1) Electrons are accelerated by a 1000 V potential drop. (a) Calculate the de Broglie wavelength. (b) Calculate the wavelength of the X-rays that could be produced when these electrons strike a solid. (12%)

2) Calculate the degeneracies of the first three levels for a particle in a cubical box. (12%)

3) The molecular diameter of nitrogen is 0.375 nm. What is the mean free path of nitrogen at 1 bar and 25°C? What is the average time between collisions? (12%)

4) The rate constant for the reaction $H^+ + OH^- \longrightarrow H_2O$ is $1.3\times10^{11}\ dm^3\ mol^{-1}\ s^{-1}$. Calculate the half-life for the neutralization process if (a) $[H^+] = [OH^-] = 10^{-1}$ M and (b) $[H^+] = [OH^-] = 10^{-4}$ M. (10%)

5) The combustion of $C_2H_5OH(l)$ in a constant-volume calorimeter produces $1364.34\ kJ\ mol^{-1}$ at 25°C. What is the value of ΔH° for the reaction

$$C_2H_5OH(l) + 3O_2(g) = 2CO_2(g) + 3H_2O(l)$$ (12%)

6) For a solution of ethanol and water at 20°C which has a mole fraction of ethanol of 0.2, the partial molar volume of water is $17.9\ cm^3\ mol^{-1}$ and the partial molar volume of ethanol is $55.0\ cm^3\ mol^{-1}$. What volumes of pure ethanol and water are required to make a liter of this solution? At 20°C the density of ethanol is $0.789\ g\ cm^{-3}$ and the density of water is $0.998\ g\ cm^{-3}$. (14%)

7) At 1273 K and at a total pressure of 30.4 bar the equilibrium in the reaction $CO_2(g) + C(s) = 2CO(g)$ is such that 17 mole% of the gas is CO_2. (a) What percentage would be CO_2 if the total pressure were 20.3 bar? (b) What would be the effect on the equilibrium of adding N_2 to the reaction mixture in a closed vessel until the partial pressure of N_2 is 10 bar? (c) At what pressure of the reactants will 25% of the gas be CO_2? (14%)

8) (a) Write the reaction that occurs when the cell

$$Zn\,|\,ZnCl_2(0.555\ mol\ kg^{-1})\,|\,AgCl\,|\,Ag$$

delivers current and calculate (b) ΔG, (c) ΔS, and (d) ΔH at 25°C for this reaction. At 25°C $E = 1.015$ V and $(\partial E/\partial T)_p = -4.02\times10^{-4}\ VK^{-1}$ (14%)