**Reminders 11-24-10:**
-Thermal Physics Conceptual Questions Due Monday.
-Exam 4 Wednesday December 1, Ch. 10-12.
-Watch for sig. fig questions on Final Exam.
-Read and Understand Examples and Quick Quizzes in textbook for Chapters 10-12. Look for one or two of them on the next exam.

-Final Exam Wednesday December 8 (**THIS EXAM CANNOT BE ONE OF YOUR DROPPED EXAMS**)

**Objectives:**
-First Law of Thermodynamics Examples
-Second Law of Thermodynamics
-Heat Engines, Refrigerators, and Coefficient of Performance

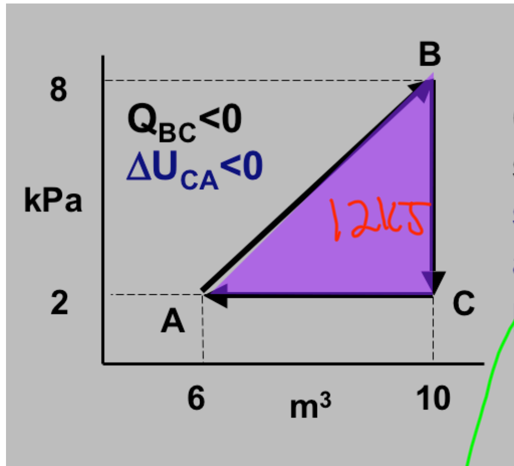
- **A gas is compressed at a constant pressure of 3.00 atm such that its volume decreases by $5.0 \times 10^{-4} m^3$. During the process 420J of heat is given off to its surroundings. What is ΔU for this process?**

$Q = -420\,J$

$W = -P\Delta V = -(3\,atm)\left(101300 \frac{Pa}{atm}\right)\left(-5.0 \times 10^{-4}\right)$

$W = 151\,J$

$\Delta U = 151\,J + -420\,J = -268\,J$




A → B
gas expands
$W_{AB} < 0$
$\Delta U_{AB} > 0$
$Q_{AB} > 0$

B → C
$W_{BC} = 0$
$Q_{BC} < 0$
$\Delta U_{BC} < 0$

C → A volume decreases
$W_{CA} > 0$
P constant
$Q_{CA} < 0$
$\Delta U_{CA} < 0$

$\Delta U_{cycle} = 0$

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$W_{AB} = -(8\,kPa\,m^3 + 12\,kPa\,m^3) = -20\,kPa\,m^3 = -20\,kJ$

