PHY 341/641
Thermodynamics and Statistical Physics

Lecture 35

Review and examples

- Chemical potential example – atmospheric pressure
- Chemical potential example – battery operation

24	3/26/2012	Bose and Fermi particles	6.5-6.11		
25	3/28/2012	Phase transformations	7.1-7.3	HW 21	03/30/2012
26	3/30/2012	Van der Waals Equation	7.4		
27	4/02/2012	Equilibrium constants	7.4-7.5	HW 22	04/04/2012
28	4/04/2012	Equilibrium constants	7.5		
	4/06/2012	*Good Friday Holiday*			
29	4/09/2012	Review -- begin take-home exam	5-7		
	4/11/2012	No class -- work on exam	5-7		
30	4/13/2012	Simulation of chemical potential	7.2	Exam continued	
31	4/16/2012	Classical treatment of dense systems	8.1-8.2	Exam due	
32	4/18/2012	Review exam; Virial expansion	8.3-8.4		
33	4/20/2012	Radial distribution function	8.5		
34	4/23/2012	More topics on classical fluids	8.6-8.9		
35	4/25/2012	Review			
36	4/27/2012	Review			
	4/30/2012	Student presentations I			
	5/02/2012	Student presentations II			
	5/09/2012	9 AM Final exam			

4/30– Laurence, Zac, Eric

5/2 -- Kristen, Audrey, Griffin

E FOREST
RSITY

Department of Physics

WFU Physics Colloquium

TITLE: Honors theses presentations

TIME: Wednesday April 25, 2012 at 3:30 PM

PLACE: Room 101 Olin Physical Laboratory

Refreshments will be served at 3:00 PM in the Olin Lounge. All interested persons are cordially invited to attend.
Note early start time

SPEAKERS

- Matthew Martin
- Dillon Sanders
- Griffin Shoemaker
- Hannah Reynolds
- Molly Binder
- Daniel David

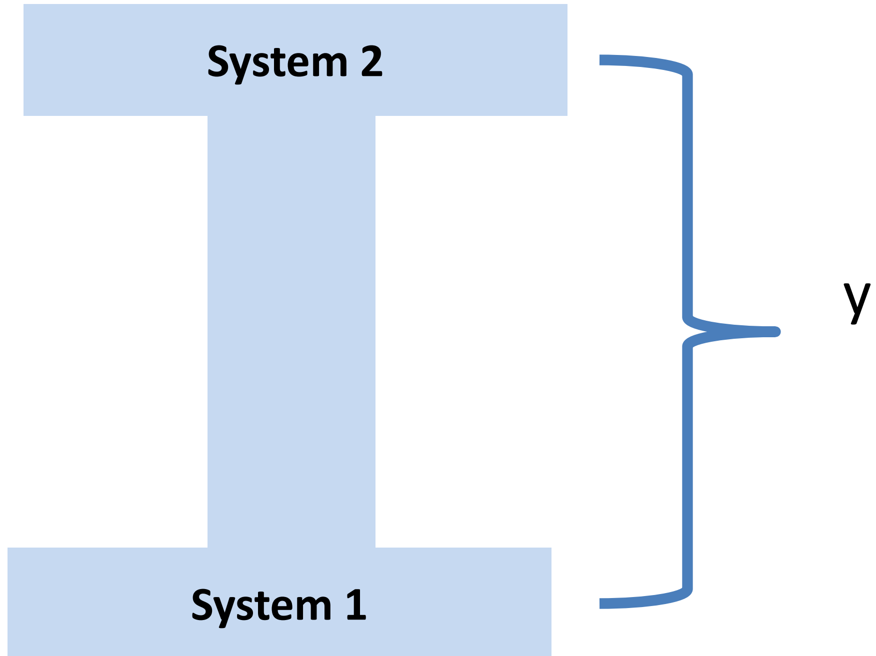
Example systems involving analysis of chemical potentials

Ref. Kittel and Kroemer, **Statistical Physics**

In the following examples, the “internal chemical potential” is augmented with an external potential which can be added to make a “total” chemical potential

Model of the variation of the atomospheric pressure with altitude based on the consideration of two volumes of gas at different heights in a uniform gravitational field in thermal and diffusive contact. (Ignor temperature and gravitational potential variations with height.)

$$\Phi_{gravity}(y)=mgy$$



$$\Phi_{gravity}(0)=0$$

Here m denotes the average mass per particle, and g denotes the gravitation acceleration.

