

國立彰化師範大學 99 學年度博士班招生考試試題

系所：科學教育研究所

丙組

科目：基礎化學（含無機、物化）

☆☆請在答案紙上作答☆☆

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一. 單選題 (63%)

1. How many significant figures are there in the number 0.04560700?
(A) 4 (B) 5 (C) 7 (D) 8 (E) 9
2. A mixture is prepared from 15.0 L of ammonia and 15.0 L chlorine measured at the same conditions; these compounds react according to the following equation:
$$2\text{NH}_3(\text{g}) + 3\text{Cl}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 6\text{HCl}(\text{g})$$

When the reaction is completed, what is the volume of each gas (NH_3 , Cl_2 , N_2 , and HCl , respectively)? Assume the final volumes are measured under identical conditions.
(A) 0.00 L, 5.00 L, 7.50 L, 45.0 L (B) 5.00 L, 0.00 L, 5.00 L, 30.0 L
(C) 0.00 L, 0.00 L, 7.50 L, 45.0 L (D) 0.00 L, 0.00 L, 5.00 L, 30.0 L
(E) 0.00 L, 10.0 L, 15.0 L, 90.0 L
3. The reaction $3\text{NO} \rightarrow \text{N}_2\text{O} + \text{NO}_2$ is found to obey the rate law, $\text{Rate} = k[\text{NO}]^2$. If the first half-life of the reaction is found to be 2.0 s, what is the length of the fourth half-life?
(A) 2.0 s (B) 4.0 s (C) 8.0 s (D) 12.0 s (E) 16.0 s
4. Consider the following system at equilibrium: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + 92.94 \text{ kJ}$
Which of the following changes will shift the equilibrium to the right?
I. increasing the temperature
II. decreasing the temperature
III. increasing the volume
IV. decreasing the volume
V. removing some NH_3
VI. adding some NH_3
VII. removing some N_2
VIII. adding some N_2
(A) I, IV, VI, VII (B) II, III, V, VIII (C) I, VI, VIII (D) I, III, V, VII (E) II, IV, V, VIII
5. The reaction quotient for a system is 7.2×10^2 . If the equilibrium constant for the system is 36, what will happen as equilibrium is approached?
(A) There will be a net gain in product. (B) There will be a net gain in reactant.
(C) There will be a net gain in both product and reactant.
(D) There will be no net gain in either product or reactant.
(E) The equilibrium constant will decrease until it equals the reaction quotient.

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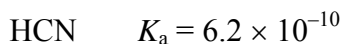
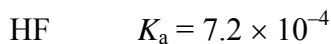
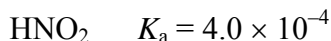
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6. Using the following K_a values, indicate the correct order of base strength.

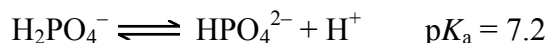
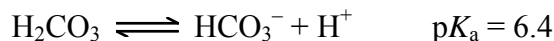


- (A) $\text{CN}^- > \text{NO}_2^- > \text{F}^- > \text{H}_2\text{O} > \text{Cl}^-$ (B) $\text{Cl}^- > \text{H}_2\text{O} > \text{F}^- > \text{NO}_2^- > \text{CN}^-$
(C) $\text{CN}^- > \text{F}^- > \text{NO}_2^- > \text{Cl}^- > \text{H}_2\text{O}$ (D) $\text{H}_2\text{O} > \text{CN}^- > \text{NO}_2^- > \text{F}^- > \text{Cl}^-$ (E) none of these

7. Consider a 0.70 M solution of HOCl. If the molarity was decreased to 0.3 M, which of the following statements would be true?

- (A) The percent dissociation would not change. (B) The percent dissociation would increase.
(C) The percent dissociation would decrease. (D) The equilibrium constant would stay the same.
(E) Two of these.

8. Consider a solution consisting of the following two buffer systems:



At pH 6.4, which one of the following is true of the relative amounts of acid and conjugate base present?

- (A) $[\text{H}_2\text{CO}_3] > [\text{HCO}_3^-]$ and $[\text{H}_2\text{PO}_4^-] > [\text{HPO}_4^{2-}]$
(B) $[\text{H}_2\text{CO}_3] = [\text{HCO}_3^-]$ and $[\text{H}_2\text{PO}_4^-] > [\text{HPO}_4^{2-}]$
(C) $[\text{H}_2\text{CO}_3] = [\text{HCO}_3^-]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$
(D) $[\text{HCO}_3^-] > [\text{H}_2\text{CO}_3]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$
(E) $[\text{H}_2\text{CO}_3] > [\text{HCO}_3^-]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$

9. Which of the following is the net ionic equation for the reaction that occurs during the titration of nitric acid with potassium hydroxide?

- (A) $\text{HNO}_3 + \text{K}^+\text{OH}^- \rightleftharpoons \text{KNO}_3 + \text{H}_2\text{O}$
(B) $\text{HNO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NO}_3^- + \text{H}_3\text{O}^+$
(C) $\text{HNO}_3 + \text{KOH} \rightleftharpoons \text{K}^+ + \text{NO}_3^- + \text{H}_2\text{O}$
(D) $\text{HNO}_3 + \text{OH}^- \rightleftharpoons \text{NO}_3^- + \text{H}_2\text{O}$
(E) $\text{H}^+ + \text{OH}^- \rightleftharpoons \text{H}_2\text{O}$

10. You have 100.0 mL of 0.100 M aqueous solutions of each of the following acids: HCN, HF, HCl, and $\text{HC}_2\text{H}_3\text{O}_2$. You titrate each with 0.100 M NaOH(aq). Rank the pHs of each of the solutions when each are titrated to the equivalence point, from highest to lowest pH.

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$$K_a \text{ for HCN} = 6.2 \times 10^{-10}$$

$$K_a \text{ for HF} = 7.2 \times 10^{-4}$$

$$K_a \text{ for HC}_2\text{H}_3\text{O}_2 = 1.8 \times 10^{-5}$$

- (A) HCN, HC₂H₃O₂, HF, HCl (B) HCl, HF, HCN, HC₂H₃O₂
(C) HF, HCN, HC₂H₃O₂, HCl (D) HC₂H₃O₂, HCl, HCN, HF (E) none of these

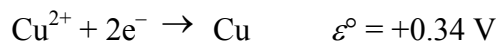
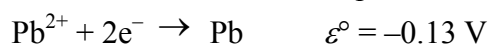
11. For which of the following processes would ΔS° be expected to be most positive?

- (A) $\text{O}_2(g) + 2\text{H}_2(g) \rightarrow 2\text{H}_2\text{O}(g)$
(B) $\text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(s)$
(C) $\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(g)$
(D) $2\text{NH}_4\text{NO}_3(s) \rightarrow 2\text{N}_2(g) + \text{O}_2(g) + 4\text{H}_2\text{O}(g)$
(E) $\text{N}_2\text{O}_4(g) \rightarrow 2\text{NO}_2(g)$

12. Which of the following is true for the cell shown here? $\text{Zn}(s)|\text{Zn}^{2+}(aq)||\text{Cr}^{3+}(aq)|\text{Cr}(s)$

- (A) The electrons flow from the cathode to the anode.
(B) The electrons flow from the zinc to the chromium.
(C) The electrons flow from the chromium to the zinc.
(D) The chromium is oxidized.
(E) The zinc is reduced.

13. A cell is set up with copper and lead electrodes in contact with $\text{CuSO}_4(aq)$ and $\text{Pb}(\text{NO}_3)_2(aq)$, respectively, at 25°C. The standard reduction potentials are:



If sulfuric acid is added to the $\text{Pb}(\text{NO}_3)_2$ solution, forming a precipitate of PbSO_4 , the cell potential:

- (A) increases (B) decreases (C) is unchanged
(D) can't tell what will happen (E) none of these

14. What is the electron configuration of the Sc(I) ion?

- (A) $[\text{Ar}] 4s^1 4d^1$ (B) $[\text{Ar}] 4s^1 3d^1$ (C) $[\text{Ar}] 3s^1 3d^1$ (D) $[\text{Ar}] 4s^2$ (E) $[\text{Ar}] 3d^2$

15. Give the number of geometrical isomers for the octahedral compound $[\text{MA}_2\text{B}_2\text{C}_2]$, where A, B, and C represent ligands.