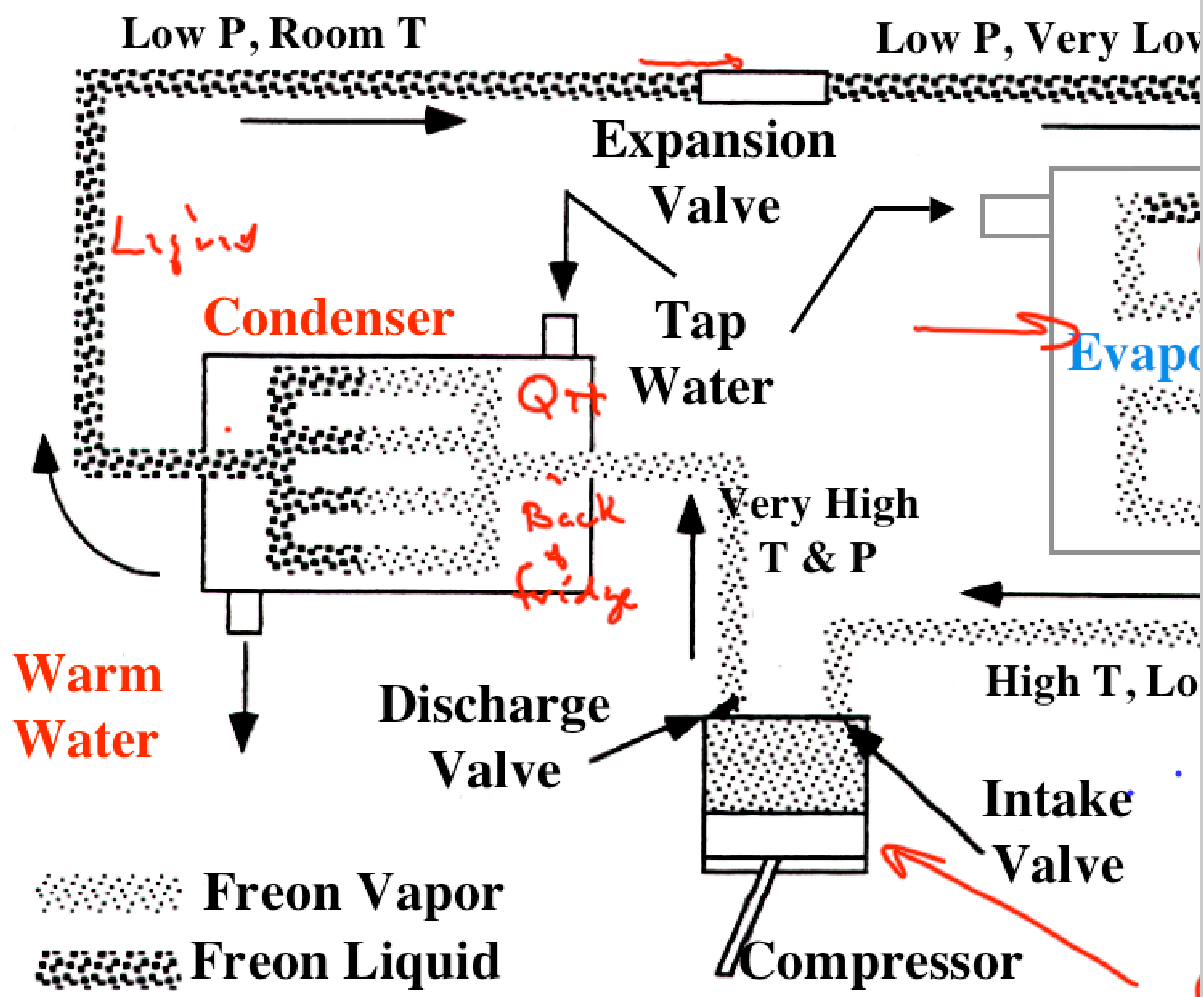
$W_{BC} = 0$ $W_{CA} = +8\,kJ$

$W_{cycle} = -20\,kJ + 8\,kJ = -12\,kJ$

$Q_{cycle} = +12\,kJ$

To figure out Q's need # of moles of gas; then apply Ideal gas law to find T's.

# The Refrigerator



- A heat pump has a COP of 3.0 and is rated to do work at a rate of 1500W. How much heat can be added to a room per second? If you ran this as an air conditioner, what do you expect the COP to be?

$$COP_H = \frac{Q_H/t}{W/t} \quad 3.0 = \frac{Q/t}{\text{Power}}$$

$$= (1500\,W)(3.0) = \boxed{4500\,W}$$

$$COP_{AC} = \frac{Q_c/t}{W/t} = \frac{(|Q_H| - |W|)/t}{W/t}$$

$$= \frac{3000\,W}{1500\,W} = \boxed{2.0}$$

# 2nd Law of Thermodyna

- A heat engine absorbs 200J of heat
hot reservoir, and exhausts 160J to a
reservoir. What is the efficiency of t
engine?

$|Q_H| = 200J$ $|Q_c| = 16$

$W = |Q_H| - |Q_c| =$

$e = \frac{40J}{200J} = .2$ or

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A 33% efficient power plant puts out 800MW of electrical energy. Cooling towers are used to take exhaust heat. If air temp. can rise by 7.0°C, what volume of air is heated per day? If the heated air were to form a layer 200m thick, what area would it cover for 24h of operation?($c_{air}$=1008J/kg°C $\rho_{air}$=1.29kg/m³)

