1. Given: $Br_2 + 2H_2O \rightleftharpoons 2HOBr + 2H^+ + 2e \qquad \varepsilon_1^\circ = -1.59$ V

$Br_2 + 6H_2O \rightleftharpoons 2BrO_3^- + 12H^+ + 10e \qquad \varepsilon_2^\circ = -1.52$ V

Calculate ε° for $BrO_3^- + 5H^+ + 4e \rightleftharpoons HOBr + 2H_2O$ at the same temperature. (10%)

2. Using the Boltzmann equation, calculate the ratio of populations of gaseous molecules at 25°C with energy levels separated by 2 kcal/mol. (10%)

3. What is the separation efficiency of 1000 porous barriers in the separation of $^{235}UF_6$ and $^{238}UF_6$ by diffusion? (At. Wt. F = 19) (10%)

4. The rate constant for the $SO_2Cl_2 \rightarrow SO_2 + Cl_2$ reaction at 320°C is 2.20×10^{-5} s⁻¹. If a sample of SO_2Cl_2 is heated for 10 hours at 320°C, what fraction of it will be left? (10%)

5. If spherical molecules of 0.50 nm radius are packed in (a) face-centered cubic and (b) body-centered cubic, what is the length of the side in each unit cell? (10%)

6. Which of the following are linear operators?
(a) d/dx ; (b) Multiply by a constant ; (c) Add a constant; (d) Take the square root ; (e) Leave it as it is. (5%)

7. Give the designations for the ground state energy levels of the first eight elements. (e.g. $^3P_0$ for carbon) (8%).

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8. Determine the point group of the following:
   (a) CH_2Cl_2 (b) SO_3 (c) IF_4^- (d) B_2H_6 (8%)
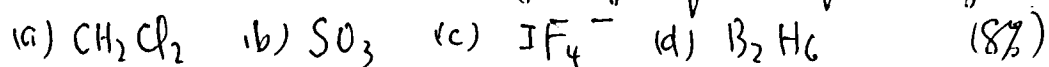
9. Sketch a ESCA nitrogen 1s spectrum of trans-$[Co(en)_2(NO_2)_2]NO_3$. Explain your answer. (en = $NH_2CH_2CH_2NH_2$).   (8%)

10. How would you expect the intensities of the $C\equiv C$ stretching vibration to compare in the infrared and in the Raman spectra of the compounds:
    (a) $HC\equiv CH$ (b) $HC\equiv C-Cl$.
    Explain your answer.   (6%)

11. Calculate the moment of inertia of NO for which the equilibrium bond length is 1.151×10^{-8} cm.
    (At. wt.: N=14.0 ; O=16.0)   (6%)
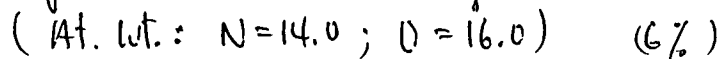
12. The bond distance in ICl is 2.32 Å. Calculate the frequencies of the lowest three rotational transitions in Mcps or in cm^{-1}.
    (At. wt.: I=126.5 ; Cl=35.5) (9%)