37. The first law of thermodynamics
 a. is a restatement of the law of conservation of energy which includes heat as a form of energy YES!
 b. ~~allows~~ requires that internal energy can be completely converted into work. FALSE
 c. treats mass as another form of energy. FALSE
 d. guarantees that the work extracted by a cyclic heat engine can never be less than the heat inserted. FALSE! (TRUE IF ~~less~~ → more.)
 e. All of the above statements are true of the first law. NOT SO

38. When an ideal gas was compressed, its internal energy increased by 50 J and it gave off 30 J of heat. How much work was done on the gas?
 a. 30 J
 b. 50 J
 c. 80 J
 d. 110 J
 e. None of the above.

$W_{IN} = \Delta U + Q_{out} = 50 + 30$

39. The third law of thermodynamics
 a. is a restatement of the law of conservation of energy.
 b. says that heat cannot be completely converted to mechanical energy.
 c. says that we can never reach the absolute zero of temperature.
 d. says that all motion ceases at absolute zero.
 e. guarantees that temperature is useful for predicting heat transfer.
 f. None of the above completions yields a true statement.

40. Heat is
 a. the same as temperature.
 b. thermal energy that is transferred from one object to another.
 c. potential energy associated with temperature.
 d. a massless fluid generated by doing work on the system.
 e. entirely equivalent to work.
 f. None of the above.

41. Why do winter lakes freeze from the upper surface down?
 a. Because water has a high latent heat of vaporization. NOT RELEVANT
 b. Because lakes have lower elevations, and cool air flows downhill. "
 c. Because water has a relatively high specific heat. "
 d. Because below 4°C water becomes less dense as it cools towards 0° C. YES!
 e Because water has a high latent heat of fusion IRRELEVANT
 f. None of the above is true.

42. Water has a specific heat of 1.0 cal/gm°C and a latent heat of fusion of 80 cal/gm. How many calories must be removed from 75gm of water at 10°C in order to freeze it entirely into ice?
 a) 6750 cal.; b) 6075 cal.; c) 5250 cal.; d) 90 cal.; e) 81 cal.

$75 \cdot 1 \cdot 10 + 75 \cdot 80 = 6750$ cal

(to reduce T to 0°) (to convert liq to ice.)

43. Suppose that the specific heat of copper is 0.20 cal/gm°C? In an experiment a 200 gm slug of copper at 80°C is inserted into 200 gm bath of water at 20°C. If there is heat lost from the copper/water system to the surroundings as it comes to the final equilibrium temperature, we can be sure that the final temperature is

a. more than 70°C;
b. more than 50°C;
c. more than 30°C;
d. less than 20°C;
e. less than 30°C.
f. None of the above conclusions is certain

Q_L = Heat Lost = $-\Delta U_{INT} = -[(200)(0.2)(T_f - 80) + (200)(1)(T_f - 20)]$

$+|Q_L| + 40T_f + 200T_f = (40)(80) + 4000$

$240T_f = 7200 - |Q_L|$

$T_f = \frac{7200}{240} - Q_L/240 \leq 30°C$

44. How many calories are required to heat 300 g of water from 3°C to 10°C, most nearly ?

a. 7.0
b. 300
c. 2000
d. 3000
e. 20,000
f. None of the above is within 10% of the correct answer

$1 \cdot 7 \cdot 300 = 2100$ cal

45. Joule's experiments in which hanging weights turned paddle wheels in water

a. showed that a specific amount of work always converted into the same amount of heat.
b. showed that 4.2 joules of work are equivalent to 1 calorie of heat.
c. were used to fix the ratio of the unit of heat energy to the unit of work energy.
d. showed that mechanical energy could be converted 100% to heat.
e. All of the above statements are true of Joule's experiments.
f. None of the above statements is true.

46. Which of the following statements does **NOT** correctly describe what happens when a hot block is placed in thermal contact with a cool block? (Ie, which is **false**?) (I.e.,

a. Heat flows from the hot block to the cool block. TRUE
b. The average kinetic energy of the particles decreases in the hot block and increases in the cool block. TRUE
c. The temperature of the hot block decreases and that of the cool block increases. TRUE
d. Temperature flows from the hot block to the cool block. FALSE
e. All of the above statements a) through d) are false. NOT SO
f. None of a) through d) is false: all correctly describe what happens. NOT SO! (d) IS FALSE

47. The first law of thermodynamics

a. states that a temperature of absolute zero can never be attained.
b. says that heat cannot be completely converted to mechanical energy.
c. is the basis for the definition of temperature.
d. is the basis for the definition of entropy.
e. includes the second law of thermodynamics as a special case.
f. states the impossibility of attaining a temperature of absolute zero.
g. None of the above.

