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。(餘請詳閱試場規則)

1. (25 pts) Write down the answers inside the parenthesis, which are correct. Note that sometimes there are more than one right answer.

a. (5 pts) A reversible process is one that proceeds by a succession of very small incremental steps, all of which are at **(equilibrium, spontaneous, enthalpically driven, entropically driven).**

b. (5 pts) **(ΔH, ΔS, ΔG, ΔE)** implies constant pressure.

c. (5 pts) For a process that can be carried out by either a reversible or an irreversible path, the change in **(P, T, V, q, E, H, w)** must be the same for both paths.

d. (5 pts) When a sample of liquid is converted reversibly to its vapor at its normal boiling point, **(q, w, ΔP, ΔV, ΔT, ΔE, ΔH, ΔS, ΔG)** is equal to zero for the system.

e. (5 pts) An ideal gas expands adiabatically into a vacuum. ΔE for the system is **(greater than zero, equal to zero, less than zero)**.

2. (15 pts) Consider a two-dimensional square box of length L, containing six non-interacting electrons with each mass as M. Given that the energy levels for electrons in 2-D box are

$$E_{nm}=(h^2/8ML^2)\,(n^2+m^2).$$

a. (5 pts) Calculate the energy of the ground state of this system, i.e. these six electrons, in terms of L and M.

b. (5 pts) Calculate the energy of the transition from the ground state to the first excited state in terms of L and M.

c. (5 pts) Calculate the wavelength of the transition in terms of c (speed of light), L and M.

3. (25 pts) For each of the following energies or wavelengths, which the type of molecular transition that most probably corresponds to this value, e.g., rotational, vibrational or electronic transition.

a. 3 cm b. 10μm c. 6.4×10^{-19} J d. 0.25 eV e. 6.626×10^{-23} J

4. (20 pts) Consider the simple Michaelis-Menten mechanism for an enzyme-catalyzed reaction:

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P$$

Assume k_1 and k_{-1} are very fast. The equilibrium constant of first reaction K_m and reaction rate constant of k_2 can be measured in different temperatures. Assume at temperature T_p, k_2 is k_p and K_m is K_p; and at temperature T_q, k_2 is k_q and K_m is K_q.

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。(餘請詳閱試場規則)

a. (10 pts) Express the activation energy E_a for k_2 in terms of T_p, k_p, K_p, T_q, k_q, and K_q.

b. (10 pts) Express the standard thermodynamic enthalpy (ΔH°) for formation of ES from E and S?

5. (15 pts) Answer the questions below using the following terms.
Fluorescence, internal conversion, intersystem crossing, phosphorescence, (excited state) vibrational relaxation.

a. (5 pts) What molecular photophysical process(es) involves a change in spin multiplicity?

b. (5 pts) List the non-radiative process(es).

c. (5 pts) List the five photophysical processes in terms of relative rate, from slowest (top) to fastest (bottom).