Instructor Test Bank

Chapter 1 – Introduction

- It is determined that 1,200 Joules of work needs to be done on a crate in order to push the crate on a level floor for 1.5 meters. What is the force needed to do this amount of work?
  [Ans: 800 N]

- What is the kinetic energy of a 30 gram ball moving at 200 meters per second?
  [Ans: 600 J]

- How much work is needed to be expended in order to raise a 50 kg box to a height of 1.5 meters above the floor?
  [Ans: 740 J]

- What is the efficiency of a Carnot engine if the $T_c = T_h$?
  [Ans: 0%]

- What must the T_c temperature be in order to obtain a 100% efficient Carnot engine?
  [Ans: 0 K]

- Consider a fluid in an enclosed vessel. What is the change in energy of the fluid if the work done on the fluid in the tank is 4000 kJ and the energy transferred to the air is 2000 kJ.
  [Ans: 2000 kJ]

Chapter 2 – Fossil Fuels

- A coal fired power plant burns at 825 K and uses a reservoir at 300 K. What is the maximum efficiency of this power plant?
  [Ans: 64%]

- A gasoline fueled automobile is burning at 400 K. What is the maximum efficiency of the internal combustion engine if the ambient temperature is 290 K?
  [Ans: 27.5%]

- How much coal is required for a 1 GW coal burning electrical power plant? Assume it takes 3 times the thermal energy to produce the electrical energy; and, express your answer in kilograms per year.
  [Ans: 5×10^9 kg/year]

- A 750 MW power plant burns 500 tons of coal every hour. If the energy content of its coal is 7500 Btu/lb; what is the efficiency of the power plant?
  [Ans: 34%]

Chapter 3 – Nuclear Power (Basic Science)

- Calculate the energy density of ^{235}U given that one atom will produce about 200 MeV of energy; and, one mole is 0.24 kg.
  [Ans: 8×10^{13} J/kg]

- What is the yield of a nuclear bomb whose shock wave generates a pressure of 10^3 N/m2 across a volume of 4×10^9 m^3?
  [Ans: 4×10^{12} J or about 1 kiloton equivalent]

Chapter 4 – Nuclear Power (Technology)

- How much fuel will a 1 GW nuclear power plant require per year? Assume the uranium fuel is only 5% of the uranium and the energy density of ^{235}U is that as calculated in the problem section of Chapter 3. Also, how much uranium is this expressed in tons?
  [Ans: 2×10^4 kg/yr; 20 tons]

- If you were located 100 km from a 1 GW nuclear power plant, what would the neutrino flux be at your location? Assume that a 1 GW nuclear power plant releases 10^{21} neutrinos per second; and, you present a 1 square meter surface to the neutrino flux.
  [Ans: 10^{10} neutrinos per second per square meter]

Chapter 5 – Biofuels

- How much Btu could be generated in a year in the USA if all biomass waste were incinerated for heat energy. Assume that there is 1000 lbs of biomass waste per person per year and the energy content is 4300 Btu/lb of biomass waste. Approximately what percentage of the total energy consumption of the USA does this biomass waste heat generated represent?
  [ANS: 1.3×10^{15}; 1%]

- How much corn field area would be required if you were to replace all of the oil consumed in the USA with ethanol from corn? Use the following assumptions: a corn field is 1.5% efficient at converting radiant energy into stored chemical potential energy; conversion from corn to ethanol is 17% efficient; assume a 1.2:1 ratio for farm equipment to energy production; a 50% growing season; and, 200 W/ m^2 solar insolation. What would the length of each side of a square be to have such an area?
  [ANS: 5×10^{12} m^2; 2200 km on a side]

Chapter 6 – Geothermal Energy

- Calculate the amount of thermal energy available by cooling 1 m^3 of rock from 240^o C to 100^o C. Assume the rock specific heat is 2.4 J/cm^3 ^{o} C.
  [Ans: 3.4 x 10^8 J]

- Imagine a steam turbine electric generator power plant that utilizes geothermal renewable energy. With a steam temperature of 210^o C and a heat reservoir at 25^o C; what is the maximum efficiency possible? Also, what percentage of the steam's energy will be dissipated as waste heat?
  [Ans: 38%; 62%]

Chapter 7 – Wind Power

- What is the power density for a 22 mile per hour (10 m/s) wind?
  [Ans: 610 W/m^2]

- What is the power density for a 44 mile per hour (20 m/s) wind?
  [Ans: 4880 W/m^2]

