說明：1. 答案一律寫在答案卷作答區上，否則不予計分；並依題序且標明題號作答。
2. 選擇題為單選，答錯不倒扣；計算題必須寫出計算過程，否則不給分。
3. c=2.998x10^{8} m/s, h=6.626x10^{-34} J s, N_A=6.022x10^{23}, R=8.314 J/mol K, O: 16

(一) 選擇題，每題 5 分，共 30 分

(1) 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) Which of the following statements is false when considering the molecular orbital description of the NO^- anion?
(A) NO^- is paramagnetic. (B) NO^- is isoelectronic with CO.
(C) The bond order in NO^- is 2. (D) The bond energy in NO^+ is greater than that in NO^-.
(E) Statements A through D are false.

(3) 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 id greater than the ideal pressure.
(C) They are equal. (D) The relationship depends on the gas. (E) none of these

(4) 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) $w < 0, \Delta E < 0$

(5) An electron in a one-dimensional box requires energy with wavelength 8080 nm to excite it from the n=2 to the n=3 energy level. What is the length of the box?
(A) 1.00 nm (B) 1.50 nm (C) 2.50 nm (D) 3.00 nm (E) 3.50 nm

(6) For the vaporization process benzene(ℓ) → benzene(g) at 1 atm, ΔH°_{vap} = 30.5 kJ/mol and ΔS°_{vap} = 86.4 J/mol K. Assuming these values are independent of T, What is the normal boiling point of benzene?
(A) −80°C (B) 0°C (C) 80°C (D) 353°C (E) none of these

(二) 簡答題，每題 5 分，共 20 分

(1) Which of the vibrational mode(s) of H_2O is(are) Raman active? (ν_1: symmetric stretch 3652 cm^{-1}, ν_2: bending 1595 cm^{-1}, or ν_3: antisymmetric stretch 3756 cm^{-1})

(2) What is the *rms*(root mean square) speed of oxygen molecules at STP?

(背面仍有題目,請繼續作答)

(3) What is the de Broglie wavelength of an oxygen molecule at room temperature?

(4) How many moles of photons does a laser with an intensity of 0.10 watt at 560 nm produce in one hour?

(三) 解釋名詞，每題 5 分，共 20 分

(1) Compton effect

(2) Doppler effect

(3) Stark effect

(4) tunnel effect (tunnelling)

(四) 計算題，每題 10 分，共 30 分

(1) An ideal monatomic gas is heated from 300 K to 1000 K and the pressure is allowed to rise from 1 bar to 2 bar. Calculate the change in molar entropy.

(2) The equilibrium internuclear distance R_e of gas $^{23}Na^{35}Cl$ molecule is 236 pm. Calculate (A) the moment of inertia in $kg \cdot m^2$ and (B) the rotational energy of J=1 in joule.

(3) For CaF_2, $K_{sp} = 3.9 \times 10^{-11}$ at 25°C and the standard Gibbs energy of formation of $CaF_2(s)$ is -1167 kJ/mol. Calculate the standard Gibbs energy of formation of $CaF_2(aq)$.