※ 注意：請於試卷上「選擇題作答區」依序作答。

I. 單選題 (每題 2 分，答錯不倒扣)。 40%

1. Which of the following transitions for a hydrogen atom occurs at the longest wavelength?

   (a) $n = 2 \rightarrow n = 1$ (b) $n = 3 \rightarrow n = 2$ (c) $n = 4 \rightarrow n = 2$ (d) $n = 5 \rightarrow n = 4$ (e) $n = 5 \rightarrow n = 3$

2. Pure rotational transitions of a molecule occur in what region of electromagnetic radiation?

   (a) microwave (b) X-ray (c) infrared (d) ultraviolet (e) γ-ray

3. Which of the following would NOT change by heating an ideal gas at a constant volume?

   (a) density (b) kinetic energy (c) V/T (d) PV (e) P/T

4. Which of the following pairs illustrate the Law of Multiple Proportions?

   (a) O_2, O_3 (b) H_2O, D_2O (c) CO_2, SiO_2 (d) IF_3, ICl_3 (e) H_2O, H_2O_2

5. Which one of the following relations is true for the reaction $H_2(g) \rightarrow 2\ H(g)$.

   (a) $\Delta H = 0$, $\Delta S > 0$ (b) $\Delta H > 0$, $\Delta S < 0$ (c) $\Delta H > 0$, $\Delta S > 0$ (d) $\Delta H < 0$, $\Delta S > 0$ (e) $\Delta H > 0$, $\Delta S = 0$

6. Which one of the following compounds is NOT soluble in a strong basic solution?

   (a) BeO (b) ZnO (c) Al_2O_3 (d) Fe_2O_3 (e) Cr_2O_3

7. Which one of the following compounds is most soluble in water?

   (a) $PbCl_2$ (b) $Pb(ClO_4)_2$ (c) $Pb(OH)_2$ (d) $PbSO_4$ (e) PbS

8. Which one of the following atoms has the lowest second ionization energy?

   (a) Na (b) Mg (c) Al (d) K (e) Ba

9. Which one of the following species has a square planar structure?

   (a) IF_4^- (b) ClO_4^- (c) SO_4^{2-} (d) NH_4^+ (e) PO_4^{3-}

10. What is the density (in $g \cdot L^{-1}$) of a 1:3 (mole ratio) mixture of CH_4 and O_2 at STP?

    (a) 0.71 (b) 0.89 (c) 1.02 (d) 1.25 (e) 2.50

11. Which one of the following compounds would have the largest melting point?

    (a) H_2O (b) NaCl (c) MgO (d) $MgCl_2$ (e) CCl_4

12. What is the number of unpaired electrons in a low-spin $[CoBr_6]^{3-}$? (Z = 27 for Co)

    (a) 0 (b) 2 (c) 4 (d) 5 (e) 6

13. If $[A]_0 = 0.1$ M and $k = 10^{-2}\ M^{-1} \cdot s^{-1}$ for the elementary reaction $A + A \xrightarrow{k} B$, what is the half-life (in s) of the reaction?

    (a) 10 (b) 69 (c) 100 (d) 693 (e) 1000

14. Which one of the following transition elements has a positive $E°$ for $M^{2+}_{(aq)} + 2e \rightarrow M_{(s)}$?

    (a) Mn (b) Co (c) Ni (d) Cu (e) Zn

15. Which one of the following atoms is diamagnetic?

    (a) Li (b) Be (c) B (d) C (e) N

16. Which element has the most metallic character?

    (a) B (b) Ba (c) Be (d) Al (e) Si

17. Which one of the following quantities is largest for 1 mol of a given substance?

    (a) enthalpy of fusion (b) enthalpy of vaporization (c) enthalpy of sublimation (d) heat capacity of solid (e) heat capacity of liquid

18. Which one of the following molecules would be polar?

(a) CO_2 (b) BCl_3 (c) SF_4 (d) PCl_5 (e) SF_6

19. Which of the following is the most significant factor in acid rain?

(a) CO_2 (b) SO_3 (c) O_3 (d) CO (e) NO

20. Which one of the following ions would be colorless?

(a) Sc^{3+} (b) Cr^{3+} (c) Mn^{2+} (d) Co^{2+} (e) Ni^{2+}

※ 注意：請於試卷上「非選擇題作答區」依序作答，並應註明作答之大題及小題題號。

II. Answer the following questions. 40%

1. Draw the molecular shape for SF_5^- and indicate the hybrid orbitals used by S atom.

2. Draw all isomers for $[Co(en)_2Cl_2]^+$, where en = ethylenediamine. Indicate the geometric and optical isomers for $[Co(en)_2Cl_2]^+$.

3. A 0.02 M solution of H_2SO_4 has an osmotic pressure of 1.125 atm at 25°C. Find K_a for HSO_4^-.

4. The unit cell of iron is body-centered cubic. If the atomic radius of iron is 124 pm, what is the density of iron? (Fe = 55.8)

5. Decomposition of 1.06 g M_2CO_3 yields 0.62 g M_2O. Write a balanced equation for the reaction and find the atomic mass of M.

6. Bombardment of $^{232}_{90}Th$ with an α-particle gives a uranium atom and a neutron. Write the nuclear equation. If the mass defect for the nuclear reaction is 0.0118 amu (atomic mass unit), find the nuclear energy (in kJ/mol) released.

7. Arrange the following aqueous solution (all 0.1 M) in the order of increasing acidity.

$CH_3COOH(aq)$, $CH_3COONa(aq)$, $CH_3COONH_4(aq)$, $NH_4Cl(aq)$, $NH_3(aq)$

8. Write the structural formula for 2-hydroxypropanoic acid. Represent the structure of the condensation polymer made from 2-hydroxypropanoic acid.

III. A galvanic cell is constructed as follows: $Zn \mid 0.1\ M\ ZnSO_4 \mid\mid 0.1\ M\ KMnO_4, 0.01\ M\ Mn^{2+}, [H^+] = 1.0\ M \mid Pt$. Answer the following questions using the thermodynamic data (at 25°C) below. 20%

	Zn(s)	Zn^{2+}(aq)	Mn^{2+}(aq)	MnO_4^-(aq)	H^+(aq)	$H_2O(l)$
ΔH_f^o (kJ·mol^{-1})	0	− 154	− 221	− 541	0	− 286
S_f^o (J·K^{-1}·mol^{-1})	42	− 112	− 74	191	0	70

(A) Write the balanced cell reaction and indicate the oxidizing and reducing agents.

(B) Find ΔH^o and ΔS^o for the cell reaction at 25°C.

(C) Calculate ΔG^o and E_{cell}^o for the cell reaction at 25°C.

(D) Calculate the cell potential for the constructed galvanic cell at 25°C.

(E) If the cell generates a constant current of 1.0 A for the first 5 minutes, find the rate of disappearance (in M/min) at 25°C for MnO_4^- during this period of time. (F = 96485 coulombs)