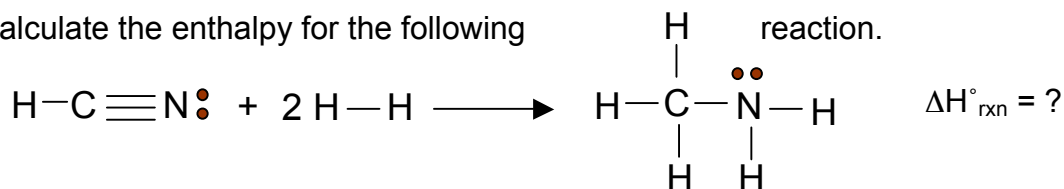


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**Worksheet 9: Organic Chemistry**


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1. Calculate the enthalpy for the following reaction.



Bond	Energy in kJ/mol	Bond	Energy in kJ/mol
C - N	305	N-H	391
C $\equiv$ N	891	N-N	160
C-H	413	N-O	201
H-H	432	N=N	418
O = O	498	N $\equiv$ N	945

2. Use the average bond energies to estimate the enthalpy changes of the following reactions:

- $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$
- $\text{N}_2 + 2 \text{H}_2 \rightarrow \text{H}_2\text{NNH}_2$
- $2 \text{N}_2 + \text{O}_2$  (double bond)  $\rightarrow 2 \text{N}_2\text{O}$

3. Name the following compounds (or draw the molecule if given the name):

Structure	Name
(a) $\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3\text{CHCH}_2\text{CH}_3 \end{array}$	
(b) $\begin{array}{c} \text{H}_2\text{C}=\text{CHCH}_2\text{CH}-\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	
(c) $\begin{array}{c} \text{Cl} \\   \\ \text{CH}_3\text{CHCH}_2\text{CH}_3 \end{array}$	
(d) $\begin{array}{c} \text{OH} \\   \\ \text{CH}_3\text{CHCH}_2\text{CH}_3 \end{array}$	
(e) $\begin{array}{c} \text{O} \\    \\ \text{CH}_3\text{CCH}_2\text{CH}_3 \end{array}$	
(f) $\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\   \quad   \\ \text{CH}_3\text{C}=\text{CHCHCH}_2\text{CH}_3 \end{array}$	

(g)	$\begin{array}{c} \text{CH}_2\text{CH}_2\text{CH}_3 \\   \\ \text{HOCH}_2\text{CCH}_3 \\   \\ \text{CH}_2\text{CH}_2\text{CH}_3 \end{array}$	
(h)		2,4,5-trimethylnonane
(i)		4-bromo-2-pentyne
(j)		3-heptanone
(k)		5,6 -dimethyl-1-octanol

4. Determine the types of isomers the following represent. The choices are skeletal, positional, geometric, and functional isomers. (Be careful! It may be the same molecule just drawn a different way.)

	Molecules	Type of Isomer
(a)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ $\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3\text{CHCH}_2\text{CH}_3 \end{array}$	
(b)	$\begin{array}{c} \text{H}_3\text{C} \quad \text{CH}_3 \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H}_3\text{C} \quad \text{CH}_3 \end{array}$ $\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H}_3\text{C} \quad \text{CH}_2\text{CH}_3 \end{array}$	
(c)	$\begin{array}{c} \text{H}_3\text{CH}_2\text{C} \quad \text{CH}_2\text{CH}_2\text{CH}_3 \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ $\begin{array}{c} \text{H}_3\text{CH}_2\text{C} \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{CH}_2\text{CH}_2\text{CH}_3 \end{array}$	
(d)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$ $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	

(e) $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{OH}$	$\begin{array}{c} \text{O} \\    \\ \text{CH}_3\text{CCH}_2\text{CH}_3 \end{array}$	
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5. In the space below, sketch what you would expect the GC data to look like for a liquid mixture containing equal amounts of the following three alkanes: decane, hexane, and octane. *Be sure to label the axes and peaks appropriately.*

(b) Explain why you plotted the data the way you did, particularly commenting on the relationship between alkane structure (and length), boiling points, and retention time.

6. Given the information in the table below, what relationship do you notice between bond strength and IR vibrational frequency? Between bond length and vibrational frequency? Explain this trend below.

Bond	IR Vibrational Frequency (in $\text{cm}^{-1}$ )
C — O	~1180
C = O	~1730

7. NOCl (1 chlorine) has 4 possible structures. They are broken into two groups. Two resonance structures are isomers of the other two resonance structures. (a) Draw all 4 structures. (*Hint: N and Cl have the same electronegativity.*) (b) Which structure is the best? Why?

Key:

1. -158 kJ
2. a. -105 kJ b. 85 kJ c. 96 kJ
3.
  - a. methylbutane or 2-methylbutane
  - b. 4-methyl-1-pentene
  - c. 2-chlorbutane
  - d. 2-butanol
  - e. butanone or 2-butanone
  - f. 2,4-dimethyl-2-hexene
  - g. 2-methyl-2-propyl-1-pentanol
4.
  - a. skeletal
  - b. skeletal
  - c. geometric
  - d. same molecule
  - e. functional
5.
  - a. x-axis: retention time (s), y-axis: Port (V), Three peaks with equal areas, first peak is hexane, then octane, then decane
  - b. Longer chain, higher boiling point, longer retention time
6. Longer bonds, weaker bonds, less vibrational energy
7.
  - a. Four structures are:
    - Cl single bond N double bond O with enough lone pairs on each to give each 8 electrons
    - Cl double bond N single bond O with enough lone pairs on each to give each 8 electrons
    - N single bond Cl double bond O with enough lone pairs on each to give each 8 electrons
    - N double bond Cl single bond O with enough lone pairs on each to give each 8 electrons
  - b. Best structure is first one mentioned. Lowest formal charges (zero on everything).