考生注意：1. 依次序作答，只要標明題號，不必抄題。
2. 答案必須寫在答案卷上，否則不予計分，並限以藍黑色筆作答。
3. 試題隨卷繳回。(詳請詳閱試場規則)

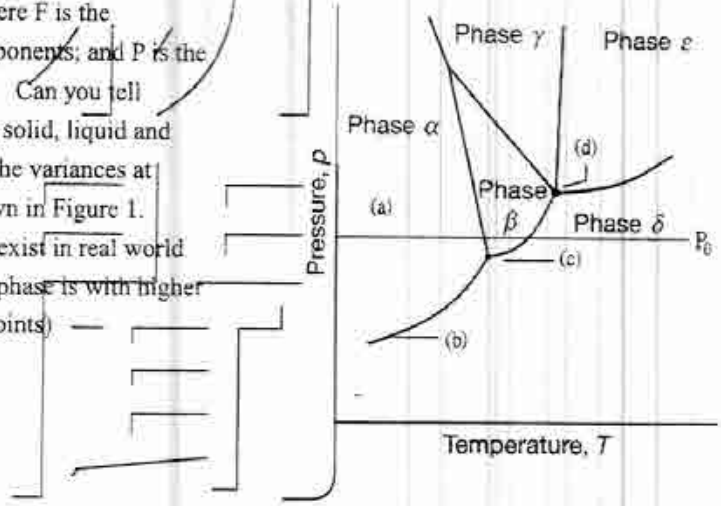
1. Without making any lengthy calculations, gives the values of the following integrals for an electron in a hydrogen atom: (20 points)
(Ψ_{211} means principle quantum number $n = 2$, orbital angular momentum quantum number $l = 1$, magnetic quantum number $m_l = 1$, and μ is the electronic dipole moment)

(a) $\int \Psi_{211}^{*} \Psi_{211} d\tau$　(b) $\int \Psi_{211}^{*} \hat{\mu} \Psi_{211} d\tau$

(c) $\int \Psi_{211}^{*} \hat{\mu} \Psi_{431} d\tau$　(d) $\int \Psi_{210}^{*} \Psi_{211} d\tau$

2. In one component system, the phase diagram must obey the phase rule F=C-P+2, where F is the variance; C is the number of components; and P is the number of phases at equilibrium. Can you tell which phase is (or phases are) the solid, liquid and gas phases? Please write down the variances at points (a), (b), (c) and (d), as shown in Figure 1. Please indicate which one cannot exist in real world and why. At pressure P_0, which phase is with higher density, phase α or β? (20 points)

Figure 1



3. The Lindemeann-Hinshelwood mechanism, as shown in below, can explain the unimolecular reactions successfully even though it failed in some cases. Please derive its rate equation in term of concentration P and C ([P] and [A], respectively) and rate constants k_1, k_2 and k_3. Please indicate in what condition the rate equation becomes first order. When does it become second order? Note the steady- state approximation is applied to the concentration of A^*. (20 points)

$A + A \xrightarrow{k1} A + A^{*}$　(1)

$A + A^{*} \xrightarrow{k2} A + A$　(2)

$A^{*} \xrightarrow{k3} P$　(3)

4. There are a lot of spectroscopic instruments used in Chemistry laboratory. One can judge from the energy scale to know the underlying microscopic motion of molecule, which an instrument operates on. Please find the suitable instruments and their corresponding microscopic motion of molecule for the following operating energy range (in terms of frequencies): (a) ultraviolet, (b) visible light, (c) infrared, (d) microwave, and (e) radio wave. For example x-ray is for inner electron transition motion and x-ray emission spectroscopy. (20 points)

5. A particle is in a state described by the wavefunction $\varphi(x) = (\cos\theta)\, e^{ikx} + (\sin\theta)\, e^{-ikx}$ where θ is a parameter. What is the probability that the particle will be found with a linear momentum (a) $\hbar k$, (b) $-\hbar k$, (c) What form would the wavefunction have if it were 50 percent certain that the particle had the linear momentum $\hbar k$. (20 points)