12.1 At a power plant that produces 1 GW (10^9 watts) of electricity, the steam turbines take steam at a temperature of 500° C, and the waste heat is expelled into the environment at 20° C. What is the maximum possible efficiency of this plant? Suppose you develop a new material for making pipes and turbines which can go up to 600^oC. Roughly how much money can you make a year by installing the new material if you sell the additional electricity generated for 5 cents per kilowatt-hour?

12.2 What is the maximum COP for a cyclic refrigerator operating between a high temperature reservoir at 1K and a low-temperature reservoir at 0.01K? How much heat is extracted from the cold temperature for 1 KJ of work used in running the refrigerator?

12.3 Work out the efficiency of Carnot engine that uses as the working substance a gas of photons. Problem 3 of Chapter 8 of the text (Kittel and Kroemer). You will have to use the thermodynamic properties of a gas of photons (good review).

$$U/V = C\tau^4; C \text{ is a constant}$$
$$p = \tfrac{1}{3}\frac{U}{V}$$
$$\sigma = C'\tau^3; \text{ where } C' \text{ is a constant} \neq C$$

12.4 Problem 10 of Chapter 8 of the text (Kittel and Kroemer). This problem deals with the irreversible expansion of an ideal Fermi gas (instead of a.classical gas). However the final volume is so large that the gas can be treated classically. Hint: In one part of the problem use your understanding of quantum concentration.