KE = $\frac{1}{2} MV^2$, $g = 9.8 \text{ m/s}^2$, $PE_g = Mgh$

1 ft/s = 0.305 m/s, 1 BTU = 1055 J,
1 kcal = 4184 J, 1 hp = 746 W
1 W = 3.41 BTU/h, 1 mile = 5280 ft, 1 h = 3600 s,

Q = $\Delta T/R$

1) Define Energy

   \text{Ability to do work}

2) Define Work

   \text{Force} \times \text{distance}

3) Define Power.

   \text{Energy} / \text{Time}

4) Define Heat.

   \text{Energy transferred as a result of a temperature difference}
5) What is the first law of thermodynamics?

That energy is conserved

or

\[ Q_{to} - W_{by} = \Delta E \]

6) What is the 2nd law of thermodynamics?

Can't convert heat 100% into work

or

Heat does not flow by itself from cold to hot

or

Entropy of universe never decreases

7) What is Newton's 2nd law?

\[ F = Ma \]
8) What are the principle US non-renewable sources of energy?

Oil, gas, coal, (nuclear)

9) What will happen to the rate of US production of oil in the near future and why?

It will decrease further because we are running out of oil.

10) When a conventional car stops, where does the original kinetic energy go? When a high efficiency Prius hybrid car stops where does the kinetic energy go?

Conventional car converts kinetic energy into heat.

Prius stores some of the kinetic energy as chemical energy in battery.

For converts it to electrical energy... in generator.
11) The efficiency of a heat engine is the ratio of what two quantities?

Work out / Heat in

12) If energy is always conserved, how can we use less fuel?

We can avoid converting energy into less useful forms

or We can use E more efficiently
13) A 12 kg weight is hung from a long string as a pendulum. If the weight is moved, 5 m/s at the bottom of its swing, how high will it rise?

\[ KE = \frac{1}{2} m v^2 \rightarrow = M g \cdot h \]

\[ h = \frac{v^2}{2 g} = \frac{(5 \text{ m/s})^2}{2 \cdot (9.8 \text{ m/s}^2)} = 1.28 \text{ m} \]

14) My automobile burns 1000 joules of gasoline at an absolute temperature of 1400 K and discards 800 J of heat to the radiator at a temperature of 350K. Calculate the actual efficiency of my car.

\[ \text{Work} = 1000 - 800 = 200 \text{ J} \]

\[ \text{Efficiency} = \frac{\text{Work}}{\text{Heat in}} = \frac{200 \text{ J}}{1000 \text{ J}} = 0.2 \]
15) Your German Shepard Spot has a mass of 40 kg. As a heat engine Spot is 15% efficient for converting chemical energy into mechanical energy. Spot eats a jelly doughnut (a million Joules of chemical energy) and climbs a hill. How high up the hill can he get on the energy from that one doughnut?

\[ E = 0.15 \times 10^6 \text{ J} = M \cdot g \cdot h \]

\[ h = \frac{0.15 \times 10^6 \text{ J}}{40 \text{ kg} \left(9.8 \text{ m/s}^2\right)} = 1383 \text{ m} \]

16) A single pane window has an area of 25 ft\(^2\) and a thermal resistance of \( R = 0.8 \text{ ft}^2\cdot\text{h}^\circ\text{F}/\text{BTU} \). Calculate the heat loss through the window during one 8 hour cold Bloomington night when the outside temperature is -10\(^\circ\text{F}\) and the inside temperature is 65\(^\circ\text{F}\).

\[ Q_c = \frac{t \cdot A \cdot \Delta T}{R} \]

\[ = \frac{(8 \text{ h}) \cdot 25 \text{ ft}^2 \cdot 75^\circ\text{F}}{0.8 \text{ ft}^2\cdot\text{h}^\circ\text{F}/\text{BTU}} \]

\[ Q_c = 18750 \text{ BTU} \]
17) How fast would a snow ball (block of ice) have to travel in m/s so that if its kinetic energy were totally converted to heat it could melt all of the ice? Assume the heat of vaporization of H₂O is 2260 kJ per kg and the heat of fusion is 326kJ per kg.

\[ KE = \frac{1}{2} m v^2 = 326 \text{ kJ} \quad \text{(Heat of Fusion)} \]

\[ v = \left[ \frac{326000}{2} \right]^{1/2} = 807 \text{ m/s} \]

18) Suppose you left a 100 W light bulb on continuously for one month. If the electrical generation and transmission efficiency is 30%, how much chemical energy (in Joules) was wasted at the power plant for this one sight?

\[ E_{\text{tot}} = \frac{100 \text{ W} \times 24 \text{ h} \times 30 \text{ days}}{0.30} \]

\[ = 100 \frac{\text{J}}{\text{s}} \left( 24 \frac{\text{h}}{\text{day}} \right) \left( 3600 \frac{\text{s}}{\text{h}} \right) \times 30 \text{ days} \]

\[ = 8.64 \times 10^8 \text{ J} \]