This experiment was to distill water nitric acid from a mixture of sodium nitrate and nitric acid. 25 grams of Sodium Nitrate (Old Salt) and 15 grams of concentrated nitric acid, were put into a retort.

And arranged as in figure. The new worms I had to a constant cool by cold water. At first its color was filled with a dark brown for a bit it became almost transparent, and towards the end of the experiment, when the nitrate in the retort, was almost dried up, its color was filled with a very high gas.

After enough acid had been distilled, or rather when the sodium nitrate had become dry, the contents of retort were crystallized from water.

The nitric acid obtained had a yellowish brown color and appeared to be very strong as it gave off white fumes in contact with air.

Friday 23rd May 1890.
Phase Diagram for CO\textsubscript{2}
Phase Diagram for $H_2O$
Masterpiece in Focus

Soap Bubbles

by Jean-Siméon Chardin
The Liquid State

- Density
- Compressibility
- Diffusion
- Evaporation
- Vapor pressure
- Surface tension
- Viscosity
- Adhesive/cohesive forces
- Capillary action
Density of Ice and Water
Compressibility
Surface Tension
Equilibrium Vapor Pressure
Vapor Pressure Curves

![Vapor Pressure Curves Diagram](image)

- Diethyl ether: Normal b.p. 34.6°C
- Ethyl alcohol: Normal b.p. 78.5°C
- H₂O: Normal b.p. 100°C
Trouton’s Rule

An interesting and useful “approximation:

• Says that the ratio of the heat of vaporization and the boiling point is (roughly) constant.
  \[ \Delta H_{\text{vap}} / T_{\text{b.p.}} \sim 88 \text{ J/mol} \]

• Boiling point of cyclohexane is 69°C. Therefore,
  \[ \Delta H_{\text{vap}} = (69 + 273)(88) \sim 30 \text{ kJ/mol} \]
  which is within 2-3% of the experimental value.

• Works well for unassociated liquids and gives useful information about degree of association.
Trouton’s Rule

Nonassociated (ideal) liquids, $\Delta H_{vap}/T_{b.p.} \sim 88$ J/mol
- carbon tetrachloride
- benzene
- cyclohexane

Associated liquids, $\Delta H_{vap}/T_{b.p.} > 88$ J/mol
- water (110)
- methanol (112)
- ammonia (97)

Association in the vapor state, $\Delta H_{vap}/T_{b.p.} < 88$ J/mol
- acetic acid (62)
- hydrogen fluoride (26)
Colligative Properties

- Thought Experiment -

(a) Sea water

(b) Pure water
Colligative Properties

- Elevation of the normal boiling point
- Lowering of the normal freezing point
Elevation of the normal b.p.
Raoult’s Law

- Nonvolatile solute in volatile solvent:
  \[ p = p^\circ X_{\text{solvent}} \]
  \[ p^\circ - p = \Delta p = p^\circ X_{\text{solute}} \]

- Elevation of the boiling point:  \[ \Delta T = K_{bp} m \]

- Depression of the freezing point:  \[ \Delta T = K_{fp} m \]

- Osmostic pressure:  \( \Pi = cRT \)
### Boiling and Freezing Point Constants for Some Solvents

<table>
<thead>
<tr>
<th>Solvent</th>
<th>$K_b(^\circ C/m)$</th>
<th>Solvent</th>
<th>$K_t(^\circ C/m)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>0.52</td>
<td>water</td>
<td>−1.86</td>
</tr>
<tr>
<td>ethyl alcohol</td>
<td>1.20</td>
<td>acetic acid</td>
<td>−3.90</td>
</tr>
<tr>
<td>benzene</td>
<td>2.67</td>
<td>chloroform</td>
<td>−4.68</td>
</tr>
<tr>
<td>acetic acid</td>
<td>2.93</td>
<td>benzene</td>
<td>−5.12</td>
</tr>
<tr>
<td>chloroform</td>
<td>3.85</td>
<td>naphthalene</td>
<td>−7.00</td>
</tr>
<tr>
<td>carbon tetrachloride</td>
<td>5.02</td>
<td>camphor</td>
<td>−40.0</td>
</tr>
</tbody>
</table>
Phase Diagram for H₂O
Colligative Properties

