Physics 06-04 Heat and Temperature Change	*Name: ______________________*

Heat

- Heat is ___________ that flows from a ___________ -temperature object to a ___________ -temperature object because of the ___________ in temperatures
- Unit: ___________ (J), ___________ (cal), kilocalorie (kcal or Cal)

Mechanical Equivalent of Heat

- Since heat is energy, other types of ___________ can make the ___________ effect as heat

$$1\ kcal = 4186\ J$$

- To ___________ the temperature of an object heat is ___________
- The amount of ___________ required is related to
  - ___________ of the object
  - ___________ of temperature change
  - ___________ of the object

$$Q = mc\Delta T$$

- Where Q = heat; c = specific heat capacity (based on material Table 14.1); m = mass; ΔT = change in temperature

Table 14.1 Specific Heats[1] of Various Substances

Substances	Specific heat (c)	
Solids	J/kg·ºC	kcal/kg·ºC[2]
Aluminum	900	0.215
Asbestos	800	0.19
Concrete, granite (average)	840	0.20
Copper	387	0.0924
Glass	840	0.20
Gold	129	0.0308
Human body (average at 37 °C)	3500	0.83
Ice (average, -50°C to 0°C)	2090	0.50
Iron, steel	452	0.108
Lead	128	0.0305
Silver	235	0.0562
Wood	1700	0.4
Liquids		
Benzene	1740	0.415
Ethanol	2450	0.586
Glycerin	2410	0.576
Mercury	139	0.0333
Water (15.0 °C)	4186	1.000
Gases [3]		
Air (dry)	721 (1015)	0.172 (0.242)
Ammonia	1670 (2190)	0.399 (0.523)
Carbon dioxide	638 (833)	0.152 (0.199)
Nitrogen	739 (1040)	0.177 (0.248)
Oxygen	651 (913)	0.156 (0.218)
Steam (100°C)	1520 (2020)	0.363 (0.482)

A pot of 10 kg of 15-°C water is put on a stove and brought to a boil. How much heat was needed?

What is the increase in temperature of a 50 g nail hit by a hammer with force of 500N? The length of the nail is .06m its specific heat capacity is 450 J/kg°C.

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Homework	

1. Two identical mugs contain hot chocolate from the same pot. One mug is full, while the other is only one-quarter full. Sitting on the kitchen table, which mug stays warmer longer? Explain.
2. How is heat transfer related to temperature?
3. When heat transfers into a system, is the energy stored as heat? Explain briefly.
4. What three factors affect the heat transfer that is necessary to change an object's temperature?
5. On a hot day, the temperature of an 80,000-L swimming pool increases by 1.50°C. What is the net heat transfer during this heating? Ignore any complications, such as loss of water by evaporation. (OpenStax 14.1) $\mathbf{5.02 \times 10^8}$ **J**
6. To sterilize a 50.0-g glass baby bottle, we must raise its temperature from 22.0°C to 95.0°C. How much heat transfer is required? (OpenStax 14.3) $\mathbf{3.07 \times 10^3}$ **J**
7. The same heat transfer into identical masses of different substances produces different temperature changes. Calculate the final temperature when 1.00 kcal of heat transfers into 1.00 kg of the following, originally at 20.0°C: (a) water; (b) concrete; (c) steel; and (d) mercury. (OpenStax 14.4) **21.0 °C, 25.0 °C, 29.3 °C, 50.0 °C**
8. Rubbing your hands together warms them by converting work into thermal energy. If a woman rubs her hands back and forth for a total of 20 rubs, at a distance of 7.50 cm per rub, and with an average frictional force of 40.0 N, what is the temperature increase? The mass of tissues warmed is only 0.100 kg, mostly in the palms and fingers. (OpenStax 14.5) **0.171 °C**
9. A 0.250-kg block of a pure material is heated from 20.0°C to 65.0°C by the addition of 4.35 kJ of energy. Calculate its specific heat and identify the substance of which it is most likely composed. (OpenStax 14.6) **0.0924 kcal/kg·°C**
10. The number of kilocalories in food is determined by calorimetry techniques in which the food is burned and the amount of heat transfer is measured. How many kilocalories per gram are there in a 5.00-g peanut if the energy from burning it is transferred to 0.500 kg of water held in a 0.100-kg aluminum cup, causing a 54.9°C temperature increase? (OpenStax 14.8)**5.73 kcal/g**
11. Even when shut down after a period of normal use, a large commercial nuclear reactor transfers thermal energy at the rate of 150 MW by the radioactive decay of fission products. This heat transfer causes a rapid increase in temperature if the cooling system fails (1 watt = 1 joule/second or 1 W = 1 J/s and 1 MW = 1 megawatt). (a) Calculate the rate of temperature increase in degrees Celsius per second (°C/s) if the mass of the reactor core is 1.60×10^5 kg and it has an average specific heat of 0.3349 kJ/kg·°C. (b) How long would it take to obtain a temperature increase of 2000°C, which could cause some metals holding the radioactive materials to melt? (The initial rate of temperature increase would be greater than that calculated here because the heat transfer is concentrated in a smaller mass. Later, however, the temperature increase would slow down because the 5×10^5-kg steel containment vessel would also begin to heat up.) (OpenStax 14.10) **2.80 °C/s, 11.9 min**
12. Blood can carry excess energy from the interior to the surface of the body, where the energy is dispersed in a number of ways. While a person is exercising, 0.6 kg of blood flows to the surface of the body and releases 2000 J of energy. The blood arriving at the surface has the temperature of the body interior, 37.0°C. Assuming that blood has the same specific heat capacity as water, determine the temperature of the blood that leaves the surface and returns to the interior. (Cutnell 12.39) **36.2 °C**
13. If the price of electrical energy is $0.10 per kilowatt·hour, what is the cost of using electrical energy to heat the water in a swimming pool (12.0 m × 9.00 m × 1.5 m) from 15 to 27 °C? (Cutnell 12.41) **$230**