『普通化學』部份，單選題 25 題，總分 100 分

1. Using the following K_a values, indicate the correct order of base strength.

   HNO_2 $K_a = 4.0 \times 10^{-4}$
   HF $K_a = 7.2 \times 10^{-4}$
   HCN $K_a = 6.2 \times 10^{-10}$

   (a) $CN^- > NO_2^- > F^- > H_2O > Cl^-$ (b) $Cl^- > H_2O > F^- > NO_2^- > CN^-$
   (c) $CN^- > F^- > NO_2^- > Cl^- > H_2O$ (d) $H_2O > CN^- > NO_2^- > F^- > Cl^-$
   (e) none of these

2. Determine the molarity of a solution of the weak acid $HClO_2$ ($K_a = 1.10 \times 10^{-2}$) if it has a pH of 1.25. (note: $10^{-1.25} = 0.0562$)

   (a) 0.287 M (b) 1.23 M (c) 0.819 M (d) 3.17 M (e) 1.52 M

3. A 0.10-mol sample of a diprotic acid, H_2A, is dissolved in 250 mL of water. The K_{a1} of this acid is 1.0×10^{-5} and K_{a2} is 1.0×10^{-10}. Calculate the concentration of A^{2-} in this solution.

   (a) 1.0×10^{-5} M (b) 2.0×10^{-3} M (c) 4.0×10^{-6} M (d) 1.0×10^{-10} M
   (e) 0.40 M

4. Which of the following molecules are nonlinear?

   (a) XeF_2, ICl_2^- (b) CO_2, N_3^- (c) NO_2^-, O_3 (d) N_3^-, XeF_2
   (e)all are linear

5. Which in the following answers are all paramagnetic?

   (a) NO, NO_2, N_2O_4, C_2^{2-} (b) NO, NO_2, O_2^{2-}, O_2 (c) O_2, O_2^+, O_2^-, O_3
   (d) NO, NO_2, O_2, O_2^+ (e) NO_2, O_2^+, O_2^-, O_3

6. What is the sum for all the coefficients when the following chemical equation is balanced?

   $OH^-(aq) + Cl_2(g) \leftrightarrows Cl^-(aq) + OCl^-(aq) + H_2O(l)$

   (a) 5 (b) 6 (c) 7 (d) 8 (e) none of these

7. Consider a concentration cell as shown below. What is the cell potential at 25°C?

   $Ag|Ag^+(0.01M)||Ag^+(1.0M)|Ag$

   (a) 0.0591 V (b) 0.591 V (c) 0.118 V (d) 0.018 V (e) none of these

8. It took 250 seconds for 50% for a particular substance to decompose. If the initial concentration was 0.05 M and the decomposition reaction follows second-order kinetics, what is the value of rate constant?
(a) 8.0×10^{-2} L/mol·s
(b) 1.0×10^{-4} L/mol·s
(c) 1.0×10^{-3} L/mol·s
(d) 4.0×10^{-2} L/mol·s
(e) 8.0×10^{-3} L/mol·s

9. How many geometric isomers does the complex $[Cr(en)(NH_3)_2I_2]^+$ have? Note: en is an abbreviation for the bidentate ligand ethylenediamine.
(a) 2 (b) 3 (c) 4 (d) 5 (e) none of these

10. How many unpaired electrons are present in the tetrahedral ion $FeCl_4^-$?
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5

11. What is the sum for all the coefficients when the chemical equation for the following Galvanic cell is balanced?
$Pt(s)|ClO_3^-(aq), ClO_4^-(aq), H^+(aq)||H^+(aq), MnO_4^-(aq), Mn^{2+}(aq)|Pt(s)$
(a) 23 (b) 24 (c) 25 (d) 26 (e) none of these

12. Calculate ΔH for the synthesis of diborane from its elements, according to the equation, $2B(s) + 3H_2(g) \rightarrow B_2H_6(g)$, using the following data:
$2B(s) + 3/2\ O_2(g) \rightarrow B_2O_3(s)$ ΔH = -1273 kJ
$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(s) + 2H_2O(g)$ ΔH = -2035 kJ
$H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(l)$ ΔH = -286 kJ
$H_2O(l) \rightarrow H_2O(g)$ ΔH = 44 kJ
(a) 432 kJ (b) -48 kJ (c) 36 kJ (d) -168 kJ (e) none of these

13. A sample weighing 0.456 g was dissolved in 20.0-g benzene, and the freezing-point depression was determined to be 0.250°C. The freezing-point depression constant (K_f) for benzene is 5.12 °C·kg/mol. What is the molar mass of the sample?
(a) 546 g/mol (b) 648 g/mol (c) 345 g/mol (d) 467 g/mol (e) none of these

14. When ignited, solid ammonium dichromate decomposes in a fiery display. This is the reaction for a "volcano" demonstration. The decomposition produces nitrogen gas, water vapor, and chromium(III) oxide. The temperature is constant at 25°C. Given the following thermodynamic parameters, determine $\Delta G°$ (in kJ/mol).

