Self-assessment test for basic chemistry knowledge

First Part – Analytical Chemistry

1. For the preparation of pretzels, a sodium hydroxide solution (mass share $\omega_{NaOH} = 4.0\%$) with a density $\rho(20\,°C)$ of $1.04\ g/cm^3$ is used. Calculate the concentration of this solution in mol/L ($M(NaOH) = 40\ g/mol$).

2. Determine the pH values of the following solutions approximately.
   a) $0.1\ M\ HNO_3$ b) $0.1\ M\ NaH_2PO_4$ c) $0.1\ M$ acetic acid   d) $0.1\ M\ NH_4OAc$
   (NH_3: $K_B = 1.78 \cdot 10^{-5}\ mol/L$, acetic acid: $K_s = 1.75 \cdot 10^{-5}\ mol/L$)

3. What is the basic measurement principle of a pH electrode?

Second Part – Physical Chemistry

4. Note the second principle of thermodynamics as well as the statistical definition of entropy. What does this last equation mean?

5. Note the equation of Gibb's free enthalpy. The table below shows four conditions regarding changes in enthalpy ΔH and entropy ΔS. Give the conditions for a spontaneous process ($\Delta G < 0$) according to the given criteria.

| Change in enthalpy	Change in entropy	Conditions for spontaneous process
exothermic ($\Delta H < 0$)	decrease ($\Delta S < 0$)	
exothermic ($\Delta H < 0$)	increase ($\Delta S > 0$)	
endothermic ($\Delta H > 0$)	decrease ($\Delta S < 0$)	
endothermic ($\Delta H > 0$)	increase ($\Delta S > 0$)	

6. Organic chemistry often deals with free rotation around sigma-bonds. Quantum mechanical calculations show that the difference in energy between staggered and eclipsed conformation of ethane is around 10 kJ/mol. At which ratio the two conformers of ethane equilibrate at room temperature (25 °C)?

Third Part – Inorganic Chemistry

7. Sketch some realistic valence bond formulas for the following molecules and predict their three-dimensional shape by applying VSEPR theory. Only take electrons of the outer shells into account.
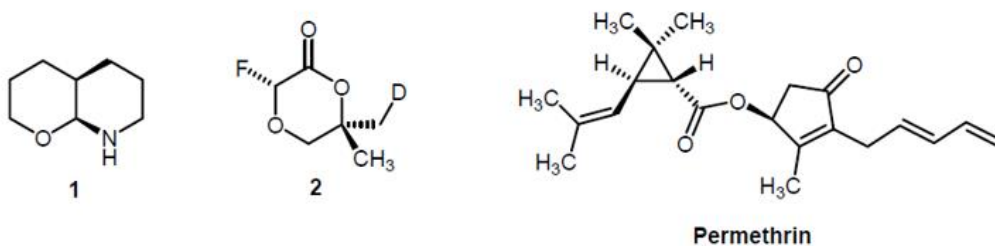
   a) CO_2 b) N_2O c) NO_3^- d) NCCN   e) ClO_2^- f) PCl_3

8. Describe the zinc blende (ZnS) crystal structure. Refer to the lattice type and the bases. How many anions and cations can be found in a unit cell of ZnS?

9. Give the chemical equations for the following transformations. How do the products differ?

   a) $NaCl + H_2SO_4 \rightarrow$ b) $NaI + H_2SO_4 \rightarrow$
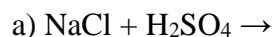
Fourth Part – Organic Chemistry

10. Sketch (R,S)-2,3-dibromobutane and (R,R)-2,3-dibromobutane in their ecliptic and staggered conformation as Sawbuck and Newman projections respectively. Are these molecules chiral?

11. a) Determine the absolute configuration of all stereocenters (R/S) of the molecules given below. Please also give the relative configuration of all double bonds (E/Z) in **Permethrin**, an insecticide. b) Draw the enantiomer of molecule **1** and a diastereomer of molecule **2**.

1   2   Permethrin

12. Complete the following transformations if a reaction seems possible.

NaCN / S_N2

NaOH / S_N2

Br$_2$ / radical starter

NBS / radical starter

H$^+$, H$_2$O / S_N1

NaOH / S_N2

H$_2$, Pd/C