

科目：普通化學

適用：應化系

考生注意：

1. 依次序作答，只要標明題號，不必抄題。
2. 答案必須寫在答案卷上，否則不予計分。
3. 限用藍、黑色筆作答；試題須隨卷繳回。

本試題

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I. Multiple-Choice (40%, 2% each)

1. Which of the following is *not* the correct chemical formula for the compound named?
 - A) $\text{Mg}(\text{C}_2\text{H}_3\text{O}_2)_2$ magnesium acetate
 - B) $\text{Al}(\text{OH})_2$ aluminum hydroxide
 - C) Fe_2O_3 iron(III) oxide
 - D) LiCN lithium cyanide
2. How many molecules of ammonia are present in 7.5 g of ammonia?
 - A) 2.7×10^{23}
 - B) 4.4×10^1
 - C) 9.0×10^{23}
 - D) 4.5×10^{24}
3. Caffeine consists of carbon, hydrogen, oxygen, and nitrogen. When 0.1920 g of caffeine is burned in an excess of oxygen, 0.3482 g of carbon dioxide and 0.0891 g water are formed. Caffeine is 28.84% nitrogen by mass. Its molar mass is between 190 and 200 g/mol. What is the formula for caffeine?
 - A) $\text{C}_6\text{H}_4\text{N}_4\text{O}_4$
 - B) $\text{C}_3\text{H}_2\text{N}_2\text{O}_2$
 - C) $\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$
 - D) none of above
4. The empirical formula of a group of compounds is CHCl . Lindane, a powerful insecticide, is a member of this group. The molar mass of lindane is 290.8. How many atoms of carbon does a molecule of lindane contain?
 - A) 3
 - B) 8
 - C) 4
 - D) 6
5. How many grams of $\text{Ca}(\text{NO}_3)_2$ can be produced by reacting excess HNO_3 with 7.40 g of $\text{Ca}(\text{OH})_2$?
 - A) 7.40 g
 - B) 8.22 g
 - C) 16.4 g
 - D) 10.2 g
6. The limiting reactant in a reaction
 - A) has the lowest coefficient in a balanced equation.
 - B) has the lowest ratio of coefficient in the balanced equation to moles available.
 - C) has the lowest ratio of moles available to coefficient in the balanced equation.
 - D) is the reactant for which you have the least number of moles.
7. When 0.2 M sodium hydroxide and 0.2 M barium nitrate are mixed, a precipitate is formed. What is the net ionic equation for the formation of this precipitate?
 - A) $\text{Ba}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Ba}(\text{OH})_2(\text{s})$
 - B) $\text{Ba}^{2+}(\text{aq}) + 2\text{NO}_3^{-}(\text{aq}) \rightarrow \text{Ba}(\text{NO}_3)_2(\text{s})$
 - C) $\text{Na}^{+}(\text{aq}) + \text{NO}_3^{-}(\text{aq}) \rightarrow \text{NaNO}_3(\text{s})$
 - D) $\text{Na}^{+}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{NaOH}(\text{s})$
8. If you know K_b for ammonia, NH_3 , you can calculate the equilibrium constant K_a for the reaction: $\text{NH}_4^{+} \rightleftharpoons \text{NH}_3 + \text{H}^{+}$ by which of the following equations?
 - A) $K_a = K_w/K_b$
 - B) $K_a = K_b/K_w$
 - C) $K_a = 1/K_b$
 - D) $K_a = K_w/K_b$

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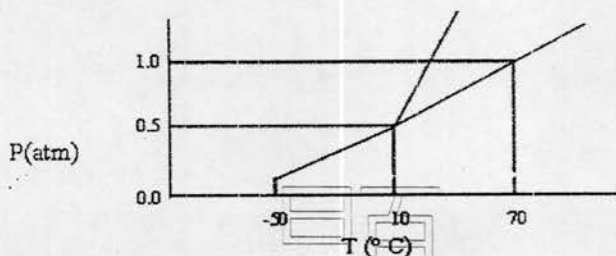
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9. Buffers in the human body
- A) help to keep the body temperature constant.
 - B) help to maintain a constant blood pH.
 - C) precipitate proteins so enzymes are inactive.
 - D) help change the blood plasma pH when foods are eaten.
10. According to crystal field theory, how many unpaired electrons are present in the complex ion $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$?
- A) 0
 - B) 1
 - C) 2
 - D) 4
11. Which of the following elements is(are) found in bauxite?
- A) Tl
 - B) Ga
 - C) B
 - D) Al
12. Which of the following has the highest melting point?
- A) Na(s)
 - B) K(s)
 - C) Li(s)
 - D) Rb(s)
13. What is the expected osmotic pressure, in torr, of a 0.0100 M solution of NaCl in water at 25°C?
- A) 372 torr
 - B) 186 torr
 - C) 0.245 torr
 - D) 15.6 torr
14. The energy expressions for the electrons in the He^+ ion and the hydrogen atom are $E_n(\text{H}) = -a/n^2$ and $E_n(\text{He}^+) = -4a/n^2$. Which of the following statements is(are) correct?
- a. For the transitions $n_1 \rightarrow n_2$, the frequency is larger for H than for He^+ .
 - b. The first ionization energy of the H atom is smaller than the second ionization energy of the He atom.
 - c. The 1s orbital in He^+ is larger (in the sense that the probability density is shifted outward) than the 1s orbital in H.
- A) b only
 - B) c only
 - C) a only
 - D) a, b, and c
15. A certain substance has the phase diagram shown below. At which of the following values of T and P is the substance a pure liquid?