Substance	$\Delta H°_f$(kJ/mol)	$S°$ (kJ/mol·K)
Cr_2O_3 (*g*)	−1140	0.0812
H_2O(*l*)	−242	0.1187
N_2 (*g*)	0	0.1915
$(NH_4)_2Cr_2O_7$	−22.5	0.1137

(a) −6119.7 (b) −2274.7 (c) −3042.6 (d) −5419.3 (e) −1488.8

15. Due to environmental concerns, researchers have been seeking low-cost alternatives to fossil fuels. What is a promising alternative, which can be liberated from water, using solar energy?

(a) hydrogen (b) oxygen (c) carbon (d) ozone (e) none of these

16. Which of the following statements is true?

(a) When two opposing processes are proceeding at identical rates, the system is at equilibrium.
(b) Catalysts are an effective means of changing the position of an equilibrium.
(c) The concentration of the products equals that of reactants and is constant at equilibrium.
(d) An endothermic reaction shifts toward reactants when heat is added to the reaction.
(e) None of these statements is true.

17. The equilibrium constant K_p (in atm) for the dissociation reaction of Cl_2 was measured as a function of temperature (in K).

$$Cl_2 \rightleftharpoons 2Cl$$

A graph of ln K_p versus $1/T$ for this reaction gives a straight line with a slope of -1.352×10^4 and an intercept of 14.51. (gas constant R = 8.31451 J/K·mol or 0.08206 L·atm/K·mol)

The value of ΔH for this dissociation reaction is:

(a) −122.1 kJ (b) 112.4 kJ (c) −112.4 kJ (d) 122.1 kJ
(e) none of these

18. Calculate the percent dissociation for a 0.22 M solution of chlorous acid ($HClO_2$, $K_a = 1.2 \times 10^{-2}$)

(a) 6 % (b) 16 % (c) 21 % (d) 28% (e) none of these

19. Which of the following found the law of definite proportion?
(a) Antoine Lavoirsier
(b) Robert Boyle
(c) John Dalton
(d) Joseph Priestly
(e) Joseph Proust

20. Which of the following is the point group of ICl_3?
(a) C_{2v} (b) D_{3h} (c) C_{3v} (d) D_{3d} (e) C_s

21. Given the following information:

$Li(s) \rightarrow Li(g)$	heat of sublimation of $Li(s)$ = 166 kJ/mol
$HCl(g) \rightarrow H(g) + Cl(g)$	bond energy of HCl = 427 kJ/mol
$Li(g) \rightarrow Li^+(g) + e^-$	ionization energy of $Li(g)$ = 520. kJ/mol
$Cl(g) + e^- \rightarrow Cl^-(g)$	electron affinity of $Cl(g)$ = –349 kJ/mol
$Li^+(g) + Cl^-(g) \rightarrow LiCl(s)$	lattice energy of $LiCl(s)$ = –829 kJ/mol
$H_2(g) \rightarrow 2H(g)$	bond energy of H_2 = 432 kJ/mol

Calculate the net change in energy for the reaction
$2Li(s) + 2HCl(g) \rightarrow 2LiCl(s) + H_2(g)$
(a) 363 kJ
(b) –562 kJ
(c) –179 kJ
(d) –73 kJ
(e) None of these

22. Which of the following exhibits the strongest ligand field in octahedral complexes?
(a) NH_3 (b) OH^- (c) CN^- (d) Cl^- (e) F^-

23. Which of the following cannot be chiral?
(a) $[Co(en)_3]^{3+}$
(b) $[Cr(en)(NH_3)_2I_2]^+$
(c) sodium ammonium tartrate
(d) $[Co(NH_4)_2Cl_2]^+$
(e) fructose

24. Consider the following data concerning the equation:

$H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$

	$[H_2O_2]$	$[I^-]$	$[H^+]$	rate
I	0.100 M	5.00×10^{-4} M	1.00×10^{-2} M	0.137 M/sec
II.	0.100 M	1.00×10^{-3} M	1.00×10^{-2} M	0.268 M/sec
III.	0.200 M	1.00×10^{-3} M	1.00×10^{-2} M	0.542 M/sec
IV.	0.400 M	1.00×10^{-3} M	2.00×10^{-2} M	1.084 M/sec

The rate law for this reaction is

(a) rate = $k[H_2O_2][I^-][H^+]$
(b) rate = $k[H_2O_2]^2[I^-]^2[H^+]^2$
(c) rate = $k[I^-][H^+]$
(d) rate = $k[H_2O_2][H^+]$
(e) rate = $k[H_2O_2][I^-]$

25. In 2009, Venkatraman Ramakrishnan, Thomas A. Steitz and Ada E. Yonath won the Nobel prize in chemistry for which of the following contribution?

(a) studies of the molecular basis of eukaryotic transcription

(b) discovery and development of the green fluorescent protein

(c) studies of chemical processes on solid surfaces

(d) studies of the structure and function of the ribosome

(e) development of the metathesis method in organic synthesis