

※ 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 分)

1. When 4.0 L of oxygen gas (O_2) reacts with 2.0 L of nitrogen gas (N_2), 4.0 L of gaseous product is formed. All volumes of gases are measured at the same temperature and pressure. What is the formula of the product?
(A) NO_4 ; (B) NO_2 ; (C) N_2O_3 ; (D) N_2O ; (E) NO .
2. What is the correct formula for lead(IV) oxide?
(A) PbO_4 ; (B) PbO_3 ; (C) Pb_2O_3 ; (D) PbO_2 ; (E) Pb_4O .
3. The empirical formula of styrene is CH ; its molar mass is 104.1. What is the molecular formula of styrene?
(A) C_8H_{16} ; (B) C_8H_8 ; (C) $C_{10}H_{10}$; (D) $C_{12}H_{24}$; (E) C_4H_4 .
4. When the equation $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$ is balanced with the smallest set of integers, the sum of the coefficients is:
(A) 57; (B) 37; (C) 24; (D) 58; (E) 47.
5. Consider five solutions that all have the same mass of solute in 100.0 mL of solution. Which has the highest concentration as measured in molarity?
(A) NaF ; (B) $NaCl$; (C) KF ; (D) Na_2SO_4 ; (E) KCl .
6. What is the oxidation state of chromium in $K_2Cr_2O_7$?
(A) +5; (B) +6; (C) +7; (D) -4; (E) -6.
7. A balloon contains 10.0 g of neon gas. With the temperature kept constant, 10.0 g of argon gas is added. What happens?
(A) The volume of the balloon expands by more than 2 times.
(B) The balloon doubles in volume.
(C) The volume of the balloon expands by less than 2 times.
(D) The balloon stays the same size, but the pressure increases.
(E) None of these.

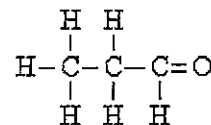
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8. Four identical 1.0-L flasks contain the gases He, Cl₂, CH₄, and NH₃, each at 0°C and 1.0 atm pressure. Which gas has the highest density?
(A) He ; (B) CH₄ ; (C) NH₃ ; (D) Cl₂ ; (E) All the gases have the same density.
9. The equilibrium constant for $A + 2 B \rightleftharpoons 3 C$ is 1.0×10^{-6} . Determine the equilibrium constant for $12 C \rightleftharpoons 4 A + 8 B$.
(A) 1.0×10^{-24} ; (B) 1.0×10^{-6} ; (C) 1.0×10^{24} ; (D) 1.0×10^6 ; (E) 1.0×10^{-12} .
10. To increase the value of K for the following exothermic reaction, we should
 $2H_2(g) + O_2(g) \rightleftharpoons H_2O(g)$
(A) decrease the temperature. ; (B) increase the temperature. ; (C) decrease the pressure. ;
(D) increase the pressure. ; (E) Two of these are necessary.
11. Calculate the pH of the $3.0 \times 10^{-12} M$ HCl aqueous solutions at 25°C.
(A) pH \approx 4.0–5.0 ; (B) pH \approx 11.0–12.0 ; (C) pH \approx 8.0–9.0 ;
(D) pH \approx 5.0–6.0 ; (E) pH \approx 6.0–7.0.
12. If K_a for HCN is 5.0×10^{-10} , what is K_b for CN⁻ at 25°C?
(A) 5.0×10^4 ; (B) 5.0×10^{-24} ; (C) 2.0×10^9 ; (D) 2.0×10^{-5} ; (E) 5.0×10^{15}
13. An indicator HIn has $K_a = 1 \times 10^{-8}$. At pH = 7.0, what is the ratio HIn/In⁻?
(A) 1/100 ; (B) 1/10 ; (C) 100/1 ; (D) 10/1 ; (E) none of these
14. Equal volumes of 0.1 M HCl and 0.1 M CH₃COOH are titrated with 0.1 M NaOH. Which of the following would be equal for both titrations?
(A) the pH at the equivalence point; (B) the initial pH; (C) the pH at the halfway point;
(D) the volume of NaOH added to reach the equivalence point;
(E) two of the above.
15. How many different possible dimethylbenzenes exist?
(A) 6 ; (B) 5 ; (C) 4 ; (D) 3 ; (E) 2.

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16. Identify the type of organic compound shown:

(A) amine ; (B) ketone ; (C) ester ; (D) aldehyde ; (E) alcohol.



17. Liquid A has vapor pressure x . Liquid B has vapor pressure y , and $x > y$. What is the mole fraction of A in the liquid mixture when the vapor above the solution is 50% A?

