### SI Prefixes and Symbols

<table>
<thead>
<tr>
<th>Multiplication</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^9$</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>$10^6$</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>$10^3$</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>$10^2$</td>
<td>centi</td>
<td>c</td>
</tr>
</tbody>
</table>

### Prefixes and Symbols (cont.)

<table>
<thead>
<tr>
<th>Multiplication</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-3}$</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>micro</td>
<td>μ</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>nano</td>
<td>n</td>
</tr>
</tbody>
</table>

### SI Base Units and Symbols

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Base Unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>meter</td>
<td>m</td>
</tr>
<tr>
<td>mass</td>
<td>kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>temperature</td>
<td>Kelvin</td>
<td>K</td>
</tr>
<tr>
<td>amount</td>
<td>mole</td>
<td>mol</td>
</tr>
</tbody>
</table>

1 mole = $6.02 \times 10^{23}$ atoms or molecules
Derived SI Units

Force = Mass x Acceleration
Units: Newton (N) (kg m s⁻²)

Note:
A negative exponent, such as m⁻² means that the term is in the denominator. Thus, N m⁻² is equivalent to \( \frac{N}{m^2} \)

Derived SI Units

Force (N)

\[ \text{Area (m}^2) \]

Pressure = Force/Area
Units: Pascal (Pa) (N m⁻²)
Energy (work) = Force x Distance
Units: Joule (J) (N m)

It is useful to note that at 20°C, 1 gram of water must absorb 2450 J of energy to change from a liquid to a gaseous state. In other words, it takes 2450 J of energy to evaporate 1 g of liquid water whose temperature is 20°C.

Power (energy flux) = Energy/Time
Units: Watt (W) (J s⁻¹)
**Derived SI Units**

![Energy Flux Diagram](image)

Energy Flux (W) → Area (m²)

Energy Flux Density = Flux/Area

Units: W m⁻² (J s⁻¹ m⁻²)

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**A Note on Flux Density**

Most leaves have two surfaces (top and bottom). Flux densities for leaves are usually expressed per m² of projected area. For a flat leaf, projected area is half that of the total area.

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**A Note on Flux Density (cont.)**

Expressing flux densities on a projected area basis assumes that all of the flux originates or is received by one surface of the leaf only.
Question

If the flux density of radiant energy from the sun is 1000 J s⁻¹ m⁻², how much radiant energy is being received by a soybean leaf in 1 second if its leaf area is 10 cm²?

Solution

Amount per sec = flux density x leaf area
= 1000 J s⁻¹ m⁻² x 10 cm² x m²/10000 cm²
= 1 J s⁻¹

Derived SI Units

Concentration (mole fraction)
Units: mol mol⁻¹

\[ c_{\text{purple}} = \frac{\text{mol}_{\text{purple}}}{\text{mol}_{\text{purple}} + \text{mol}_{\text{green}}} \]
**Derived SI Units**

**No. of moles**

Volume (m³)

Concentration (molar density)
Molar density = moles/volume
Units: mol m⁻³

**Derived SI Units**

Mole Flux (mol s⁻¹)

Area (m²)

Mole Flux Density = Mole Flux/Area
Units: mol s⁻¹ m⁻²

**Derived SI Units**

Mass (kg)

Volume (m³)

Density = Mass/Volume
Units: kg m⁻³
**Derived SI Units**

Mass Flux (kg s\(^{-1}\))

Area (m\(^2\))

Mass Flux Density = Mass Flux/Area

Units: kg s\(^{-1}\) m\(^{-2}\)

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**Law of Partial Pressures**

\[ P_{\text{total}} = P_{\text{green}} + P_{\text{purple}} \]

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**Law of Partial Pressures**

One method of expressing the concentration of water vapor in the air is in terms of the partial pressure of water vapor in the air. This partial pressure is called vapor pressure.
Law of Partial Pressures

At sea level, the total atmospheric pressure is about 100 kPa. A typical value of vapor pressure is 2 kPa. This means that of the total atmospheric pressure of 100 kPa, the water vapor contributes 2 kPa, or 2%.

Diffusion and Fick’s Law

Transport is driven by the concentration difference $c_{p2} - c_{p1}$.
Fick’s Law (cont.)

\[ J_p = -g \left( c_{p2} - c_{p1} \right) \]

\( g \) (m s\(^{-1}\)) is conductance which describes the ease of transport. \( g \) increases with temperature, and decreases with pressure and size of the molecule.

Fick’s Law (cont.)

\[ J = -g \left( c_2 - c_1 \right) \]

\( g \) (m s\(^{-1}\)) is conductance which describes the ease of transport. \( g \) increases with temperature, and decreases with pressure and size of the molecule.

Ficks’ Law (cont.)

\[ J = -\frac{(c_2 - c_1)}{r} \]

\( r \) (s m\(^{-1}\)) is a resistance (1/g) which describes resistance to transport. \( r \) decreases with temperature, and increases with pressure and size of the molecule.
**Sign Convention**

Flux density has a sign associated with it that indicates the direction of the flux.

\[
\begin{array}{c}
+ \\
J \\
- \\
J \\
\end{array}
\]

Surface

**Question**

If the water vapor concentration in the interior of a soybean leaf is 30 g m\(^{-3}\), the water vapor concentration in the air surrounding the leaf is 20 g m\(^{-3}\), and the leaf conductance to vapor diffusion is 0.01 m s\(^{-1}\), what is the flux density of water vapor diffusing from the leaf to the air?

**Solution**

From Fick’s law

\[
J_v = -g_v (C_{v(leaf)} - C_{v(air)})
\]

where \(J_v\) is the flux density of water vapor diffusing from the leaf, \(g_v\) is leaf conductance to vapor diffusion, and \(C_{v(leaf)}\) and \(C_{v(air)}\) are water vapor concentrations in the leaf and air, respectively.

\[
J_v = -0.01 \text{ m s}^{-1} (30 \text{ g m}^{-3} - 20 \text{ g m}^{-3})
\]

\[
= -0.1 \text{ g m}^{-2} \text{ s}^{-1}
\]