UNIVERSITY OF GHANA
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FACULTY OF ENGINEERING SCIENCES

DEPARTMENT OF FOOD PROCESS ENGINEERING

B.Sc FIRST SEMESTER FINAL EXAMINATION, 2012/2013

FAEN/FENG 205: THERMODYNAMICS I

INSTRUCTIONS **TIME:2HRS**

Please read the INSTRUCTIONS carefully

[1] Answer ALL questions in SECTION A

[2] Answers to SECTION A must be written on this question sheets

[3] Answer THREE questions from SECTION B

[4] Answers to SECTION B must be written in an Answer Booklet

[5] Write your STUDENT ID NUMBER on all the question sheets and tie them inside the Answer Booklet

[6] Do NOT remove any question paper or Answer Booklet from the Examination Room

SECTION A

1. Write the first law of thermodynamics for a closed system

2. Two types of data are needed for thermodynamic analysis; name them

3. Write the defining expression for compressibility factor, Z

4. A gas has a temperature of 50°C and pressure of 45kPa, if the critical temperature and vapour pressure are 150°C and 90kPa respectively, what is the reduced temperature

5. Water flows over a waterfall 80 m in height. For 1 kg of water what is the potential energy of the water at the top of the falls if acceleration due to gravity is 10 m/s^2. (Don't compute final answer.)

6. How many degrees of freedom have a mixture of ice block in equilibrium with liquid water?

7. State the mathematical definition of the Second law of Thermodynamics.

8. If air at 1 bar and25°C is compressed to 4 bar and 25°C, calculate the change in internal energy U, if the heat capacity at constant volume, C_v is given by 20.8 J/mol-K

9. Write the energy balance equation for steady-state flow processes for one entrance and one exit

10. Write the mathematical expression for isothermal compressibility, K_T.

11. Write the first three terms of the virial equation of state

12. On a PV diagram, the critical isotherm exhibits a horizontal inflection at the critical point, leading to two derivative expressions. Write them.

13. The principle that correlates reduced temperature T_r and reduced pressure P_r of gases to their compressibility factor Z, is known as?

14. Write the equation relating the heat capacities, C_v and C_p and the gas universal constant R

15. Write the Maxwell relation resulting from the following thermodynamic function

dG=VdP-SdT

SECTION B: Answer three questions in this Section

B1. One mole of an ideal gas with $C_p = (7/2)R$ and $C_v = (5/2)$ R expands from P_1=10 bar and T_1= 700K to P_2 =1 bar by each of the following paths:

a) Constant volume
b) Constant temperature
c) Adiabatically

i) Sketch each path on a single PV diagram
ii) Assuming mechanical reversibility, calculate W, Q and ΔU for each process

B2. Given that U is a function of T and V, i.e. $U=U(T,V)$, derive the following expression

$$dU = C_v dT + \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right] dV$$

where U is the internal energy, and all other variables have the usual meanings. The following relations may be helpful

$$dU = -pdV - SdT$$

$$C_V = \left(\frac{\partial U}{\partial T}\right)_V$$

B3. One mole of an ideal gas is compressed isothermally but irreversibly at 400K from 3 bar

to 8 bar in a piston/cylinder device. The work required is 40% greater than work of reversible isothermal compression. Calculate the entropy change of

a) the gas
b) the reservoir
c) ΔS_{total}

B4. Find the equation for the work of a reversible isothermal compression of 1 mol of gas in a piston/cylinder assembly if the molar volume of the gas is given by

$$V=RT/P + b$$

where b and R are positive constants.

b) Show that for any isothermal process, whether reversible or irreversible, the entropy change is never less than zero.

Q5. A logic circuit has 2 inputs A and B with only one output C. The output of that circuit is logic 0 when the same signal is fed to it's inputs.

(a) Draw a logic circuit using only NAND gates to implement this condition. [8marks]

(b) Use Karnaugh map to simplify the function

$f(A,B,C,D)=\sum m(0,1,6,7,9,13,14,15)$ [8marks]

(c) Draw a logic circuit of the simplified function. [4marks]

Q6. (a) A 4 bit serial-in serial-out shift register with a positive edge triggering clock pulse is fed at it's input with the data 1011.

(i) Draw the circuit using either D or JK flip-flops [5marks]

(ii) Show the status of the register at the various clock pulses [10mark]

(b) State one application of serial-in serial-out shift register. [2marks]

(c) An 8 bit register has a clock frequency of 2MHz.

Calculate the delay time Δt introduced by the register. [3marks]