CONCEPT: REFRIGERATORS

● Remember, heat *ALWAYS* flows from hotter to colder, never the other way around!

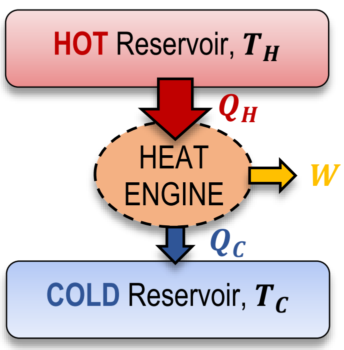
Second Law of Thermodynamics – Clausius / "Refrigerator" Statement

● In a cyclic process, it is impossible for heat to flow from COLDER to HOTTER temperature without an input of _______.

● A **Refrigerator** is the opposite of a heat engine – it takes in ________ to pump heat energy from ________ to ________.

- Your home fridge takes heat from food/liquid (Q_C) and work from electricity (W), and expels heat to the room (Q_H).
- Efficiency = how "good" a heat engine is. Coefficient of Performance = how "good" a refrigerator is.

Heat Engine



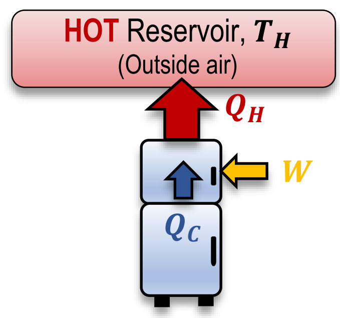
● $\Delta E_{int} = 0 \rightarrow$ $|W| = |Q| = |Q_H| - |Q_C|$

● Efficiency: $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$

What you got out of it

What you "paid" to get it

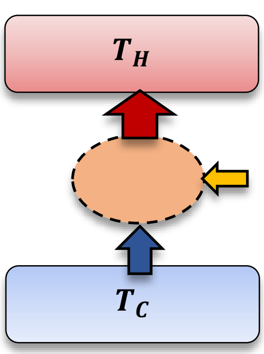
Refrigerator



● $\Delta E_{int} = 0 \rightarrow$ $|W| = |Q| =$ ________

● Coefficient of Performance: $K = \frac{\quad}{\quad} = $ ________

EXAMPLE: A refrigerator takes in 600 kJ of heat from the food inside, and releases 720 kJ of energy to the (much warmer) room. Calculate: **a)** the work required to run the refrigerator each cycle; **b)** the coefficient of performance of the refrigerator.



PROBLEM: A refrigerator has a coefficient of performance of 2.4. Each cycle, it takes in 3×10^4 J of heat from the cold reservoir. How much is expelled to the hot reservoir?

A) 2.5×10^4 J
B) 4.25×10^4 J
C) 2.1×10^4 J
D) 1.25×10^4 J

HEAT ENGINES & REFRIGERATORS
$\Delta E_{int} = 0$ $\lvert W\rvert = \lvert Q_H\rvert - \lvert Q_C\rvert$ $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$ $K = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}$

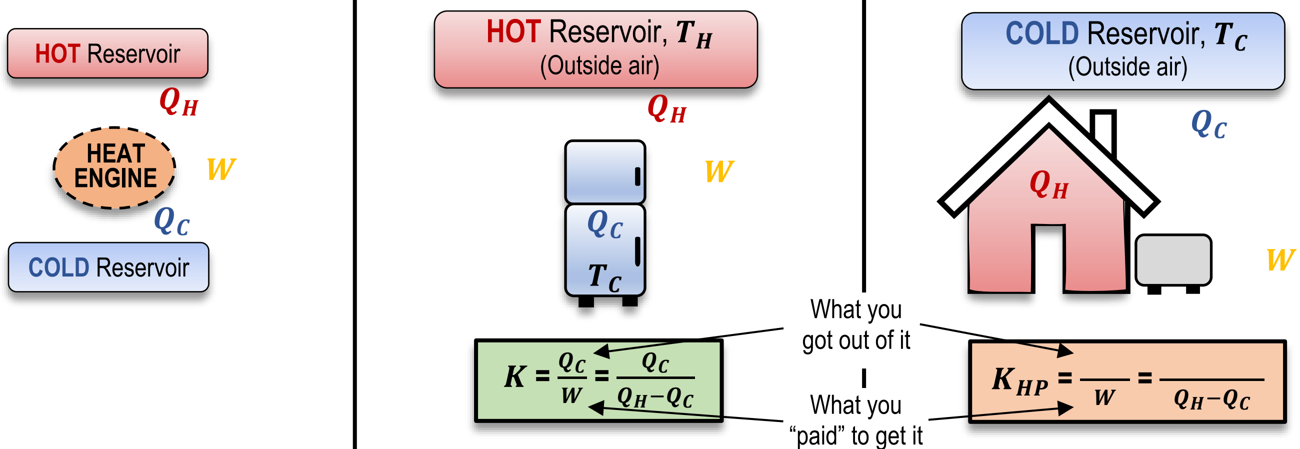
PROBLEM: A common household mini-refrigerator has K = 3 and power input of 85 W. A sample of water of mass 0.5 kg and temperature 20.0°C is placed in the freezer compartment. How long does it take to freeze the water to ice at 0°C?

HEAT ENGINES & REFRIGERATORS
ΔE_{int} = 0
$\lvert W \rvert = \lvert Q_H \rvert - \lvert Q_C \rvert$
$e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$
$K = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}$
$Q = mc\Delta T$
c_{water} = 4186 J/(kg·K)
L_f = 3.34×10^5 J/kg

CONCEPT: HEAT PUMPS

● **Heat Pumps**, like refrigerators, pump heat from **COLDER** to **HOTTER.** However, the reservoirs are _____________.

Heat Engine (e.g. generator) | **Refrigerator** (e.g. fridge or air conditioner) | **Heat Pump** (e.g. space heater)



[PRODUCES | REQUIRES] Work

[PRODUCES | REQUIRES] Work

Cold reservoir is **[INSIDE | OUTSIDE]**

Hot reservoir is **[INSIDE | OUTSIDE]**

[PRODUCES | REQUIRES] Work

Cold reservoir is **[INSIDE | OUTSIDE]**

Hot reservoir is **[INSIDE | OUTSIDE]**

EXAMPLE**:** A heat pump has a coefficient of performance of 3.6 and a power supply of 7×10^3 W**.** Calculate the heat energy delivered into a home over 4 hours of use**.**

EQUATIONS
$\lvert W \rvert = \lvert Q_H \rvert - \lvert Q_C \rvert$
$P = \frac{W}{\Delta t}$