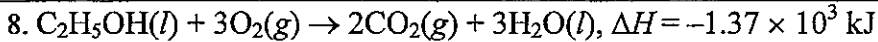


※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

一、選擇題(50%；每題 2%)

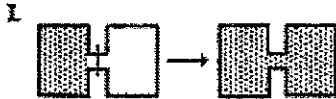
- How many of the following postulates of Dalton's atomic theory are still scientifically accepted?
I. All atoms of the same element are identical.
II. Compounds are combinations of different atoms.
III. A chemical reaction changes the way atoms are grouped together.
IV. Atoms are indestructible.
A) 0 B) 1 C) 2 D) 3 E) 4
- The limiting reactant in a reaction
A) is the reactant for which there is the least amount in grams
B) is the reactant which has the lowest coefficient in a balanced equation
C) is the reactant for which there is the most amount in grams
D) is the reactant for which there is the fewest number of moles
E) none of the above
- A solution contains the ions Ag^+ , Pb^{2+} , and Ni^{2+} . Dilute solutions of NaCl , Na_2SO_4 , and Na_2S are available to separate the positive ions from each other. In order to have an effect separation, the solutions should be added in which order?
A) Na_2SO_4 , NaCl , Na_2S B) Na_2SO_4 , Na_2S , NaCl C) Na_2S , NaCl , Na_2SO_4
D) NaCl , Na_2S , Na_2SO_4 E) NaCl , Na_2SO_4 , Na_2S
- How is the volume of the container related to the volume of an ideal gas?
A) The volume of the container is less than the volume of an ideal gas.
B) The volume of the container is more than the volume of an ideal gas.
C) They are equal.
D) The relationship depends on the gas.
E) none of these
- For a particular system at a particular temperature, there are _____ equilibrium constant(s) and _____ equilibrium position(s).
A) an infinite number of, one B) one, an infinite number of
C) one, one D) an infinite number of, an infinite number of
E) none of these
- The salt BX , when dissolved in water, produces an acidic solution. Which of the following could be true?
A) HX is a weak acid. B) HX is a strong acid.
C) The cation B^+ is a weak acid. D) All of these could be true.
E) Both HX and the cation B^+ are weak acids.
- Which of the following will *not* produce a buffered solution?
A) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.5 M HCl
B) 100 mL of 0.1 M NaHCO_3 and 25 mL of 0.5 M HCl
C) 100 mL of 0.1 M Na_2CO_3 and 125 mL of 0.2 M HCl
D) 50 mL of 0.2 M Na_2CO_3 and 5 mL of 1.0 M HCl
E) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH



For the combustion of ethyl alcohol as described in the above equation, which of the following statements is(are) true?

- I. The reaction is exothermic.
 II. The enthalpy change would be different if gaseous water were produced.
 III. The reaction is not an oxidation-reduction one.
 IV. The products of the reaction occupy a larger volume than the reactants.
 A) I, II B) I, II, III C) I, III, IV D) III, IV E) I only

9. Which of the following result(s) in an increase in the entropy of the system?



- I. (See diagram.)
 II. $\text{Br}_2(g) \rightarrow \text{Br}_2(l)$
 III. $\text{NaBr}(s) \rightarrow \text{Na}^+(aq) + \text{Br}^-(aq)$
 IV. $\text{O}_2(298 \text{ K}) \rightarrow \text{O}_2(373 \text{ K})$
 V. $\text{NH}_3(1 \text{ atm}, 298 \text{ K}) \rightarrow \text{NH}_3(3 \text{ atm}, 298 \text{ K})$
 A) I B) II, V C) I, III, IV D) I, II, III, IV E) I, II, III, V

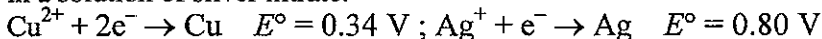
10. For the reaction $\text{A} + \text{B} \rightarrow \text{C} + \text{D}$, $\Delta H^\circ = +40 \text{ kJ}$ and $\Delta S^\circ = +50 \text{ J/K}$. Therefore, the reaction under standard conditions is

- A) spontaneous at temperatures less than 10 K.
 B) spontaneous at temperatures greater than 800 K.
 C) spontaneous only at temperatures between 10 K and 800 K.
 D) spontaneous at all temperatures.
 E) nonspontaneous at all temperatures.

