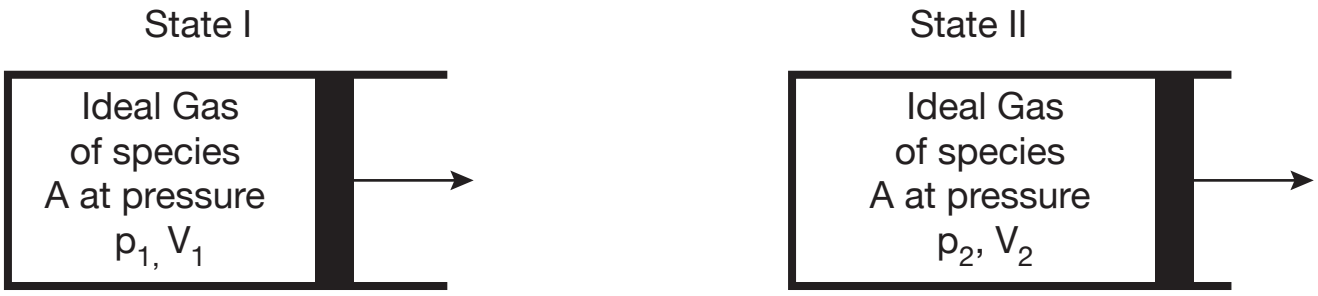
Take Home HW Exam (due back on Wednesday Nov 04, 2020)

Second Topic: REDOX Reactions

Please read the problems carefully and answer specifically what is being asked.

1.



The gas in the above picture consists of species A (just one species). In State II the piston has moved to the right by a distance ΔL. The cross sectional area of the piston is S.

Ideal gas obeys $pV = RT$

•Keep in mind that the difference between the chemical potential of a species between two states is equal to the work that can be done by or on the system by the surroundings (if the work is done on the surroundings then the chemical potential of the second state is lower than that of the first state – and vice versa).

The chemical has the following general form:

$\mu_S = \mu_S^o + RT \ln a_S$

where μ_S^o is the chemical potential of species S in the standard state, and a_S is the activity of the species.

Show that

$a_S = p_{O_2}$ where the oxygen partial pressure is measured in atm. What is the value of the standard state?

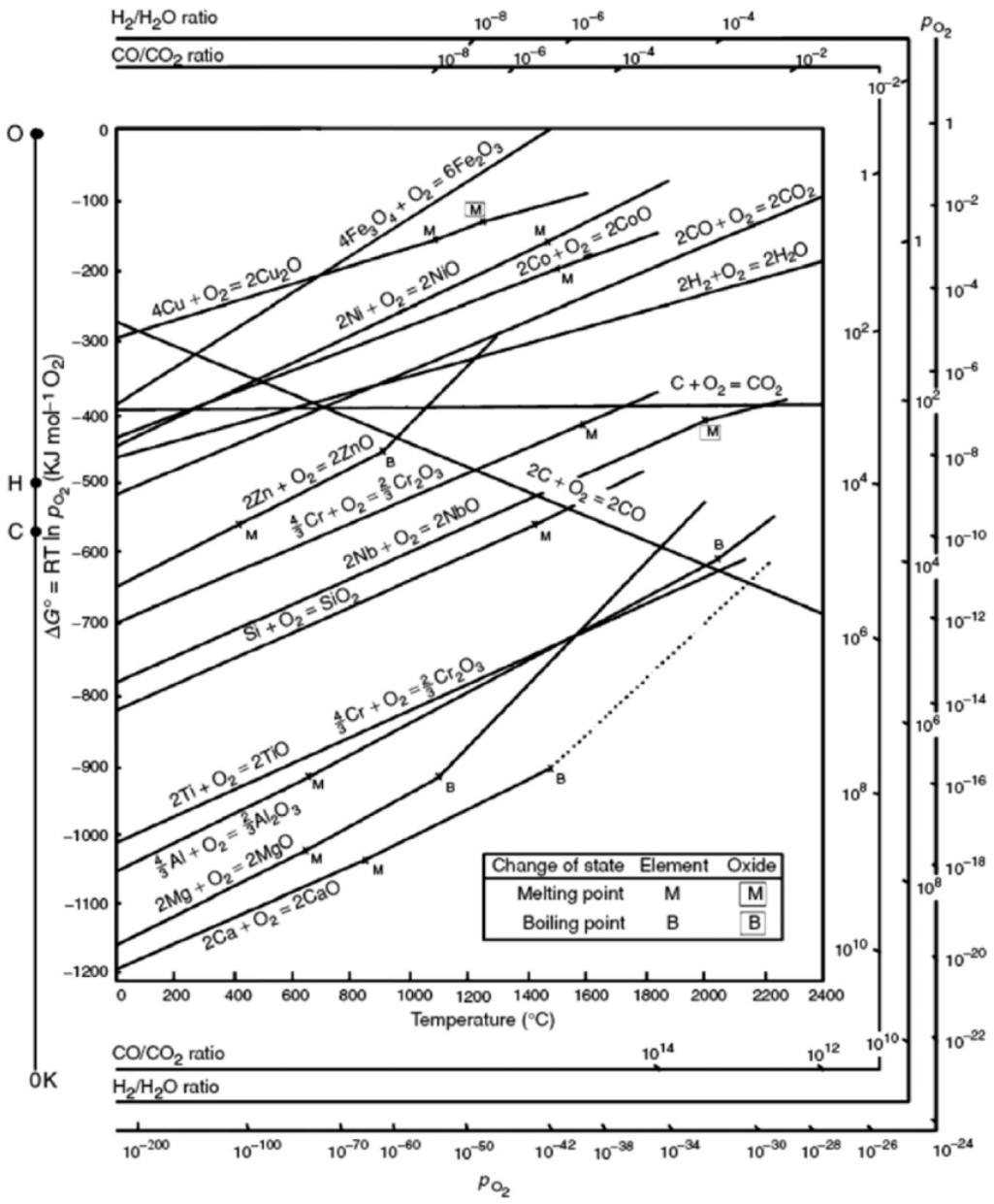
2. In a few words describe three ways (using the hints given just underneath*) that the Ellingham diagram (given in the next page) can be used. For each case give an example using the diagram reproduced on the next page.

* (i) p_{O_2}

(ii) p_{CO} / p_{CO_2}

(iii) $Si + O_2 = SiO_2$ and $4Cu + O_2 = 2Cu_2O$

Please mark your result on the Diagram to guide the reader



3. (i) Construct an Ellingham Diagram for the following equation

$$2B + 3O_2 = 2BO_3$$

(Eq. 1)

Where B and the oxide are solids and oxygen is a gas phase.

Assume that the The standard Gibbs Free "formation" Energy of the oxide is given by

$\Delta G^o_{BO_3}$ = -1500 + 0.25T in units of kJ mol^{-1}, where T is in Kelvin

Notes:

•Note that the equation above is written in terms of three moles of oxygen! Ellingham is in one mole of oxygen.

•You need draw the diagram only for the case of oxygen partial pressure

(ii) Further in Problem 4: If B is present not in its pure form (its standard state) but as in alloy with copper, then will it lower or increase the tendency of B to oxidize at the same partial pressure oxygen. B is a hypothetical metal.

4. Show that the growth of SiO2 layer on silicon in oxygen partial pressure of the $p_{O_2} = 1 atm$ will be parabolic, following equation

$$h^2 = k_p t \qquad \text{(Eq. 5)}$$

Clearly state the assumptions in your analysis.

In Eq. (6), h is the time dependent growth of the silica overlayer, and k_p is the parabolic rate constant.