說明：一、請一律以「答案卷」作答，作答時不得使用鉛筆，違者該科答案卷不予計分；限用黑色或藍色墨水的筆書寫。
二、考生應在答案卷上規定範圍內作答，且不得書寫任何與答案無關之文字、符號，違者該科不予計分。
三、答案卷以每人一張為限，不得要求增補；試題與答案卷必須繳回，不得攜出試場。

***可使用工程型計算機**

第一部分 單選題 (60%, 4% each)

1. A 0.4987 g sample of a compound known to contain only carbon, hydrogen, and oxygen was burned in oxygen to yield 0.9267 g of CO_2 and 0.1897 g of H_2O. What is the empirical formula of the compound?
(A.) CHO; (B.) C_2H_2O; (C.) $C_3H_3O_2$; (D.) $C_6H_3O_2$; (E.) $C_3H_6O_2$

2. A 0.307 g sample of an unknown triprotic acid is titrated to the third equivalence point using 35.2 mL of 0.106 M NaOH. Calculate the molar mass of the acid. (Na: 22.99 g/mol)
(A.) 247 g/mol; (B.) 171 g/mol; (C.) 165 g/mol; (D.) 151 g/mol; (E.) 82.7 g/mol

3. The partial pressures of CH_4, N_2, and O_2 in a sample of gas were found to be 135 mm-Hg, 508 mm-Hg, and 571 mm-Hg, respectively. Calculate the mole fraction of nitrogen.
(A.) 20.4; (B.) 0.470; (C.) 0.418; (D.) 0.751; (E.) 0.359

4. A 32.5 g piece of aluminum (which has a molar heat capacity of 24.03 J/°C·mol) is heated to 82.4°C and dropped into a calorimeter containing water (specific heat capacity of water is 4.18 J/g°C) initially at 22.3°C. The final temperature of the water is 24.2°C. Ignoring significant figures, calculate the mass of water in the calorimeter. (Al: 26.98 g/mol)
(A.) 212 g; (B.) 5.72 kg; (C.) 6.42 g; (D) 1.68 kg; (E.) none of these

5. Which of the following statements is (are) true?
I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
III. The energy of electromagnetic radiation increases as its frequency increases.
IV. An electron in the n = 4 state in the hydrogen atom can go to the n = 2 state by emitting electromagnetic radiation at the appropriate frequency.
V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
(A.) II, III, IV; (B.) III, V; (C.) I, II, III; (D.) III, IV, V; (E.) I, II, IV

6. Consider the following reaction:
$A_2 + B_2 \rightarrow 2AB \quad \Delta H = -365$ kJ
The bond energy for A_2 is half the amount of AB. The bond energy of B_2 = 447 kJ/mol. What is the bond energy of A_2?
(A.) 812 kJ/mol; (B.) 630 kJ/mol; (C.) 271 kJ/mol; (D) –183 kJ/mol; (E) none of these

7. Consider the molecular orbital energy level diagrams for O_2 and NO. Which of the following is true?
I. Both molecules are paramagnetic.
II. The bond strength of O_2 is greater than the bond strength of NO.
III. NO is an example of a homonuclear diatomic molecule.
IV. The ionization energy of NO is smaller than the ionization energy of NO^+.
(A.) I only; (B.) I and II; (C.) I and IV; (D.) II and III; (E) I, II, and IV

8 If equal, rigid spheres are arranged in a simple cubic lattice in the usual way (i.e., in such a way that they touch each other), what fraction of the corresponding solid will be empty space?
(A.) 0.52; (B.) 0.32; (C.) 0.68; (D.) 0.48; (E.) none of these

9 At a given temperature, you have a mixture of benzene (vapor pressure of pure benzene = 745 torr) and toluene (vapor pressure of pure toluene = 290 torr). The mole fraction of benzene in the vapor above the solution is 0.590. Assuming ideal behavior, calculate the mole fraction of toluene in the solution.
(A.) 0.213; (B.) 0.778; (C.) 0.641; (D.) 0.359; (E.) 0.590

10. A 1 L container originally holds 0.4 mol of N_2, 0.1 mol of O_2, and 0.08 mole of NO. If the volume of the container holding the equilibrium mixture of N_2, O_2, and NO is decreased to 0.5 L without changing the quantities of the gases present, how will their concentrations change?
(A.) The concentration of NO will increase; the concentrations of N_2 and O_2 will decrease.
(B.) The concentrations of N_2 and O_2 will increase; and the concentration of NO will decrease.
(C.) The concentrations of N_2, O_2, and NO will increase.
(D.) The concentrations of N_2, O_2, and NO will decrease.
(E.) There will be no change in the concentrations of N_2, O_2, and NO.

