Disclaimer: This exam is multiple years old and is likely to be obsolete.

MSE 120 First mid-term, 2004

Monday, Sept 27, 1.10-2pm

Closed book, closed notes, no calculators

Put the answers on the pages provided and keep the question pages.

There are two questions; each carries the same maximum credit.
Try to spend no more than one minute on each part of question 1.

Question 1:
Select the letter for each of the following to correctly complete the statement. [No marks subtracted for wrong answers - this is not the SAT - so guess if you do not know.]

1. The value of the materials produced each year in the US is approximately
    a. $400 thousand
    b. $400 million
    c. $400 billion
    d. $400 trillion

2. Most beverage cans are made of aluminum in this country. These cans can be recycled and the percentage of the number produced that get recycled is approximately
    a. 5%
    b. 20%
    c. 50%
    d. 95%

3. Bronze is an alloy of
    a. copper and zinc
    b. copper and tin
    c. zinc and tin
    d. iron and carbon

4. Aluminum has been produced in industry since Hall and Héroult discovered how to do this in
    a. the 17th century
    b. the 18th century
    c. the 19th century
    d. none of the above

5. With almost no exception, our materials are either recycled materials or are extracted from the Earth's
    a. lithosphere
    b. hydrosphere
    c. cryosphere
    d. biosphere

6. The geological mechanism by which placer deposits are formed is
    a. supergene enrichment
    b. selective natural leaching
    c. evaporation of surface waters
    d. weathering, transportation and settling

7. "Gangue" is
    a. a group of workers hired to do mining
    b. the worthless constituent of an ore body
    c. a reagent used in flotation
    d. none of the above

8. "Flotation" is a mineral processing technique that separates particles by
    a. differences in density
    b. liberation
    c. differences in hydrophobicity/hydrophilicity
    d. differences in particle size

9. The following is a statement of the first law of thermodynamics (E = internal energy, dq = heat added to the system, w = work done by system on surroundings, H = enthalpy, S = entropy)
    a. $dE = dq - w$
    b. $dE = dq + w$
    c. $H = S + dq$
    d. $H = S - w$

10. The heat capacity at constant pressure (C_p) is equal to

   a. rate of increase of internal energy (per mole or per unit mass of a substance) with temperature at constant pressure
   b. rate of increase of entropy (per mole or per unit mass of a substance) with temperature at constant pressure
   c. rate of increase of enthalpy (per mole or per unit mass of a substance) with temperature at constant volume
   d. none of the above

11. A system is at a state of equilibrium when its

   a. internal energy is at a maximum with respect to other states at the same volume
   b. Gibbs free energy is at a maximum with respect to other states at the same temperature and pressure
   c. Gibbs free energy is at a minimum with respect to other states at the same temperature and pressure
   d. enthalpy is at a minimum with respect to other states at the same temperature and pressure

12. An isolated system is one which

   a. can exchange both energy and matter with its surroundings
   b. can exchange neither energy nor matter with its surroundings
   c. the same as a closed system
   d. can exchange energy but not matter with is surroundings

13. In class we had an equation giving the entropy (per mole) of a species at temperature T. With something missing, that equation was

$$\bar{S} = \bar{S}_0 + \int_0^T \frac{\bar{C}_p dT}{T} + \sum$$

The quantity missing after the summation sign is

a. $\Delta \bar{H}_{PC} / T$

b. $\Delta \bar{H}_{PC} / T_{PC}$

c. PV / RT

d. none of the above

14. We would expect an entropy decrease for which of the following (carried out at constant temperature)
    a. growth of a crystal from a solution
    b. the reaction of solid carbon with oxygen (gas) to produce carbon monoxide (gas)
    c. dissolving sugar in coffee
    d. boiling of water

15. With the symbols used in class

$$\left(\frac{\partial G}{\partial n_i}\right)_{n_1, n_2, \ldots n_{i-1}, n_{i+1}, \ldots. n_m}$$

is

    a. the partial molar volume of species i
    b. the chemical potential of species m
    c. the chemical potential of species 1
    d. the chemical potential of species i

Question 2.

A metal oxide MO_3 is to be reduced with hydrogen gas at a high temperature to produce a metal M and water vapor. A large quantity of MO_3 is placed with hydrogen in a closed reactor at temperature and allowed to reach chemical equilibrium. We are interested in calculating the composition of the gas in the box when equilibrium is reached. MO_3 and M are separate pure solid phases.

a. Write down a chemical equation for the reaction.
b. What thermodynamic data do we need to carry out the calculation?
c. Give the equation that enables us to calculate an equilibrium constant from thermodynamic data.
d. There is a thermodynamic quantity appearing in the equation of part c. Give an equation for that quantity in terms of the data appearing in your answer to part b.
e. Write the equilibrium constant in terms of activities.
f. Replace those activities with more familiar quantities (pressures, concentrations or whatever).
g. If the equilibrium constant equals 8, what is the mole fraction of hydrogen in the gas when equilibrium is reached. The only gasses present are hydrogen and water vapor.
h. Is the result you calculated in part g valid if only a small quantity of MO_3 is placed in the reactor (say 0.1 mole of MO_3 and 12 moles of hydrogen)? Explain.