

## Developing Skills

## A.5 Hydrocarbon Boiling Points

Chemists investigate substances' physical and chemical properties and identify useful patterns among data, often stimulating efforts to explain such regularities.

Organic nomenclature will be introduced in *Investigating Matter A.7*. That scheme will relate to total carbon atoms, reinforcing ideas presented here.

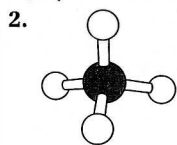
## Answers

- a. Alphabetically  
b. Only in a very limited context, such as in a handbook or chart for locating a hydrocarbon
- a. Arranged by boiling-point values or total carbons (or hydrogens)  
b. With lowest boiling point first, the order is methane, ethane, propane, butane, pentane, hexane, heptane, octane, nonane, decane.
- Methane, ethane, propane, butane
- It must be less than 22 °C.
- Pentane
- Decane's boiling point is higher, suggesting that decane's intermolecular forces are greater than those among butane molecules.

## Additional ChemQuandaries

2. A transparent butane lighter reveals at least some butane is in the liquid. Explain why this is possible if the liquid is at room temperature.

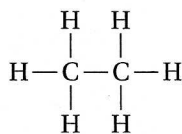
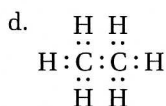
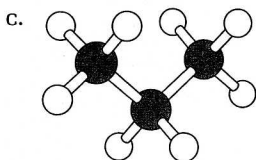
Discussion: A liquid's boiling point also depends on pressure. Apparently, butane is under pressure above 1 atm (where it boils at 0.5 °C); its boiling point at this pressure is greater than room temperature. Therefore, some is liquid.



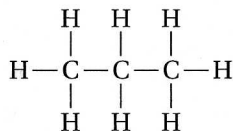
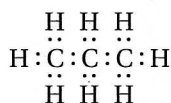
Modeling Alkane

3. a. 6

b. 8



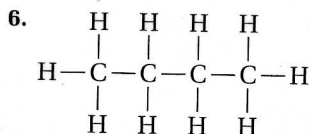
ethane



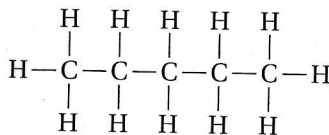
propane

4. C<sub>3</sub>H<sub>8</sub>C<sub>4</sub>H<sub>10</sub>

5. No question—students disassemble models.



butane



pentane

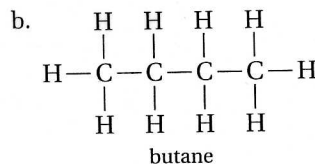
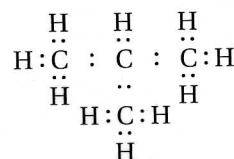
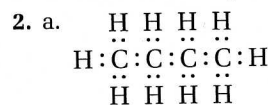
- a. (i) heptane (ii) nonane  
b. (i) C<sub>7</sub>H<sub>16</sub> (ii) C<sub>9</sub>H<sub>20</sub>
- a. C<sub>25</sub>H<sub>52</sub>  
b. The molecular formula. This shorter version takes much less time and space.
- 5(12) + 12(1) = 72 g/mol
- a. ethane (C<sub>2</sub>H<sub>6</sub>): 2(12) + 6(1) = 30 g/mol  
b. butane (C<sub>4</sub>H<sub>10</sub>): 4(12) + 10(1) = 58 g/mol  
c. octane (C<sub>8</sub>H<sub>18</sub>): 8(12) + 18(1) = 114 g/mol

## Answers DS 3A.8

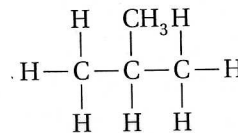
- Graphs should show a direct relationship.
- Approximately 30 °C. (The ΔT as one -CH<sub>2</sub>- is added is represented by the slope of the line.)  
a and b.  
C<sub>11</sub>H<sub>24</sub>: 204 °C (actual: 196 °C);  
C<sub>12</sub>H<sub>26</sub>: 234 °C (actual: 216 °C);  
C<sub>13</sub>H<sub>28</sub>: 264 °C (actual: 235 °C)
- Attractive forces increase in strength as the number of carbons in each alkane molecule increases.

## Answers IM 3A.9

1. Two isomers are possible.



butane



2-methylpropane

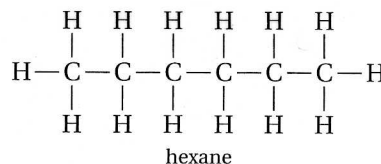
3. Build.

## PENTANE ISOMERS AND THEIR BOILING POINTS

Structural Formula	Boiling Point (°C)
CH <sub>3</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>3</sub>	36.1
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \end{array}$	27.8
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	9.5

Table 3.4

4. a. Students draw several hexane isomers:



hexane

See Board!