Test 1 — Dr. Weppner
PHN 242 — Feb. 2006

Review

NAME ____________ ☐ Pledged SCORE____ / 100 pts

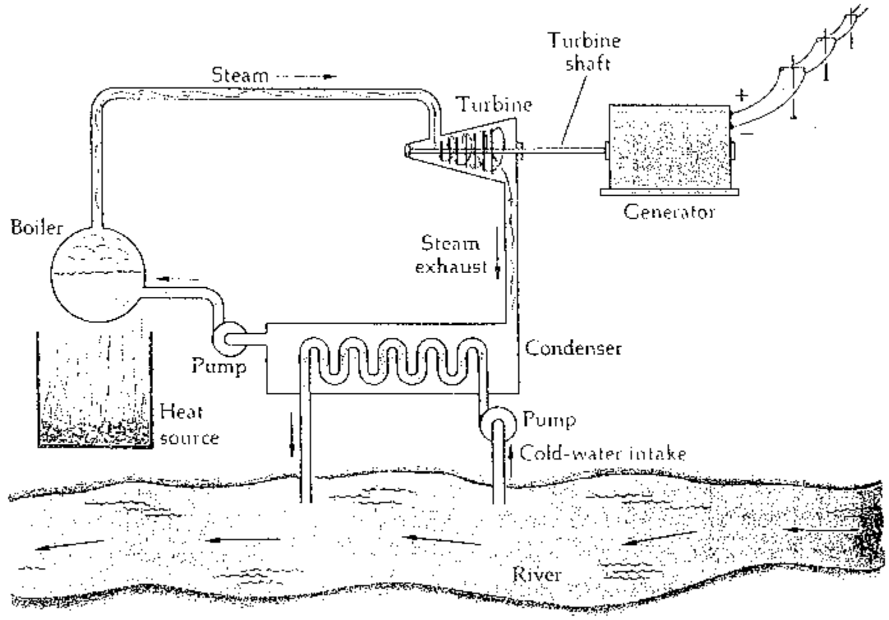
Remember to get full credit label answers with correct units, show all work, draw diagrams.

1. [10 pts] Shown is a steam engine at a power plant.

(A) Explain How it works: What are the two temperature reservoirs? Where is the system of gas that converts heat to work? What is this work and what actually turns?

(B) The steam engine is inefficient. It has a typical efficiency of **65% of the Carnot efficiency**. If it has steam entering at 285° C and water cooling at 30° C, what percent of entering heat is converted into work?

Hot: heat source
Cold: River
-gas is steam
which turns a
turbine and shaft



$$e = .65\left(1 - \frac{303}{558}\right) = .297$$

so 29.7%

2. [6 pts] During this recent cold spell our county Pinellas was always the warmest in the area. What is special about its geographical location that keeps it warm?

It is surrounded by Water. Water takes a long time to heat up and cool down.

3. [10 pts] Given half a chicken, water, carrots, peppers, spices. Rank various combinations of these materials in terms of amount of entropy and explain ranking. Try to use both the macroscopic and microscopic definitions when applicable.

(1) materials sitting in your refrigerator

(2) materials simmering on your stove

(3) materials sitting in your stomach after an hour

least ⟶ most entropy

Refridge — Stove — Stomach

Refridge ↓ cold, Bonds intact

Stove ↓ warmer, some Bonds Breaking down

Stomach ↓ Chewed, acid is put to them. Materials are unrecognizable, a mush.

4. [16 pts] A steel rod is 3.000 cm in diameter at 25.0°C. A copper ring has an interior diameter of 2.9992 cm at 25.0°C. At what common temperature will the ring just slide into the rod?

$$\Delta L = L_0 \alpha \Delta T$$

$$L_f - L_0 = L_0 \alpha \Delta T \Rightarrow L_f = L_0 + L_0 \alpha \Delta T$$

$$L_{f\,steel} = L_{f\,copper} \Rightarrow \boxed{L_{0s} + L_{0s}\alpha_s(T_f - T_{0s}) = L_{0c} + L_{0c}\alpha_c(T_F - T_{0c})}$$

$$3cm + 3cm(12\times10^{-6})(\Delta T) = 2.9992cm + (2.9992)(17\times10^{-6})\Delta T$$

$$.0008cm = 1.499\times10^{-5}\Delta T \quad / \quad \Delta T = 53^\circ,\ T_F = 78^\circ C$$

