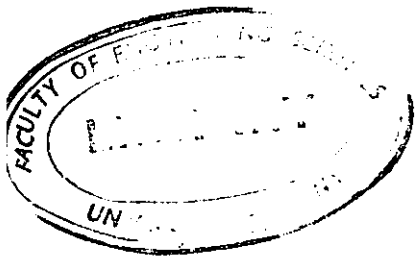



**UNIVERSITY OF GHANA**



**FACULTY OF ENGINEERING SCIENCES**

**BSc. (ENG) SECOND SEMESTER EXAMINATIONS: 2011/2012**

**MTEN 204 THERMODYNAMICS OF MATERIALS (2 CREDITS)**

**TIME ALLOWED: 2 HOURS**

***Answer ALL Questions***

***Note: Some of the equations needed are provided on page 5, R=8.314 J/molK***

***Section A (Circle the correct answer)***

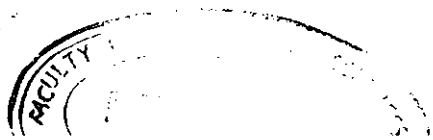
1. Of the following only ..... is not a state function.
   a) E b) H c) S d) q E) T

2. The First Law of Thermodynamics can be given as .....
   a) The entropy of a pure crystalline substance at absolute zero is zero
   b) $\Delta E = q + w$
   c) $\Delta H^0_{rxn} = \Sigma\left(n\Delta H^0_f(products)\right) - \Sigma\left(m\Delta H^\circ_f(reactants)\right)$
   d) For any spontaneous process the entropy of the universe increases
   e) $\Delta S = q_{rev}/T$ at constant temperature

3. The thermodynamic quantity that expresses the degree of disorder in a system is .....
   a) Heat flow b) enthalpy c) entropy d) internal energy e) bond energy

4. The second Law of thermodynamics can be given as.....
   a) $\Delta S = q_{rev}/T$ at constant temperature
   b) $\Delta E = q + w$
   c) For any spontaneous process the entropy of the universe increases
   d) The entropy of a pure crystalline substance at absolute zero is zero
   e) $\Delta H^0_{rxn} = \Sigma\left(n\Delta H^0_f(products)\right) - \Sigma\left(m\Delta H^\circ_f(reactants)\right)$





5. ΔS is positive for the reaction.....
   a) $CO_{2(g)} \rightarrow CO_{2(s)}$
   b) $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
   c) $BaF_{2(s)} \rightarrow Ba^{2+}_{(aq)} + 2F^{-}_{(aq)}$
   d) $2Hg_{(l)} + O_{2(g)} \rightarrow 2HgO_{(s)}$
   e) $2NO_{(g)} \rightarrow N_2O_{4(g)}$

6. A reaction that is spontaneous as written .....
   a) Will proceed without outside intervention
   b) Is very slow
   c) Has an equilibrium position that lies far to the left
   d) Is very rapid
   e) Is also spontaneous in the reverse direction

7. A reverse process is one that.....
   a) Must be carried out at high temperature
   b) Can be reversed with no net change in either system or surroundings
   c) Happens spontaneously
   d) Must be carried out at low temperature
   e) Is spontaneous in both directions

8. Which of the following is a reverse process?
   a) Freezing of water at -10°C and 1 atm
   b) Melting of ice at 0°C and 1 atm
   c) Freezing of water at -25°C at 1 atm
   d) Melting of ice at 25°C at 1 atm
   e) Evaporation of water at 25°C at 1 atm

9. Which of the following can be seen as the condition for equilibrium?
   a) $\Delta S>0$
   b) $\Delta S<0$
   c) $\Delta G>0$
   d) $\Delta G<0$
   e) $\Delta G=0$

10. Consider the reaction $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \rightarrow AgCl_{(s)}$, given the following table of thermodynamic data at 298K

| Substance | $\Delta H^0$ (kJ/mol) | $S^0$ (J/Kmol) |
|---|---|---|
| $Ag^{+}_{(aq)}$ | 105.9 | 73.93 |
| $Cl^{-}_{(aq)}$ | -167.2 | 56.5 |
| $AgCl_{(s)}$ | -127.0 | 96.11 |

Calculate the value of the equilibrium constant K for the reaction at 298K

a) $1.8x10^{4}$
b) 810
c) $1.9x10^{-10}$
d) $3.7x10^{10}$
e) $5.4x10^{9}$

***20 MARKS***

***Section B***

***Question 1***

a. A 50 kg iron block and a 20 kg copper block, both initially at 80°C, are dropped into a large lake at 15°C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water.
Determine
   I. The entropy change of the Iron
   II. The entropy change of the Copper
   III. The entropy change of the lake
   IV. The entropy change for the process

[***The specific heats of iron and copper at room temperature are $C_{iron}$ = 0.45 kJ/kg.K and $C_{copper}$ = 0.386 kJ/kg.K***

b. One mole of ideal gas at 25°C and 1 atm undergoes the following reversible process:

   - Isothermal expansion to 0.5 atm, followed by
   - Isobaric expansion to 100°C, followed by

- Isothermal compression to 1 atm, followed by
- Isobaric compression to 25°C

Calculate the total work done by the reversible process described above.

c. A closed system consisting of elastic membrane enclosing a colloidal suspension is squeezed. The compressive pressure is 10 Pa and the volume of the system changes from 100 L to 80 L. During this process 1J of heat is released. Calculate the change in internal energy of the system. [1000L=1m$^3$] ***25MARKS***

***Question 2***

a. Hot liquid Sodium at 400°C flows through a solid Plutonium pipe, also at 400°C. Naturally, one should worry about the amount of Plutonium that can be dissolved in liquid Sodium. Assume that the system is at 1 atm pressure and that the Sodium is virtually insoluble in solid plutonium; but plutonium forms an ideal solution with liquid sodium. Find a thermodynamic estimate of the maximum composition of plutonium in the liquid Sodium. [at 400$^0$C, $\bar{G}^{Solid}_{Plutonium,o} = 42.436 kJ/mol$ and $\bar{G}^{Liquid}_{Plutonium,o} = 42.233 kJ/mol$]

b. The global reaction for the aluminum-air corrosion cell at 60°C is written below:

$$4Al + 4OH^- + 3O_2 \rightarrow 4AlO_2^- + 2H_2O$$

I. Using the thermodynamic data provided in the table below, calculate the Gibbs energy for each specie in the reaction above.
II. Calculate the ΔG for the cell
III. Calculate the electrode potential (E) for the cell

| Specie | $G^{\circ}_{(60\,^{\circ}C)}$, J/mol | Activity ($a_i$) |
|---|---|---|
| Al | -1,040.43 | 1 |
| $OH^-$ | -157,849 | 1 |
| $O_2$ | -7,234.04 | 0.2 |
| $AlO_2^-$ | -841,778 | 0.1 |
| $H_2O$ | -239,483 | 1 |

***25 MARKS***

***The following equations may be helpful***

$$\Delta G = -nFE$$

$$G_{i(T)} = G^{0}_{i(T)} + RT ln a_i$$

$$\mu_i^{\alpha} = \mu_{i,o}^{\alpha} + RT ln X_i^{\alpha}$$

$$G_i^{\alpha} = G_{i,o}^{\alpha} + RT ln X_i^{\alpha}$$

$$E_{in} - E_{out} = \Delta E_{system}$$

$$\Delta U = mC(T_2 - T_1)$$

$$\Delta S = mC_{avg} ln \frac{T_2}{T_1}$$

$$\Delta S = \frac{Q}{T}$$

$$dU = \delta Q - \delta W$$

$$PV = nRT$$