Physics 1408/1420

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Hello Fellow Physicists

I am Aman Patel, the Master Tutor for Physics this semester. I have created this resource document to help you review some of the topics you have been introduced to this semester to better prepare for your Final in physics.

<u>Keywords:</u> Heat, Thermal Expansion, Specific Heat, Latent Heat

Important Notes
Important Conventions

<u>Heat:</u>

Heat is the transfer of energy for one object to another because of a difference in temperature. The important distinction to remember between temperature and heat is that heat can flow from object to object. One of the commonly used quantization's of heat is calorie. A calorie is the amount of heat required to raise the of water by one degree Celsius. Calorie (with a capital C) is actually kilocalories.

$$4.186\ \text{J} = 1\ \text{cal};$$
$$4.186\ \text{kJ} = 1\ \text{kcal}$$

The SI unit of heat is Joule.

The total energy of all the molecules of an object is that objects internal or thermal energy. These distinctions are extremely important in thermodynamics.

<u>Specific Heat</u>

The specific heat of an object is the energy required per kilogram to change the temperature of the object by 1° C. This is a value that is unique for different substances. This is important because it allows us to find the amount heat that is needed to change the temperature of these substances based on the scenarios of use. We use the following equation to calculate the heat.

$$Q = mc\,\Delta T$$

Calorimetry

When are looking at these systems, we are considering them to be closed and isolated systems, we assume that no energy passes in and out of the boundary of the system we define. When different parts of the system have different temperatures, heat will flow in the system until it reaches thermal equilibrium. In an isolated system, the energy is conserved. So, the heat out is equal to the heat in. Or $\sum Q = 0$ for the isolated system. This is the basis of calorimetry. We use and isolated system where the object is present in water at a known temperature and a calorimeter with a known specific heat. So based on the heat exchanged, unknown objects can be identified.

Example:

An engineer wishes to determine the specific heat of a new metal alloy. A 0.150-kg sample of the alloy is heated to 540°C. It is then quickly placed in 0.400 kg of water at 10.0°C, which is contained in a 0.200-kg aluminum calorimeter cup. The final temperature of the system is 30.5°C. Calculate the specific heat of the alloy

Solution:

when you first start the problem, begin with the basic premise of isolated systems

Heat out = Heat in

Heat out is the thermal energy lost by the hotter object and heat in is the heat absorbed by the other object.

$Q_{alloy} = Q_{water} + Q_{calotrimeter}$

$- Mc_a(T_f - T_i) = Mc_{water}(T_f - T_i) + Mc_{water}(T_f - T_i)$

- (0.15) c_a(30.5 – 540) = (0.4)(4186)(30.5-10) + (0.2)(900)(30.5 – 10)

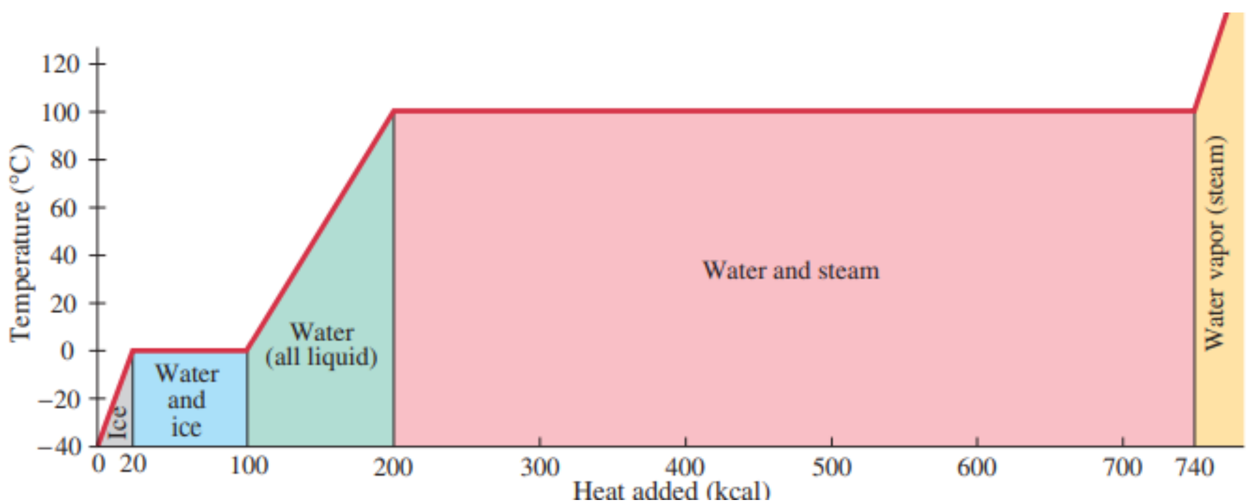
C_a = 38015.2 / (0.15)(540 – 30.5)

C_a = 497 J/kg.C°

Latent Heat

The increase and decreases in the temperature of a substance is governed by the specific heat of the substance. But when the material undergoes a phase change, it requires heat to break the bonds between the molecules to change the phase of the material. This heat absorbed does not change the temperature of the material, only its phase. This heat is called latent heat. The heat required to go from solid to liquid and liquid to gas are specific to the material. The latent heat required to go from solid to liquid is called the heat of fusion. The latent heat required to go from liquid to gas is called the heat of vaporization. When the object is at its melting point and boiling point, these latent heats are required.

$$Q = mL,$$



The behavior of the temperature of the material when heated is best represented by the graph above. This behavior relates to other materials as well, just at different temperature and with different heat.

Example

How much energy does a freezer have to remove from 1.5 kg of water at 20°C to make ice at -12°C?

Solution

$Q = Q_{0\text{-}20°C} + Q_{fusion} + Q_{0\text{-}(-12)°C}$

$= mc_w (T_f - T_i) + mL_f + mc_i (T_f - T_i)$

$= (1.5)(4186)(20 - 0) + (1.5)(333000) + (1.5)(2100)(0\text{-}(-12))$

$= 662880$ J

All Images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli