一、 選擇題（單選題，每題 3 分，共 75 分，答錯不倒扣）

※ 注意：選擇題請於答案卷之「選擇題作答區」依序作答。

1) What is the sum of x, y, and z in the following balanced reaction?

$mMnO_4^-(aq) + nH^+(aq) + pFe(s) \rightarrow xMn^{2+}(aq) + yFe^{3+}(aq) + zH_2O(l)$

(A) 8 (B) 12 (C) 16 (D) 20 (E) 24

2) Which salt yields acidic solution?

(A) NaCl (B) NH_4Cl (C) NH_4OH (D) $NaNO_3$ (E) CH_3COONa

3) If the pH value for a 10-mL solution containing 0.1 M HA after adding 5-mL 0.1 M NaOH is 4.5, what is the pK_a for HA?

(A) 4.0 (B) 4.5 (C) 5.0 (D) 5.5 (E) 6.0

4) The standard cell potential ($E°_{cell}$) is +0.63 V for the reaction between $Pb^{2+}(aq)$ and $Zn(s)$. What is the cell potential for this reaction when $[Zn^{2+}] = 1.0$ M and $[Pb^{2+}] = 2.0 \times 10^{-4}$ M?

(A) 0.52 (B) 0.85 (C) 0.41 (D) 0.74 (E) 0.63 V

5) The standard cell potential ($E°_{cell}$) of the reaction between $Pb(s)$ and $H^+(aq)$ is +0.126 V. What is the value of $\Delta G°$ for the reaction?

(A) -12 (B) +12 (C) -24 (D) +24 (E) -50 kJ mol^{-1}

6) Cyanide (CN^-) and gold ions (Au^+) form a stable complex $Au(CN)_x^{n-}$. What is the number of x?

(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

7) Which element is oxidized in the reaction below?

$Fe(CO)_5(l) + 2HI(g) \rightarrow Fe(CO)_4I_2(s) + CO(g) + H_2(g)$

(A) Fe (B) C (C) O (D) H (E) I

8) The formation constant values for $Ag(NH_3)^+$ and $Ag(NH_3)_2^+$ are 2.1×10^3 and 8.2×10^3, respectively. What is the solubility of AgCl (K_{sp} 1.6×10^{-10}) in 0.1 M $NH_3(aq)$?

(A) 1.3×10^{-5} (B) 2.1×10^3 (C) 0.03 (D) 0.32 (E) 0.48 M

9) What is the change in entropy that occurs when a sample containing 2.00 mol of water is heated from 50 to 100 °C? The molar heat capacity for $H_2O(l)$ is 75.3 J K^{-1} mol^{-1}.

(A) -11 (B) 11 (C) -22 (D) 22 (E) 33 J K^{-1}

10) Which compound is the strongest acid in water?

(A) HF (B) HCl (C) HI (D) HCOOH (E) CH_3COOH

11) The coordination numbers of cobalt(III) and of chromium(III) in their complexes are always:

(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

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12) The complex $[Zn(NH_3)_2Cl_2]^{2+}$ does not exhibit cis-trans-isomerism. The geometry of this complex must be:
(A) tetrahedral (B) trigonal bipyramidal (C) octahedral
(D) square planar (E) either tetrahedral or square planar

13) Which aqueous solution has the highest electrical conductivity?
(A) 0.1 M CH_3COOH (B) 0.1 M $CH_2ClCOOH$ (C) 0.1 M $CHCl_2COOH$
(D) 0.01 M CH_3COOH (E) 0.01 M $CHCl_2COOH$,

14) Which pair of the following aqueous solution can produce precipitates?
(A) $NaNO_3$ and H_2SO_4
(B) $AgNO_3$ and H_2SO_4
(C) $CuCO_3$ and HNO_3
(D) $CaCl_2$ and HNO_3
(E) $Pb(NO_3)_2$ and H_2SO_4

15) What is the purpose of adding EDTA to prepared foods?
(A) to keep ions such as Ca^{2+} in solution so the foods look good
(B) to complex trace metal ions that catalyze decomposition reactions
(C) to complex iron(III) ions so they can catalyze protein decomposition on cooking
(D) to aid in browning of the surface during cooking
(E) to prevent dissolution of the container in the food when stored for long periods of time

16) How much time is required for a first-order reaction to be 75% complete if it has a half-life of 20 min?
(A) 20 (B) 30 (C) 40 (D) 50 (E) 60 min

17) Which Co(III) complex is most likely high-spin?
(A) $[Co(NH_3)_6]^{3+}$ (B) $[Co(NO_2)_6]^{3-}$ (C) $[Co(CN)_6]^{3-}$
(D) $[CoF_6]^{3-}$ (E) $[Co(CH_3CN)_6]^{3+}$

18) Which compound has the highest water solubility?
(A) octanol (B) pentane (C) acetone (D) AgCl (E) nonanoic acid

19) Which is a common catalyst used in the reaction between benzene and nitric acid to form nitrobenzene?
(A) H_2SO_4 (B) $FeCl_3$ (C) CH_3COOH (D) CH_3NO_2 (E) NH_3

20) Which is the major species for H_3A ($pK_{a1} = 2.0$, $pK_{a2} = 5.0$, and $pK_{a3} = 9.0$) at pH 6.0?
(A) H^+ (B) H_3A (C) H_2A^- (D) HA^{2-} (E) A^{3-}

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21) When the volume of a balloon changes from 4.0×10^6 to 4.5×10^6 L by addition of 1.0×10^8 J of energy as heat, what is the energy change (ΔE) at a constant pressure (1.0 atm)?
(A) 3.0 (B) 3.5 (C) 4.0 (D) 4.5 (E) 5.0 $\times 10^7$ J

22) Which statement is correct for gold nanoparticles?
(A) Their sizes are about 1 mm.
(B) They can be used in sensing of mercury ions.
(C) They are commonly prepared by melting gold.
(D) Their oxidation state is +3.
(E) $KMnO_4$ is used as an oxidant in their preparation from gold ions.

23) Which statement is correct for green chemistry?
(A) A system has green color.
(B) A system uses an expensive and low-efficient catalyst.
(C) A system minimizes waste.
(D) A system can produce large amounts of byproducts.
(E) A system uses large amount of reagents.

24) Which one is the best aqueous buffer at pH 5.0?
(A) 0.1 M NH_4Cl adjusted with NH_3
(B) 0.01 M NH_4Cl adjusted with NH_3
(C) 0.1 M NH_4Cl adjusted with NaOH
(D) 0.1 M CH_3COOH adjusted with NaOH
(E) 0.01 M CH_3COOH adjusted with NaOH

25) Which compound has the highest boiling point?
(A) H_2O (B) NH_3 (C) CH_4 (D) H_2 (E) CH_3OH

二、 簡答題（共 25 分，不需解釋）

1) Draw valid Lewis structures for **(a)** NO_3^-, **(b)** XeF_4, **(c)** B_2H_6（每小題 4 分，共 12 分）

2) Write down the formula of the monomer for **(a)** Teflon and **(b)** polystyrene（每小題 4 分，共 8 分）

3) Write down a mechanism for the reaction between gaseous nitrogen dioxide and fluorine to produce $NO_2F_{(g)}$ if the experimentally determined rate law is $Rate = k\,[NO_2]\,[F_2]$ （5 分）

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