

Thermodynamics

1 – Transforming Energy

Energy: *CANNOT* (forget Einstein for now ☺) be created or destroyed but *CAN* be converted from one form to another.

$$\Delta E = \Delta E_K + \Delta E_P + \Delta E_H \dots = W$$

We often convert one from to another in order to utilize the energy.

- Chemical Energy of gasoline is converted to Thermal Energy in a car, which in turn is converted to Mechanical Energy to move the car.
- Potential Energy of water in a dam is converted to Mechanical Energy as it falls, which is then converted to Electrical Energy by a turbine.

During these processes we often say Energy is lost... but this can't be true. **Energy can neither be created or destroyed.**

In fact energy is not lost, but instead converted to an undesired form. (Often Thermal Energy)

We use the term efficiency to describe the effectiveness of an energy conversion.

$$e = \frac{\text{what you get out}}{\text{what you put in}} \times 100\%$$

→ W_{out}/P_{out}

→ W_{in}/P_{in}

Example:

A 75 W incandescent light bulb produces 2.8 W of visible light. Calculate the efficiency of the bulb.

$$e = \frac{P_{out}}{P_{in}} \times 100\% = \frac{2.8W}{75W} \times 100\% = \boxed{3.7\%}$$

A 15 W light CFB (Compact Fluorescent Bulb) produces the same visible light. Calculate the efficiency of the bulb.

$$e = \frac{P_{out}}{P_{in}} \times 100\% = \frac{2.8W}{15W} \times 100\% = \boxed{19\%}$$

How many times more efficient is a CFB than an incandescent light bulb?

$$\frac{18.7\%}{3.7\%} \sim \boxed{5x}$$

Example:

Cranes are often used to increase an objects potential energy. Crane 1 used 25 kJ of energy to lift a 200 kg box to the top of a building. Crane 2 uses 10 kJ to lift a 120 kg box to the same roof. Which crane is more efficient?

$$\text{Crane 1} \rightarrow e = \frac{mgh}{25,000J} \times 100\% = 7.84h\%$$

$$\boxed{\text{Crane 2}} \rightarrow e = \frac{m_2gh}{10,000J} \times 100\% = 11.8h\%$$

Energy in the Body: Bio again.... ☺

In the cells of our body glucose is converted into energy.

cellular
respiration



The energy is then stored in a molecule called adenosine triphosphate (ATP). This energy is released to do the work of life!

1g of glucose releases ~ 17 kJ of Energy

Eating Calories		
Food	E content in Cal	E content in kJ
Fried Egg	100	418
Apple	125	523
Beer (can)	150	628
Latte	260	1088
Slice of Pizza	300	1255
Apple Pie Slice	400	1674

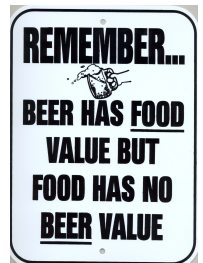
Burning Calories (70 kg person)	
Activity	Rate at which we consume E (W)
Typing	125
Walking @ 5 km/h	380
Cycling @ 15 km/h	480
Swimming (Fast Front Crawl)	800
Running @ 15 km/hr	1150

$$1 \text{ Cal} = \underline{4.184} \text{ kJ}$$

Example:

A 12 oz can of beer contains 150 cal of beer. If all that energy is stored in the simple carbohydrate Glucose how many g's of sugar are in the beer?

$$150 \text{ cal} \times \frac{4.184 \text{ kJ}}{1 \text{ cal}} \times \frac{1 \text{ g}}{17 \text{ kJ}} = \boxed{37 \text{ g sugar}}$$



Example:

A cyclist racing in the Gran Fondo pedals for 5.0 hrs at a speed of 15 km/hr. How much metabolic energy (in kJ's) is required? How much energy goes to forward propulsion is the process is only 25% efficient.

→ 180,000s

$$\Delta E = W = \Delta P \cdot t = (480 \text{ J/s})(180,000 \text{ s})$$

$$\Delta E = \cancel{3.24 \times 10^7 \text{ kJ}}$$

$$8.64 \times 10^6 \text{ kJ}$$

$$E_{out} = \cancel{3.24 \times 10^7 \text{ kJ}} \times 0.25$$

$$\boxed{E_{out} = \cancel{8.1 \times 10^6 \text{ kJ}} \quad 2.16 \times 10^3 \text{ kJ}}$$

Example:

How many flights of stairs could you climb on the energy contained in a 12 oz can of beer? Assume that your mass is 70 kg and that each flight of stairs has a vertical displacement of 3.0 m. Again assume 25% efficiency.

$$E_{in} = 628 \text{ kJ} \times 0.25 = 157 \text{ kJ}$$

$$E_{in} = mgh$$

$$h = \frac{E_{in}}{mg} = \frac{157,000 \text{ J}}{(70 \text{ kg})(9.8 \text{ m/s}^2)} = 229 \text{ m}$$

$$\text{flights} = \frac{229 \text{ m}}{3.0 \text{ m}} = 76.3 \text{ flights}$$

$$\boxed{76 \text{ flights}}$$