UNIVERSITY OF GHANA

SCHOOL OF ENGINEERING SCIENCES
DEPARTMENT OF FOOD PROCESS ENGINEERING
B.Sc FIRST SEMESTER FINAL EXAMINATION, 2014/2015

FAEN 205: THERMODYNAMICS (3 Credits)

TIME ALLOWED: TWO (2) HOURS

Answer TWO (2) Questions from SECTION A and ONE (1) Question from SECTION B

SECTION A

1. (a) State the two versions of the Second law of Thermodynamics and indicate the application of each.
(b) Define the coefficient of performance of a refrigerator and a heat pump and show the relationship between them.
(c) The food compartment of a refrigerator is maintained at 5°C by removing heat at a rate of 8kW, if the power requirement is 2kW, calculate:

   (i) the rate at which heat is rejected to the kitchen environment in kJ/min
   (ii) the coefficient of performance of the refrigerator.

   Hint: draw a schematic diagram of the refrigerator

2. (a) What is a heat reservoir or a thermal energy reservoir?
(b) What is a reversible process?
(c) A Carnot heat engine receives 1MJ of heat per cycle from a high temperature heat source maintained at 627°C, calculate:

   (i) the thermal efficiency of the heat engine;
   (ii) the heat rejected to the low temperature sink at 27°C; and
   (iii) the percentage of energy turned into useful work.

SECTION B

3. The combined mechanical and electrical efficiency of a compressor in an air conditioning unit is estimated to be 80%. The air conditioner uses R134a as refrigerant and operates as an ideal vapour cycle. The vapour enters the compressor which operates between 0.3MPa and 1.2MPa as saturated vapour. The liquid from the condenser exits as a saturated liquid. Calculate the power requirement if the cooling load of the room is 9.6 MJ/hr.

   NB. Illustrate with T-s diagram and a schematic diagram of the cycle.

4. A quantity of gas is compressed to ten times its initial pressure of 140 kPa according to the law $PV^{1.30}$ = constant. If the initial volume and temperature are 14×10^4 cm^3 and 27°C respectively, determine:

   (i) the change in entropy,
   (ii) the work transfer to the gas, and
   (iii) the heat transfer to the gas

   Take C_p=1.041 kJ/kg K, C_v=0.743kJ/kg K.

(b) (i) Given the energy due to volume change, U_v to be

$$U_v = \frac{(1-2\upsilon)}{6E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)]$$

Show that distortion energy in uniaxial stress state is given by

$$U_{du} = \frac{(1+\upsilon)}{3E}{S_y}^2$$ [10 marks]

Where $S_y = \sqrt{\frac{(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2}{2}}$

(ii) What is the physical meaning of S_y ?

(iii) Explain briefly one industrial application of failure theory. [7 marks]