48. During a process, 40 joules of heat are transferred into a system, while the system itself does 15 joules of work and exhausts 10 joules of heat. The internal energy of the system

a. decreases by 15 joules.
b. decreases by 25 joules.
c. remains the same.
d. increases by 15 joules.
e. increases by 25 joules.
f. None of the above is within 10%

$Q_{IN}^{NET} + W_{IN}^{NET} = +\Delta U$
$40 - 15 - 10 = 15 J$

49. A 60-m long copper wire (coefficient of thermal expansion of 1.7 x 10-5/°C) experiences a temperature change of 20°C. What is the change in length of the wire, most nearly ?

a) 0.33 mm; b) 1 mm; c) 1.7 mm; d) 12 mm; e) 20 mm.

$\Delta L = L \cdot \alpha \Delta T = (60 m)(1.7 \times 10^{-5}/°C)(20°C) = 2040 \times 10^{-5} = 2.04 \times 10^{-2} m = 20.4 \times 10^{-3} m$

50. If the internal energy of an ideal gas increases by 80 J when 150 J of work are done to compress it, how much heat is transferred?

a. 80 J of heat out of the gas
b. 80 J of heat into the gas
c. 70 J of heat into the gas
d. 150 J of heat out of the gas
e. 230 J of heat into the gas
f. None of the above is within 10% of the correct answer.

$Q_{IN} + W_{IN} = \Delta U$
$Q_{IN} + 150 J = 80 J$
$Q_{IN} = -70 J \Rightarrow$ Heat transferred OUT = 70 J (... MINUS SIGN!)

51. Given that ice has a specific heat that is one-half that of water, when the temperature of 5 grams of water and that of 5 grams of ice both drop by 6°C

a. the water gives off twice as much heat as the ice.
b. the ice gives off twice as much heat as the water.
c. both give off the same amount of heat, but the ice does so quicker.
d. both give off the same amount of heat, but the water does so quicker.
e. None of the above.

$\Delta Q = C \Delta T$: $\frac{\Delta Q_W}{\Delta Q_I} = \frac{C_W}{C_I} \cdot \frac{(6K)}{(6K)} = 2$

52. Why is steam at 100°C more dangerous to tissue than water at 100°C?

a. The steam is hotter. NO T IS Same!
b. The steam has more internal energy per gram. INDEED!
c. The steam has a higher specific heat. FALSE
d. The steam has less viscosity. IRRELEVANT
e. In fact water is more dangerous than steam at 100°C. FALSE
f. None of the above is a true statement about steam and water. X

53. Which type of bench would have the warmest equilibrium temperature on a cold winter day?

a. aluminum
b. marble
c. wood
d. iron
e. None of the above: all would come to the same temperature

54. Aluminum and air have almost the same values for their specific heats: 0.21cal./gm °C and ~~0.24~~ ← EC
21cal./gm °C, respectively. Therefore, 10^4 calories of heat will raise the temperature of 1 liter of aluminum __________ 1 liter of air. (Assume T = 20°C, and P = 1 atm.)

a. much more than
b. slightly more than
c. about the same as
d. slightly less than
(e.) much less than

Because 1l of air has much less mass than 1l of Al, Al. requires much more heat.

(The remaining problems may require more computation than those above.)

55. Two rocket ships are recorded by a space station both to be approaching at 90% of the speed of light from opposite directions along the same line of travel. Recall that the Galilean transformation of v along the line of motion (v = v′ +V) has to be replaced by the Lorentz transformation , $v = (v' + V)/(1 + v'V/c^2)$. Then compute the speed which the observer in one rocket ship measures for the other rocket ship.

a. 0.810c
b. 0.900c
c. 0.950c
(d.) 0.995c
e. 1.000c
f. 1.800c
g. None of the above is within 0.5% of the correct answer.

$$\frac{v}{c} = \frac{(0.9+0.9)}{1+0.81} = \frac{1.80}{1.81} = 0.9945$$

$$v = 0.995c$$

56. A neutron at rest has a 50% probability of decaying in 10.6 minutes (= 636 seconds), and a fifty percent probability of surviving for more than 636 seconds. Is it possible for a neutron to travel to the earth from a location 1.34×10^{13} m from earth and still to survive with the same 50% probability? (Recall that $c = 3 \times 10^8$ m/sec, and choose the most nearly correct answer.)