11. In which of the following cases can E° be equal to zero?

- I. In any cell at equilibrium II. In a concentration cell
 III. E° can never be equal to zero.
 A) I only B) II only C) III D) I and II E) none of these

12. You make a cell with a copper electrode in solution of copper nitrate and a silver electrode in a solution of silver nitrate.



If you could increase the concentration of Ag^+ , which of the following would be true about the cell potential?

- A) It would increase. B) It would decrease.
 C) It would remain constant. D) This cannot be determined.

13. Which of the following statements about quantum theory is *incorrect*?

- A) The energy and position of an electron cannot be determined simultaneously.
 B) Lower energy orbitals are filled with electrons before higher energy orbitals.
 C) When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
 D) No two electrons can have the same four quantum numbers.
 E) All of these are correct.

14. According to the VSEPR model, the electron pairs around NH_3 and those around CH_4 are arranged
- differently, because in each case there are a different number of atoms around the central atom.
 - differently, because in each case there are a different number of electron pairs around the central atom.
 - the same, because both nitrogen and carbon are in the second period.
 - the same, because in each case there are the same number of electron pairs around the central atom.
 - differently or the same, depending on the conditions leading to maximum repulsion.
15. Specify the hybridization of the nitrogen atom in each of the following, in order.
- | | | | | | |
|-------------------|---------------------|---------------------|-----------------------|------------------|--|
| NO_3^- | N_2 | NO_2^- | | | |
| A) sp^3, sp, sp | B) sp^2, sp, sp^2 | C) sp^2, sp, sp^3 | D) sp^3, sp^2, sp^3 | E) none of these | |
16. What is the hybridization of the nitrogen atom?
- sp
 - sp^2
 - sp^3
 - dsp^3
 - d^2sp^3
17. A general reaction written as $2A + 2B \rightarrow C + 2D$ is studied and yields the following data.
- | $[A]_0$ | $[B]_0$ | Initial $\Delta[C]/\Delta t$ |
|---------|---------|--|
| 0.100 M | 0.100 M | $4.00 \times 10^{-5} \text{ mol/L} \cdot \text{s}$ |
| 0.200 M | 0.100 M | $4.00 \times 10^{-5} \text{ mol/L} \cdot \text{s}$ |
| 0.100 M | 0.200 M | $8.00 \times 10^{-5} \text{ mol/L} \cdot \text{s}$ |
- For the first of the reactions in the table of data, determine $-\Delta[B]/\Delta t$.
- 4.00×10^{-5}
 - 8.00×10^{-5}
 - 1.60×10^{-4}
 - 2.00×10^{-5}
 - none of these
18. The reaction $A \rightarrow B + C$ is known to be zero order in A with a rate constant of $5.0 \times 10^{-2} \text{ mol/L} \cdot \text{s}$ at 25°C . An experiment was run at 25°C where $[A]_0 = 1.0 \times 10^{-3} \text{ M}$. What is the integrated rate law?
- $[A] = kt$
 - $[A] - [A]_0 = kt$
 - $[A]_0 - [A] = kt$
 - $\ln \frac{[A]}{[A]_0} = kt$
 - $\frac{[A]}{[A]_0} = kt$
19. A liquid placed in a closed container will evaporate until equilibrium is reached. At equilibrium, which of the following statements is *not* true?
- The partial pressure exerted by the vapor molecules is called the vapor pressure of the liquid.
 - Liquid molecules are still evaporating.
 - The number of vapor molecules remains essentially constant.
 - The boundary (meniscus) between the liquid and the vapor disappears.
 - All of these statements are true.
20. The molar mass of a solid as determined by freezing-point depression is 10% higher than the true molar mass. Which of the following experimental errors could *not* account for this discrepancy?
- Not all the solid was dissolved.
 - More than the recorded amount of solvent was pipetted into the solution.
 - The solid dissociated slightly into two particles when it dissolved.
 - Some solid was left on the weighing paper.
 - Before the solution was prepared, the container was rinsed with solvent and not dried.

21. The compound SiO_2 does not exist as a discrete molecule while CO_2 does. This can be explained because:

- A) The Si-O bond is unstable. B) The SiO_2 is a solid while CO_2 is a gas.
 C) The Lewis structure of SiO_2 has an even number of electrons.
 D) The 3p orbital of the Si has little overlap with the 2p of the O.
 E) None of these.

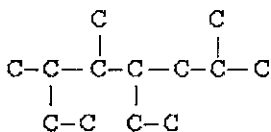
22. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of AgNO_3 ?

