1. For each set of drawings below, draw the curved arrow(s) that get from one structure to the next.

   a.

   b.

   c.

   d.

   e.

2. For each of the compounds below, draw all resonance contributors.

   a.
3. Circle the most significant resonance contributor(s) in #2 above.

Additional Information:
Delocalized e- are shared by more than two atoms and contribute to the stability of the compound.

Resonance structures/contributors
Used to show the possible locations of delocalized e-s.
Use $\leftrightarrow$ between contributors and curved arrows to show how e-s “moved”.
Differ from ea. other ONLY in the location of the e-s and lone pairs (must have same atoms connected in the same order).
Delocalized Electrons: Resonance Structures - KEY

Combine most significant resonance structures to get the resonance hybrid (actual structure of molecule).

Drawing Resonance Structures/Contributors:
See also Special Topic V: Drawing Resonance Contributors in Study Guide and Solutions Manual of text.
Tail of a curved arrow shows where e- came from (bond or lone pair, never a + charge or empty space).
Head of curved arrow shows where e- go to (point between atoms to form bond or point to an atom to form lone pair, never into – charge and only very rarely into empty space (EX. Diels-Alder reaction)).

Two rules/commandments
1. Do NOT break a single bond.
2. Do NOT exceed an octet for second-row elements (C, N, O, F) – can have less than an octet (use formal charge) but NOT more – or 12 electrons for a third-row element (P, S, etc).

<table>
<thead>
<tr>
<th>Factors that INCREASE Stability</th>
<th>Factors that DECREASE Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>complete octets on all atoms</td>
<td>incomplete octets</td>
</tr>
<tr>
<td>no formal charge (FC)</td>
<td>separated charges/large FC/like charges on adjacent atoms</td>
</tr>
<tr>
<td>more covalent bonds</td>
<td>fewer covalent bonds</td>
</tr>
<tr>
<td>negative FC on more EN atoms</td>
<td>negative FC on less EN atoms</td>
</tr>
<tr>
<td>positive FC on less EN atoms</td>
<td>positive FC on more EN atoms</td>
</tr>
</tbody>
</table>

Predicting Relative Stability of Resonance Structures/Contributors:

Some examples comparing stabilities

```
violates rule 2

OK

violates rule 1
```
The more stable a resonance structure, the lower its energy and the more it contributes to the structure of the hybrid/actual molecule. The hybrid can be thought of as a weighted (based on stability) average of the resonance structures. In general, the more resonance structures you can draw for a particular compound, the more stable that compound – this is attributed to Resonance Stabilization Energy (RSE). RSE is defined as the difference in energy between the energy of the hybrid and the estimated energy of the lowest energy resonance contributor.

\[ RSE = E_{\text{hybrid}} - E_{\text{lowest E contributor}} \]

EX. Which is more stable, methoxide ion or methanoate ion?

The methanoate ion is more stable b/c it has resonance (RSE) whereas methoxide does not.

Some examples of BAD resonance structures:

- atoms (nuclei) are not in the same positions – not the same connectivity between atoms.
- two structures do NOT have the same number of unpaired electrons
- is OK, but not common to use these “no-bond” resonance structures
- these structures can NOT conform to any molecular geometry – too much strain