Practice Problems – Unit 3

1. The specific heat capacity of copper is 390 J/kgK. How much energy does a 4 kg piece of copper give off when it cools 6 K?

9360 J

2. The coefficient of linear expansion for steel is 13x10-6 m/K. Suppose a 6 m piece of steel is heated from 300 K to 600 K, find its new length.

6.0234 m

3. Suppose a 2 kg piece of iron (c=450 J/kgK) at 500 K is put in thermal contact with a 3 kg piece of lead (c=130 J/kgK) at 600 K, find the final temperature of the two metals.

530.23 K

4. By how much does the temperature of ice change during its melting phase?

0 K

5. Suppose you have a 4 kg block of ice (c=2093 J/kgK) at -6 C. You want to eventually turn this chunk into steam (c=1890 J/kgK) at a temperature of 120 C. How much energy is required to do this? (Lfus= 3.33x105 J/kg, Lvap=2.26x106 J/kg)

1.22x107 J

6. Suppose you drop a 0.64 kg piece of aluminum (c=910 J/kgK) at a temperature of 90 C into a 3 kg sample of water (c=4186 J/kgK) at 20 C. Find the final temperature of the system.

23.1 C

7. Suppose you place a 12 kg piece of Titanium (c=540 J/kgK) at a temperature of 62 C on top of a 0.8 kg block of ice at a temperature of -7 C. The ice heats and eventually melts. Find the final temperature of the water.

12.58 C

8. An ideal gas in a piston undergoes an isobaric process at 200 Pa in which its volume changes from 2.6 m3 to 2.8 m3. Draw the PV diagram for this process and determine how much work was performed by the gas during its expansion.

40 J

9. An ideal gas in a piston is compressed a distance of 0.4 m using an average force of 600 N. Suppose that 30 J of heat are allowed to flow out of the gas during this process. Find the net change in the internal energy of the gas.

210 J

10. Suppose you had an ideal engine in your car that performed at its maximum potential efficiency (a Carnot engine). When it’s hot and miserable during the abomination known as summer time, your engine performs less efficiently than it does when it’s wonderfully cold outside (one of a million reasons why winter is better than summer). If the operating temperature inside your engine is 478 K, find the difference between your wretched summer efficiency (T=320 K) and your glorious winter efficiency (T=245 K).

15.69 %

11. Your body is more complex (and more efficient) than an ideal heat engine. But just for fun, let’s pretend it is that simple. Assume calories are burned, producing heat, which is then used to create mechanical work. The temperature inside your body is 37o C. Room temperature is 22o C. Find your body’s ideal efficiency. How many Joules must be burned for you to climb 3 flights of stairs in the science building? Assume your mass is 80 kg and your elevation change is 20 m, you ascend at a constant velocity. How much heat does your body emit during this process? (Deodorant)

e = 4.8%

Q = 324210 J

Q = 308530 J

12. Suppose a certain heat engine operates at an efficiency of 22%. How much heat must be exhausted by this engine in order for it to perform 1200 J of work?

4254.5 J