國立臺灣科技大學
115學年度碩士班招生

試題

系所組別：0410材料科學與工程系碩士班甲組

科　　目：物理化學

<<504101>>

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（總分為100分；所有試題務必於答案卷內頁依序作答）

物理化學研究所考題

1. (40 points) multiple choice question:

(1) (4 points) For which order reaction is the half life of the reaction independent of the initial concentration of the reaction(s)?

(A) zero order　　(B) first order　　(C) second order　　(D) all of the above　(E) none of above

(2) (4 points) A system which undergoes an adiabatic change and does work on the surroundings has the following conditions.

(A) $w < 0, \Delta E = 0$　(B) $w > 0, \Delta E > 0$　(C) $w > 0, \Delta E < 0$　(D) $w < 0, \Delta E > 0$　(E) $w < 0, \Delta E < 0$

(3) (4 points) For the vaporization process benzene(l) $\rightarrow$ benzene(g) at 1 atm, $\Delta H_{vap} = 30.5$ kJ mol^{-1} and $\Delta S_{vap} = 86.4$ J $mol^{-1} K^{-1}$. Assuming these values are independent of T, what is the normal boiling point of benzene?

(A) $-80\ ^{\circ}C$　　(B) $0\ ^{\circ}C$　　(C) $80\ ^{\circ}C$　　(D) $353^{\circ}\ C$　　(E) none of these

(4) (4 points) How does the observed pressure of a gas relate to the ideal pressure?

(A) The observed pressure is less than the ideal pressure.

(B) The observed pressure is greater than the ideal pressure.

(C) They are equal.

(D) The relationship depends on the gas.

(E) none of these

(5) (4 points) Which of the following vibrational mode(s) of H_2O is (are) Raman active?

(v_1: symmetric stretch 3652 cm^{-1}; v_2: bending 1595 cm^{-1}; v_3: antisymmetric stretch 3756 cm^{-1})

(A) v_1 only　　(B) v_2 only　　(C) v_3 only　　(D) v_1 and v_2　　(E) v_1, v_2, and v_3

(6) (4 points) What is the root mean square (rms) speed of oxygen molecules at STP? (R = 8.314 J $mol^{-1}K^{-1}$)

(A) 460 m s^{-1}　　(B) 320 m s^{-1}　　(C) 230 m s^{-1}　　(D) 150 m s^{-1}　　(E) 78 m s^{-1}

(7) (4 points) Which of the following statements best describes the tunnel effect (quantum tunneling)?

(A) A particle can pass through a potential energy barrier only if its kinetic energy is greater than the barrier height.

(B) A particle has a finite probability of passing through a potential barrier even when its energy is lower than the barrier height.

(C) Quantum tunnelling occurs only at high temperatures where thermal energy is sufficient.

(D) Quantum tunnelling is a purely classical phenomenon caused by molecular collisions.

(E) Tunnelling can occur only for macroscopic objects with large masses.

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(8) (4 points) Which of the following statements best describes the Doppler effect?

(A) The change in wavelength of radiation caused by the absorption of photons by molecules.

(B) The splitting of spectral lines due to the presence of an external electric field.

(C) The broadening or shift of spectral lines resulting from the relative motion between the radiation source and the observer.

(D) The quantum mechanical penetration of particles through a potential energy barrier.

(E) The shift in spectral lines caused by intermolecular collisions at high pressure.

(9) (4 points) How many moles of photons are produced by a laser with an intensity of 0.10 W at a wavelength of 560 nm in one hour? ($h = 6.626 \times 10^{-34}$ J s; $c = 2.998 \times 10^8$ m s^{-1}; $N_A = 6.022 \times 10^{23}$ mol^{-1}

(A) 1.7×10^{-3} mol (B) 3.0×10^{-4} mol (C) 6.5×10^{-4} mol (D) 1.7×10^{-4} mol (E) 1.0×10^{-2} mol

(10) (4 points) The mobility of a chloride ion in aqueous solution at 25 °C is $u = 7.91 \times 10^{-8}$ m^2 V^{-1} s^{-1}. What is the molar ionic conductivity of Cl$^-$? ($F = 96485$ C mol^{-1})

(A) 7.63×10^{-3}　(B) 5.48×10^{-3}　(C) 3.62×10^{-3}　(D) 1.64×10^{-3}　(E) 0.65×10^{-3}　S m^2 mol^{-1}

2. (10 points) For each of the following processes, state which of the quantities ΔU, ΔH, ΔS, ΔA, and ΔG are equal to zero:

(1) (2 points) Isothermal reversible expansion of an ideal gas.

(2) (2 points) Adiabatic reversible expansion of a nonideal gas.

(3) (2 points) Isothermal expansion of a nonideal gas against vacuum.

(4) (2 points) Reaction between H_2 and O_2 in a thermally insulated bomb.

(5) (2 points) Reaction between H_2SO_4 and NaOH in dilute aqueous solution at constant temperature and pressure.

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3. (30 points) One mole of an ideal monatomic gas undergoes a reversible adiabatic expansion from an initial state (T_1 = 400 K, P_1 = 10.0 atm) to a final pressure P_2 = 1.00 atm. Please calculate the work done by the gas. You may use the following information: $\gamma = \frac{C_p}{C_v} = \frac{5}{3}$, $C_v = \frac{3}{2}R$, $R = 8.314$ J mol^{-1} K^{-1}

4. (20 points) A chemical reaction at constant temperature and pressure has a negative standard Gibbs free energy change, $\Delta G° < 0$.

   (1) (8 points) Which of the following statements is correct? Please select one correct answer.

   (a) The reaction must proceed rapidly.

   (b) The equilibrium constant is greater than 1.

   (c) The activation energy of the reaction is zero.

   (d) The reaction cannot be reversed once it starts.

   (2) (12 points) Explain briefly why a reaction with $\Delta G° < 0$ may still proceed very slowly at room temperature.