What's That Stuff? Engaging the Next Generation of Scientists

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Like Ralph Ellison’s unnamed protagonist or H.G. Wells’ troubled scientist known only as Griffin, chemistry is too *INVISIBLE* to the everyday comings and goings of the non-scientific American public.
American society and commerce depend heavily on cars so why not teach some chemistry intimately associated with how cars work?
How does a car’s non-electrical, purely mechanical radiator thermostat work?

$6
Car Radiator Thermostat immersed in beaker of water

\[ T_{\text{water}} = \sim 25^\circ\text{C} \]

Valve closed (no water flow into radiator)

Cylinder filled with wax, \( T_{mp} = \sim 180^\circ\text{F} \)

Look here
\[ T_{\text{water}} = 100^\circ C \]

- Valve open
- Water flows into radiator
- Cylinder below thermostat bottom
Concepts:
- melting temp, phase change
- thermal expansion
- density (solid vs. liquid)
- intermolecular forces
Air Conditioning/Refrigeration: Some **COOL** Chemistry

1 = compressor       2 = condenser       3 = filter/dryer
4 = expansion valve       5 = evaporator & blower unit

High pressure gas
High pressure liquid
Low pressure liquid
Low pressure gas
Why the difference in the diameters of the AC tubing?

High or low pressure?

Liquid or gas?

Flow in or out?
What chemical concepts help formulate an effective car coolant?

Properties:
- boiling & freezing temperatures
- heat capacity
- viscosity
- thermal lability/reactivity
Patented Carboxylate Protection

Silicate & Phosphate Free
<table>
<thead>
<tr>
<th>Coolant Concentration</th>
<th>Freeze Point Protection</th>
<th>Boilover Protection</th>
<th>Product Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>40% Coolant 60% water</td>
<td>-7°F</td>
<td>260°F</td>
<td>5 years or 150,000 miles</td>
</tr>
<tr>
<td>50% Coolant 50% water</td>
<td>-34°F</td>
<td>265°F</td>
<td></td>
</tr>
<tr>
<td>66% Coolant 34% water</td>
<td>-84°F</td>
<td>270°F</td>
<td></td>
</tr>
</tbody>
</table>

**Values based on using a 15 lb. pressure cap**

*DEXCOOL is a registered trademark of General Motors Corporation.*
Properties to consider:

- boiling & freezing temperatures
- hygroscopicity
- viscosity
- heat capacity
- others?

Minimum Wet Boiling Temp. 284°F
What information is needed to verify this marketing statement?
Hmmm...let’s see. It’s poured into the gas tank so how can the water be physically removed? Bogus claim?
1,1,1,2-Tetrafluoroethane = R-134a

Commercially available auto recharge refrigerant

F
F
F

F
C
C
H

F
H
Influence of Bond Type on Physical Properties of Certain Refrigerants

R-143a

\[ \text{F} - \text{C} - \text{C} - \text{H} \]

R-134a

\[ \text{F} - \text{C} - \text{C} - \text{H} \]

- VP at 20°C (kPa)
  - R-143a: 1120
  - R-134a: 570

- MP (°C)
  - R-143a: -111
  - R-134a: -101

- BP (°C)
  - R-143a: -48
  - R-134a: -27

- Specific gravity (gas)
  - R-143a: 2.9
  - R-134a: 3.25

Source: Air Liquide
Based on the information below, which compound is the best refrigerant?

- **R-12**
  - BP at 1atm (°C): -30
  - VP at 20°C (kPa): 567
  - Latent H_{vap} at BP (kJ/kg): 167
  - Density @ 1atm, 15°C (kg/m³): 5.11

- **R-22**
  - BP at 1atm (°C): -41
  - VP at 20°C (kPa): 908
  - Latent H_{vap} at BP (kJ/kg): 234
  - Density @ 1atm, 15°C (kg/m³): 3.66

- **R-32**
  - BP at 1atm (°C): -52
  - VP at 20°C (kPa): 1380
  - Latent H_{vap} at BP (kJ/kg): 360
  - Density @ 1atm, 15°C (kg/m³): 2.72

Source: Air Liquide
CCA (Chromated Copper Arsenate)
Pressure-Treated Dimensional Lumber

$\text{Cu}^{+2}$ & $\text{Cr}^{+3}$ = fungicide
$\text{As}$ = termite poison
Cu$^{+2}$, Cr$^{+3}$, As$^{+5}$ ↔ electron configurations
Aluminum should not be used in direct contact with this wood. To do so would require an adequate physical barrier between the metal and wood.
Al^{3+} (aq) + 3e^- \rightarrow Al(s), E_{\text{red}}^O = -1.66V

Cr^{3+} (aq) + 3e^- \rightarrow Cr(s), E_{\text{red}}^O = -0.74V

Cr^{3+} (aq) + e^- \rightarrow Cr^{2+} (aq), E_{\text{red}}^O = -0.41V

Cu^{2+} (aq) + e^- \rightarrow Cu^+ (aq), E_{\text{red}}^O = +0.16V

Cu^{2+} (aq) + 2e^- \rightarrow Cu(s), E_{\text{red}}^O = +0.34V

E_{\text{cell}} > 0V, \Delta G = (-), spontaneous

Electrochemistry In Action: Imagine our world without these three architectural gems?
DAP Dry Dex Spackling

Dry Time Indicator

Goes on pink!
- Dries white when it's time to sand & paint

Interior/Exterior

No shrinking
Fast drying

WARNING OR SWALLOW CAREFULLY

Masilla con indicador de tiempo de secado

Cuidados

America's Number 1 Seller
**Phenolphthalein**

\[
\text{CO}_2(g) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{CO}_3(aq) \quad \downarrow \text{pH}
\]

(from air)
Density- Ceiling or Wall?

Recalibration- What is it? It's just not a word used in chemistry.
Confused with Units?

Watts ≠ Energy
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