- Elevation of the normal boiling point
- Lowering of the normal freezing point
Elevation of the normal b.p.
Super Slurper

Pampers phases
ULTRA DRY THINS
XL X-Large Diapers for Boys
Walker 3
26 lbs. and over
24
Super Slurper

• “Slurper” molecules are polymers with hydrophilic ends that grab onto water molecules.
• Sodium salt of poly(acrylic acid).
• $\text{R-COO}^-, \text{Na}^+$
Osmosis/Osmotic Pressure

Applications:
- Treating industrial wastes
- Pulp and paper manufacture
- Reclamation of brackish/salt water
- Sewage treatment
- Electrodialysis
- Many biological/ecological processes
Osmosis/Osmotic Pressure

Diagram:
- Sugar solution
- Semipermeable membrane
- Water
Osmosis/Osmotic Pressure

- DRIED PLUMS... (used to be "prunes")
- Carrots
- Eggs
- Blood cells
(a) Isotonic solution  (b) Hypertonic solution  (c) Hypotonic solution
Osmosis/Osmotic Pressure

In dilute solutions:
\[ \Pi V = n_2RT = \left[\frac{g_2}{M_2}\right]RT \]
\[ \Pi = cRT \text{ where } c \sim \text{mol/L} \]

Solubility of hemoglobin in water is 5.0 g/L
Strategy/LOGIC?
\[ \Pi = 1.80 \times 10^{-3} \text{ atm @ 25°C} \]
\[ C = \frac{\Pi}{RT} = \text{mol/L} \]
\[ MW = \left[\frac{g/L}{\text{mol/L}}\right] = g/\text{mol} \]
Normal and Reverse Osmotic Systems
Desalting Water on Catalina Island

Reverse osmosis, a popular technology for small- and medium-sized desalting plants, will be used on Santa Catalina Island off California. It is the first seawater-desalting plant for an American residential community.

1. Salt water is filtered to remove big particles.
2. A pump pushes the salt water into a reverse osmosis unit.
3. Cylinders with membranes remove impurities and salt from the water.
4. The water is treated with chlorine, lime and carbon dioxide and stored.

Saltwater or media filters: Layers of gravel and sand that remove all big particles.

Chlorinator: Chemicals are used to disinfect the water and make it less acidic.

Source: Hamilton Cove Associates
Example

Estimate the “back pressure” needed to obtain pure water from sea water by “reverse” osmosis.

Strategy/LOGIC?
Van't Hoff i-Factor

- Colligative effects depend on number of particles.
- Ionization and dissociation multiply colligative effects.
- Association acts in the opposite sense.
Van’t Hoff i-factor

\[ i = \frac{\Delta T_{\text{electrolyt}}}{\Delta T_{\text{nonelectro}}} \]

\[ \Delta T = iK_{bp}m \text{ (boiling point elevation)} \]
\[ \Delta T = iK_{fp}m \text{ (freezing point depression)} \]
\[ \Pi = icRT \text{ (osmotic pressure)} \]
Natural de-icer means you’ll have to shovel less this winter

All-natural grain juices dissolve away snow, prevent snow from adhering for 10-14 days! Perfect for clearing driveways, walks and protecting plants.

Snowy nights will never keep me awake now! Now I sleep through the storm. mornings, all other guys on the block are up shoveling, with shovels, ice choppers, bags of salt—but my driveway and sidewalk are easier to clear! I’m dreaming! No, ac this stuff is real. Put it on the ground before a storm and it reduces the amount of snow that accumulates. Yeah, I didn’t believe it either, until I heard what the toughest road crews in America were saying about Bare Ground. Storms tested by state highway departments. These are the guys who stay up all night breaking through drifts, plowing, fighting hazardous road. If they use it, it must be good! And it is. Bare Ground Anti-Ice® is a liquid that you spray or spread on a road or sidewalk. It not only stops snow and ice but prevents future deposits from sticking for 10 to 14 days! It’s not expensive either, because a little goes a long way! One gallon equals 30 pounds of salt. Already got snow or ice on your sidewalk or driveway? No problem. Just spray on a day or two after snowfall. Bare Ground liquid. Instead of staying on top it sinks down to the bare pavement and dissolves the bond of snow or ice that holds it to the surface. No long waiting either—it starts working in about 20 minutes. Another reason the dollar-conscious pros use it: one gallon of Bare Ground is the equivalent of 30 pounds of salt or pellets!

