MSE120 FALL 2006 – First mid-term – Sept. 25th – 1.10-2pm

Closed books, closed notes, no calculators.

There are two questions – the first carries 45% of the maximum credit.
Write your answers on the sheets provided and keep the question pages.

First question

On your answer sheet write down the one letter corresponding to the best completion of each of the following:

Compared with annual production in 1970, the recent annual world production of aluminum is
About 10% lower
About the same
About 10% higher
More than double.

If we rank the following three major US industries in order of **increasing** energy consumption the correct ranking is
Textiles/apparel, primary metals, petroleum
Primary metals, textiles/apparel, petroleum
Primary metals, petroleum, textiles/apparel
Textiles/apparel, petroleum, primary metals.

As we increase the amount of carbon in an iron-carbon alloy (say from 0% to 3%) the alloy generally becomes:
Harder and has a lower melting point
More ductile and has a lower melting point
Harder and has a higher melting point
More ductile and has a higher melting point.

Except for recycling we rely on only two of the Earth's geological zones for the source of our materials. Those zones are:
The atmosphere and lithosphere
The siderosphere and hydrosphere
The lithosphere and hydrosphere
The siderosphere and lithosphere.

"It is impossible to economically extract materials from a composition of minerals having the average composition of the lithosphere". We can economically obtain materials because:
The statement in quotes is wrong

The lithosphere is very heterogeneous with big departures from the average composition.
We can dig down to the siderosphere and use that to get our materials.
All our materials come from recycling now.

In mineral processing "gangue" is:
The overburden at the mine
The valuable part of the ore from the mine
Separated (at least partially) from the valuable mineral in mineral processing
A group of miners.

Flotation is a separation technique that
relies on differences in surface chemistry (hydrophobicity/hydrophilicity)
relies on differences in density
usually does not achieve a perfect separation between particles that are hydrophobic and ones that are hydrophilic
the words of both a and c apply to.

Gibbs' free energy, G is given by (using symbols employed in class):
G = E + PV + TS
G = H + TS
G = E – PV – TS
G = H – TS

If we look at how thermodynamic quantities vary with temperature we usually find (using symbols employed in class)
EMBED Equation.DSMT4 and EMBED Equation.DSMT4 are approximately constant
EMBED Equation.DSMT4 , EMBED Equation.DSMT4 and EMBED Equation.DSMT4 are approximately constant, provided there are no phase changes
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EMBED Equation.DSMT4 and EMBED Equation.DSMT4 are approximately constant, provided there are no phase changes

In a chemical reactor containing several reacting species, one species with a high chemical potential, compared to the others, will tend to:
React away as equilibrium is approached
Increase in amount as equilibrium is approached
Generate electricity by giving up its electrons
Serve as an effective reducing agent because it has a high Gibbs free energy.

The activity of a species will:
Numerically equal one when the species is in its standard state

Be equal to the concentration times an activity coefficient when the species is in solution
Equal the partial pressure (in atmospheres) when the species is an ideal gas
Be all of the above.

The species AB_2 is formed when two moles of B react with one mole of A. 100 moles of A are placed in a reactor with 1 mole of B at 1000K. When equilibrium has been reached it is found that the reactor contains 99.501 moles of A. The standard Gibbs free energy for reaction is
Greater than 20kJ/mol
Close to zero
Less than -20kJ/mol.
Greater than 99.501

An Ellingham diagram for oxides is a plot of:
Standard Gibbs' free energy of formation of oxides (per mole of oxide) versus temperature
Standard Gibbs' free energy of formation of oxides (per mole of oxygen) versus temperature
Standard enthalpy of formation of oxides (per mole of oxide) versus temperature
Standard Gibbs' free energy of formation of oxides (per mole of oxygen) versus reciprocal temperature.

In the Ellingham diagram for oxides the line for carbon going to CO runs from downwards towards the lower right of the diagram; the line for vanadium going to its oxide (V_2O_3) runs from lower left towards the upper right. The two lines intersect at about 1700K. Above 1700K we would expect:
Carbon to oxidize V_2O_3 to vanadium
Vanadium oxidize carbon monoxide to carbon
Carbon to reduce V_2O_3 to vanadium
Vanadium to reduce carbon monoxide to carbon

In the Pigeon process for producing magnesium, magnesium oxide is reduced by silicon to produce magnesium and SiO_2. This is contrary to what you might expect from thermodynamics (e.g. the Ellingham diagram). The reaction happens because
The Ellingham diagram is incorrect
Thermodynamics does not tell you about kinetics and the reaction is slow.
Magnesium escapes from the reactor as a gas, preventing equilibrium being reached.
The technology is exploited in China where thermodynamics is different.

Second question

SnO_2 is placed in a reactor at room temperature along with carbon and argon (the only gas present at this point). The reactor is then brought up to 1000K and the total pressure is observed to be 100 atmospheres. There is no SnO_2 left in the reactor; it contains only SnO, tin, carbon, carbon monoxide, carbon dioxide and argon. The tin is a pure liquid while the SnO and carbon form pure separate solid phases. Show how the gas composition can be calculated from the data below, assuming chemical equilibrium. [Because you do not have a calculator you will not be able to give the composition as numerical values for the three mole fractions. Additions, subtractions and multiplications should not be a problem but divisions and finding exponentials will be difficult or next to impossible. Therefore I expect to see answers in terms of exponentials but the arguments of the exponentials should contain numbers, not symbols.]

R = 8.314J/(mol.K)

Standard Gibbs' free energies of formation at 1000K (in kJ/mol):

CO	-200.39
CO_2	-395.47
SnO	-182.25
SnO_2	-372.65

Name …………..