UNIVERSITY OF GHANA

SCHOOL OF ENGINEERING SCIENCES

BSc (ENG) MATERIALS SCIENCE AND ENGINEERING

END OF SECOND SEMESTER EXAMINATIONS: 2014/2015

MTEN 204: THERMODYNAMICS OF MATERIALS (2 CREDITS)

TIME ALLOWED: 2 HRS

Section A: Answer all Questions (*20 marks*)

1. What quantities appear in the first law of thermodynamics?

A. Force, mass, acceleration

B. Inertia, torque, angular momentum

C. Work, heat, thermal energy

D. Work, heat, entropy

E. Enthalpy, entropy, heat

2. What was the original unit for measuring heat?

A. BTU

B. Watt

C. Joule

D. Pascal

E. Calorie

3. What is the name of an ideal-gas process in which no heat is transferred?

A. Isochoric

B. Isentropic

C. Isothermal

D. Isobaric

E. Adiabatic

4. Heat is

A. the amount of thermal energy in an object.

B. the energy that moves from a hotter object to a colder object.

C. a fluid-like substance that flows from a hotter object to a colder object.

D. both A and B.

E. both B and C.

5. The thermal behaviour of water is characterized by the value of its

A. heat density

B. heat constant

C. specific heat

D. thermal index

E. conductivity ratio

6. Why is water high in dissolved oxygen is more corrosive.

A. The anode is exposed to the atmosphere.

B. Depolarization removes hydrogen gas surrounding the cathode and exposing it to the oxygen.

C. Formation of tubercles on the wall of the pipe.

D. Bubbles are easily formed in oxygen-rich water.

E. The water is acidic.

3. A galvanic cell is set up with electrodes of solid aluminum and solid aluminum-zinc alloy and an electrolyte of molten $AlCl_3 - NaCl$. When the mole fraction of Al in the alloy electrode is 0.38, the EMF of the cell is 7.43 millivolts at 380 °C, and the temperature coefficient of the EMF is $2.9\times10^{-5}\ volts/degree$.

   a. Write the cell reaction. ***(5 Marks)***

   Calculate

   b. The ΔG^o for the cell. ***(4 Marks)***

   c. The activity of Al in the alloy ***(8 Marks)***

   d. The partial molar Gibbs free energy of mixing of Al in the alloy ***(4 Marks)***

   e. The partial molar enthalpy of mixing of Al in the alloy. ***(4 Marks)***

SECTION B: ANSWER ONE QUESTION FROM THIS SECTION

4. 1 mole of SiC is heated from 25 °C to 1000 °C at a constant pressure of 1 atm. The constant pressure molar heat capacity of SiC varies with temperature as

$$C_p = 50.79 + 1.97\times10^{-3}T - 4.92\times10^{6}T^{-2} + 8.20\times10^{8}T^{-3}\ J/mole\cdot K$$

   a. The combined statement of the 1st and 2nd law of thermodynamics in terms of the enthalpy is $dH = TdS + VdP$, that is H(S,P). Deduce the relation for H(T,P). ***(10 Marks)***

   b. Use the expression derived in 4(a) to calculate the enthalpy change for the heating of SiC at constant pressure of 1 atm. Comment on your answer. ***(15 Marks)***

5. 1 mole of SiC is heated from 25 °C to 1000 °C at a constant pressure of 1 atm. The constant pressure molar heat capacity of SiC varies with temperature as

$$C_p = 50.79 + 1.97\times10^{-3}T - 4.92\times10^{6}T^{-2} + 8.20\times10^{8}T^{-3}\ J/mole\cdot K$$

   a. Deduce the relation for S(T,P) **(10 Marks)**

   b. Use the expression derived in 5(a) to calculate the entropy change for the heating of SiC at constant pressure. Comment on your answer. ***(15 Marks)***

6. Carbon in the form of diamond can form graphite according to the reaction

$$C_{(diamond)} = C_{(graphite)}$$

   Using the thermodynamic data provided in the Table 2

a. Calculate ΔG^o for the reaction in which diamond changes to graphite ***(12 Marks)***

b. Calculate the equilibrium constant, ***(8 Marks)***

c. Is the reaction spontaneous at 298 K? Explain ***(5 Marks)***

Table 2

	Graphite	Diamond
Heat of formation (ΔH_f^o)	0	$1.90\ kJ/mol$
Standard Entropy (S^o)	$5.69\ J/K \cdot mol$	$2.4\ J/K \cdot mol$

THE FOLLOWING EQUATIONS AND CONSTANTS ARE PROVIDED

$$dS = \frac{C_P}{T}dT - V\alpha dP$$

$$dH = C_P dT + V(1 - T\alpha)dP$$

$$E = E^o - \frac{RT}{zF}\ln J$$

$$\Delta G = -zFE$$

$$\Delta G^o = -zFE^o$$

$$\Delta H = -zF\left[E - T\frac{dE}{dT}\right]$$

$$\Delta G = \Delta G^o + RT\ln J$$

$$\overline{\Delta H}_A = \Delta H + X_B\frac{d(\Delta H)}{dX_A}$$

Faraday's constant: $96480\ C/mol$

$$1\ atm\ cm^3 = 0.1013\ J$$

$$\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P = -V\alpha$$