國立成功大學

111學年度碩士班招生考試試題

編　號：95

系　所：材料科學及工程學系
(綠色應用材料碩士班)

科　目：化學

日　期：0220

節　次：第 2 節

備　註：可使用計算機

編號： 95

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

化學共 50 題選擇題，每題答對得 2 分，答錯倒扣 0.5 分；滿分 100 分，倒扣至 0 分為止。

1. If reaction A has an activation energy of 250 kJ and reaction B has an activation energy of 100 kJ, which of the following statements must be correct? (a) If reaction A is exothermic and reaction B is endothermic then reaction A is favored kinetically. (b) At the same temperature the rate of reaction B is greater than the rate of reaction A. (c) The energy of reaction A must be greater than the energy of reaction B. (d) The energy of reaction B must be greater than the energy of reaction A.
2. Which of the following 0.1M aqueous solution has the lowest pH?(a) $NaNO_3$ (b) $C_6H_5NH_3NO_3$ (c) $C_6H_5NH_2$ (d) NaOH.
3. The reversible reaction: $2SO_2(g) + O_2(g) \leftrightarrows 2SO_3(g)$ has come to equilibrium in a vessel of specific volume at a given temperature. Before the reaction began, the concentrations of the reactants were 0.060 mol/L of SO_2 and 0.050 mol/L of O_2. After equilibrium is reached, the concentration of SO_3 is 0.040 mol/L. What is the equilibrium concentration of O_2? (a) 0.010 M (b) 0.020 M (c) 0.030 M (d) 0.040 M.
4. For an exothermic process, (a) the entropy of system decreases, and the entropy of the surrounding increases. (b) the enthalpy of system increases, and the enthalpy of the surrounding decreases. (c) it can be a spontaneous process during heating. (d) it is normally accompanied with the increase of system entropy.
5. An aqueous solution consisting of a mixture of a weak acid and its conjugate base (or vice versa) is: (a) neutral solution (b) very weak solution (c) barrier solution (d) buffer solution.
6. The sodium atom has 11 electrons. Two of them occupy a 1s orbital, two occupy a 2s orbital, and one occupies a 3s orbital. Which of those electrons experience the lowest effective nuclear charge? (a) 1s (b) 2s (c) 3s (d) 2p.
7. When a nonvolatile solute is dissolved in a solvent, (a) the freezing point of the solution is lower than that of pure solvent, because the vapor pressure of solvent is lowered by the interactions with solutes. (b) the freezing point of the solution remains the same because the vapor pressure of solvent is not influenced by the interactions with solutes. (c) the boiling point of the solvent decreases since the solute is nonvolatile. (d) the boiling point of the solvent remains the same since the solute is nonvolatile.
8. Please estimate the diameter of a benzene ring (a) 0.014 nm (b) 0.14 nm (c) 0.028 nm (d) 0.28 nm.
9. Please Indicate an increase or decrease in the entropy variation of the following two reactions: $CO_2(s)$ -> $CO_2(g)$; $CaO(s) + CO_2(g)$ -> $CaCO_3(s)$. (a) decrease; increase (b) increase; increase (c) decrease; decrease (d) increase; decrease.
10. For ideal gas, which one will NOT cause the increase of temperature? (a) to keep PV constant (b) to increase the volume of the gas particles at constant pressure (c) to increase the pressure at constant volume of the gas particles (d) to increase the average kinetic energy of the gas particles
11. A correct reaction mechanism for a given reaction usually is: (a) the same as its balanced chemical equation. (b) obvious if its heat of reaction is known. (c) obvious if its reaction order is known. (d) sometimes difficult to prove.

