $\propto$

Maximum probability density $\propto$

Total energy $\propto$

8. (4 minutes) Draw lines between the columns to choose the best experimental technique for studying each phenomenon.

No explanations required!

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Phenomena</th>
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<tr>
<td>Scanning Tunneling Microscopy</td>
<td>Dissolution of monomolecular layers from an organic crystal into a solvent</td>
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<tr>
<td>Atomic Force Microscopy</td>
<td>Shape of covalent bonds</td>
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<tr>
<td>X-ray crystallography</td>
<td>Location of atoms in a molecule deposited on graphite</td>
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9. (7.5 min) The second laser scattering during our in-class demonstration involved a mask with a large set of evenly-spaced PAIRS of vertical bars. Sketch the resulting scattering pattern that appeared on the projection screen AND MENTION its relevance to Rosalind Franklin’s x-ray pattern from a fiber of b-DNA.
10. The diagram is part of an “Erwin Meets Goldilocks” plot with two trial wave functions for the potential energy, which is shown in gray.

A) (2 min) Draw a horizontal line showing the TOTAL ENERGY for the ψ curve that becomes horizontal at the right. Be as accurate as you can.

B) (2 min) Is the total energy for the other trial ψ (the one that has a value of 0 at the right) higher or lower than that the one you drew in A? Explain your thinking.

C) (3 min) Assuming that this is a Hooke’s Law single-minimum problem, draw in the correct lowest-energy ψ function (NOT its energy), and extend all three ψ curves to the right as far as possible.

D) (5 min) Now assume that this potential is in fact the left half of a symmetric double minimum, and the original two ψ traces are part of correct solutions. Explain how one ψ may be considered “bonding”, and the other “antibonding”.
11. (0.5 min only – cheap, don’t waste time until you’ve finished the previous questions)

A class member created the following cartoon.

Briefly explain its relevance to our approach to quantum mechanics.