Review Exercises - 3:

Review Exercises - 3:

For an ideal heat engine, according to Carnot:

a. $T_h/T_c = Q_c/Q_h$ b. $T_c/T_h = Q_c/Q_h$ c. $T_h/Q_c = T_c/Q_h$ d. $T_c/Q_c = Q_h/T_h$

If an ordinary household refrigerator is left operating in a closed, perfectly insulated room with the refrigerator door standing open, after a long time, the temperature in the room will

a. go up b. remain constant c. go down d. fluctuate

The maximum efficiency of a heat engine that has steam injected into it at 850° C and that rejects the steam at 225° C is

a. 74% b. 56% c. 44% d. 20%

A typical efficiency for a coal-burning electric power plant is

a. 1% b. 2% c. 5% d. 10% e. 25% f. 33% g. 66% h. 90%

The methane in natural gas burns according to $CH_4 + 2O_2 \rightarrow CO_2 + {}_2H_2O$. How many tons of CO_2 are produced for each ton of methane that is burned?

a. 2.75 b. 3.7 c. 12 d. 36 e. 44 f. 93

An inventor claims to have developed a wonderful new heat engine that operates with a relatively cool (and therefore nonpolluting) flame at 150° C and discharges waste heat to the environment at 20° C. His promotional literature advertises that 45% of the fuel energy is converted into useful work. Calculate the maximum efficiency that can be expected for such an engine and compare it to the inventor's claim.

Maximun efficiency = (1 – 293/423) = 30.7% < 45%

Because individual natural gas-fueled water heaters in homes do not have air pollution control devices, it has been proposed that water in homes be heated with electrical energy generated at a distant power plant that is equipped with effective air pollution control devices. The power plant burns natural gas and produces electrical energy with 40% efficiency; the electric transmission line between the plant and the home loses 10% of the electrical energy as heat. All that remains goes into heating the water. In contrast, the water heater gets only 60% of the fuel energy into the water. Which scheme uses more natural gas to heat a given quantity of water?

Total efficiency for power plant = 40% (1 – 10%) = 36% < 60%

So the first scheme uses more natural gas.

Why are fossil fuel-burning electric power plants situated near lakes or rivers or provided with cooling towers?

To keep T_c at low temperature and get high efficiency.

An electrically powered heat pump can deliver more energy than it draws from the power line without violating the Principle of Energy conservation. Explain how this can happen.

For heat pump, $Q_{hot} = W + Q_{cold.}$

So, $Q_{hot} > Q_{cold}$

Show that the combination of a 40% efficient power plant with a heat pump having a coefficient of performance of 4.0 would actually deliver 60% more heat energy than if the fuel were used directly to heat a house with 100% efficiency.

4.0 x 40% = 160%, 60% more than 100%