Assuming ideal gas equation of state:

$$\mu_{tot}(y) = -kT \ln\left[\frac{V}{N(y)}\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\right] + \Phi_{gravity}(y)$$

$$\equiv -kT \ln\left[\left(\frac{2\pi mkT}{h^2}\right)^{3/2}\right] + kT\ln\big(n(y)\big) + \Phi_{gravity}(y)$$

where $n(y) \equiv \frac{N(y)}{V}$ represents the gas density as a function of height

Thermodynamic equilibrium implies:

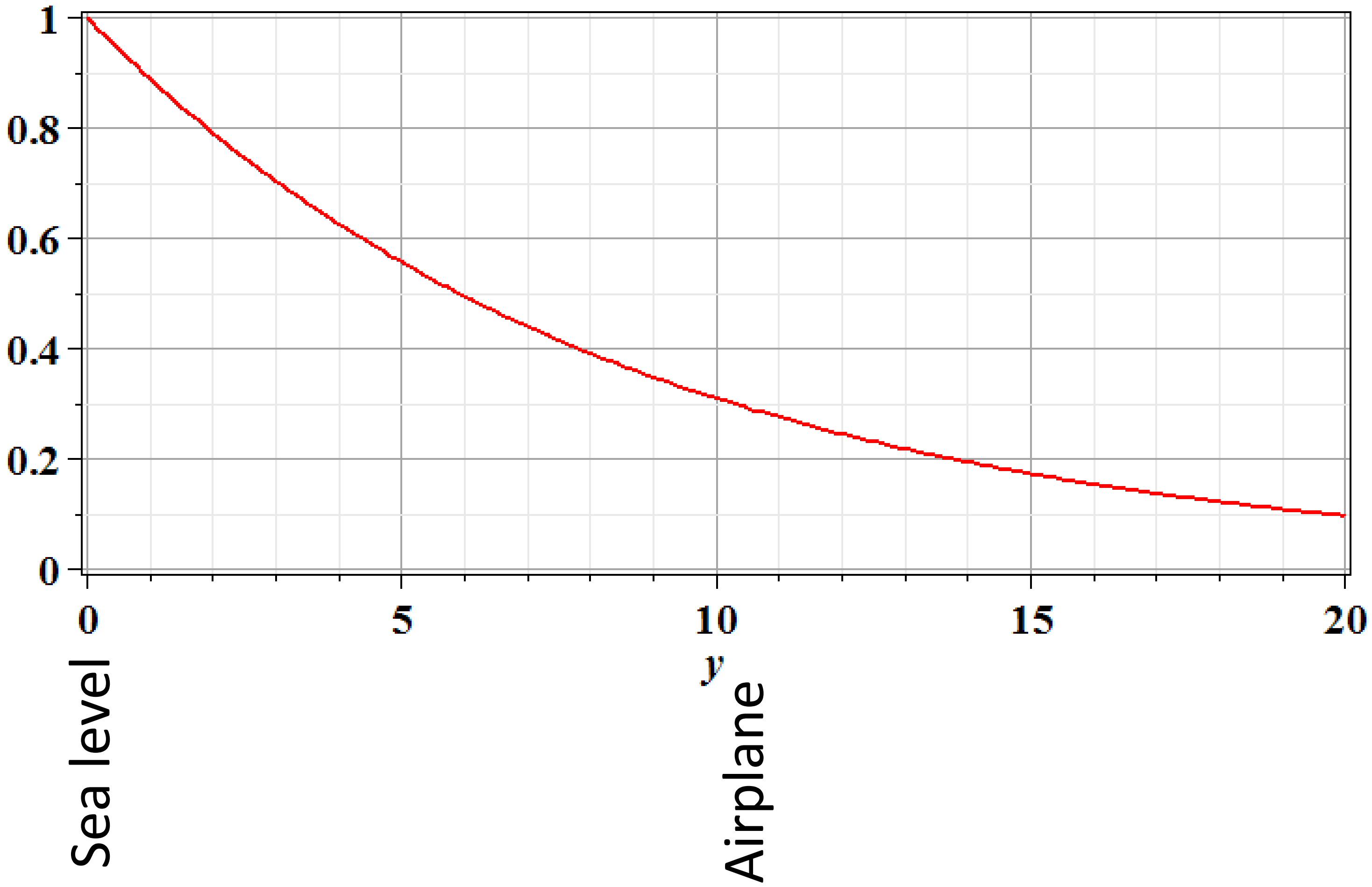
$$\mu_{tot}(y) = \mu_{tot}(0)$$

$$\Rightarrow kT\ln\big(n(y)\big) + mgy = kT\ln\big(n(0)\big)$$

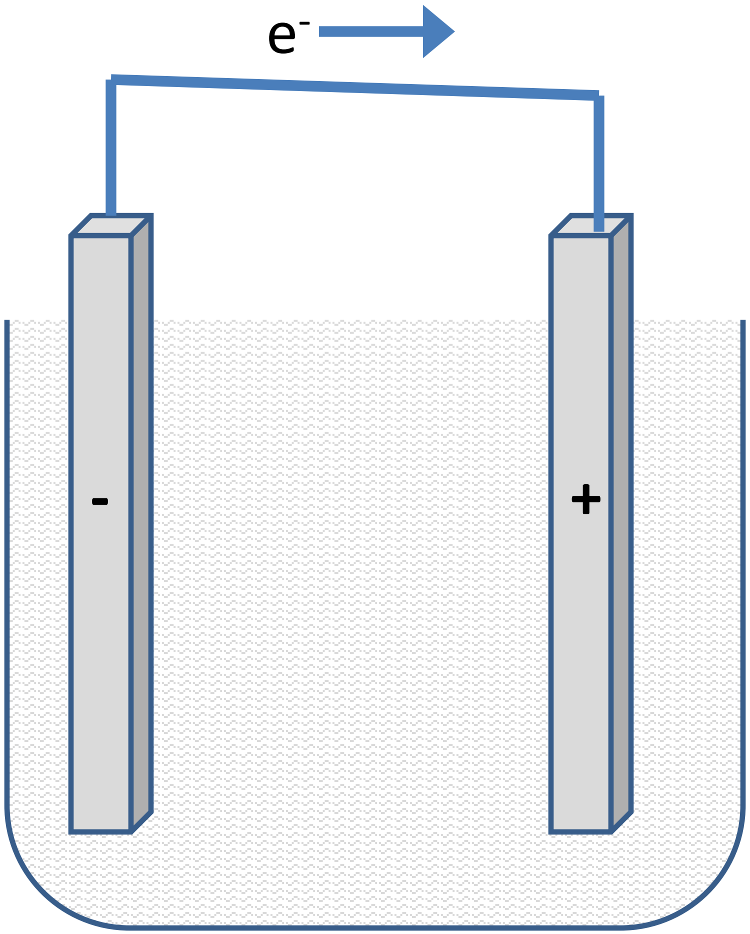
