

1. Q_H , Q_C , W or ΔU ? (Use the diagrams on the notes.)

- A. _____ Heat removed by the coils outside of a refrigerator.
- B. _____ When the refrigerant passes thru the expansion valve of a refrigerator.
- C. _____ Heat absorbed by the refrigerant inside the refrigerator.
- D. _____ Changes inside the compressor of a refrigerator.
*1500 J of energy is added at the boiler of a heat engine. 600 J is lost when the steam is cooled.
900 J of useful energy is produced by the engine.*
- E. _____ 1500 J
- F. _____ 600 J
- G. _____ 900 J
- H. _____ Is 0 for a cyclic process.

2. Adiabatic, isovolumetric, or isothermal?

- A. _____ In the compressor of a refrigerator.
- B. _____ In the boiler of a heat engine.
- C. _____ In the piston of a heat engine.
- D. _____ When heat is absorbed by the refrigerant while inside the refrigerator.
- E. _____ When heat is dissipated in the coils at the back of the refrigerator.
- F. _____ Steam is cooled after the piston of a heat engine.
- G. _____ At the expansion valve of a refrigerator.

3. +, -, or 0?

- A. _____ Q for the refrigerant inside the refrigerator compartment.
- B. _____ W by the gas at the refrigerator's expansion valve.
- C. _____ Q for the refrigerant when outside the refrigerator compartment.
- D. _____ ΔU for the refrigerant during one entire cycle.
- E. _____ W by the gas in a heat engine's piston.
- F. _____ ΔU for any cyclic process.
- G. _____ Q in the boiler of a heat engine.
- H. _____ W for the refrigerant inside the refrigerator compartment.
- I. _____ Q in the radiator of a steam engine (after the piston).

NOTE: "by the gas" is the same as "by the system".

4. A heat engine does 55 J of work each cycle and expels 29 J of heat in the radiator.

- A. How much heat was added at the boiler?
- B. How efficient is the engine?

5. A heat engine has an efficiency of 84%. If 3500J of work is done by the engine, how much heat is lost in the cycle?

6. A refrigerator expels 3.5 kJ per cycle. If the compressor does 2.0 kJ each cycle, how much heat is removed from inside the refrigerator each cycle?

7. Consider the compressor stage of a refrigerator.

- A. What kind of thermodynamic process is it?
- B. Write the First Law of Thermodynamics, being exact as for +'s or -'s.

8. The air conditioner pulls 900 J each second (otherwise known as _____) from the passenger cabin. If 1700 W of heat is exhausted to the outside, how much work is done by the compressor?

9. An engine gains $2.56 \times 10^7 \text{ J}$ of energy from combustion. If the engine expels $1.15 \times 10^7 \text{ J}$, how efficient is the engine?
10. If a refrigerator is left open in the middle of a room, does the room's overall temperature increase or decrease over time? (And defend your answer, of course.)
11. If heat only travels from hot to cold, how can a refrigerator move heat from the cold interior of the refrigerator to the hotter exterior?
12. Why does there need to be radiator in a heat engine's cycle?

From the "Thermodynamic Processes" notes:

13. Fill in the following table. (Try to do this from memory, first.)

Process	What equals zero	First Law of Thermodynamics
isovolumetric		
isothermal		
adiabatic		

More Notes:

Second Law of Thermodynamics (Entropy):

- **Clausius statement:** heat can flow spontaneously from a hot object to a cold object; heat will not flow spontaneously from a cold object to a hot object.
 - **Clausius statement (formal):** no device is possible whose sole effect is to transfer heat from one system at a temperature T_L into a second system at a higher temperature T_H .
 - **General Statement:** The total entropy of any system plus that of its environment increases as a result of any natural process.
 - **General Statement:** Natural processes tend to move toward a state of greater disorder.
 - **General Statement:** In any natural process, some energy becomes unavailable to do useful work.
14. In any natural process:
 A. The energy of the universe: increases; decreases; stays the same.
 B. The entropy of the universe: increases; decreases; stays the same.
15. Which has more positional entropy: a solid or a liquid?
16. A. Which has more entropy a ball falling thru the air, or the ball after it has hit the ground.
 B. Explain.
17. Imagine a closed system.
 A. If it is closed, can there be any outside work?
 B. The entropy of the system: increases; decreases; stays the same.