**Student Code Number**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Thermodynamics**

**Ph.D. Qualifying Exam**

**Department of Mechanical Engineering**

**Michigan State University**

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**Exam Prepared By:**

**E. Toulson and N. Mueller**

**Network Devises Are Not Allowed**

**All Work Should Be Shown For Full Credit**

**Directions: Work all five problems. Problems are equally weighted. Students are allowed one book and five sheets of notes**

1. **A heat pump with refrigerant R-134 as the working fluid is used to keep a space at 25°C by absorbing heat from geothermal water that enters the evaporator at 60°C at a rate of 0.065 kg/s and leaves at 40°C. Refrigerant enters the evaporator at 12°C with a quality of 15 percent and leaves at the same pressure as saturated vapor. If the compressor consumes 1.6 kW of power determine:**
2. **The mass flow rate of refrigerant**
3. **The rate of heat supply**
4. **The COP**
5. **A passive solar house that is losing heat to the outdoors at an average rate of 50,000 kJ/h is maintained at 22°C at all times during a winter night for 10 hours. The house is to be heated by 50 glass containers each containing 20 liters of water that is heated to 80°C during the day by absorbing solar energy. A thermostat-controlled 15 kW backup electric resistance heater turns on whenever necessary to keep the house at 22°C.**
6. **How long did the electric heating system run that night?**
7. **How long would the electric heater run that night if the house incorporated no solar heating?**
8. **An ideal diesel cycle has a compression ratio of 18 and a cutoff ratio of 1.2, where the cutoff ratio is the ratio of the cylinder volumes after and before the combustion process. Determine the maximum temperature of the air and the thermal efficiency of the cycle when the state of the air at the beginning of the compression is 90 kPa and 20 °C. Use constant specific heats at room temperature.**
9. **Water is the working fluid in a Rankine cycle. Superheated vapor enters the turbine at 10 MPa, 480°C, and the condenser pressure is 6 kPa. The turbine and pump have isentropic efficiencies of 80 and 70%, respectively. Determine for the cycle**
10. **the rate of heat transfer to the working fluid passing through the steam generator, in kJ per kg of steam flowing.**
11. **the thermal efficiency.**
12. **the rate of heat transfer from the working fluid passing through the condenser to the cooling water, in kJ per kg of steam flowing.**
13. **Air enters the compressor of a cold air-standard Brayton cycle at 100 kPa, 300 K, with a mass flow rate of 6 kg/s. The compressor pressure ratio is 10, and the turbine inlet temperature is 1400 K. The turbine and compressor each have isentropic efficiencies of 80%. For k=1.4, calculate**
14. **the thermal efficiency of the cycle.**
15. **the back work ratio.**
16. **the net power developed, in kW.**
17. **the rates of exergy destruction in the compressor and turbine, respectively, each in kW, for T0=300 K.**