- A) $T = 10^\circ\text{C}$, $P = 1 \text{ atm}$
- B) $T = 10^\circ\text{C}$, $P = 0.5 \text{ atm}$
- C) $T = 80^\circ\text{C}$, $P = 1 \text{ atm}$
- D) $T = 70^\circ\text{C}$, $P = 1.2 \text{ atm}$

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16. What is the oxidation state of Mn in MnO_2 ?
A) +2 B) +4
C) +3 D) +9
17. Calculate the solubility of Ag_2CrO_4 [$K_{sp} = 9.0 \times 10^{-12}$] in a $1.0 \times 10^{-2} \text{ M AgNO}_3$ solution.
A) $2.3 \times 10^{-8} \text{ mol/L}$ B) $1.3 \times 10^{-4} \text{ mol/L}$
C) $9.0 \times 10^{-10} \text{ mol/L}$ D) $9.0 \times 10^{-8} \text{ mol/L}$
18. One mole of an ideal gas at 25°C is expanded isothermally from 5.0 L to 10.0 L under such conditions that no work is produced in the surroundings. Which statement is correct?
A) $\Delta S_{\text{univ}} = 0$ B) $\Delta S_{\text{gas}} = 0$
C) $\Delta S_{\text{surr}} = 0$ D) $\Delta S_{\text{gas}} = \Delta S_{\text{surr}}$
19. Which of the following complexes would be diamagnetic (all electrons paired)?
A) $[\text{Co}(\text{CN})_6]^{3-}$ B) $[\text{Mn}(\text{CN})_6]^{4-}$
C) $[\text{Cr}(\text{CN})_6]^{3-}$ D) $[\text{V}(\text{CN})_6]^{3-}$
20. An element with the electron configuration $[\text{Xe}]4f^{14}5d^76s^2$ would belong to which class on the periodic table?
A) alkaline earth elements B) transition elements
C) halogens D) rare earth elements

II. Assays (60%) 請列出關鍵公式與計算過程。

1. Write the balanced molecular equation for the reaction between aqueous solutions of lithium phosphate and sodium hydroxide. (10%)
2. Calculate the molarity of the solution made by dissolving 100.0 g of calcium nitrate in 450.0 mL of aqueous solution. (10%)
3. Iodate can react with iodide to form iodine in acidic solution. Please answer the following questions.
(a) Balance the reaction. (5%)
(b) What volume of 0.2 M HCl is needed to produce $2.00 \times 10^{-3} \text{ mol}$ of iodine with an excess of potassium iodate and potassium iodide? (5%)
4. $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}(s)$ $E^\circ = 0.80 \text{ V}$; $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}(s)$ $E^\circ = 0.34 \text{ V}$. In a galvanic cell, the silver compartment contains a silver electrode and excess $\text{AgCl}(s)$ ($K_{sp} = 1.6 \times 10^{-10}$). The copper compartment contains a copper electrode, and $[\text{Cu}^{2+}] = 2.0 \text{ M}$. Please answer the following questions:
(a) Calculate the potential for this cell at 25°C . (5%)
(b) Assuming 1.0 L of 2.0 M Cu^{2+} in the copper compartment, calculate how many moles of NH_3 would have to be added to establish the cell potential at 0.52 V at 25°C (assume no volume change on addition of NH_3). ($\text{Cu}^{2+} + 4\text{NH}_3 \rightleftharpoons \text{Cu}(\text{NH}_3)_4^{2+}$ $K_f = 1.0 \times 10^{13}$) (5%)

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5. An electron is promoted from the π to the π^* molecular orbital in an N_2 molecule following the absorption of a photon. Please answer the following questions:
- (a) Which region of the electromagnetic spectrum is absorbed? (4%)
 - (b) Use the MO model to give the electron configuration for the excited N_2 . (3%)
 - (c) Compare the bond length in the non-excited molecule with that in the excited molecule. (3%)
6. Consider the reaction: $X_2Y(g) \rightarrow 2X(g) + Y(g)$. At $25^\circ C$, pure $X_2Y(g)$ was placed in a flask. The kinetics of the reaction were studied by monitoring the total pressure as a function of time. The following data were recorded for $\text{Rate} = -dP_{XY}/dt$. Determine the differential rate law for the reaction, and determine the value of the rate constant k . (10%)

| Time (h) | Total pressure ($\times 10^{-2}$ atm) | Time (h) | Total pressure ($\times 10^{-2}$ atm) |
|----------|--|----------|--|
| 0 | 1.00 | 100 | 2.42 |
| 20 | 1.66 | 120 | 2.49 |
| 40 | 1.99 | 140 | 2.55 |
| 60 | 2.19 | 160 | 2.59 |
| 80 | 2.32 | | |