Chapter 1
Temperature and Density

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Temperature Scale

This is a measure of hotness. Heat will flow from higher temperature to lower temperatures.

Units:
- Celsius, °C
- Fahrenheit, °F
- Kelvin, K

Temperature Unit Conversions:
- \( °C = (°F - 32) \times \frac{5}{9} \)
- \( °F = \frac{9}{5} \times °C + 32 \)
- \( K = °C + 273 \)
Solved Problem:
In winter, the average low temperature in interior Alaska is \(-30.\,^\circ F\) (two significant figures). What is this temperature in degrees Celsius and in kelvins?

\[
t_C = \left( t_F - 32^\circ F \right) \frac{5^\circ C}{9^\circ F}
\]

\[
t_C = (-30.\,^\circ F - 32^\circ F) \frac{5^\circ C}{9^\circ F}
\]

\[
t_C = (-62^\circ F) \frac{5^\circ C}{9^\circ F}
\]

\[
t_C = -34.4444444^\circ C
\]

\[
t_C = -34^\circ C
\]

\[
t_K = \left( t_C \times \frac{1K}{1^\circ C} \right) + 273.15 \, K
\]

\[
t_K = \left( -34^\circ C \times \frac{1K}{1^\circ C} \right) + 273.15 \, K
\]

\[
t_K = -34 \, K + 273.15 \, K
\]

\[
t_K = 239.15 \, K
\]

\[
t_K = 239 \, K
\]
Derived Units

• These are a combination of the same unit (m\(^2\)) or two different units (m/s).

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Definition of Quantity</th>
<th>SI Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>length × length</td>
<td>m(^2)</td>
</tr>
<tr>
<td>Volume</td>
<td>length × length × length</td>
<td>m(^3)</td>
</tr>
<tr>
<td>Density</td>
<td>mass per unit volume</td>
<td>kg/m(^3)</td>
</tr>
<tr>
<td>Speed</td>
<td>distance per unit time</td>
<td>m/s</td>
</tr>
<tr>
<td>Acceleration</td>
<td>change in speed per unit time</td>
<td>m/s(^2)</td>
</tr>
</tbody>
</table>
Density

- Mass per unit volume
- Units: g/cm^3 (solids), g/mL (liquids and gases)

Solved Problem:
Oil of wintergreen is a colorless liquid used as a flavoring. A 28.1-g sample of oil of wintergreen has a volume of 23.7 mL. What is the density of oil of wintergreen?

\[ m = 28.1 \, \text{g} \]
\[ V = 23.7 \, \text{mL} \]

\[ d = \frac{m}{V} \]

\[ d = \frac{28.1 \, \text{g}}{23.7 \, \text{mL}} \]

\[ d = 1.18565491 \, \text{g/mL} \]

\[ d = 1.19 \, \text{g/mL} \]
Solved Problem:
A sample of gasoline has a density of 0.718 g/mL. What is the volume of 454 g of gasoline?

\[ m = 454 \text{ g} \]
\[ d = 0.718 \frac{\text{g}}{\text{mL}} \]

\[ V = \frac{m}{d} \]
\[ V = \frac{454 \text{ g}}{0.718 \frac{\text{g}}{\text{mL}}} \]

\[ V = 632.311978 \text{ mL} \]

\[ V = 632 \text{ mL} \]
Dimensional Analysis

• A systematic way of calculating by using units during calculations.
• Start with what you know and then sequentially use conversion factors to get the right answer.
• Tips for Problem Solving
  • Read carefully; find information given and what is asked for
  • Find appropriate equations, constants, conversion factors
  • Check for sign, units and significant figures
  • Check for reasonable answer
Solved Problem:
Convert 12.00 inches to meters.
Conversion factors needed:

\[
2.54 \text{ cm} = 1 \text{ in} \quad \text{and} \quad 100 \text{ cm} = 1 \text{ meter}
\]

\[
12.00 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 0.3048 \text{ m}
\]

Solved Problem:
The Food and Drug Administration (FDA) recommends that dietary sodium intake be no more than 2400 mg per day. What is this mass in pounds (lb), if 1 lb = 453.6 g?

\[
2400 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} = 5.3 \times 10^{-3} \text{ lb}
\]
Key Words/Concepts

• Temperature
• Density
• Dimensional Analysis