1. (16%) Explain the following terms: (1) The Third Law of Thermodynamics, (2) Helmholtz energy, (3) Gibbs energy of mixing of an ideal gas mixture, (4) Clapeyron equation for phase transition, (5) isolation method used in chemical kinetics, (6) steady state approximation, (7) eigenvalue, (8) uncertainty principle.

2. (16%) 1.0 mole of Ar (g) expands isothermally and reversibly at a temperature of 300 K from 10.0 L to 20.0 L. Find q, w, ΔU, ΔS, ΔS_{surr}, ΔH, ΔA, ΔG.

3. (18%) 1.0 mole of n-butane (C_4H_{10}) is mixed with an amount of O_2 that is 2.0 times the amount needed to completely oxidize butane to CO_2 and H_2O at room temperature in a fixed-volume container. (1) Calculate the mole fraction of each component in the resulting mixture after oxidation if H_2O is present as a gas. (2) Keeping temperature of the reaction mixture constant, how much will the pressure vary? (3) If the heat released by the oxidation is used to heat up a pot of water of 50 Kg, how high the temperature of the water will be raised? Given the following thermodynamic data:

	n-C_4H_{10}(g)	O_2(g)	CO_2(g)	H_2O(g)	H_2O(l)
ΔH_f^0(kJ mol^{-1})	-125.7	0	-393.5	-241.8	-285.8
C_p^0(J mol^{-1}K^{-1})	97.5	29.4	37.1	33.6	75.3

4. (15%) 2.0 mole of Ar (g) was compressed suddenly (and irreversibly) from 3.0 L to 1.0 L by driving in a piston. During this process, the temperature was increased from 20.0^{o}C to 25°C. Assuming Ar(g) is an ideal gas. Please calculate the entropy change of the gas.

5. (20%) Please write down the integrated rate law and explain how half-life ($t_{1/2}$) of the reaction

   changes with the initial concentration $[A]_0$ for (a) zeroth order reaction (b) first order reaction

   (c) second order reaction.

6. (15%) For a particle in a one-dimensional box (length=L), the wave function is given as:

   $\psi(x) = (\frac{2}{L})^{1/2} \sin(\frac{n\pi x}{L})$, given n is an integral . Please prove that the probability of finding a particle

   in the left half of the box is independent of n and equal to 1/2. Hint:$\int \sin^2 bx \, dx = x/2 - (\sin 2bx)/4b$.