a. It is not possible, because the proton would have to travel faster than the speed of light.
b. Yes, it is possible, but only if it travels with a speed greater than 0.9 c
c. Yes, it is possible, but only if it travels with a speed greater than 0.99 c
d. Yes, it is possible, but only if it travels with a speed greater than 0.999 c
(e.) Yes, it is possible, but only if it travels with a speed greater than 0.9999 c
f. Yes, it is possible, but only if it travels with a speed greater than 0.99999 c

neutron, N, can travel nearly 636c = 1.908×10^{11} m in 636 sec ($3 \times 10^8 \frac{m}{s} = c$)
To complete the trip in time, N must travel so fast that distance, 1.34×10^{13} m, is contracted to 1.908×10^{11}. I.e $\gamma \geq \frac{1.34 \times 10^{13}}{1.908 \times 10^{11}} = 7.02 \times 10 = 70.2 = \frac{1}{\sqrt{1 - v^2/c^2}}$

Then $(70.2)^2 = \frac{1}{(1+v/c)(1-v/c)} = \frac{1}{2(1-v/c)}$

OR $1 - v/c = \frac{1}{2(70.2)^2} = 1 \times 10^{-4} \Rightarrow v/c = 0.9999$ (e)

57. If a liter of gas initially has a pressure of 1.0 atmosphere, what will the pressure be if the average kinetic energy of the molecules is doubled, while the volume is reduced to 0.2 liter?

a. 0.2 atm
b. 0.5 atm
c. 2.0 atm
d. 5.0 atm
(e.) 10.0 atm
f. None of the above is within 10% of the correct answer.

Doubling ⟨KE⟩ ⇒ Doubling Tabs. : $T_F = 2T_i$

$\frac{P_F V_F}{P_i V_i} = \frac{cT_F}{cT_i} = 2 = \frac{P_F}{(1.0 \text{ atm})} \cdot \frac{0.2 \ell}{1 \ell} \Rightarrow P_F = 10$ atm.

58. Your car's right rear tire has to support a weight of 744lb. Normally the tire pressure is 32 pounds per square inch and the contact area of your tire with the road is 150 cm^2. If the tire pressure is suddenly reduced to 24 pounds per square inch, what must the new contact area be in order to support the car?

a. 225 cm^2
(b.) 200 cm^2
c. 175 cm^2
d. 150 cm^2
e. 100 cm^2
f.. None of the above is within 10% of the correct answer.

$\frac{F}{A} = P \Rightarrow F = P \cdot A = P_1 A_1 = P_2 A_2$

$(32)(150) = (24) A_2$

$A_2 = 200\ cm^2$ (b)

59. If 100 g of water at 100° C and 100 g of ice at 0° C are mixed in a completely insulated container, what is the final equilibrium temperature, most nearly ? Recall that the latent heat of fusion of ice is 80 cal/g, and the latent heat of vaporization of water is 540cal/gm.

(a.) 10° C
b. 20° C
c. 30° C
d. 40° C
e. 50° C

Heat IN + Work IN = $\Delta U \equiv 0$ (insulated!)

$0 = 100g \cdot 1 \frac{cal}{gm^\circ c} (T_f - 100^\circ C) + 100g \cdot \frac{80 cal}{gm} + 100 \cdot 1 \cdot (T_f - 0^\circ)$

$-8000 + 10{,}000 + 0 = T_f(200)$

$= T_f = 10^\circ C$ (a)

$\frac{+2000}{200}$

60. Six grams of liquid X at 35°C ar added to two grams of Liquid Y at 30°C. The specific heat of liquid X is 1.5 cal/gm°C , and that of liquid Y is 4.5 cal/gm°C. The final equilibrium temperature of the mixture is, within 0.1 °C,

a. 30.5°C
b. 31.5°C
c. 32.5°C
d. 33.5°C
e. 34.5°C
f.. None of the above is within 0.1°C of the correct answer

Heat IN + WORK IN = $\Delta U = 0$

$0 = 6(1.5)(T_f - 35°) + 2(4.5)(T_f - 30°)$

$9 \cdot (35+30) = T_f(9+9)$: $T_f = \frac{35+30}{2} = 32.5°C$

End of Exam III