Directionality of Heat Transfer

- Heat always transfers from hotter object to cooler one.
- **EXO**thermic: heat transfers from **SYSTEM** to **SURROUNDINGS**.

T(system) goes down
T(surr) goes up
Directionality of Heat Transfer

- Heat always transfer from hotter object to cooler one.
- **ENDO**thermic: heat transfers from **SURROUNDINGS** to the **SYSTEM**.

\[ T(\text{system}) \text{ goes up} \]
\[ T(\text{surr}) \text{ goes down} \]
All of thermodynamics depends on the law of **CONSERVATION OF ENERGY**.

- The total energy is unchanged in a chemical reaction.
- If PE of products is less than reactants, the difference must be released as KE.
Energy Change in Chemical Processes

PE of system dropped. KE increased. Therefore, you often feel a T increase.
HEAT CAPACITY

The heat required to raise an object’s T by 1 °C.

Which has the larger heat capacity?
Specific Heat Capacity

How much energy is transferred due to T difference?
The heat \( q \) “lost” or “gained” is related to

a) sample mass  
b) change in T and  
c) specific heat capacity

Specific heat capacity  
\[
= \frac{\text{heat lost or gained by substance (J)}}{(\text{mass, g})(\text{T change, K})}
\]
## Specific Heat Capacity

<table>
<thead>
<tr>
<th>Substance</th>
<th>Spec. Heat (J/g•K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O</td>
<td>4.184</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>2.39</td>
</tr>
<tr>
<td>Al</td>
<td>0.897</td>
</tr>
<tr>
<td>glass</td>
<td>0.84</td>
</tr>
</tbody>
</table>

![Aluminum structure](image)

**Aluminum**
Specific Heat Capacity

If 25.0 g of Al cool from 310 °C to 37 °C, how many joules of heat energy are lost by the Al?

Specific heat capacity = \[
\frac{\text{heat lost or gained by substance (J)}}{\text{(mass, g)(T change, K)}}
\]
Specific Heat Capacity

If 25.0 g of Al cool from 310 °C to 37 °C, how many joules of heat energy are lost by the Al?

Heat gain/lose = \( q = (\text{sp. ht.})(\text{mass})(\Delta T) \)

where \( \Delta T = T_{\text{final}} - T_{\text{initial}} \)

\[
q = (0.897 \text{ J/g}\cdot\text{K})(25.0 \text{ g})(37 - 310)\text{K}
\]

\[ q = -6120 \text{ J} \]

Notice that the negative sign on \( q \) signals heat “lost by” or transferred OUT of Al.
Heat Transfer
No Change in State

\[ q \text{ transferred} = (\text{sp. ht.})(\text{mass})(\Delta T) \]
Heat Transfer with Change of State

Changes of state involve energy \((\text{at constant } T)\)

Ice + 333 J/g (heat of fusion) \(\rightarrow\) Liquid water

\[ q = \text{(heat of fusion)} \times \text{(mass)} \]
Heat Transfer and Changes of State

**Liquid $\rightarrow$ Vapor**

Requires energy (heat).
This is the reason

a) you cool down after swimming
b) you use water to put out a fire.
Heat water

Evaporate water

Melt ice

Note that T is constant as ice melts
What quantity of heat is required to melt 500. g of ice and heat the water to steam at 100 °C?

Heat of fusion of ice = 333 J/g
Specific heat of water = 4.2 J/g•K
Heat of vaporization = 2260 J/g
Create 10 questions from the notes, with 3 answer choices per question. Use complete sentences.