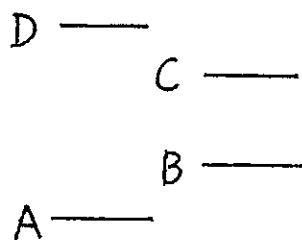


※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

$$R = 8.3 \text{ JK}^{-1}\text{mol}^{-1} = 0.082 \text{ L atm K}^{-1}\text{mol}^{-1} \quad \ln 2 = 0.69 \quad \ln 3 = 1.10 \quad e = 2.72$$

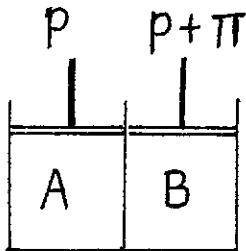
- 1.0 mole of a perfect gas at 300 K is expanded isothermally and reversibly from 2.0 atm to 1.0 atm. Determine the values of (a) q (b) w (c) ΔU (d) ΔH (e) ΔS (f) ΔS_{univ} . (g) How do you conduct the isothermal and reversible expansion for the gas in a cylinder with piston. (21 分)
- (a) Write down the quantized energy for a particle of mass m confined in an one-dimensional box of length a . (b) The energy gap between the HOMO and LUMO of 1,6-diphenyl-1,3,5-hexatriene ($\text{C}_6\text{H}_5\text{-CH=CH-CH=CH-CH=CH-C}_6\text{H}_5$) is $h\nu$. The six π electrons are confined in the one-dimensional space of length a between the two phenyl groups. Drive the equation, $a = (7h/8m\nu)^{1/2}$, where m is the mass of an electron. (10 分)
- Draw two graphs of V vs. T and of H vs. T that show the characteristic first-order phase transition and explain them. (10 分)
- Consider a system of distinguishable particles having only two nondegenerate energy levels separated by an energy of kT at 30 K. (a) Calculate the ratio of population in the two states (n_1/n_2). (b) Write down the molecular partition function at 30 K. (c) Write the relation between molar internal energy and molecular partition function. (9 分)
- Describe the basic principle that a four-level laser operates. (6 分)



- In an experiment of X-ray photoelectron emission, a 4f electron of a gold atom is ejected into vacuum by X-ray. (a) Write down all the term symbols for the f^{13} system. (b) Write down the number of microstates for each term. (c) State the Hund's rule to show the lowest energy term. (12 分)

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7.



A: pure water

B: 0.1M sucrose solution

(a) Sucrose is a disaccharide formed from glucose and fructose. Calculate the osmotic pressure (Π atm) for the system, using the van't Hoff equation at 300 K. (b) Explain the origin of the osmotic pressure. (c) Derive the van't Hoff equation.

(14 分)

8. (a) Use arrows (\rightarrow) to show the atom motions for the three normal modes (bending, symmetric stretching, and antisymmetric stretching) of H_2O . (b) The first overtone for the bending mode is 3200 cm^{-1} . Calculate the bending frequency (s^{-1}), assuming a harmonic motion. (c) Write down the relation between the vibrational frequency and force constant of a harmonic oscillator. (d) Given a fundamental frequency of 3000 cm^{-1} for a C-H stretching vibration, calculate the frequency of C-D for the same mode. (e) Describe the origin for the isotope effect of cleaving C-H and C-D bonds.

(18 分)