I. Introduction: 1 point

The purpose of this homework assignment is to examine our model of energy conversion devices and to acquaint you with fossil fuels, the major energy source for these energy conversion devices. For the last 140 years, our use of fossil fuels has grown exponentially. The amounts of our reserves of fossil fuels are limited so models of our consumption of these resources will be used to estimate the lifetimes of fossil fuels.

II. Questions: 6 points

Q1. Units tell us whether it’s energy or power! The kilowatt (kW) is a unit of ____________, while the kilowatt-hour (kWh) is a unit of _____________.

Q2. An energy conversion device is shown at the right.

Use Conservation of Energy to determine that:

the energy input = ____________ joules and
the efficiency of this device = ____________%.

Q3. Consider two sequential energy conversion devices each with an efficiency of 80%.

The combined efficiency of the two devices = ____________%.

Q4. Energy sources are classified according to their lifetime as renewable or nonrenewable.

__________ energy is an example of a renewable energy. Its lifetime is _________.

__________ energy is an example of a nonrenewable energy. Its lifetime is _________.

Q5. Exponential growth is defined as growth with a constant doubling time (DT). Exponential growth also has a constant percentage growth rate (%GR). The relation between DT and %GR is:

\[ DT \text{ (in years)} = \left( \frac{100}{\%GR \text{ (in } \% \text{ per year)}} \right) \]

Q6. When coal is burned, the carbon in coal combines with oxygen in the air.

The chemical process of burning is called _________.

The chemical formula of the gaseous product is _________.

III. Problems: 8 points

P1. An P125 student of mass 50 kilograms climbs from the bottom to the top of SW007, a vertical distance of 5.0 meters, in 2.5 seconds.

Her potential energy gain = ____________ joules.

Her power (rate of energy) output = ____________ watts.

P2. A car with a mass of 1200 kilograms accelerates from zero to a speed of 22 meters/second (about 50 miles/hour).

The change in the kinetic energy of the car \( [(ΔKE)] \) = ____________ joules.

Suppose the internal combustion engine (ICE) of the car has an efficiency of 20%.

The gasoline energy input required to produce this \( ΔKE \) = ____________ joules.

P3. According to our Energy Flow Diagram for the US in 1980 (Figure 2 in UFAE):

the total amount of oil consumed = ____________ Qbu (quads) and
the percentage of the total oil consumed that was imported = ____________%.

(over)
P4. Assuming constant rates of use (at the 1997 production rates in Priest, Table 3.1),
give estimates of the lifetimes in years of the US proven reserves:

- Oil lifetime = _______ years, Natural Gas lifetime = _______ years, and
- Coal lifetime = _______ years.

P5. Over the last five years the daily consumption of pizza in the United States has doubled.
Assuming that the growth is exponential,
- the growth rate = _______ % per year.

P6. The electrical power consumption of a small community is 100 MW and it is growing exponentially with a growth rate of 3.5% per year. Suppose we want to determine when the power consumption will grow to be 400 MW.
- The doubling time (DT) = _______ years.
- The growth factor = (final value) / (initial value) = _______.
- Since _______ doubling times will be required to give this growth factor, the time for the power consumption to reach 400 MW = _______ years.

P7. The total coal reserves in Indiana are estimated to be 30 x 10^8 tons and our present coal production rate in the state is 25 x 10^6 tons/year. For a constant rate of use, the expected lifetime = (total reserves) / (rate of use).
- The lifetime of Indiana’s coal reserves = _______ years.

P8. An approximate production curve for oil in the Soviet Union is shown at the right. If this model is correct, the total Soviet oil production will be given by the area of the triangle or

\[(1/2) \times \text{base} \times \text{height} \]

The total Soviet oil production = _______ barrels of oil.

IV. Essay Question: 10 points

Instructions: Type your response to the Essay Question in the window provided. Your answer to the Essay Question should begin with a title describing its content and it should be about 300 words or 5 paragraphs in length. You can work on this essay in more than one sitting, but please be sure to SAVE the contents of your window often!

Essay Question:

The total energy consumption per year in the United States since 1850 is plotted in Figure 1 of UFAE. The plot shows that the US energy use grew exponentially from 2.3 quads in 1850 to 81 quads in 1990. This corresponds to an increase in the energy use by a factor of 35 over the 140 year period. Over this same period, the US population also grew exponentially from 20 million to 250 million people, which corresponds to an increase by a factor of 12.5 over the same time period.

These results indicate that the most important factor leading to the increase in energy consumption in the US is the exponential growth of the population (with an average growth rate of 1.8% per year). Another factor is the increase in energy use by each person by a factor of 2.8.

Write an essay about the exponential growth of our energy consumption. Include a discussion of the above observations of exponential growth and their impact on our attempts to develop models of our energy use in the US in the future.

If it were to continue, what impact would this exponential growth have on our current estimates of the lifetimes of fossil-fuel reserves made using a constant rate of use?

Is this exponential growth only a problem for the US or does it also have important implications for global energy issues, such as depletion of reserves or environmental pollution?