Question 1 (5 pts). Consider the resiliency of the urban Sumerian society with that of the agrarian Egyptian society. Which society was more resilient? Explain your answer.

Question 2 (3 pts). The Sumerian civilization was destroyed in part by salt accumulating in the soil. Hughes (ref. 21) claims that this probably did not happen to the same extent in ancient Egypt. Given the different hydrology of these two regions as mentioned in the text, why was there not as much of a serious problem with salt accumulation in Egypt?

Question 3 (3 pts). Wertime (ref. 6) suggests that metalworkers had considerable experience in removing unwanted silicates as byproducts of copper smelting by the time period 2000 BCE to 1500 BCE, and furthermore they had experience using alkali materials (e.g., lime) as fluxes in smelting copper ores. Many of the copper ores used at this time also contained iron, which led to the beginning of iron smelting. On this basis, explain why Wertime concludes that the manufacture of glass and the manufacture of iron probably both had their origins together at roughly this time in history.

Question 4 (3 pts). Ancient Egypt enjoyed a relatively long period with few attacks from outsiders, probably because of protection afforded by natural barriers such as the Mediterranean Sea, the Red Sea, the Sinai peninsula, and expansive deserts to the south and west. When the Egyptians became weakened by drought, however, several groups attempted to conquer them. Clearly, one factor making Egypt a target of conquest was its rich agricultural lands. What other factor was also very important in making it a target of conquest?

Question 5 (4 pts). What examples existed in early times of local resource depletion? What was done in each case to solve the problem?

Question 6 (8 pts) Give one example (and brief description) of each of the following in these early civilizations:
   a) Design for disassembly
   b) Re-use
   c) Recycling
   d) Material substitution

Question 7 (10 pts). Wertime (ref. 14, page 451) estimates that 5 to 6 million metric tons of charcoal were used to smelt 0.2 to 0.4 million tons of copper in Cyprus in ancient times. He further estimates that 5 to 6 million acres of coppice (stands of short trees and brush) were cleared to produce this copper. In this problem, you are
as asked to use the average values of 5.5 million metric tons of charcoal, 0.3 million metric tons of copper, and 5.5 million acres of coppice.

a. How does Wertime’s estimate of charcoal use in units of kg charcoal used per kg copper compare with the estimate of charcoal use for making copper mentioned in the chapter?

b. How many hectares of coppice must have been cleared over the centuries of Cyprus copper smelting to yield the 0.3 million metric tons of copper? How does this compare with Wertime’s estimate if we assume 10 metric tons of fuelwood per hectare?

c. If you were living during these ancient times, would you expect to see 5.5 million acres of cleared land due to the copper smelting? Or would you expect to see much less or much more? Explain your answer.

d. Sass (ref. 2, p. 96) notes that 8 pounds of charcoal were needed in ancient times to smelt each pound of iron, and that today there are about one billion English tons of iron (and steel) manufactured annually. If we were still using fuelwood to make iron today, determine the dimensions of a square of land containing coppice with a sufficient amount of fuelwood to accomplish this task.

e. We have seen that many civilizations, including the ancient Greeks, chose to switch their copper and bronze metallurgy over to iron and steel shortly after iron smelting was developed. The text mentions that iron and steel are much stronger than the other metals, so certainly that was one reason for making the switch. But saving energy, hence trees, is another reason. How many hectares of coppice in Cyprus would have been saved if the metalworkers had made 0.3 million metric tons of iron instead of copper? Use the charcoal consumption rate given in the chapter as the rate for copper, and the number of hectares of coppice you calculated in part b as the baseline land area.

Question 8 (4 pts) Consider two different methods of harvesting timber for construction. In the first method, all trees including very young saplings are cut down, and the land is turned into an area for grazing livestock. In the second method, the oldest and largest trees in the forest are selected for harvesting. The remaining trees are left to grow until they reach a size where they will be harvested, and new trees are planted to replace those that are cut down. Which of Aristotle’s three categories of wealth apply to lumber from each of these methods of forestry? Explain your answers.

Question 9 (10 pts) Consider the following three examples of engineered products: a 2008 Toyota Prius (hybrid car), a local and certified-organically grown bushel of corn, and an iPhone. For each of the 12 principles of Green Engineering (Anastas and Zimmerman), assess briefly how each product meets or fails to meet the principle (feel free to do this in bullet point or tabular form).