**UNIVERSITY OF ABERDEEN SESSION 2011-2012**

**Degree Examination in EG3539 Thermodynamics.**

**Wednesday 30 May 2012 2.00 p.m. – 5.00 p.m.**

# Notes: (i) Candidates ARE permitted to use an approved calculator

***(ii) Candidates ARE permitted to use Engineering Mathematics Handbook***

***Candidates should attempt FIVE questions.***

**PLEASE NOTE THE FOLLOWING**

1. You **must not** have in your possession any material other than that expressly permitted in the rules appropriate to this examination. Where this is permitted, such material **must not** be amended, annotated or modified in any way.
2. You **must not** have in your possession any material that could be determined as giving you an advantage in the examination.
3. You **must not** attempt to communicate with any candidate during the exam, either orally or by passing written material, or by showing material to another candidate, nor must you attempt to view another candidate’s work.

**Failure to comply with the above will be regarded as cheating and may lead to disciplinary action as indicated in the Academic Quality Handbook**

**(**[**www.abdn.ac.uk/registry/quality/appendix7x1.pdf**](http://www.abdn.ac.uk/registry/quality/appendix7x1.pdf)**) Section 4.14 and 5.**

**Steam tables are provided**

**Acceleration due to gravity = 9.81 m s-2**

**Gas constant = 8.314 J K-1mol-1**

**Question 1**

1. Calculate the efficiency and specific work output of a simple gas turbine plant operating ideally on the Brayton cycle. The maximum and minimum temperatures of the cycle are respectively 1000K and 288K. The pressure ratio is 6. Find the efficiency and the work output. The ratio of principal specific heats of air is 1.4.

**[10 marks]**

1. A stationary power plant operating on an ideal Brayton cycle has a pressure ratio of 8. The gas temperature is 300K at compressor inlet and 1300K at turbine inlet. Determine the gas temperatures at compressor exit and at turbine exit and the thermal efficiency.

**[10 marks]**

**Question 2**

Steam at 0.6 MPa and 200oC enters an insulated nozzle with a velocity of 50 m s-1. It leaves at a pressure of 0.15 MPa and a velocity of 600 m s-1. The exiting steam is saturated. Starting with the steady flow equation and explaining each step of your working, determine the temperature of the steam in the final state and the dryness fraction.

**[20 marks]**

**Question 3**

1. A Carnot refrigerator absorbs heat at -17.0°C and rejects heat at 40.0°C. What is the coefficient of performance of this refrigerator?

**[2 Marks]**

1. Draw a labelled process flow diagram of a vapour-compression refrigeration cycle and show the cycle on a Temperature-Entropy diagram.

**[4 Marks]**

1. A vapour-compression refrigeration cycle accepts heat at -17.0°C and rejects heat at 40.0°C. 42.75 kW of heat are to be absorbed at the lower temperature and the working fluid is to be Refrigerant 12 (dichlorodifluoromethane). The compressor in the cycle has an isentropic efficiency of 77.5%.
   1. At what mass flow rate should the working fluid be circulated?

**[4 Marks]**

* 1. What is the coefficient of performance of the cycle?

**[10 Marks]**

**Question 4**

Air at a pressure of 1 bar is at 32oC and has a humidity of 52%. Calculate:

1. The partial pressures of the vapour and dry air

**[5 marks]**

1. The specific humidity

**[5 marks]**

1. The dew point

**[5 marks]**

1. The specific enthalpy of the mixture in its initial state (i.e., before cooling to the dew point).

**[5 marks]**

Molar masses/kg: water 0.0180; air 0.0288

**Question 5**

A coal-fired power plant operates on an ideal Rankine cycle with water as working fluid. The boiler is fed with water (sub-cooled liquid with specific enthalpy 260 kJ/kg) and produces steam at 600 oC and 190 bar. The steam is then expanded in a turbine (adiabatic and reversible) to the condensation pressure 0.08 bar.

1. Neglecting the work uptake of the pump, calculate the thermal efficiency of the cycle.

**[10 marks]**

1. What is the thermal efficiency if the steam from the boiler is initially expanded in a high pressure turbine to 50 bar, then re-heated to 600oC, and eventually expanded to its condensation pressure (0.08 bar) in a low pressure turbine.

**[10 marks]**

**Question 6**

1. Explain in your own words the differences between an Otto engine and a Diesel engine. Draw both ideal cycle processes in PV diagrams.

**[10 marks]**

1. Draw the Carnot cycle in a TS and a PV diagram. Why is it difficult to implement a Carnot cycle in reality?

**[6 marks]**

1. Use the first and second law of thermodynamics to derive the equation for the thermal efficiency of the Carnot engine as a function of the process temperatures.

**[4 marks]**

**Question 7**

1. Draw labelled Process Flow Diagrams of a Linde Liquefaction Process and a Claude Liquefaction Process.

**[10 Marks]**

1. Dry methane is supplied by a compressor and pre-cooling system to the chiller of a Linde liquid-methane system at 180 bar and 300 K. The low pressure methane leaves the chiller at a temperature 6°C lower than the incoming high-pressure methane. The separator operates at 1 bar and the product of the process is saturated liquid at this pressure. What is the maximum fraction of the high-pressure methane entering the chiller that can be liquefied?

**[6 Marks]**

1. Why is the maximum fraction that can be liquefied, referred to in part b), not practically achievable?

**[4 Marks]**