

Problem 1

a) For the following elements, (1) give the electron configuration with the correct atomic orbitals, (2) clearly indicate which electrons are the core electrons and which electrons are the valence electrons, and (3) give the charge and electron configuration of the most stable ion formed by these elements.

- (i) S
- (ii) Mg

b) Organize the following atoms and ions in terms of size (small to large), and explain your answer:

B^{3+} , Be, Br^- , Se

c) What is the 3D structure of (i) $B(CH_3)_3$, and (ii) $N(CH_3)_3$? Explain your answer using Lewis structure drawings and VSEPR theory.

Problem 2

a) draw the complete Lewis structure (including free electron pairs) of:

- (i) CH_2CHCHO
- (ii) H_2SiO_3
- (iii) SO_2

b) Ethylamine ($CH_3CH_2NH_2$) and acetamide ($CH_3C(=O)NH_2$) are both water soluble bases, with pK_a values of their conjugate acids of 10.6 and 15.1, respectively. Why is ethylamine a stronger base than acetamide? Explain your answer using Lewis structures and/or resonance structures.

Problem 3

Alessandro Volta discovered in the 18th century that a potential difference develops between a copper plate and a zinc plate, when they are brought in contact through a conducting solution. A contemporary of Volta wanted to know if a potential difference also develops between iron and zinc plates in a similar setup. For this purpose, he makes a simple galvanic cell based on these two metals.

- a) draw such a galvanic cell, consisting of an iron electrode in 100 mL aqueous 1M $FeCl_2$ solution, and a zinc electrode in 100 mL aqueous 1M $ZnCl_2$ solution. The solutions are connected by a salt bridge, and the electrodes can be connected with a copper wire. Indicate in your drawing what are the cathode and the anode, what half-reactions happen there, and in which direction the current will flow when the anode and cathode are connected.
- b) What is the potential of the simple galvanic cell in problem 3a? Explain your answer using a simple calculation.
- c) When the cathode and anode are connected through a lamp, this lamp will light up because the cell will generate a current. Indicate what happens in the galvanic cell with the concentrations of the Fe^{2+} ions, the Zn^{2+} ions, and the cell potential after the cell has generated a current for some time.
- d) At what concentration of Fe^{2+} and Zn^{2+} will the cell stop providing a current?