11. In titrating 0.20 M hydrochloric acid, HCl, with 0.20 M NaOH at 25°C, the solution at the equivalence point is (Cl: 35.45 g/mol):
(A.) 0.20 M NaCl; (B.) very acidic; (C.) slightly acidic; (D.) 0.10 M HCl and 0.20 M NaOH;
(E.) 0.10 M NaCl

12. Consider a solution containing the following cations: Na^+, Hg^{2+}, Mn^{2+}, Al^{3+} and Ag^+. Treatment of the solution with dilute HCl followed by saturation with H_2S results in formation of precipitate(s). Which ions still remain in solution ?
(A.) Ag^+ only; (B.) Na^+, Hg^{2+}, Al^{3+}; (C.) Ag^+ and Hg^{2+}; (D.) Na^+, Al^{3+}, and Mn^{2+}; (E.) Na^+ only

13. A mixture of hydrogen and chlorine remains unreacted until it is exposed to ultraviolet light from a burning magnesium strip. Then the following reaction occurs very rapidly:

$$H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)} \quad \Delta G = -45.54 \text{ kJ}; \quad \Delta H = -44.12 \text{ kJ}; \quad \Delta S = -4.76 \text{ J/K}$$

Which of the following is consistent with this information?
(A.) The reactants are thermodynamically more stable than the products.
(B.) The reaction has a small equilibrium constant.
(C.) The ultraviolet light raises the temperature of the system and makes the reaction more favorable.
(D.) The negative value for ΔS slows down the reaction.
(E.) The reaction is spontaneous, but the reactants are kinetically stable.

14. The smallest amount of radioactive material that will support a self-sustained fission reaction is called the
(A.) molar mass; (B.) moderator; (C.) supercritical mass; (D.) subcritical mass; (E.) critical mass

15. Give the number of geometrical isomers for the octahedral compound $[MA_2B_2C_2]$, where A, B, and C represent ligands.
(A.) 1; (B.) 2; (C.) 3; (D.) 5; (E.) none of these

第二部分 非選擇題 (40%,)

1. Consider the following hypothetical data collected in two studies of the reaction.

2A + 2B → C + 2D

In experiment 1, $[B]_0$ = 10.0 M
In experiment 2, $[B]_0$ = 20.0 M
Rate = $-\Delta[A]/\Delta t$
Solve the value of the rate constant (*k*) for the reaction. Include units. **(10%)**

Time (s)	Experiment 1 [A] (mol/L)	Experiment 2 [A] (mol/L)
0	1.0×10^{-2}	1.0×10^{-2}
10	8.4×10^{-3}	5.0×10^{-3}
20	7.1×10^{-3}	2.5×10^{-3}
30	6.0×10^{-3}	1.3×10^{-3}
40	5.0×10^{-3}	6.3×10^{-4}

2. Calculate the equilibrium concentration of HPO_4^{2-} and PO_4^{3-} in a 1.00 M solution of H_3PO_4 where the K_{a1}, K_{a2} and K_{a3} for H_3PO_4 are 7.5×10^{-3}, 6.2×10^{-8}, and 4.8×10^{-13}, respectively. Besides, what's the pH of this solution? **(10%)**

3. You have a concentration cell with Cu electrodes and $[Cu^{2+}]$= 1.00 M (right side) and $[Cu^{2+}]= 1.0 \times 10^{-4}$ M (left side). Calculate the potential for this cell at 25°C. ($Cu^{2+} + 2e^- \rightarrow Cu$; ε^o= 0.34 V; **6%**)

4. Carbon tetrachloride, CCl_4, has a vapor pressure of 213 torr at 40°C and 836 torr at 80°C. What's the normal boiling point of CCl_4 (in K)? **(8%;** R: 8.314 $J \cdot K^{-1}mol^{-1}$ = 0.082 $L \cdot atm \cdot K^{-1}mol^{-1}$**)**

5. Consider the following reaction at 25°C:

$2NO_{2(g)} \leftrightarrow N_2O_{4(g)}$

The value of ΔH^o and ΔS^o are -58 kJ/mole and -176.6 J/K·mol, respectively. Calculate the value of K at 100°C assuming ΔH^o and ΔS^o do not depend on the temperature. **(6%;** R: 8.314 $J \cdot K^{-1}mol^{-1}$ = 0.082 $L \cdot atm \cdot K^{-1}mol^{-1}$**)**