Thermodynamics is the study of how heat moves.

Heat always transfers from **hot** to **cold**. Heat does not rise (hot air rises).

**Insulators** slow down heat transfer. Materials with air pockets are good insulators.

**Conductors** easily allow heat transfer. Most metals are good conductors.

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**Conduction**

Conduction transfers heat through objects touching.

All atoms are vibrating (moving), which means they have kinetic energy. Hot atoms have more $E_k$. When hot atoms bump into cold atoms they transfer some energy.

Heat transfer continues until both objects are at **thermal equilibrium**: the same temperature.

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**Convection**

Convection transfers heat through moving currents in gases or liquids.

Gases transfer heat poorly through conduction. Convection currents speed up thermal transfer.

Convection currents can only happen in gases (like air) or liquids (like water), not in solids because solids can’t move.

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**Radiation**

Radiation transfers heat through electromagnetic radiation; occurs even in a vacuum (empty space).

Radiation transfers heat in all **directions**—even down. Convection currents always rise.

Radiation requires no contact—convection and conduction require touching.

Radiation can go through transparent materials (barriers) like glass.

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**Thermal energy (heat) is transferred in three ways: Conduction; Convection; Radiation.**

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**Solid**

Better conductors

**Liquid**

Better insulators

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Radiation transfers heat through electromagnetic waves — pure thermal energy.

All energy on earth comes originally from the sun. Space is a vacuum (no matter at all). So only radiation can travel through space to the earth.

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Dark objects absorb more radiation than light objects. Dull objects absorb more radiation than shiny objects.
<table>
<thead>
<tr>
<th>What Kind of Thermal Transfer?</th>
<th>A. Heat transfer through electromagnetic waves.</th>
<th>B. Thermal (heat) transfer by the contact (touching) of two objects.</th>
<th>C. Transfers heat by moving currents in gases and liquids.</th>
<th>D. When two objects are at the same temperature.</th>
<th>E. The study of how heat moves.</th>
<th>F. Caused by convection currents in the earth’s atmosphere.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which of the following are at thermal equilibrium?</td>
<td>25°C</td>
<td>5°C</td>
<td>5°C</td>
<td>25°C</td>
<td>5°C</td>
<td>5°C</td>
</tr>
<tr>
<td>____ When hot air rises.</td>
<td>____ Causes wind.</td>
<td>25°C</td>
<td>5°C</td>
<td>C. 5°C</td>
<td>5°C</td>
<td></td>
</tr>
<tr>
<td>____ When two objects are touching.</td>
<td>____ Between a stove and a pot.</td>
<td>B. 25°C</td>
<td>25°C</td>
<td>D. 5°C</td>
<td>25°C</td>
<td></td>
</tr>
<tr>
<td>____ When nothing is touching.</td>
<td>____ Within a pan of water.</td>
<td>____ More occurs with dark objects.</td>
<td></td>
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<tr>
<td>____ When atoms collide.</td>
<td>____ Through a car’s windows at night.</td>
<td>thermal Insulator or Thermal Conductor?</td>
<td>Metal</td>
<td>Glass</td>
<td>A coat</td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>A penny</td>
<td>Styrofoam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>Water</td>
<td>Aluminum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorbs heat (heats fast) or Reflects heat (heats slowly)?</td>
<td>Dark liquids</td>
<td>Dull objects</td>
<td>Aluminum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear liquids</td>
<td>White paper</td>
<td>Styrofoam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shiny objects</td>
<td>Black paper</td>
<td>Dark car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is this diagram correct or incorrect and why?</td>
<td>Heat transfer</td>
<td>25°C</td>
<td>15°C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Does heat rise?

Does hot air rise?

Why?