

- 說明：1. 答案一律寫在試卷上，否則不予計分。
2. 請依序作答、並標明題號，但不必抄題。
3. 計算題可用計算機，但必須寫出計算過程，否則不予計分。

一、選擇題：(50%，每題2分，不倒扣)

- Which of the following reactions would be endothermic?
(A) $\text{H}_2(g) \rightarrow 2 \text{H}(g)$ (B) $2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(g)$ (C) $\text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l)$
(D) $\text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$ (E) none of the above
- Which of the following particles has the largest charge-to-mass ratio?
(A) a proton (B) a neutron (C) an α -particle (D) an electron (E) a Li^+ ion
- Which of the following transitions in a hydrogen atom results in the absorption of a photon with the largest energy?
(A) $n=2$ to $n=3$ (B) $n=2$ to $n=4$ (C) $n=1$ to $n=4$ (D) $n=3$ to $n=1$
(E) $n=3$ to $n=2$
- Which of the following sets of n , l , m , and s quantum numbers can describe an electron in a $2p$ orbital?
(A) $2, 1, 0, \frac{1}{2}$ (B) $2, 0, 0, \frac{1}{2}$ (C) $2, 2, 1, \frac{1}{2}$ (D) $3, 2, 1, \frac{1}{2}$ (E) $3, 1, 0, \frac{1}{2}$
- Which of the following ionization energies (IE) is the largest?
(A) 1st IE of Ba (B) 1st IE of Mg (C) 2nd IE of Ba (D) 2nd IE of Mg
(E) 3rd IE of Al (F) 3rd IE of Mg
- Which of the following molecules have the same shape or geometry?
(A) NH_2^- and H_2O (B) NH_2^- and BeH_2 (C) H_2O and BeH_2
(D) NH_2^- , H_2O , and BeH_2 (E) none of the above
- Which of the following describes the products of the reaction of calcium metal and water?
(A) Ca^{2+} , OH^- , and H_2 (B) Ca^{2+} , H^- , and O_2 (C) Ca^{2+} , H^- , and OH^-
(D) Ca^{2+} and OH^- (E) Ca^{2+} , OH^- , and H^+
- Which of the following compounds should not exist?
(A) Na_3P (B) $(\text{NH}_4)_3\text{PO}_4$ (C) PO_2 (D) PH_3 (E) POCl_3
- Which of the following ions is the conjugate base of a strong acid?
(A) OH^- (B) HSO_4^- (C) NH_2^- (D) S^{2-} (E) H_3O^+

(請接下一頁繼續作答)

10. Which of the following is not an example of a d^0 transition-metal complex?
(A) TiO_2 (B) VO_2^+ (C) $\text{Cr}_2\text{O}_7^{2-}$ (D) MnO_4^- (E) none of the above
11. Sodium crystallizes in a structure in which the coordination number is eight. Which structure best describes this crystal?
(A) simple cubic (B) body-centered cubic (C) cubic closest packed
(D) hexagonal closest packed (E) none of the above
12. Which of the following statements correctly describes a system for which Q_c is larger than K_c ?
(A) The reaction is at equilibrium. (B) The reaction must shift to the right to reach equilibrium. (C) The reaction must shift to the left to reach the equilibrium.
(D) The reaction can never reach equilibrium. (E) none of the above
13. Under which set of conditions will the following reaction shift to the right to reach equilibrium?
$$2 \text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{SO}_3(g)$$

(A) $K_c < 1$ (B) $K_c > 1$ (C) $Q_c < K_c$ (D) $Q_c = K_c$ (E) $Q_c > K_c$
14. Which of the following describes the change that occurs in the concentration of H_2O when ammonia reacts with oxygen to form nitrogen oxide and water according to the following equation if the change in the NH_3 concentration is Δ ?
$$4 \text{NH}_3(g) + 5 \text{O}_2(g) \rightleftharpoons 4 \text{NO}(g) + 6 \text{H}_2\text{O}(g)$$

(A) Δ (B) 1.5Δ (C) 2Δ (D) 4Δ (E) 6Δ
15. Which of the following equations correctly describes the relationship between K_b for the formate ion (HCO_2^-) and K_a for formic acid (HCO_2H)?
(A) $K_b = K_w \times K_a$ (B) $K_b = K_a / K_w$ (C) $K_b = K_w / K_a$ (D) $K_b = K_w + K_a$
(E) $K_b = K_w - K_a$
16. Which of the following mixtures would make the best buffer?
(A) HCl and NaCl (B) NaOAc and NH_3 (C) HOAc and NH_4Cl
(D) NaOAc and NH_4Cl (E) NH_3 and NH_4Cl
17. Which of the following is a Lewis acid?
(A) CO (B) C_2H_2 (C) BeF_2 (D) CH_4 (E) NF_3
18. Which of the following equations describes the relationship between the complex formation equilibrium constant, K_f , and the complex dissociation equilibrium constant, K_d , for the $\text{Fe}(\text{CN})_6^{3-}$ complex ion?
(A) $K_f = K_d$ (B) $K_f = K_w / K_d$ (C) $K_f = K_d / K_w$ (D) $K_f = K_w \times K_d$
(E) $K_f = 1 / K_d$
19. Which of the following cannot be an reducing agent?
(A) H_2 (B) Cl_2 (C) Fe^{3+} (D) Al (E) LiH