$$\Rightarrow n(y) = n(0)e^{-mgy/kT}$$

Variation of air density with height :

$$n(y) = n(0)e^{-mgy/kT} \equiv n(0)e^{-y/y_c} \quad y_c \approx 8.5km$$



Another example of chemical potential analysis -- battery

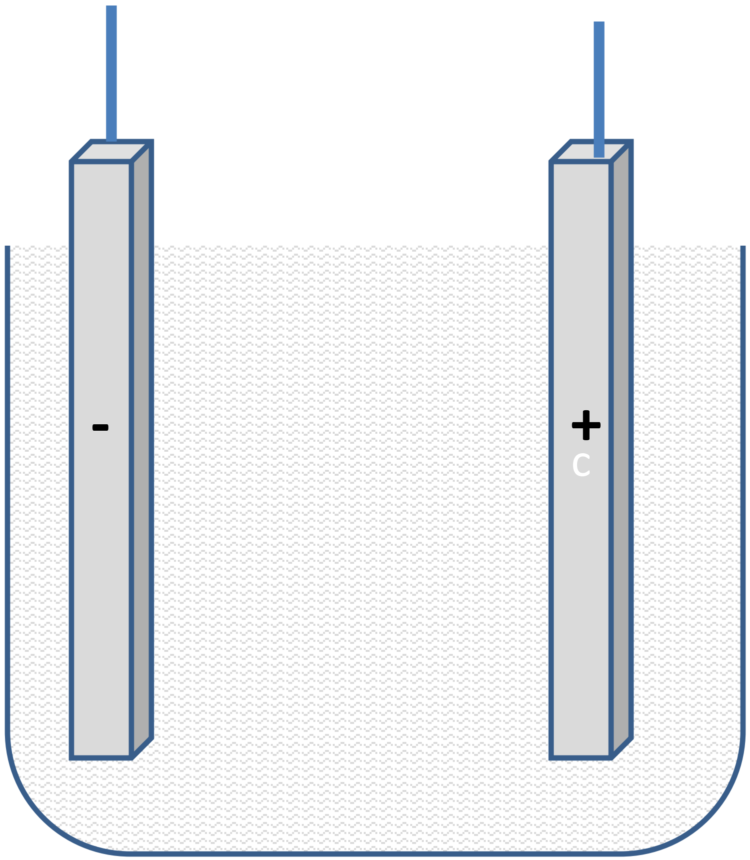


Negative electrode (Pb): $\mu\left(SO_4^{-2}\right)$

$$Pb + SO_4^{-2} \rightarrow PbSO_4 + 2e^-$$

Positive electrode (PbO_2): $\mu\left(H^+\right)$

$$PbO_2 + H_2SO_4 + 2H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$$



Open circuit voltage:

$$\Delta V_+ - \Delta V_- = 1.6V - (-0.4V) = 2V$$

Negative electrode (Pb):

