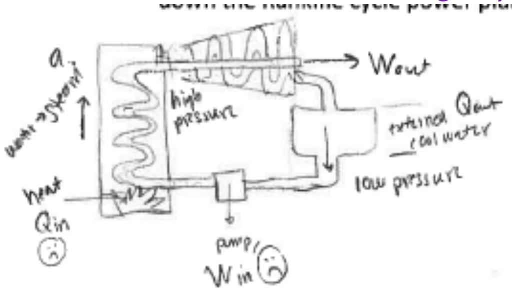
Assessment #1 PHYS-310. Please do all the problems. I only have to recognize that you know what you're doing.

1) What is the approximate population of:
   a. World?________
   b. The USA?______
   c. California?______

2) Rankine Cycle (steam turbine):
   a. Make a quick labeled drawing
   b. Make a brief explanation of how it works
   c. Identify where we put work *into* the device with a frowny face ☹.
   d. We have a machine in order to get work *OUT*. How is it that we get more work out of the Rankine Cycle than we put in without violating conservation of energy?
   e. Morro Bay Power Plant is a Rankine cycle. It was originally petroleum (hence the large cylindrical petroleum containers) and then it was natural gas. And now it's closed down. Why are we closing down the Rankine cycle power plants? *Remember to properly distinguish work from heat. We get more work out because we put more heat in (than we get out). The work is put in where the pump transfers the water from the low pressure side to the high pressure side. The pressure doesn't change in the high pressure side, but when we boil the water, the volume increases greatly, providing more work out than we put in.*
   Also, for part e), yes, we do want to go combustion free and have all renewables. However we're not even close. The single cycle Rankine are being replaced with NGCC to nearly double efficiency.

a.



b. Rankine pumps water into a chamber where the water then turns into steam (volume expanded ~ 1000x). The steam then pushes the turbine blades to get work out. To turn steam back into water, there is an external cool water supply to lower the pressure & turn steam back into water that is then pumped again.

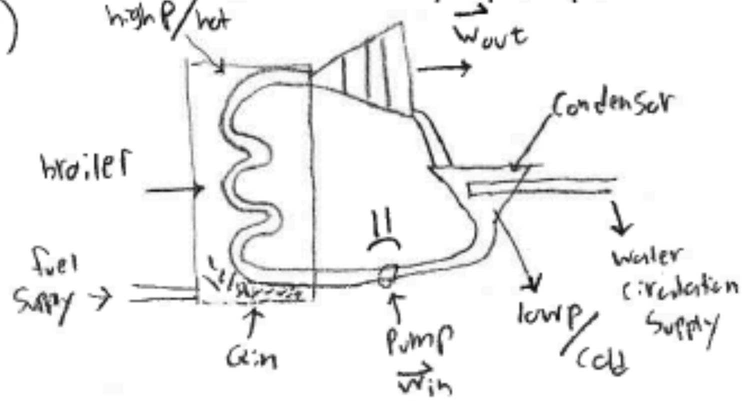
c. We have to pump the water (W_{in}) & provide heat to turn water → steam

d. conservation of energy, not work! We get more work because of the increase in pressure, and the expansion of water → steam (volume increase). Energy is conserved in other ways such as the Q we have to put in and the Q that comes out
↑ heat energy

A

e. Part of why they are closing down comes down to efficiency. Rankine is pretty inefficient at about 30%. There are better options, such as NGCC that gives ~60% efficiency. Rankine can be used for NGCC, but on its own it wastes a lot of energy. Another reason could come down to cost to operate on CA coast b/c I have to imagine that is expensive down the Rankine cycle power plants?

a)



A!

b) Cold water is pumped into a broiler where heat is being produced by some method (maybe a fuel is burned). Here the water is converted into steam which increases in ~~pressure and~~ volume, this steam escapes through a turbine and produces work out. The steam is the condensed back into water and the cycle repeats

d) Because the heat we put into it in stored chemical potential must also be accounted for, in all the total energy put in is = to the total energy out.

e) It is because they are very inefficient compared to other energy sources like the combined cyle

3) Most folks want to start by calculating energy in Joules… but we can easily see how many kW and hr there are involved… start with kWh! Additionally, we pay for electricity by the kWh, so kWh (3.6 MJ) is a better unit to use. 4 days is about 100 hrs, yielding about 10 kWh of electrical energy consumption. Or at California rates, about $1.50.