(A) $y/(2x + 2y)$; (B) $x/(2x + 2y)$; (C) $y/(x + y)$; (D) $x/(x + y)$; (E) $y/(x + 2y)$.

18. The osmotic pressure of a 0.010 M solution of NaCl in water at 25°C is found to be different from 372 torr because:

(A) osmotic pressures are hard to measure ; (B) Na^+ and Cl^- ions are strongly hydrated ;
 (C) NaCl does not dissociate in water; (D) Na^+ and Cl^- ions can form ion pairs;
 (E) Cl^- ions can react with water.

19. A certain solid substance that is very hard, has a high melting point, and is nonconducting unless melted is most likely to be:

(A) Ni ; (B) diamond; (C) I_2 ; (D) H_2O ; (E) NaCl.

20. Which of the following statements is true about p -type silicon?

(A) Electrons are the mobile charge carriers. (B) It is produced by doping Si with Ga or In.
 (C) It does not conduct electricity as well as pure Si. (D) All are true. (E) None is true.

21. What ions are very important for the proper functioning of biologic systems, such as nerves and muscles?

(A) alkali metal ions; (B) nitrogen ions ; (C) oxygen ions ; (D) sulfur ions;
 (E) alkaline earth metal ions.

22. Choose the correct molecular structure for PCl_4^+ .

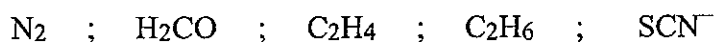
(A) trigonal bipyramidal ; (B) tetrahedral ; (C) octahedral ;
 (D) square planar ; (E) none of these.

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23. The electron pair in a C-F bond could be considered:

- (A) an inadequate model because the bond is ionic.
- (B) closer to C because carbon has a lower electronegativity than fluorine.
- (C) closer to C because carbon has a larger electronegativity than fluorine.
- (D) closer to F because fluorine has a higher electronegativity than carbon.
- (E) centrally located directly between the C and F.

24. How many of the following molecules and ions contain double or triple bonds?



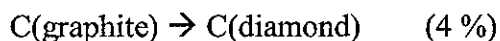
- (A) 1 ; (B) 2 ; (C) 3 ; (D) 4 ; (E) 5.

25. When the U-235 nucleus is struck with a neutron, the Zn-72 and Sm-160 nuclei are produced, along with some neutrons. How many neutrons are emitted?

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

二、非選擇題 (50%)

1. (a) Describe a simple method to measure the reaction enthalpy for a very slow reaction of



(b) Justify: at constant pressure $q_p = \Delta H$. (4%)

2. (a) Please derive the integrated rate law of the first-order reaction. (4%)

(b) Briefly describe how to get the activation energy of a reaction. (4%)

3. (a) Justify: at constant temperature and pressure $\Delta G = \text{maximum of } W_{\text{useful}}$ (6%)

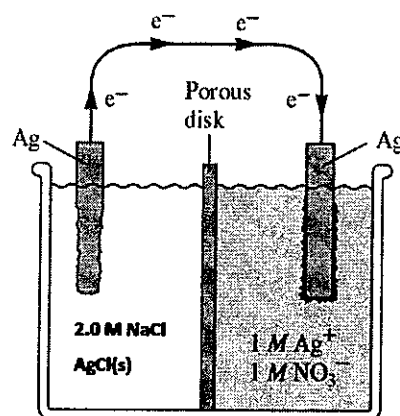
(b) What is the definition of entropy (S) by Boltzmann? (2%)

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4. (a) Write down the Nernst equation. (Hint: ϵ , ϵ° , Q) (2 %)

(b) A silver concentration cell similar to the right figure is set up at 25 °C with 1.0 M AgNO₃ in the right compartment and 2.0 M NaCl along with excess AgCl(s) in the left compartment. The K_{sp} of AgCl = 2.0×10^{-10} . Calculate the cell voltage (ϵ).

(Ag⁺ + e⁻ → Ag; $\epsilon^\circ = 0.80$ V) (6 %)



5. (a) When a metal surface with an electron-binding energy of E_0 is radiated with a photon with a frequency ν ($h\nu > E_0$), please calculate the wavelength of the emitted electron. (The mass of electron is m_e) (4 %)

(b) Use the molecular orbital model to predict the magnetism and bond order of the NO molecule. (6 %)

6. Draw the crystal field diagrams and the possible electron arrangement for the following compounds. Are they paramagnetic? Why? (8 %)

(a) CoCl₄²⁻ (tetrahedral complex) (Co: [Ar]4s²3d⁷)

(b) Fe(CN)₆³⁻ (CN⁻ is a strong-field ligand; Fe: [Ar]4s²3d⁶)