Due Mon., Mar 5

2012 Heat and Thermo 7

1. Fill in the table at the right. Challenge yourself to do so from memory.

Process	What equals 0	First Law of Thermodynamics
Isovolumetric		
Isothermal		
Adiabatic		

2. A gas expands, doing 2600 J of work on its surroundings, while 3200 J of heat is added to the gas. Calculate the change of internal energy of the gas.

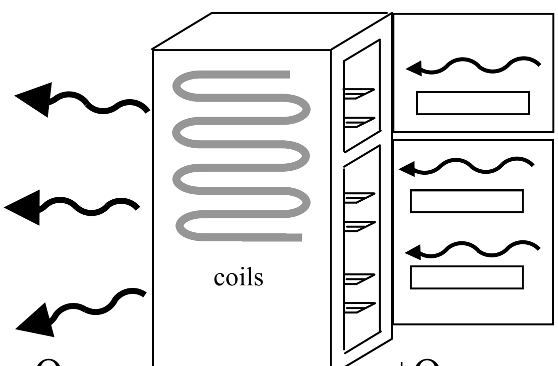
   A. * Since the gas expanded, how much work was done on the gas?
   B. * What is the value of Q?
   C. * What is the change of internal energy or the gas?
   D. * Did the gas increase or decrease its temperature?

A. $W_{on} = -2600$ J
B. Q = +3200J (added)
C. 3200−2600 = 600 J
D. increase

3. A piston's volume changes from 12 m^3 to 3 m^3 at 2 atmospheres (2×10^5 Pa). During this time 120kJ of heat is drawn from a hot reservoir attached to the piston.

   A. Given that $W_{by} = P\Delta V$ and that P (pressure) is in pascals, calculate the work done by the gas.
   B. Since heat always travels from ______ to ______ and the piston is attached to a hot reservoir (something that holds heat), is the 120kJ added to or removed from the gas?
   C. So, Q =
   D. Calculate the change of internal energy of the gas.

A. $W_{by} = (-9)\times 2\times10^5 = -18E5$ or −180kJ
B. Added
C. +120kJ
D. $\Delta U = Q - W_{by}$ = 120−(−180) = 120+180 = 300 kJ



$-Q_H$ (heat released by the hot refrigerant)

$+Q_C$ (heat absorbed by the cold refrigerant)

A hot object is placed inside a refrigerator. As the object cools it heats the air inside the refrigerator. This heat then moves to the walls of the refrigerator and is eventually absorbed by the actual refrigerant inside metal coils (conducting coils) that are inside the refrigerator walls. So, each of these is equivalent: heat is removed from the food inside the refrigerator = heat is absorbed by the coils in the walls of the refrigerator = heat is absorbed by the refrigerant inside the refrigerator (or coils). These are all Q_C for a refrigerator because it is where the refrigerator is cold. Why does the refrigerant absorb heat? Because it is colder than what you put inside the refrigerator and heat travels from hot to cold. Then this refrigerant travels to the compressor which does work, raising the temperature of the refrigerant higher than the air around the outside of the refrigerator. Behind the refrigerator more metal coils (again conductors) release heat (Q_H) to the room. Why is heat released? Because the gas is hot.

Let's learn about Q_C, Q_H and W for cyclic processes: refrigerators and heat engines.

4. Q_C is the heat gained or lost at cold temperature.
   A. For a refrigerator, where is Q_C: inside the food compartment or at the outside?
   B. Is Q_C for a refrigerator + (heat absorbed) or − (heat removed)?
   C. For a heat engine is Q_C at the boiler or the radiator after the piston?
   D. For a heat engine is Q_C + or −?

A. Inside (where it is cold)
B. + for the gas, not the food
C. radiator
D. − (radiators remove heat)

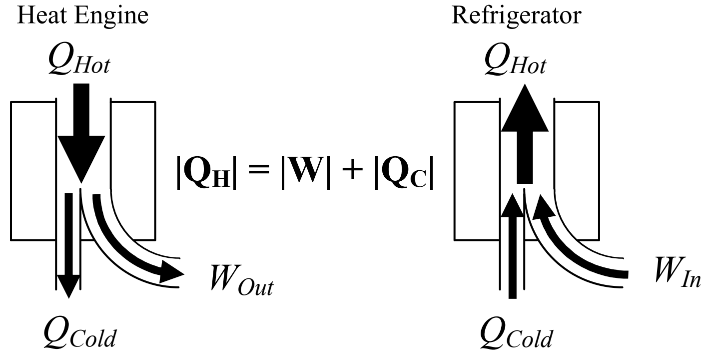
5. Q_H is the heat gained or lost at hot temperature.
   A. For a refrigerator, where is Q_H: inside the food compartment or at the outside?
   B. Is Q_H for a refrigerator + (heat absorbed) or − (heat removed)?
   C. For a heat engine is Q_H at the boiler or the radiator after the piston?
   D. For a heat engine is Q_H + or −?

A. Outside
B. −
C. Boiler (fire)
D. +

6. W is the work done on or by the gas.
   A. In a refrigerator, is W_{by} the gas + or − when in the compressor?
   B. In a refrigerator to cool down the gas is forced thru an expansion valve. Is this + or − W_{by}?
   C. In a heat engine the piston pushes out to create useable work. Is the + or − W_{by}?

A. −, compressed
B. +, expansion
C. +, expands.

These two diagrams are key to solving many cyclic process problems. Notice that in BOTH CASES (engines and refrigerators) that $|Q_H| = |W| + |Q_C|$. The difference is direction: whether work and Q_C is added or removed. Notice that the direction of Q_H, etc, is exactly what we just discussed.



7. On the heat engine diagram, label the boiler, piston, and radiator. Refer to the previous questions, if necessary.
8. On the refrigerator diagram, label the inside of the refrigerator (inside), the compressor, and the outside of the refrigerator.

Now, let's practice using these equations:

9. * If 4,000 J of heat is added at the boiler of a heat engine and 2500 J of work is done in the piston, how much heat must be removed by the radiator?

10. * If 600 J of heat is removed from food inside the refrigerator and the compressor does 300 J of work on the system (the gas), how much heat is dumped into the room around the refrigerator?

11. * 5kJ of heat is removed from the gas in a heat engine, while 12kJ is added at the boiler. How much work was done by the system?

12. 12 kJ of work is done by the compressor in a refrigerator and 20kJ of heat is dissipated in the coils behind the refrigerator. How much heat is removed from the inside food compartment?

9. $|Q_H| = |W| + |Q_C|$, so $4{,}000 = 2500 + Q_C$ and $Q_C = 4{,}000 - 2500 = 1500$ J

10. $|Q_H| = |W| + |Q_C|$, so $Q_H = 300 + 600 = 900$ J It is really this easy.

11. 7kJ