Safe for pets, kids, shrubs and carpets. Bare Ground is environmentally safe, biodegradable and non-toxic. Harmless to plants and grass. Bare Ground won’t eat up the half carpet like salt. Unlike other snow melters, you can use Bare Ground on any surface including rubber, asphalt, slate, wood, brick or new concrete. In fact, Bare Ground is so safe, you may even wish to mix it with water and apply to trees and shrubs to prevent excessive ice buildup. It was discovered by two Hungarian distillery workers when they noticed that plant was not water going into a local pond kept everything from freezing—even in the deep of frigid Hungarian winters. They isolated the key ingredients—all natural byproducts and patented the formula. And now you can throw away your shovel and hire your herman doctor forever! One gallon protects a 20’ x 50’ driveway. Think of it also as protection against a strong

How does Bare Ground Work?

Unlike rock salt or other products that sit on the surface and melt from the top down, Bare Ground works just like the water does, melting as it goes down, and not just on the sides of the area in front of the shovel. Bare Ground is not for a quick, easy and complete cleanup.

Technoscout.com

Where high tech hits home

For years, we have found high tech solutions for the problem of bringing together data to merge it into a complete picture of your business. Technoscout is now the high-tech, low-cost way to a better life.

Bare Ground Solution System with Sprayer $28.95 $25.95 (S&H)

Gallon Refill $9.95 $8.95 (S&H)

Pure Minnesota product code 7058-10071.

For fastest service, call toll-free 24 hours a day.

800-992-2966

It may be a little more to the desk location including S&H. It is a charge to your credit card, excludes state sales tax and highlights appropriate state. Virginia residents only—please include 33% sales tax.

A Continental Industries Company

Echonoscout

Bare Ground Inc.

Manufactured in Korea by Continental Industries

MADE IN KOREA
Another Estimate Problem

• ... the lowest temperature your car radiator fluid could withstand and still remain fluid if your car radiator fluid was... VODKA!

• Strategy/LOGIC?
This experiment was to distil over nitric acid from a mixture of Sodium nitrite and sulphuric acid. 25 grams of Sodium nitrite and 15 grams of concentrated sulphuric acid were put into a retort.

After enough acid had been distilled, or rather when the Sodium nitrite had become dry, the contents of the retort were crystallized from water. The nitric acid obtained had a yellowish brown color and appeared to be very strong as it gave off white fumes in contact with air.
Simple Distillation

- Mixture of benzene and toluene form a nearly ideal solution.
- Use Raoult’s law to calculate the composition of the solution.
- Use Dalton’s law to calculate the composition of the vapor above the solution.
- Vapor is “richer” in the more volatile component.
Partial Pressures and Total Pressure in a Binary Mixture

\[ P_T = p_{H_2O} + p_{C_2H_5OH} \]

\[ p_{C_2H_5OH} = p^*_{C_2H_5OH} X_{C_2H_5OH} \]

\[ p_{H_2O} = p^*_{H_2O} X_{H_2O} \]

For the case where:

- \( X_{C_2H_5OH} = 0.80 \)
- \( X_{H_2O} = 0.20 \)

From the graph:

- \( p_{H_2O} = 3.5 \) torr
- \( p_{C_2H_5OH} = 34.5 \) torr
- \( P_{Total} = 38.0 \) torr
Binary mixtures of Volatile Components

- Nearly ideal: Minor differences between intra- and intermolecular forces between molecules
- Positive deviation: Intramolecular forces favored: A–A and B–B types
- Negative deviation: Intermolecular forces favored: A–B and B–A types
Distillation

• Simple distillation... as recorded by Maxfield Parish in his freshman chemistry laboratory notebook.
• Fractional distillation... on a laboratory scale of 1000mL/h
• Separation of petroleum hydrocarbon mixtures on an industrial scale ~50,000 gal/d
Benzene and Toluene form an ideal solution