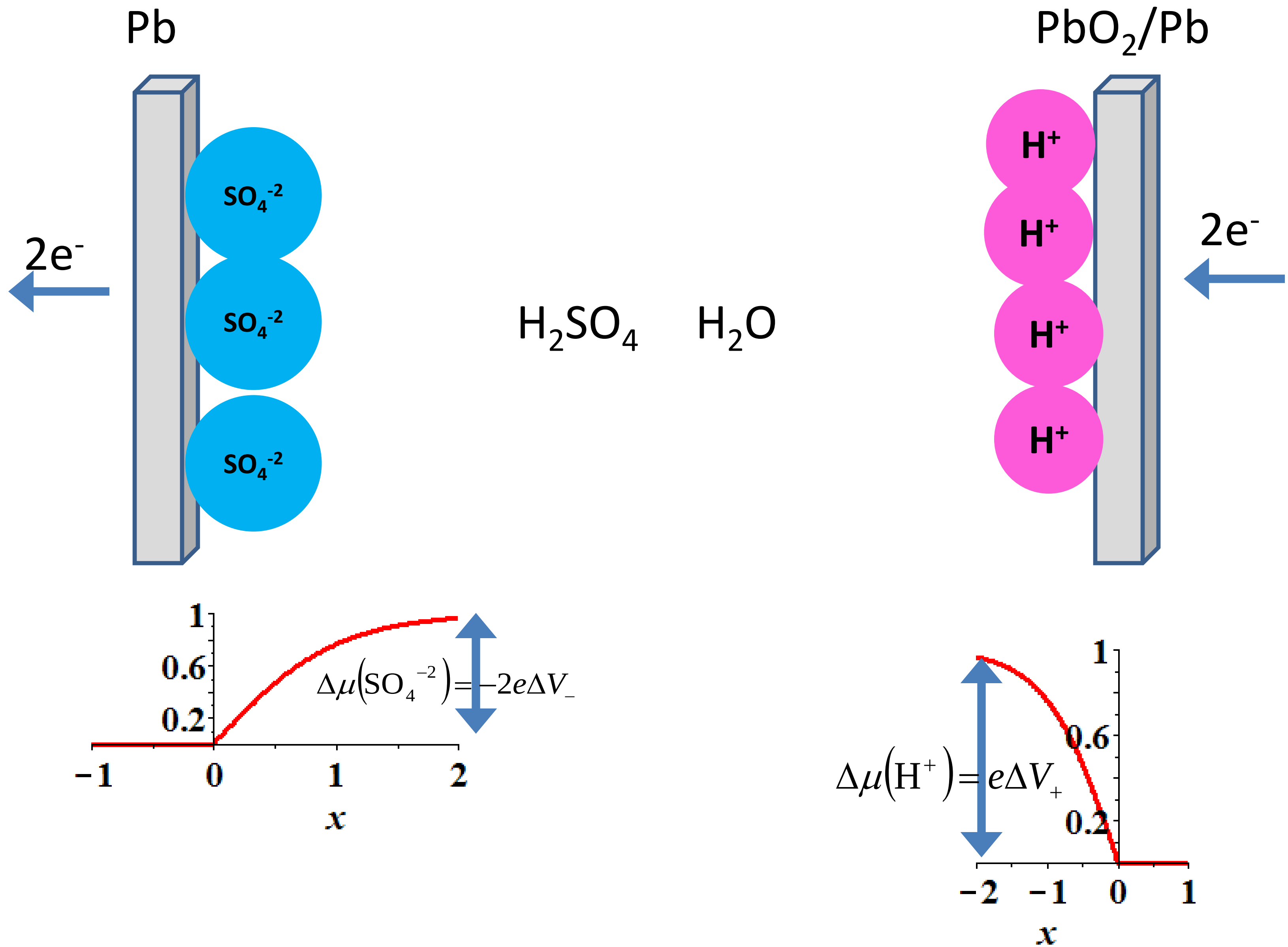
$$\Delta\mu\left(\mathrm{SO_4}^{-2}\right) = -2e\Delta V_-$$

$$\Delta V_- = -0.4V$$

Positive electrode (PbO_2):

$$\Delta\mu\left(\mathrm{H}^+\right) = e\Delta V_+$$

$$\Delta V_+ = 1.6V$$


Pb
PbO2/Pb
SO4-2
SO4-2
SO4-2
H+
H+
H+
H+
2e-
2e-
H2SO4
H2O
Δμ(SO4−2) = −2eΔV−
Δμ(H+) = eΔV+
1
0.6
0.2
−1
0
1
2
x
1
0.6
0.2
−2
−1
0
1
x