- A) $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$ B) $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ C) $\text{Cr}(\text{NH}_3)\text{Cl}]\text{NO}_3$
 D) $\text{Na}_3[\text{Cr}(\text{CN})_6]$ E) $\text{Na}_3[\text{CrCl}_6]$

23. $^{11}_6\text{C}$ is an unstable isotope. Which radioactive decay would be expected?

- A) β B) α C) fission D) ^1_0n E) ^0_1e

24. What is the compound whose carbon skeleton (minus any hydrogen atoms) appears below?



- A) 2,4-diethyl-3,6-dimethylheptane B) 2,5-dimethyl-4,6-diethylheptane
 C) 1,4-diethyl-3,6-dimethyl-tridecane D) 5-ethyl-3,4,6-trimethyloctane
 E) 4-ethyl-2,5,6-trimethyloctane

25. Which of the following interactions is not non-covalent?

- A) pi-pi interaction B) van der Waals interaction C) hydrogen bond
 D) Electrostatic interaction E) C-F

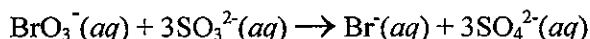
二、非選擇題(50%)

1. The isotope of an unknown element, X, has a mass number of 79. The most stable ion of the isotope has 36 electrons and forms a binary compound with sodium having a formula of Na_2X . Which of the following statements is(are) true? Correct the false statements.

(10%)

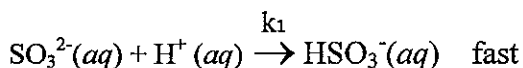
- a. The binary compound formed between X and Flourine will be a covalent compound.
 b. The isotope of X contains 38 protons.
 c. The isotope of X contains 41 neutrons

2. The rate law for the reaction



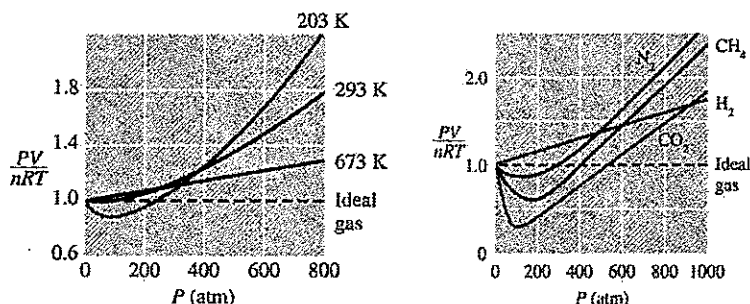
is $\text{rate} = k[\text{BrO}_3^-][\text{SO}_3^{2-}][\text{H}^+]$

The first step in a proposed mechanism is

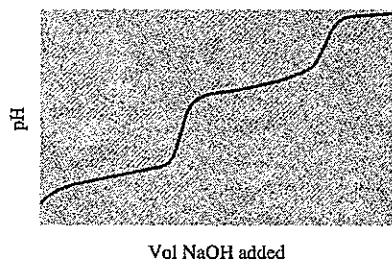


The second step is rate determining. Write a possible second step for the mechanism and derive the rate law. (10%)

3. a. The plot on the left side is obtained at three different temperatures for N_2 and the one on the right side is obtained at 200 K for several gases. Based on these two results, what conclusions can you make? (4%)



- b. Which one has the largest value of the van der Waals constant b : H_2 , N_2 , CH_4 , C_2H_6 , or C_3H_8 ? And which one has the largest value of van der Waals constant a : H_2 , N_2 , CH_4 , or CO_2 . Account for your answer. (4%)
4. When a diprotic acid, H_2A , is titrated with $NaOH$, the titration curve is a generic shape as following.



- a. If the first equivalent point occurs at 100.0 ml $NaOH$ added, what volume of $NaOH$ added corresponds to the second equivalence point? (4%)
- b. When i) between 0 and 100.0 ml of $NaOH$; ii) 100.0 ml of $NaOH$ are added respectively, list the major species present after OH^- reacts completely. (4%)
5. Liquid water at $25^\circ C$ is introduced into an evacuated, insulated vessel. Identify the signs of the following thermodynamic functions for the process that occurs: ΔH , ΔS , ΔG , ΔT_{water} , ΔS_{sum} , ΔS_{univ} . (6%)
6. A fuel cell designed to react grain alcohol with oxygen has the following net reaction:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$
 The maximum work 1 mole of alcohol can yield by this process is 1320 kJ. What is the theoretical maximum voltage this cell can achieve? ($F = 96485$ C/mol) (8%)