$W = 800\,MW = 800\times10^6\,W$

$e = \frac{800\,MW}{Q_H} = .33$

$Q_H = 2400\,MW$

$Q_c = |Q_H| - |W| = 1600\,MW$

$1600\times10^6\ \frac{J}{s}$

Energy in day $= 1600\times10^6\times86400$
$= 1.38\times10^{14}\ J/day$

$m_{air} c_{air} \Delta T = 1.38\times10^{14}\ J/day$

$m_{air} = \frac{1.38\times10^{14}\ J/day}{(1008)\ (7°C)} = 1.95\times10^{10}\ kg$

$V = \frac{1.95\times10^{10}\ kg}{1.29\ kg/m^3} = 1.52\times10^{10}\ m^3$
$= 15.2\ km^3$

$V = At$

$A = \frac{15.2\ km^3}{.2\ km} = \boxed{77\ km^2}$

- **A gas is compressed at a constant pressure of 3.00 atm such that its volume decreases by $5.0\text{x}10^{-4}\text{m}^3$. During the process 420J of heat is given off to its surroundings. What is $\Delta$U for this process?**

$$\Delta U = Q + W$$

$$W = -P\Delta V$$

$$= -(3\,atm)(101{,}300)(-5.0\text{x}10^{-4})$$

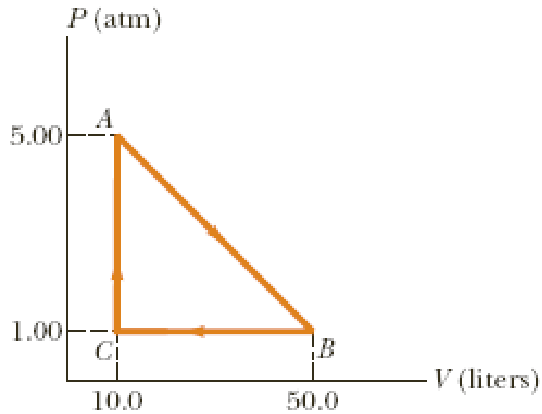
$$= 151.5\,J$$

$$\Delta U = -420\,J + 151.5\,J$$

$$= -268\,J$$

$$= -63\,cal$$

A substance undergoes the cyclic process shown in Figure P12.51. Work output occurs along path AB while work input is required along path BC, and no work is involved in the constant volume process CA. Energy transfers by heat occur during each process involved in the cycle.




(a) What is the work output during process AB?
12200 J
(b) How much work input is required during process BC?
4050 J
(c) What is the net energy input Q during this cycle?
8150 J

One mole of an ideal gas is taken through the cycle shown in Figure P12.58, with n = 7 and m = 6. At point A, the pressure, volume, and temperature are P0, V0, and T0. In terms of R and T0, find each of the following. (Hint: Recall that work equals the area under a PV curve.)

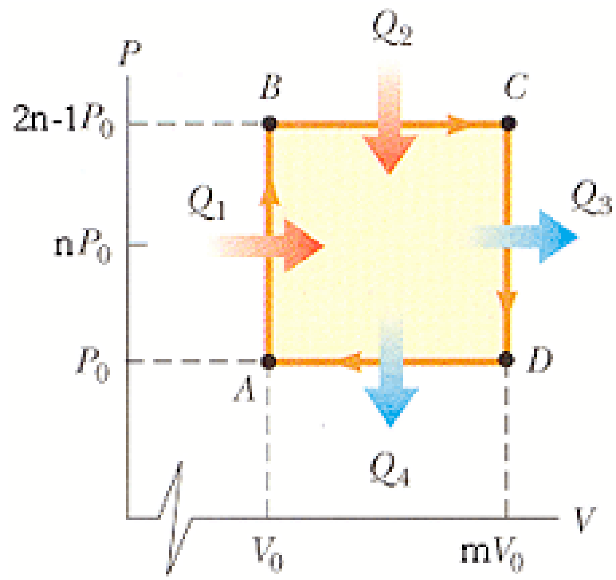



Figure P12.58

(a) the total energy entering the system by heat per cycle

180 RT0

(b) the total energy leaving the system by heat per cycle

120 RT0

(c) the efficiency of an engine operating in this cycle

33.2%

(d) the efficiency of an engine operating in a Carnot cycle between the temperature extremes for this process.

98.7%