

1. What is the kinetic energy of an electron that has a de Broglie wavelength of 6 nm? 7%
2.
 - (a) Write the molecular electronic configuration of the following homonuclear diatomic molecules. Label molecular orbitals. (i) B_2 (ii) N_2^+ (iii) O_2 (iv) F_2 (v) Ne_2^{2+}
 - (b) What are the bond orders of the five molecules above?
 - (c) Classify these molecules as paramagnetic or diamagnetic. 15%
3. The harmonic frequency of ^{16}OH radical is reported as 3738 cm^{-1} . What is the value of the force constant in units of $N\text{ m}^{-1}$? 8%
4. For each of the following processes, state which of the quantities ΔU , ΔH , ΔS , ΔA , and ΔG are equal to zero for the system specified. (U = internal energy, H = enthalpy, S = entropy, A = Helmholtz free energy, G = Gibbs free energy) 15%
 - (i) A nonideal gas is taken around a Carnot cycle.
 - (ii) An ideal gas is adiabatically expanded against a constant pressure.
 - (iii) An ideal gas is expanded isothermally and reversibly.
5. Consider the isothermal, reversible, and constant-pressure vaporization of 1 mol of water at 100°C and 1 atm, calculate ΔU , ΔH , ΔS , and ΔG for the process. Also calculate the heat absorbed and the work done by the system. (The heat of vaporization for water is $40.6\text{ kJ}\cdot\text{mol}^{-1}$ at 100°C and 1 atm; assume water vapor behaves ideally) 15%
6. Solid anthracene ($C_{14}H_{10}$) is placed in an evacuated vessel at 60°C . The sublimed anthracene vapor escapes through a small hole (1.6 mm in diameter). The weight loss of the solid anthracene is 4.0 mg over a 50-min period. 10%
 - (i) Calculate the number of anthracene molecules passing through the hole in 1 second.
 - (ii) Calculate the vapor pressure of solid anthracene at 60°C .
7. Assuming that the reaction $I + I \rightarrow I_2$ is diffusion-controlled in CCl_4 solution. The diffusion coefficient and radius of I is $2.0 \times 10^{-9}\text{ m}^2\cdot\text{s}^{-1}$ and 0.20 nm, respectively. 10%
 - (i) Estimate the diffusion-controlled rate constant for the formation of I_2 in CCl_4 .
 - (ii) Estimate the average distance diffused by an iodine atom in CCl_4 in 1 hour.
8. English test: In each of the following sentences, there is an error. Please correct the error in English. 20%
 - (a) "In Figure 4, the subdomains oriented perpendicular to the scan direction (more specifically, those with their tilt direction perpendicularly to the scan direction)...."
 - (b) Although this phenomena is complex, it is assessable.
 - (c) Since the instrument broke, I has been much busy.
 - (d) Microscopy--A Comparison among Electron, Optical, and Scanning Probe Approaches
 - (e) The resonance frequency of the system is 10 kHz.
 - (f) That student, whose very lazy, will never graduate.
 - (g) Life is the ultimate example of complexety at work.
 - (h) Although researchers have recognized this intriguing fact for sometimes,
 - (i) Scientists and engineers have long been inspired by the beautiful structures and functional properties of the materials formed within living organics.
 - (j) The controls of crystal morphology is only one of the many puzzling features of biomineralization