- (A) 1 (B) 2 (C) 3 (D) 5 (E) none of these

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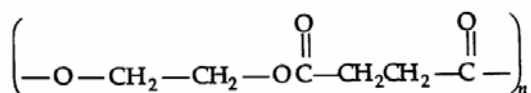
16. Which of the following statements is true about the octahedral complexes of Ni^{2+} ?
- (A) Both strong- and weak-field complexes are diamagnetic.
(B) The strong-field complex is diamagnetic and the weak-field complex is paramagnetic.
(C) The strong-field complex is paramagnetic and the weak-field complex is diamagnetic.
(D) Both strong- and weak-field complexes are paramagnetic.
(E) There are no octahedral complexes of Ni.

17. The spectrochemical series is $\text{I}^- < \text{Br}^- < \text{Cl}^- < \text{F}^- < \text{OH}^- < \text{H}_2\text{O} < \text{NH}_3 < \text{en} < \text{NO}_2^- < \text{CN}^-$
Which of the following complexes will absorb visible radiation of the highest energy (shortest wavelength)?

- (A) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ (B) $[\text{Co}(\text{I})_6]^{3-}$ (C) $[\text{Co}(\text{OH})_6]^{3-}$ (D) $[\text{Co}(\text{en})_3]^{3+}$ (E) $[\text{Co}(\text{NH}_3)_6]^{3+}$

18. Which of the following polymers is not based on a substituted ethylene monomer?
- (A) nylon (B) polyvinylchloride (C) Teflon (D) polystyrene (E) polypropylene

19. What monomer(s) is (are) needed to make the polymer shown below?



- I. $\text{HOCH}_2\text{CH}_2\text{OH}$
II. $\text{HOOCCH}_2\text{CH}_2\text{COOH}$
III. $\text{HOCH}_2\text{CH}_2\text{COOH}$
IV. $\text{HOCH}=\text{CHOH}$
V. $\text{HOOCCH}=\text{CHCOOH}$
- (A) II (B) III (C) I and II (D) IV and V (E) II and III

20. Which of the following has the smallest molar mass?

- (A) mRNA (B) dRNA (C) rRNA (D) sRNA (E) tRNA

21. Which of the following names is a correct one?

- (A) 3-methyl-4-isopropylpentane (B) 2-ethyl-4-tertiary-butylpentane
(C) 2,2,3,5-tetramethylheptane (D) *t*-butylethane (E) *trans*-1,2-dimethylethane

二. 計算與簡答 (37%)

1. Consider three identical flasks filled with different gases. Flask **A**: CO at 760 torr and 0°C ; Flask **B**:

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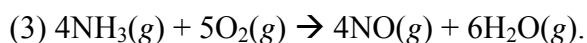
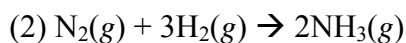
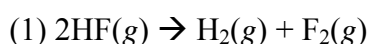
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N₂ at 250 torr and 0°C; Flask C: H₂ at 100 torr and 0°C.

(1) In which flask will the molecules have the greatest average kinetic energy? Why?

(2) In which flask will the molecules have the greatest average velocity? Why? (10%)

2. For the following reactions at constant pressure, predict if $\Delta H > \Delta E$, $\Delta H = \Delta E$, or $\Delta H < \Delta E$. Give your reasons. (9%)



3. The successive ionization energies for an unknown element are $I_1 = 896$ kJ/mol, $I_2 = 1752$ kJ/mol, $I_3 = 14,807$ kJ/mol, $I_4 = 17,948$ kJ/mol. To which family in the periodic table does the unknown element most likely belong? Give your reasons. (8%)

4. Given the following information:

Heat of sublimation of Li(*s*) = 166 kJ/mol

Bond energy of HCl = 427 kJ/mol

Ionization energy of Li(*g*) = 520 kJ/mol

Electron affinity of Cl(*g*) = -349 kJ/mol

Lattice energy of LiCl(*s*) = -829 kJ/mol

Bond energy of H₂ = 432 kJ/mol

Calculate the net change in energy for the following reaction: (10%)

