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

**Thermodynamics**

**Ph.D. Qualifying Exam**

**Department of Mechanical Engineering**

**Michigan State University**

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**Exam Prepared By:**

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

1. **Refrigerant 134a enters the condenser of a residential heat pump at 800 kPa and 35 °C at a rate of 0.018 kg/s and leaves at 800 kPa as a saturated liquid. If the compressor consumes 1.2kW of power, determine:**
2. **the heat rejected in the condenser**
3. **the COP of the heat pump**
4. **the rate of heat absorption from the outside air**
5. **A 0.3-L glass of water at 20°C is to be cooled with ice to 5°C. Determine how much ice needs to be added to the water, in grams, if the ice is at**
6. **0 °C**
7. **-20 °C**
8. **Determine how much water would be needed if the cooling is to be done with cold water at 0 °C, the melting temperature and the heat of fusion of ice at atmospheric pressure are 0 °C and 333.87 kJ/kg, respectively, and the density of water is 1 kg/l.**
9. **An ideal Stirling engine cycle operates with 1 kg of air between thermal energy reservoirs at 27 °C and 527 °C. The maximum cycle pressure is 2000 kPa and the minimum cycle pressure is 100 kPa. Determine**
10. **the cycle’s thermal efficiency and**
11. **the net work produced each time this cycle is executed.**
12. **Steam enters the turbine of a Rankine cycle at 16 MPa, 5608C. The condenser pressure is 8 kPa. The turbine and pump each have isentropic efficiencies of 85%, and the mass flow rate of steam entering the turbine is 120 kg/s. Determine**
13. **the net power developed, in kW.**
14. **the rate of heat transfer to the steam passing through the boiler, in kW.**
15. **the thermal efficiency.**
16. **An cold air-standard Brayton cycle operating at steady state produces 10 MW of power. The fluid with specific heat ratio of 1.4 and gas constant of 287J/(kgK) enters the compressor at 100kPa and 300K and the turbine at 1200kPa and 1450K. The isentropic efficiency is 85% for both, the compressor and turbine. Calculate**
17. **the mass flow rate of air, in kg/s.**
18. **the rate of heat transfer, in kW, to the working fluid**
19. **the back work ratio.**
20. **the thermal efficiency.**
21. **the rate of exergy destruction in the turbine, in kW, for T0=300 K.**