Part I Problems

1. Skip this problem.

2. At what Fahrenheit temperature is the Kelvin temperature 100 ^{o}K?

3. At what Celsius temperature is the Fahrenheit temperature three times as great?

4. At what Fahrenheit temperature is the Celsius temperature the same?

5. A 40-gram object at its melting point requires 5000 calories to melt. What is this object's latent heat of melting?

6. 6000 calories of heat must be removed from 150 grams of a certain vapor (not H_2O) to convert it to liquid at the same temperature. What is that substance's latent heat of condensation?

7. A substance has a specific heat capacity of 0.20 cal/g-C^{o}. How much heat (in cal) must be added to 200 grams of this substance at 50 ^{o}C to raise its temperature to 90 ^{o}C?

8. Four thousand calories of thermal energy are needed to raise the temperature of 200 grams of a substance from 20 ^{o}C to 70 ^{o}C. What is the specific heat capacity of this substance?

9. Chilled to the bone. Suppose equal masses of human tissue and bone lose the same amount of heat over the same time. If the tissue's temperature drops by 0.3 C^{o}, what would be the drop in the bone's temperature? Note: the heat capacity of bone is 0.10 cal/g-C^{o} and the heat capacity of tissue is the same as water, 1.0 cal/g-C^{o}.

10. How many calories of heat must be removed from 600 grams of steam at 150 ^{o}C to convert it to water at 90 ^{o}C?

11. How many calories of heat must be added to convert 70 grams of ice at 0 ^{o}C to steam at 100 ^{o}C?

12. Fifty grams of metal at 300 ^{o}C are placed in 400 grams of water at 10 ^{o}C. The specific heat capacity of the metal is 0.25 cal/g-C^{o}. What is the approximate equilibrium temperature of the mixture?

13. 100 grams of a substance at 120 ^{o}C is added to 300 grams of water at 20 ^{o}C, and after equilibrium is reached, the temperature of the mixture is 30 ^{o}C. What is the specific heat capacity of the unknown substance?

14. Fifty grams of ice at 0 ^{o}C is added to 200 grams of water at 70 ^{o}C. All the ice melts. What is the equilibrium temperature of the mixture?

15. How many kcals (kilocalories) of heat must be removed from 200 g of steam at 150 ^{o}C to convert it to 200 g of ice at -20 ^{o}C?

Solutions

<table>
<tr><td>1. Skip this problem.</td><td>2. $T_C = T - 273$
$= 100 - 273$
$= -173\ ^oC$
$T_F = (9/5)\ T_C + 32$
$= (9/5)(-173) + 32$
$= -279.4\ ^oF$</td></tr>
<tr><td></td><td>3.

$3T_C = (9/5)\ T_C + 32$
$T_C = 26.67\ ^oC$</td></tr>
<tr><td>4. $T_F = T_C$
$(9/5)\ T_C + 32 = T_C$
$T_C = -40\ ^oC$</td><td>5. $Q = +mL$
(Positive sign because heat is added.)
$L = Q/m$
$= 5000$ cal$/40$ g
$= 125$ cal/g</td></tr>
<tr><td>6. $Q = -mL$
(Negative sign because heat is removed)
$L = -Q/m$
$= -(-6000)/150$
$= 40$ cal/g</td><td>7. $\Delta T = 90 - 50$
$= 40\ C^o$

$Q = 200(0.20)\ 40$
$= 1600$ cal</td></tr>
<tr><td>8. $\Delta T = 70 - 20$
$= 50\ C^o$
$Q = mc\Delta T$
$c = Q/m\Delta T$
$= 4000/200/50$
$= 0.40$ cal/g-C^o</td><td>9. $Q = mc\Delta T$
$\Delta T_2 = Q/mc_2$ (bone)
$\Delta T_1 = Q/mc_1$ (tissue)

Divide equations (Q’s and m’s cancel):
$\Delta T_2/\Delta T_1 = c_1/c_2$
$\Delta T_2 = (c_1/c_2)\Delta T_1$
$= (1.00/0.10)\ 0.30$
$= 3.0\ C^o$</td></tr>
<tr><td colspan="2">10.
Cool steam: $600(0.5)(-50) = -15{,}000$
Condense steam: $-540(600) = -324{,}000$
Cool hot water: $600(1.0)(-10) = -6{,}000$
Sum = $-345{,}000$ cal</td></tr>
</table>

11. Melt ice: 70(80) = 5,600 Warm cold water: 70(1.0)(100) = 7,000 Boil hot water: 70(540) = 37,800 Sum = 50,400 cal	**12.** $Q_1 = 50\ (0.25)\ (T - 300)$ $Q_2 = 400\ (1.0)\ (T - 10)$ $Q_1 + Q_2 = 0$ $50(0.25)(T-300) + 400(1.0)(T-10) = 0$ $T = 18.79\ C^o$
13. $Q_1 = 100c(30-120)$ $Q_2 = 300(1.0)(30-20)$ $Q_1 + Q_2 = 0$ $c = 0.33$ cal/g-C^o	**14.** Melt ice: $Q_1 = 50(80)$ Warm ice water: $Q_2 = 50(1.0)(T-0)$ Cool warm water: $Q_3 = 200(1.0)(T-70)$ $Q_1 + Q_2 + Q_3 = 0$ $T = 40\ ^oC$
15. Cool steam: 200(0.5)(-50) = -5,000 Condense steam: -200(540) = -108,000 Cool hot water: 200(1.0)(-100) = - 20,000 Freeze cold water: -200(80) = - 16,000 Cool ice: 200(0.5)(-20) = - 2,000 Sum = -151,000 cal = -151 kcal	