- Consider a 15m diameter wind turbine. How much power could be delivered by the turbine if you had a 10 m/s wind and you are operating at 40% efficiency? What is the maximum energy density possible from such a system?
  [Ans: 100 kW; 2000 kWh/year/$meter^2$]

Chapter 8 – Hydropower

- How much energy does it take to raise 1 gram of water to the top of the troposphere? (Hint: Assume troposphere top is 10,000 meters)
  [Ans: 98 J]

- If we assume that 1.6 x 10^{10} kg of water is evaporated per second by the radiant solar energy, how much potential energy is given to the water vapor? (Hint: Assume the water vapor rises to an average height of 2000 meters.)
  [Ans: 3.14 x 10^{14} J]

- Consider the Grand Coulee Dam in the state of Washington on the Columbia River. Assuming a water "head" (height fill) of 110 meters, how much potential energy is available from each cubic meter of water? About how much power is available if the flow rate is 6,000 cubic meters per second?
  [Ans: 1.08 MJ; 6 GW]

Chapter 9 – Solar Radiation and Earth's Climate

- What is the average available solar radiant power available to the entire USA? (Hint: Average insolation for USA is 177/m^2; and, total area 3.615×10^6 square miles.) About how much solar energy is available every year? What is the equivalent number of BTUs? [Ans: 1.66×10^{15} W; 5.23×10^{22} J; 50,000 QBtu]

- Assume we were to convert $1/500^{th}$ of the available solar radiant energy of the total USA area to usable form assuming 100% efficiency. What state would be closest in area to be required to be covered completely with solar panels? What state area would be required if you had only 15% efficiency?
  [Ans: New Jersey; Pennsylvania]

Chapter 10 – Solar Thermal

- Calculate the total power output of the Sun at the distance of the Earth. Assume a power density at Earth of 1400 W/m^2 and a distance of Earth from the Sun as 1.5×10^8 km.
  [Ans: 4×10^{26} W]

- Using the above calculation for the total power output of the Sun; calculate how much solar energy is emitted in one year.
  [Ans: 10^{34} J/year]

Chapter 11 – Photovoltaics

- Assume we were to convert $1/500^{th}$ of the available solar radiant energy of the total USA area to usable form assuming 100% efficiency (Hint: see question, and your answer in Chapter 9.) What state would be closest in area to be required to be covered completely with solar panels? What state area would be required if you had only 15% efficiency?
  [Ans: New Jersey; Pennsylvania]

- What is the current available from a typical single solar photovoltaic panel (130 W) if the electric potential developed is 17.5 Volts?
  [Ans: 7.6 A]

- Consider a region where it costs an average of $8.00/W of solar panels installed. What is the cost to install a 3 kW solar photovoltaic system for a residence?
  [Ans: $24,000]

Chapter 12 – Energy Conservation and Efficiency

- A heat pump maintains a home's temperature at 20^{o} C. If the air temperature outdoors is -5^{o} C, what is the maximum coefficient of performance (COP)?
  [Ans: 11.7]

- A home freezer maintains -5^{o} C. If the home is maintained at 20^{o} C; what is the maximum efficiency in terms of the energy efficiency ratio (EER)?
  [Ans: 10.7]

Chapter 13 – Energy Storage and Transmission

- How much chemical potential energy is stored in a full tank of gasoline? Assume your tank holds 20 gallons of gasoline.
  [Ans: 2 x 10^{9} J]

- What would the weight of a battery be if it possessed the equivalent energy of a tank of gasoline? Assume a 20 gallon tank of gasoline for comparison; and, assume a battery energy density of 6 x 10^{5} J/kg.
  [Ans: 3000 kg]

Chapter 14 – Climate and Energy

- Calculate the amount of carbon dioxide emitted by an automobile in a year. Assume the car gets 20 miles per gallon and travels 10,000 miles in a year. Now estimate the total amount of carbon emitted by all automobiles using the figure just completed and assuming 150 million automobiles in the USA.
  [Ans: 8 x 103 kg of CO2 per year per car; 1 x 1012 kg per year for all cars in USA]

- Imagine if all of the coal reserves in the world were burned; and 50% of the generated CO2 is deposited in the atmosphere. Calculate the increase in the concentration of CO2 in the atmosphere in the world using this scenario. For simplicity, assume that the coal deposits are 100% carbon.
  [Ans: 230 ppm]

- In what year would you estimate the CO_2 concentration to have doubled when compared to the 1860 level of CO_2; if the rate of increase were a steady 0.4% per year? [Ans: 2033]