1. (15 marks) Using standard reduction potentials, calculate the potential for the following cell at 298 K: Zn / Zn^{2+}(aq), 0.1 M // Cu^{2+}(aq), 1.0 M / Cu

Standard reduction potential at 298 K

Zn^{2+}/Zn = -0.76 V; Cu^{2+}/Cu = 0.34 V

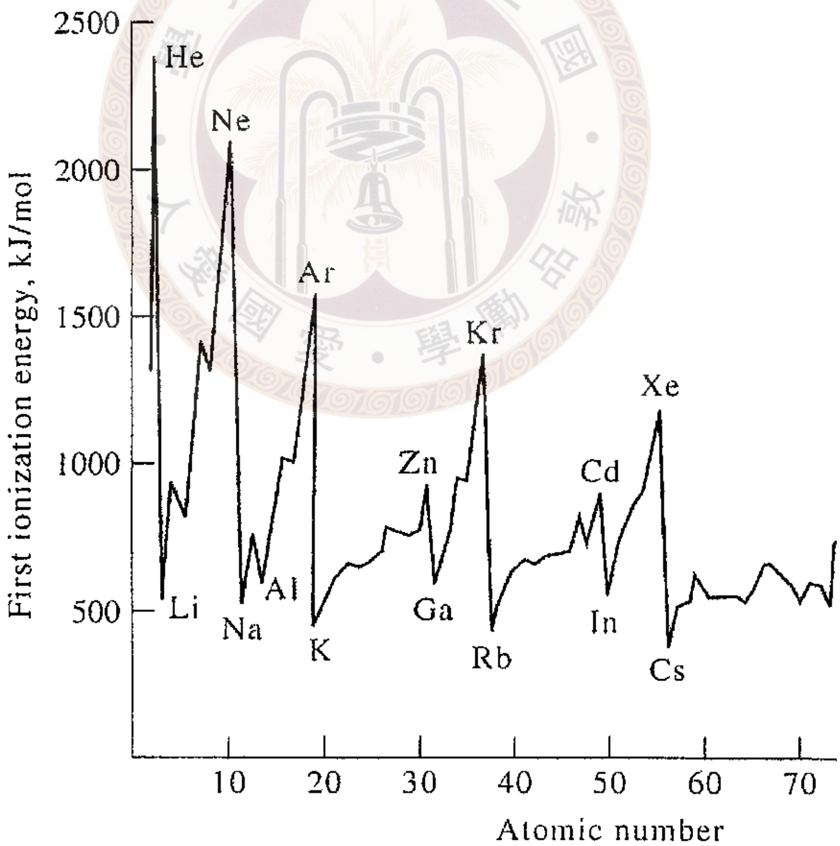
Nernst equation: $E = E^0 - (0.0592/n) \log Q$

(a) Write down the half-reaction at the anode.

(b) Write down the half-reaction at the cathode.

(c) Calculate the potential of the cell.

2. (20 marks) Given the first ionization energies shown in the following diagram:



(a) Explain the general trend of the data across a period.

(b) Explain why the first ionization energy drops from Be to B, and from N to O.

3. (10 marks) The best laboratory vacuum system can pump down to as few as 1.0×10^9 molecules per cubic meter of gas. Calculate the corresponding pressure, in atmospheres, assuming a temperature of 0 °C.

4. (20 marks)
(a) Explain the second law of thermodynamics.
(b) Define the Gibb's free energy and explain under what circumstances we have $\Delta G < 0$ for spontaneous processes.

5. (15 marks)
(a) Consider a mineral salt perovskite $MgSiO_3$. If some of the Si are substituted by Al, determine the value x for the resultant non-stoichiometric perovskite compound $MgSi_{0.95}Al_{0.05}O_x$.
(b) Calculate the molarity of pure water.
(c) Calculate the molarity of a concentrated nitric acid, which has 50 wt% HNO_3 and 50 wt% water. [You can assume the density of the mixture as 1 g/cm^3]

6. (20 marks) A 1.148-g sample of benzoic acid is burned in an excess of oxygen in a bomb calorimeter. The temperature of the calorimeter rises from 24.96 to 30.25 °C. The heat of combustion of benzoic acid is -26.42 kJ/g. In a second experiment, a 1.046-g powdered coal sample is burned in the same calorimeter assembly. The temperature rises from 24.18 to 29.73 °C. How many kilograms of this coal would have to be burned to liberate 1.00×10^9 kJ of heat?.