Chapter 15

Problems & Exercises

1.

1.6×10^9 J

3.

-9.30×10^8 J

5.

(a) -1.0×10^4 J , or -2.39 kcal

(b) 5.00%

7.

(a) 122 W

(b) 2.10×10^6 J

(c) Work done by the motor is 1.61×10^7 J ;thus the motor produces 7.67 times the work done by the man

9.

(a) 492 kJ

(b) This amount of heat is consistent with the fact that you warm quickly when exercising. Since the body is inefficient, the excess heat produced must be dissipated through sweating, breathing, etc.

10.

2.09×10^4 J

12.

(a) $W = P\Delta V = 1.76 \times 10^5$ J

(b) $W = \text{Fd} = 1.76 \times 10^5$ J. Yes, the answer is the same.

14.

$W = 4.5 \times 10^3$ J

16.

W is not equal to the difference between the heat input and the heat output.

20.

(a) 18.5 kJ

(b) 54.1%

22.

(a) 1.32×10^9 J

(b) 4.68×10^9 J

24.

(a) 3.80×10^9 J

(b) 0.667 barrels

26.

(a) 8.30×10^{12} J, which is 3.32% of 2.50×10^{14} J .

(b) -8.30×10^{12} J, where the negative sign indicates a reduction in heat transfer to the environment.

28.

403ºC

30.

(a) 244ºC

(b) 477ºC

(c)Yes, since automobiles engines cannot get too hot without overheating, their efficiency is limited.

32.

(a) $\mathrm{Eff}_1 = 1 - \frac{T_{\mathrm{c},1}}{T_{\mathrm{h},1}} = 1 - \frac{543\ \mathrm{K}}{723\ \mathrm{K}} = 0.249$ or 24.9%

(b) $\mathrm{Eff}_2 = 1 - \frac{423\ \mathrm{K}}{543\ \mathrm{K}} = 0.221$ or 22.1%

(c) $Eff_1 = 1 - \frac{T_{\mathrm{c},1}}{T_{\mathrm{h},1}} \Rightarrow T_{\mathrm{c},1} = T_{\mathrm{h},1}\,(1, -, eff_1)$ similarly, $T_{\mathrm{c},2} = T_{\mathrm{h},2}(1 - Eff_2)$

$$T_{\mathrm{c},2} = T_{\mathrm{h},1}(1 - Eff_1)(1 - Eff_2) \equiv T_{\mathrm{h},1}(1 - Eff_{\mathrm{overall}})$$

$$\therefore (1 - Eff_{\mathrm{overall}}) = (1 - Eff_1)(1 - Eff_2)$$

using $T_{\mathrm{h},2} = T_{\mathrm{c},1}$ in above equation gives $Eff_{\mathrm{overall}} = 1 - (1 - 0.249)(1 - 0.221) = 41.5\%$

(d) $\mathrm{Eff}_{\mathrm{overall}} = 1 - \frac{423\ \mathrm{K}}{723\ \mathrm{K}} = 0.415$ or 41.5%

34.

The heat transfer to the cold reservoir is $Q_\mathrm{c} = Q_\mathrm{h} - W = 25\ \mathrm{kJ} - 12\ \mathrm{kJ} = 13\ \mathrm{kJ}$, so the efficiency is $Eff = 1 - \frac{Q_\mathrm{c}}{Q_\mathrm{h}} = 1 - \frac{13\ \mathrm{kJ}}{25\ \mathrm{kJ}} = 0.48$. The Carnot efficiency is $\mathrm{Eff}_\mathrm{C} = 1 - \frac{T_\mathrm{c}}{T_\mathrm{h}} = 1 - \frac{300\ \mathrm{K}}{600\ \mathrm{K}} = 0.50$. The actual efficiency is 96% of the Carnot efficiency, which is much higher than the best-ever achieved of about 70%, so her scheme is likely to be fraudulent.

36.

(a) –56.3ºC

(b) The temperature is too cold for the output of a steam engine (the local environment). It is below the freezing point of water.

(c) The assumed efficiency is too high.

37.

4.82

39.

0.311

41.

(a) 4.61

(b) 1.66×10^8 J or 3.97×10^4 kcal

(c) To transfer 1.66×10^8 J , heat pump costs $1.00, natural gas costs $1.34.

43.

27.6ºC

45.

(a) 1.44×10^7 J

(b) 40 cents

(c) This cost seems quite realistic; it says that running an air conditioner all day would cost $9.59 (if it ran continuously).

47.

(a) 9.78×10^4 J/K

(b) In order to gain more energy, we must generate it from things within the house, like a heat pump, human bodies, and other appliances. As you know, we use a lot of energy to keep our houses warm in the winter because of the loss of heat to the outside.

49.

8.01×10^5 J

51.

(a) 1.04×10^{31} J/K

(b) 3.28×10^{31} J

53.

199 J/K

55.

(a) 2.47×10^{14} J

(b) 1.60×10^{14} J

(c) 2.85×10^{10} J/K

(d) 8.29×10^{12} J

57.

It should happen twice in every 1.27×10^{30} s or once in every 6.35×10^{29} s

$$\left(6.35 \times 10^{29}\ \text{s}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)\left(\frac{1\ \text{d}}{24\ \text{h}}\right)\left(\frac{1\ \text{y}}{365.25\ \text{d}}\right)$$

$$= 2.0 \times 10^{22}\ \text{y}$$

59.

(a) 3.0×10^{29}

(b) 24%

61.

(a) -2.38×10^{-23} J/K

(b) 5.6 times more likely

(c) If you were betting on two heads and 8 tails, the odds of breaking even are 252 to 45, so on average you would break even. So, no, you wouldn't bet on odds of 252 to 45.

63.

(b) 7

(c) 64

(d) 9.38%

(e) 3.33 times more likely (20 to 6)