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>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning Tunneling Microscopy</td>
<td>Dissolution of monomolecular layers from an organic crystal into a solvent</td>
</tr>
<tr>
<td>Atomic Force Microscopy</td>
<td>Shape of covalent bonds</td>
</tr>
<tr>
<td>SNOM</td>
<td>Location of rare fluorescent molecules on a microchip</td>
</tr>
<tr>
<td>X-ray crystallography</td>
<td>Location of atoms in a molecule deposited on graphite</td>
</tr>
</tbody>
</table>

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 $\psi$ curve that becomes horizontal at the right. Be as accurate as you can.

B) (2 min) Is the total energy for the other trial $\psi$ (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 $\psi$ function (NOT its energy), and **extend all three $\psi$ 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 $\psi$ traces are part of **correct** solutions. **Explain** how one $\psi$ 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.