說明：1. 答案一律寫在試卷上，第IV大題之計算題必須寫出計算過程，否則不予計分。
2. 請依序作答，並標明題號。
3. $R = 8.314 \ J·K^{-1}·mol^{-1}$, F=96485 $C·mol^{-1}$, m_e=9.11x10^{-31} kg, c=2.998x10^8 $m·s^{-1}$, h=6.626x10^{-34} J·s

I. Multiple choice: (24%, 3% each)

1. Predict the sign of ΔH and ΔS for the reaction: $H_2 \rightarrow 2H$
   (A) $\Delta H > 0$ and $\Delta S > 0$ (B) $\Delta H > 0$ and $\Delta S < 0$ (C) $\Delta H < 0$ and $\Delta S > 0$
   (D) $\Delta H < 0$ and $\Delta S < 0$ (E) none of the above

2. Which of the following quantum numbers is used to describe the shape of an orbital in space?
   (A) n (B) l (C) m_l (D) m_s (E) none of the above

3. Which graph is **not** a straight line for an ideal gas?
   (A) V versus T (n and P constant)   (B) T versus P (n and V constant)   (C) P versus 1/V
   (n and T constant)   (D) n versus 1/T (P and V constant)   (E) n versus 1/P (V and T constant)

4. Which one has the largest melting point?
   (A) H_2O (B) H_2S (C) H_2Se (D) H_2Te (E) H_2

5. The central atom in all of the following compounds has the same hybridization, **except**
   (A) NO_2^- (B) CO_3^{-2} (C) BF_3 (D) NH_3 (E) SO_2

6. Which of the following can be oxidized to form an aldehyde?
   (A) CH_3CH_2OH (B) $CH_3CHOHCH_3$ (C) CH_3OCH_3 (D) $(CH_3)_2C=O$
   (E) none of the above

7. Which of the following is not an example of a d^0 transition-metal complex?
   (A) TiO_2 (B) VO_2^+ (C) $Cr_2O_7^{-2}$ (D) MnO_4^- (E) none of the above

8. For the reaction $A + 2B \rightarrow 2C$, the rate law for formation of C is
   (k: the rate constant for the reaction)
   (A) rate = $k[A][B]^2$ (B) rate = $k[A][B]$ (C) rate = $k[C]^2/[A][B]^2$
   (D) rate = $k[A]^2[B]$ (E) impossible to state from the data given

II. Fill in the following blanks. (16%, 4% each)

1. For material X, the enthalpy of vaporization is 31.4 kJ/mol and the entropy of vaporization
   is 93.8 J/mol·K.   Above what temperature the vaporization of X will be spontaneous?
   Ans: $T \geq$ ___(1)___ K

2. Arrange the following species by the order of increasing pH.
   (A) human blood (B) lemon juice (C) acid rain (D) household ammonia
   Ans: ___(2)___

3. What is the formal charge of the central oxygen in ozone, O_3?
   Ans: ___(3)___

4. Write the electron configuration of the Cu^+ ion.
   Ans: ___(4)___

III. Explain the following terms. (20%, 4% each)

1. Arrhenius equation

2. colligative property

3. ferromagnetic property

4. greenhouse effect

5. Heisenberg uncertainty principle

IV. Answer the following questions. (40%; 1~4, 6% each; 5~6, 8% each)

1. Draw the Lewis structure and predict the geometric shape for the following species.
   (A) IF_3, (B) IF_4^+, and (C) IF_4^-

2. Give the expression which can be used to calculate the lattice enthalpy of NaCl from the information given below (all in kJ/mol).
   (1) heat of formation of NaCl, $\Delta H_f = A$　　(2) enthalpy of sublimation of Na(s), $\Delta H_{sub} = B$
   (3) bond enthalpy of $Cl_2 = C$　　　　　　　　(4) electron affinity of chlorine $= D$
   (5) ionization energy of sodium $= E$

3. The percentage deprotonation of benzoic acid in a 0.110 M solution at 25℃ is 2.4%. What is the pH of the solution and the K_a of benzoic acid?

4. Calculate the equilibrium constant at 25℃ of the reaction: AgCl(s) → Ag^+(aq) + Cl^-(aq).
   AgCl(s) + e^- → Ag(s) + Cl^-(aq) $E° = +0.22$ V and
   Ag^+(aq) + e^- → Ag(s) $E° = +0.80$ V

5. (A) What is the wavelength of the radio station, ICRT, transmitting at 100.7 MHz?
   (B) Calculate the wavelength of an electron moving at 1/100 (or 1%) the speed of light.

6. For the spontaneous reaction: NO_3^-(aq) + Hg(l) → Hg_2^{2+}(aq) + NO(g) in acidic solution under standard condition, (a) write the balanced equation, (b) write the cell diagram, (c) determine the standard cell emf (electromotive force), and (d) calculate $\Delta G°$.
   Reduction half-reaction $E°(NO_3^-, H^+/NO, H_2O) = +0.96$ V, $E°(Hg_2^{2+}/Hg) = +0.79$ V