1. Which of the C-C single bonds indicated in the compound below is the shortest?

```
H—C≡C—CH==C—CH2—CH3
```

a) 1  c) 3  b) 2  d) 4  
e) 1, 2, 3, and 4 all have equivalent lengths.

2. What is the hybridization of the nitrogen atom in $\text{CH}_3\text{–CH}_2\text{–C}≡\text{N}$?

a) sp  d) sp$^2$  
b) sp$^2$  e) sp$^3$  
c) sp$^3$

3. Which of the C-H bonds indicated in the compound below is the shortest?

```
H—C≡C—CH==C—CH2—CH3
```

a) 1  c) 3  b) 2  d) 4  
e) 1, 2, 3, and 4 all have equivalent lengths.

4. Given these isomers of C$_7$H$_{16}$:

1)  

2)  

Which choice below is an isomer of C$_7$H$_{16}$ not shown above?

a)  

b)  

c)  

d)  

e)  

5. How many secondary carbons are in the compound below?

```
H3C—CH(CH3)C(CH3)$_2$CH2CH2C(CH2)$_3$
```

a) 2  d) 5  
b) 3  e) 6  
c) 4

6. Given:

```
\begin{align*}
\text{N}\equiv\text{C} & \equiv\text{CH} & \equiv\text{CH} & \equiv\text{CH}_3 \\
ap & b & c
\end{align*}
```

The approximate bond angle formed by atoms a, b, and c is:

a) 180°  d) 90°  
b) 120°  e) 60°  
c) 109.5°

7. Which of the following pairs are not resonance structures?

a)  

b)  

c)  

d)  

e)  

8. What is the molecular formula of anthracene, shown below?

```
\begin{align*}
\text{H}_3\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C} & \equiv\text{C}
\end{align*}
```

a) C$_{14}$H$_{10}$  
b) C$_{14}$H$_{12}$  
c) C$_{14}$H$_{14}$  
d) C$_{18}$H$_{14}$  
e) C$_{18}$H$_{12}$
9. Which of the Newman projections corresponds to point 5 shown on the energy profile below (rotation about carbons 2 and 3 of butane)?

10. What is the IUPAC name of the compound shown?

11. What is the correct name of the compound below?

12. What is the IUPAC name of the compound shown?

13. Identify the functional group in the molecule below:

14. Which of the alkanes listed has the highest boiling point?

Part II. Short Answer.
For questions 1 and 2, use the table below:

<table>
<thead>
<tr>
<th>Bond</th>
<th>Strain Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃ ⇔ H</td>
<td>1, 3 diaxial</td>
</tr>
<tr>
<td>H ⇔ H</td>
<td>eclipsed</td>
</tr>
<tr>
<td>H ⇔ CH₃</td>
<td>eclipsed</td>
</tr>
<tr>
<td>CH₃ ⇔ CH₃</td>
<td>eclipsed</td>
</tr>
<tr>
<td>CH₃ ⇔ CH₃</td>
<td>gauche</td>
</tr>
</tbody>
</table>

1. Consider the molecule 2-methylbutane. Sighting along the C2-C3 axis, draw Newman projections of the two staggered conformations of this molecule. Use the data in the table above to calculate the total strain energy of each structure, determine the difference in energy between the two structures, and indicate which conformation is more stable.
2. Consider the following two molecules:
   - cis-1,2-dimethylcyclohexane
   - trans-1,2-dimethylcyclohexane

   Draw the more stable conformation of each molecule. Use the data in the table above to calculate the total strain energy of each structure. Indicate which, if either, is more stable, and calculate the energy difference between the two structures.

3. 2,4-pentanedione, shown below, is a weak acid with a pK<sub>a</sub> = 9.

   ![2,4-pentanedione molecule]

   a) Label the hydrogens above as primary, secondary, or tertiary.

   b) Draw all resonance structures of the conjugate base of 2,4-pentanedione. (In forming the conjugate base, be sure to remove the most acidic hydrogen.)

   c) Is 2,4-pentanedione a strong enough acid to react almost completely with NaOH? (The pK<sub>a</sub> of H<sub>2</sub>O is 15.74.) If the answer is yes, write the balanced equation.

4. Draw and name all constitutional isomers with the molecular formula C<sub>4</sub>H<sub>9</sub>Cl.

Answers to Multiple Choice:

1. b  6. b  11. a  
2. a  7. c  12. c  
3. a  8. a  13. d  
4. d  9. b  14. e  
5. c  10. e  