How does a system gain or lose energy?

System's Change in Energy ***heat*** ***work***

$$\Delta E = q + w$$

Factors that increase the system's energy

$\Delta E > 0$ (i.e. positive)
...system gains energy

q > 0 (i.e. positive)	**w > 0 (i.e. positive)**
system gains heat *(heat flows into system)*	**work done on the system**

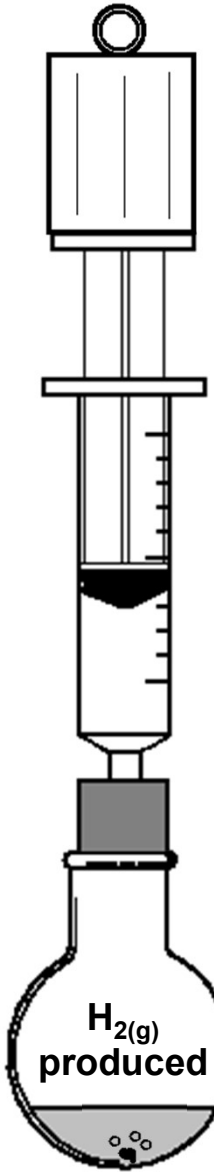
$\Delta E < 0$ (i.e. negative)
...system loses energy

q < 0 (i.e. negative)	**w < 0 (i.e. negative)**
system gives up heat *(heat flows out of system)*	**system does work on surroundings**

Factors that decrease the system's energy

Heat (q) and Work (w)

An Example



$$Zn_{(s)} + 2\,HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$$

w < 0 (negative)

System lifts weight and does work on surroundings

$$\Delta E = q + w$$

(negative) **(negative)**

$$\Delta E < 0$$

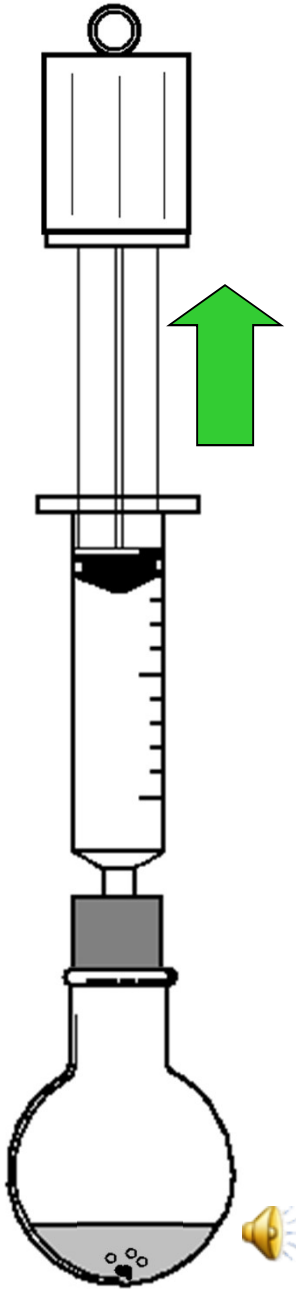
(system's energy decreases)

$H_{2(g)}$ produced

Heat

System produces heat that is released into the surroundings.

q < 0 (negative)



Energy, Work and Heat: Units

1 calorie (cal): Energy to raise the temperature of 1.00 g $_{H2O}$ by 1°C (or K)

100.0 g_{H2O}

22.5 °C → 32.5 °C

10.0 °C change in T

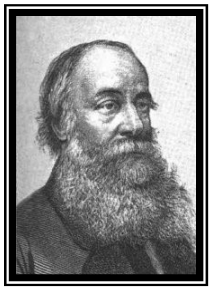
Requires 10 × 100 = 1000 calories of heat

Calorie (cal): Dietary **C**alorie (on food labels)

1000 **c**al = 1 **C**al

= 180 **C**alories = 180000 **c**alories!

Joule (J): Metric derived energy unit

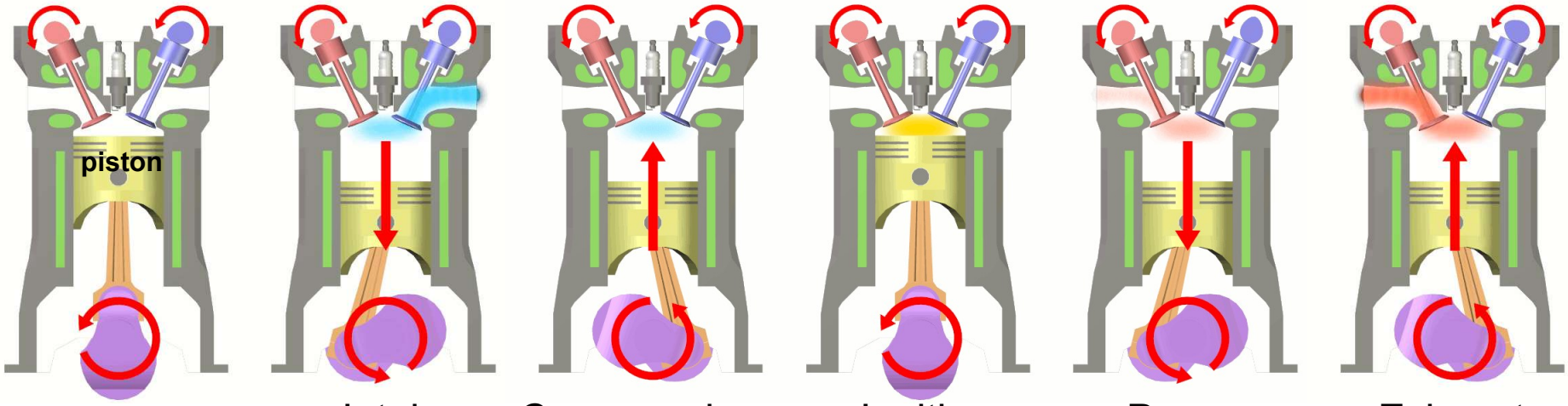


James Prescott Joule

1 **c**al = 4.184 J

1 Joule = 1 kg• m^2/s^2

The 4-stroke Auto Engine



$\Delta E = q + w$

q (neg) heat released
...heat warms engine, passengers and surroundings on cold days

w (neg) work done on surroundings
....moves car against frictional forces and gravity

Automotive engineers design engines that release as little heat as possible. Why?