$P = \frac{\Delta E}{\Delta t}$

$\Delta E = P \Delta t = 100W(4\ days)\left(\frac{24\ hours}{day}\right)\left(\frac{1\ kW}{1000\ W}\right)$ 4(24) ≈ 4(25) = 100

$\approx \frac{100}{1000}(100) = \boxed{10\ kWh}$

$W = J/s$

$= 100\frac{J}{sec}(4\ days)\left(\frac{24\ hours}{day}\right)\left(\frac{3600\ sec}{1\ hr}\right) = 100(100)(3600) = 36 \times 10^6 J$ (10^4)

$\approx \boxed{36\ MJ}$

b) guessing 1 kWh ≈ 20¢ = $0.2

10 kWh ($0.2) = $\boxed{\$2}$

A

3) I left a 100 W lightbulb on for a four-day weekend.

a. Please *estimate* the total energy I am responsible for consuming during this time. Put answer in both Joules and kWh.

b. Please estimate the bill I'll have to pay for this mistake. If you don't know the cost of electricity, make something up, and find the correct value for next time!

$\frac{100 \times 96}{1000}$ $\frac{9600}{1000} = 9.6$

a. $100w \times 4\ days \times \frac{24\ hrs}{1\ day} \times \frac{1KW}{1000W} = \boxed{9.6 KWhrs}$

$9600\ Whrs \times \frac{60 min}{1 hr} \times \frac{60 s}{1 min} \times \frac{1J}{1W \cdot S} \approx \boxed{3.6 \times 10^7 J}$

(9600 → ≈ 10000; $1 \times 10^4 \times 3.6 \times 10^3$)

9600 Whrs × 3600 s → 10,000 Whrs

A

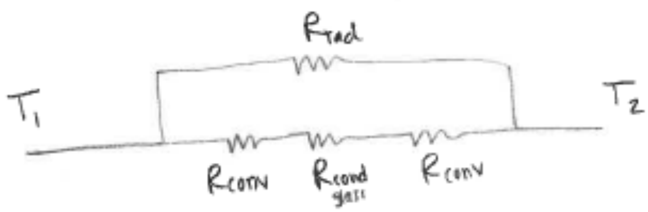
b. in CA, 15¢/kWhr

$9.6\ KWhrs \times \frac{15¢}{KWhr} = 150¢ \approx \boxed{\$1.50}$

≈ 10 KWhr

seems very low 15¢/kwhr might be incorrect

4) Let's say I have some boiling hot coffee (extra black!) inside of a closed, single-wall glass vessel of totally transparent glass, wall thickness 2 mm. It's sitting outside in the freezing cold (zero Celsius). And the outside world is covered with snow. We want to find the rate of cooling. Please draw the equivalent circuit diagram or otherwise outline how you will need to organize the calculation of heat loss. If you have time, please include approximations that you might make as well as things you will need to look up.



The radiation goes direction from the black surface of the hot coffee to the outside world. We are also concerned about radiation coming back? Probably it's not much because it is considerably colder outside, (3/4 to the fourth power is only 0.3) and the snow is white anyway, so there is not much emission. We would have to look for h factor for boiling water (temperature matters because the viscosity is low). It's a very high number… so it's not too much of a stretch to start with the inner wall being at the same temperature as the coffee… then we realize that for 2 mm, there is very small temperature drop across the glass wall. Thus we can say that the outside wall is about 100 C and use a convective U value of about 12 W/mK because we only need to convect heat away from one side to air.

Name___________________________________