說明：1. 答案一律寫在答案卷上，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. $R = 8.314\ J\ K^{-1}mol^{-1} = 8.206 \times 10^{-2}\ atm\ L\ K^{-1}mol^{-1}$

1. Explain the following terms. (20%)
(a) Boyle's law (b) standard enthalpy of formation (c) Pauli exclusion principle
(d) VSEPR model (e) high-temperature superconductors (or *perovskites*)

2. Sodium azide (NaN_3) in the air bags of cars can explosively decompose and form sodium metal and nitrogen gas within about 40 ms after the crash. (a) Please write down the chemical equation for the above statement. (b) If one air bag contains 130g of sodium azide, calculate the maximum volume of nitrogen gas can be generated after the car crash at standard conditions (25℃ and 1 atm). (Na=23, N=14) (8%)

3. Nitrogen gas and oxygen gas combine at 25℃ in a closed container to form nitric oxide as follows: $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ ΔH=+1.81 kJ $K_p=3.3\times10^{-30}$ What would the effect on the direction of equilibrium if the following changes are made to the system? (a) N_2 is added. (b) He is added. (c) The container is made larger. (d) The system is cooled. (8%)

4. Balance the following equations. (8%)
(a) $Cr_2O_7^{2-}(aq) + C_2H_5OH(l) \rightarrow Cr^{3+}(aq) + CO_2(g)$ (*in acidic solution*)
(b) $H_2O_2(aq) + MnO_4^-(aq) \rightarrow O_2(g) + Mn^{2+}(aq)$ (*in acidic solution*)

5. The complex ion $[Co(en)_3]^{3+}$ is diamagnetic. (a) Would you expect the $[Co(en)_3]^{2+}$ ion to be diamagnetic or paramagnetic? (b) The $[Co(CN)_6]^{3-}$ ion? Explain your reasoning by figure in each case. (8%)

6. A certain reaction with first-order has a half-life of 6.00 hours. (8%)
(a) Calculate the rate constant for this reaction.
(b) How much time is required for this reaction to be 90% complete?

7. Draw Lewis structures for the following species, predict their shapes, and describe the bonding (in terms of hybrid orbitals) of N atom for (a) $ClNO_2$, (b) NO_2^+, and (c) ONF molecules that N is the central atom. (9%)

8. Use molecular orbital (MO) theory to describe the electron configuration of bonding, magnetism, and relative bond energies of the (a) O_2, (b) O_2^-, and (c) O_2^{2-} species. (9%)

9. (a) In venous blood the following equilibrium is set up by dissolved carbon dioxide:
$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$ $K_{a1}=4.3\times10^{-7}$
If the pH of the blood is 7.4, what is the ratio of $[HCO_3^-]$ to $[H_2CO_3]$? (5%)
(b) How many grams of NH_4Cl must be added to 1.00 L of a 1.00 M NH_4OH solution to prepare a buffer solution with a pH of 9.00? (Cl=35.5; NH_4OH $K_b=1.8\times10^{-5}$) (5%)

10. Draw all reasonable resonance structures, select the most stable one for $(SCN)^-$ ion which carbon is the central atom, and explain your answer. (12%)