5. [16 pts] A person makes a quantity of iced tea by mixing 500 grams of hot tea ($c_{tea} = c_{water}$) with an equal mass of ice which is at its melting point (0°C). If the hot tea is originally at 91°C, what is the temperature of the final equilibrium tea-ice (or tea-water) mixture?

$$Q_{Lost} + Q_{gained} = 0 \qquad Q_{Lost} = mc(0 - 91^\circ C)$$

$$-Q_{Lost} = Q_{gained}$$

if we assume some ice is leftover!

$$Q_{gained} = m_{melted} L_f$$

$$mc(91^\circ C) = m_{melted} L_f \Rightarrow .5\left(\frac{4186 J}{Kg\ C}\right)(91^\circ C) = m_{melted}\left(3.33\times10^5 \frac{J}{Kg}\right)$$

$$m_{melted} = .571 Kg$$ (too large, need another step warm ice)

$$mc(91 - T_F) = .5Kg\left(3.33\times10^5 \frac{J}{Kg}\right) + .5Kg(4186)(T_F - 0)$$

$$(4186)(91) - (4186)(T_F) = 3.33\times10^5 \frac{J}{Kg} + 4186 T_F$$

$$T_F = 5.7^\circ C$$

6. [20 pts] An ideal Carnot engine has a power output (work generated per second) of 500 J/S. It operates between constant temperature reservoirs at 100.0° C and 30.0° C (outside air). What is

(a) the rate of heat input in J/s?

(b) The rate of exhaust heat output in J/s?

(c) How much entropy is this engine's exhaust adding to the environment every cycle?

(d) How much entropy is this engines intake subtracting from the outside environment every cycle?

$$e = 1 - \frac{303}{373} = .188$$

a) $e = \frac{W}{Q_H} = .188 = \frac{500 \text{ J/s}}{Q_H}$ $\quad Q_H = 2660 \text{ J/s}$

b) $W = |Q_H| - |Q_L|$

$$500 \text{ J/s} = 2660 \text{ J/s} - Q_L \quad Q_L = 2160 \text{ J/s}$$

c) outside env are large $T \approx$ const

$$\Delta S = \frac{2160 \text{ J/s}}{303 \text{ K}} = 7.13 \text{ J/K s}$$

d) $\Delta S = \frac{-2660 \text{ J/s}}{373 \text{ K}} = -7.13 \text{ J/K s}$

Net = 0! true for Carnot

7. [22 pts] We have one mole of a monatomic ideal gas. Its initial state has: $p_{initial} = 3.0atm$, $V_{final} = .015m^3$. Its final state has: $p_{final} = 1.5atm$, $V_{final} = .030m^3$. It follows a straight line path on a pV diagram.

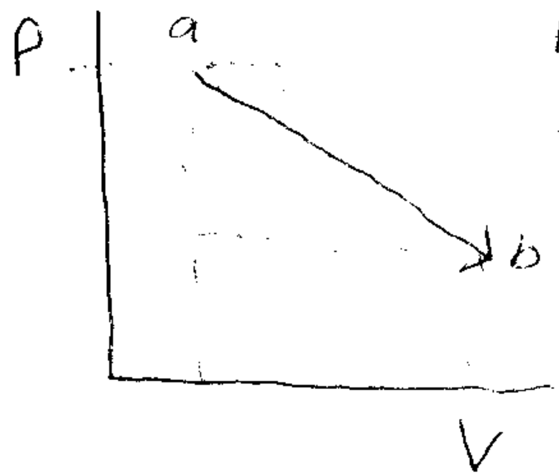
(a) draw a pV diagram of the process

(b) How much work was done by the gas during the process?

(c) What was ΔE for the process?

(d) How much heat was gained or lost?

(e) What if the process were isothermal? How much work would have been done?



$P_a = 3$ Atm

$P_b = 1.5$ Atm

$V_b = .03 m^3$

$V_a = .015 m^3$

b) Area = Δ + $\square$ = work

$= \frac{1}{2}(V_b - V_a)P_b + (P_b - P_a)(V_b - V_a)$

$= .75$ Atm $(V_b - V_a)$ + 1.5atm $(V_b - V_a)$

$= 2.25$ Atm $(.015 m^3) = 3410$ J

c) $T_a = \dfrac{P_a V_a}{(1mol)(8.315\ J/K\,mol)} = 547K$ $\quad T_b = \dfrac{P_b V_b}{(1mol)(8.315\ J/K\,mol)}$

$= 547K$

$\Delta U = 0!$

d) $Q = W = 3410 J$

e) $W = nRT \ln\left(\frac{V_f}{V_i}\right) = 3150 J$