(請接下一頁繼續作答)

20. Which of the following describes an oxidation-reduction reaction at equilibrium?
(A) $E = 0$ (B) $E^{\circ} = 0$ (C) $E = E^{\circ}$ (D) $Q_c = 0$ (E) $\ln K_c = 0$
21. Which of the following can be oxidized to form an aldehyde (R-CHO)?
(A) $\text{CH}_3\text{CH}_2\text{OH}$ (B) $\text{CH}_3\text{CHOHCH}_3$ (C) CH_3OCH_3 (D) $(\text{CH}_3)_2\text{C}=\text{O}$
(E) none of the above
22. What is the molecular geometry of the compound formed by the reaction of nitrogen with fluorine?
(A) bent (B) trigonal planar (C) trigonal pyramidal (D) trigonal bipyramidal
(E) none of the above
23. Which of the following gases would diffuse fastest at room temperature?
(A) NH_3 (B) CO (C) H_2S (D) F_2 (E) CO_2
24. 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)
25. If x mol of solid salt NaA are dissolved in a solution containing z mol/L of the weak acid HA with the acid-ionization equilibrium constant K_a , $[\text{H}_3\text{O}^+]$ is (if we assume no change in volume)
(A) z-x (B) $[(z/x)K_a]^{0.5}$ (C) $(z+x)K_a$ (D) $(z/x)K_a$ (E) none of the above

二、複擇題：(30%，每題3分，每個答案個別計算為0.5分，答對得0.5分，答錯倒扣0.5分，每題最低為0分，最高為3分，不答為0分。本大題最後四捨五入為整數分。)

1. Which of the following pairs of elements should combine to give covalent compounds?
(A) $\text{MgCl}_2 + \text{O}_2$ (B) $\text{Cl}_2 + \text{F}_2$ (C) $\text{Cl}_2 + \text{Cr}$ (D) $\text{S}_8 + \text{Na}$
(E) $\text{Cu} + \text{Sn}$ (F) $\text{Hg} + \text{Zn}$
2. Which of the following compounds should conduct an electric current when dissolved in water?
(A) MgCl_2 (B) CO_2 (C) CH_3OH (D) KNO_3 (E) Ca_3P_2 (F) C_{60}
3. For which of the following substances is ΔH_f° equal to zero?
(A) $\text{P}_4(s)$ (B) $\text{H}_2\text{O}(l)$ (C) $\text{O}_3(g)$ (D) $\text{Cl}(g)$ (E) $\text{F}_2(g)$ (F) $\text{C}_{60}(s)$
4. Which of the following molecules are best described as bent, or angular?
(A) H_2S (B) CO_2 (C) ClNO (D) NH_2^- (E) O_3 (F) BeF_2

(請接下一頁繼續作答)

5. Which of the following oxides of nitrogen are paramagnetic?
(A) N_2O (B) NO (C) NO_2 (D) N_2O_3 (E) N_2O_4 (F) N_2O_5
6. Which of the following compounds are acids when dissolve in water?
(A) SO_2 (B) HNO_3 (C) SrO (D) HI (E) K_2S (F) $Al(OH)_3$
7. Which of the following octahedral complexes can form cis/trans isomers?
(A) $Co(NH_3)_6^{3+}$ (B) $Co(NH_3)_5Cl^{2+}$ (C) $Co(NH_3)_5(H_2O)^{3+}$ (D) $Co(NH_3)_4Cl_2^+$
(E) $Co(NH_3)_4(H_2O)_2^{3+}$ (F) $Co(NH_3)_3(H_2O)_3^{3+}$
8. Which of the following can be both an oxidizing agent and a reducing agent?
(A) H_2 (B) I_2 (C) H_2O_2 (D) P_4 (E) S_8 (F) F_2
9. Which of the following molecules are planar?
(A) SO_3 (B) SO_3^{2-} (C) NO_3^- (D) PF_3 (E) BH_3 (F) CO_3^{2-}
10. Which of the following units are SI units?
(A) s (B) kg (C) atm (D) L (E) $^{\circ}C$ (F) mol

三、問答與計算：(20%)

1. The "meter" has been defined as the length equal to 1,650,763.73 wavelengths of the orange-red line of the emission spectrum of krypton-86 atom. Calculate
(a) the wavelength and (b) the frequency of this orange-red radiation. (3%, 3%)
2. Calculate (a) the pH value and (b) the H_3O^+ concentration in a 0.0001 M solution of hydrocyanic acid (HCN , $K_a = 6 \times 10^{-10}$). (3%, 3%)
3. Balance the following oxidation-reduction equations that occur in basic solution.
(a) $NO(g) + MnO_4^-(aq) \rightarrow NO_3^-(aq) + MnO_2(s)$ (4%)
(b) $NH_3(aq) + MnO_4^-(aq) \rightarrow N_2(g) + MnO_2(s)$ (4%)