Name:__________________________ Instructor:____________ ENGR 222 - Bonus Exam
Section:__________ May 15, 2015

Allowed Materials: *pencils and/or pens.*

Honor Statement: *On my honor, I promise that I have not received any unauthorized assistance on this exam (I didn't look at another student's paper, I didn't view any unauthorized written materials, I didn't talk or listen to another student, I didn't use an unauthorized calculator, I didn't use any electronic device, any visual or auditory signals, or any other techniques of exchanging information with others.) I have maintained the highest standards of academic integrity while completing this exam.*

*Signed:*____

Please put your final answers on the answer sheet that was given to you. You must show your work to receive full credit.

The words "steam" can be used to describe water in any of the following states: compressed liquid, saturated liquid, saturated mixture, saturated vapor, and superheated vapor. If you see the word "steam", DO NOT assume that it is in a vapor state. Use the state postulate to determine the state.

You must show your work for each problem (regardless of how trivial the problem is). Provide your final answer on the line provided for each answer.

Watch your units. Report your final answer in the units provided on the answer line.

You may use your book and notes to help with this exam. You may not consult with other students for help. Your work must be your own.

Some problems are designed to be tricky. Be carefult to check if the State Postulate can be used. Some problems may require you to check to see if the First or Second Law of Thermodynamics is upheld. If a problem canno be done because of the State Postulate, report "NOT ENOUGH INFO". If a problem in a system violates the First or Second Law of Thermo, report "PMM1" or "PMM2".

Good luck!

Exam Serial Number:
B435J98SKR162D

1. (5 points) The atmospheric pressure measured at the top and bottom of the building are $P_{top} = 95 \cdot kPa$ and $P_{bottom} = 98.6 \cdot kPa$, respectively. If the average density of air is constant at 1.1 kg/m^3, the height of the building is:

________________ m

2. (5 points) On a foreign planet where the gravity is 7 m/s^2, an ocean contains water whose density is greatly dependent on depth because of mineral deposits and temperatures. The atmospheric pressure directly above the ocean surface is 90 kPa. Given the equation for the density profile below, where z is the depth, the pressure exerted at a depth of $height = 1200 \cdot m$ is:

ρ (kg/m^3) = A * z(m) + B $\quad A = 0.34 \quad B = 1030$

____________ MPa

4. (5 points) A tank with $\text{volume} = 11 \cdot \text{ft}^3$ at a temperature of 310^{o}F contains a liquid-vapor mixture of water. The vapor occupies $\text{percent} = 93 \cdot \%$ of the volume. The internal energy of the water in the tank is:

___________ Btu/lbm

5. (5 points) An oxygen tank with a $\text{volume} = 2.9 \cdot \text{m}^3$ has a pressure gage that reads 500 kPa. The temperature of the tank and the surroundings is 27^{o}C. A barometer outside of the tank reads $\text{barometer} = 755 \cdot \text{mmHg}$. The mass of the gas in the tank is:

_________ kg

6. (5 points) A container has $\text{mass} = 28 \cdot \text{kg}$ of methane at 27^{o}C and 10 MPa. The volume of the tank is: (Hint: carefully look at the temperature and pressure).

__________ L

7. (5 points) A spring loaded piston cylinder device contains 20 kg of water at 250 kPa and 50°C. The cross sectional area of the piston is $\text{area} = 0.2 \cdot m^2$ and the linear spring has a spring constant of $k = 130 \cdot \frac{kN}{m}$. Heat is transferred to the water allowing it to vaporize and expand. If the spring is compressed 30 cm, the work done by the water during the expansion process is:

__________ kJ

8. (5 points) Air in a piston cylinder device is initially at $\text{pressure} = 180 \cdot kPa$ and 27°C and has a $\text{volume} = 480 \cdot L$. The piston initially rests on stops and requies a pressure of 300 kPa to move. The air is heated until the volume doubles. The amount of heat added is:

____________ kJ

9. (5 points) Air enters a pipe with $\text{diameter} = 27 \cdot cm$ steadily at 300 kPa and 25°C with a $\text{velocity} = 8 \cdot \frac{m}{s}$. As it flows through the pipe, the air is heated. At the pipe exit, the air has a temperature of 60°C and a pressure of 250 kPa. The velocity of the air at the exit is:

_________________ m/s

10. (5 points) Air enters a compressor at 100 kPa and 25°C with a negligible velocity and exits the compressor at 1 MPa and 347°C with a velocity of 110 m/s. The compressor is cooled at a $\mathrm{rate} = 1200 \cdot \frac{\mathrm{kJ}}{\mathrm{min}}$ and the power input to the compressor is $\mathrm{power} = 28 \cdot \mathrm{MW}$. The mass flow rate of the air is:

___________ kg/s

11. (5 points) An insulated, vertical piston cylinder device initially contains $\mathrm{mass} = 22 \cdot \mathrm{kg}$ of water with a quality of $x = 63 \cdot \%$ and a pressure of 200 kPa. Steam at 0.5 MPa and 350°C is allowed to enter until all the liquid in the cylinder vaporizes. The mass of the steam that enters the cylinder is:

_______________ kg

12. (5 points) A heat engine that burns coal rejects $\text{heat} = 13\cdot\text{MW}$ and has an efficiency of $\eta = 42\cdot\%$. The heating value of the coal is 28,000 kJ/kg. The amount of coal consumed in the heat engine is:

____________ kg/hr

13. (5 points) A refrigeration system use a water-cooled condenser for rejecting waste heat. The refrigerated space is maintained at 25^{o}F and the refrigerator system absorbs heat from the refrigerated space at a rate of $\text{heat} = 24000\cdot\frac{\text{Btu}}{\text{hr}}$. Water enters the condenser at 65ºF at a rate of 1.6 lbm/s. The COP of the refrigerator is $\text{COP} = 1.9$. Assuming the specific heat of water in the condenser is constant, the temperature of the water leaving the condenser is:

______________ ºF

14. (5 points) Two Carnot heat engines are operating in series such that the sink for the first heat engine serves as the source of the second engine. The temperature source for the first engine is $T_H = 1000 \cdot °C$ and the sink for the second engine is $T_L = 35 \cdot °C$. If bothe heat engines have the same thermal efficiency, the temperature of the intermediate reservoir between the two heat engines is:

_____________ ^oC

15. (5 points) An insulated piston-cylinder device contains $\text{volume} = 5 \cdot L$ of saturated liquid water at a constant pressure of 150 kPa. An electrical resistance heater transfers $\text{energy} = 2600 \cdot kJ$ to the steam. The change in entropy of the water during this process is:

___________ kJ/K

16. (5 points) An iron block with $\text{mass} = 28 \cdot \text{kg}$ initially at 350ºC is quenched in an insulated tank that holds 100 L of water initially at $\text{temperature} = 20 \cdot {}^{\circ}\text{C}$. Assuming that the specific heats are constant and that none of the water vaporizes during the process, the total change in entropy during the process is:

____________ kJ/K

17. (5 points) A frictionless piston-cylinder device contains 10 lbm of saturated liquid water at 40 psia. $\text{Heat} = 860 \cdot \text{Btu}$ is transferred to the water from a source at $\text{temperature} = 780 \cdot {}^{\circ}\text{F}$. The total entropy generated during this process is:

______________ Btu/R

18. (5 points) An aircraft engine operates on a simple ideal Brayton cycle with a pressure ration of 10. Heat is added to the cycle at a $\text{heat} = 520 \cdot \text{kW}$. Air enters the compressor at a rate of 1 kg/s at a pressure of 75 kPa and a $\text{temperature} = 2 \cdot °\text{C}$. Assuming the cold-air standard assumption applies, the thermal efficiency of the engine is:

___________ %

19. (5 points) A refrigerator operates on the ideal vapor-compression refrigeration cycle and uses R-134a as the working fluid. The condenser operates at $\text{pressure} = 300 \cdot \text{psia}$ and the evaporator at $\text{temperature} = 20 \cdot °\text{F}$. If the refrigerator uses a throttling device to drop the pressure, the COP of the refrigerator is:

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20. (5 points) A simple ideal Rankine cycle which uses water as working fluid operates between the pressure limits of $\text{pressure} = 3 \cdot \text{MPa}$ and 50 kPa. The temperature of the steam at the turbine inlet is $\text{temperature} = 300 \cdot {}^\circ\text{C}$. The mass flow rate of steam through the cycle is $\text{mass} = 35 \cdot \frac{\text{kg}}{\text{s}}$. The thermal efficiency of the cycle is:

____________ %

$$\text{ExamForm} = 1$$

$$Key_{1\_9} := \begin{pmatrix} 1 & Key_1 \\ 2 & Key_2 \\ & \\ 4 & Key_4 \\ 5 & Key_5 \\ 6 & Key_6 \\ 7 & Key_7 \\ 8 & Key_8 \\ 9 & Key_9 \end{pmatrix} \qquad Key_{10\_18} := \begin{pmatrix} 10 & Key_{10} \\ 11 & Key_{11} \\ 12 & Key_{12} \\ 13 & Key_{13} \\ 14 & Key_{14} \\ 15 & Key_{15} \\ 16 & Key_{16} \\ 17 & Key_{17} \\ 18 & Key_{18} \end{pmatrix}$$

$$Key_{1\_9} = \begin{pmatrix} 1 & 333.725 \\ 2 & 10.456 \\ & \\ 4 & 312.502 \\ 5 & 22.338 \\ 6 & 374.535 \\ 7 & 20.85 \\ 8 & 690.495 \\ 9 & 10.727 \end{pmatrix}$$

$$Key_{19\_20} := \begin{pmatrix} 19 & Key_{19} \\ 20 & Key_{20} \end{pmatrix}$$

$$Key_{10\_18} = \begin{pmatrix} 10 & 83.294 \\ 11 & 38.806 \\ 12 & 2881.773 \\ 13 & 58.64 \\ 14 & 353.205 \\ 15 & 6.762 \\ 16 & 4.454 \\ 17 & 0.489 \\ 18 & 48.205 \end{pmatrix}$$

$$Key_{19\_20} = \begin{pmatrix} 19 & 2.013 \\ 20 & 27.123 \end{pmatrix}$$