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12. Please identify a chemical formula for sodium sulfate. (a) $NaSO_4$. (b) Na_2SO_2. (c) Na_2SO_4. (d) $Na(SO_4)_2$.
13. For the standard entropy of a selected kind of molecules dispersed within a system, (a) it increases with the increase of the molar fraction. (b) it increases with the enhancement of spatial ordering of arrangement. (c) it is normally larger as the selected molecule is larger. (d) the fraction of translational entropy increases via the occurrence of crystallization.
14. Which description below is CORRECT: (a) Lewis acid donates an electron pair (b) Lewis acid/base is nothing to do with protons (c) Lewis base has a vacant valence orbital (d) Lewis acid is electrophilic.
15. Enthalpy changes for a chemical reaction are extremely important in thermochemistry. If the enthalpy content of the products of a reaction is less than that of the reactants, what kind of reaction of this? (a) heat absorption (b) endothermic (c) exothermic (d) desorption
16. Proton has the charge of (a) +1 (b) -1 (c) 0 (d) +2
17. In order to participate in molecular orbitals, atomic orbitals must overlap in space. This means (a) the valence orbitals of atom contribute significantly to the molecular orbitals of a particular molecule. (b) the 1s orbitals of Li must overlap in an appreciable extent. (c) the overlap of 1s atomic orbitals is much favored generally for atoms to be bonded together. (d) the hybridization of atomic orbitals should not include the s orbitals.
18. What is the characteristic outer-shell electron configuration of the element of Cl? (a) $3s^23p^4$ (b) $3s^13p^5$ (c) $3s^23p^6$ (d) $3s^23p^5$.
19. We know that the dissolving reaction of halide ions is $X^-_{(g)} \xrightarrow{H_2O} X^-_{(aq)}$. The enthalpies and entropies of gas halide ions dissolving in water are listed in the right table. Please refer to the table and choose the strongest halide acid. **Note:** The smaller radii, the lager Columbic interactions. (a) HF (b) HCl (c) HBr (d) HI.

X^-	$\Delta H°$ (k/mol)	$\Delta S°$ (J/K · mol)
F^-	-510	-159
Cl^-	-336	-96
Br^-	-334	-81
I^-	-291	-64

20. Which of the following samples would have the largest volume at 25℃ and 75 mmHg? (a) 100 g CH_4 (b) 100 g CO_2 (c) 100 g H_2O (d) 100 g SO_2.
21. Which statement is false? (a) If a reaction is thermodynamically spontaneous it may occur rapidly. (b) If a reaction is thermodynamically spontaneous it may occur slowly. (c) Activation energy is a kinetic quantity rather than a thermodynamic quantity. (d) If a reaction is thermodynamically spontaneous, it must have a low activation energy.

22. At equilibrium, a 1.0 liter container was found to contain 0.20 moles of A, 0.20 moles of B, 0.40 moles of C and 0.40 moles of D. If 0.10 moles of A and 0.10 moles of B are added to this system, what will be the new equilibrium concentration of A? $A(g) + B(g) \leftrightarrows C(g) + D(g)$ (a) 0.37 mol/L (b) 0.47 mol/L (c) 0.87 mol/L (d) 0.23 mol/L.
23. For the dissolution of an ionic solute, such as sodium chloride, in water, (a) the required energy to break the interactions between sodium and chloride ions renders this dissolution as an exothermic process. (b) the required energy to break the interactions between sodium and chloride ions renders this dissolution as an endothermic process. (c) the process to establish the interactions between ions and water renders this dissolution as an exothermic process. (d) the process to establish the interactions between ions and water renders this dissolution as an endothermic process.
24. A reaction/process occurred without transfer of heat or mass of substances between a thermodynamic system and its surroundings calls: (a) isothermal (b) adiabatic (c) steady state (d) equilibrium.
25. The reaction of $2O_3(g) \rightarrow 3O_2(g)$ is spontaneous at all temperatures and the reverse reaction is always nonspontaneous. Please indicate the sign of ΔH (enthalpy variation), ΔS (entropy variation), and ΔG (free energy variation), respectively. (a) –, +, – (b) –, –, – (c) +, –, + (d) –, –, +.
26. Brønsted and Lowry defined "An acid is a proton donor, a base is a proton acceptor", which is usually the concept of (a) acid-base titrations (b) oxidation-reduction reactions (c) balancing oxidation-reduction equations (d) acid-base reactions.
27. As we go across the elements located at the 2nd period of periodic table from left to the right, (a) the electron affinities generally becomes less negative. (b) the ionization energy increases generally. (c) the number of valence electrons decreases generally. (d) it is much easier to remove an electron from a lithium atom than a cesium atom.
28. Please identify the respective molecules of ICl, NF_3, and BCl_3 being polar or nonpolar. (a) Polar, polar, and nonpolar (b) Nonpolar, nonpolar, and nonpolar (c) Polar, polar, and polar (d) Nonpolar, polar, and polar.
29. The Royal Swedish Academy of Sciences had decided to award the Nobel Prize in Chemistry 2021 to Benjamin List and David MacMillan for the development of (a) asymmetric organocatalysis (b) a method for genome editing (c) lithium-ion batteries (d) the phage display of peptides and antibodies.
30. What is the number of unpaired electrons in O_2^+. (a) 0 (b) 1 (c) 3 (d) 2.
31. What is the net ionic equation for the acid-base reaction that occurs when nitric acid is added to copper(II) hydroxide? (a) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (b) $2H^+(aq) + Cu(OH)_2(s) \rightarrow Cu^{2+}(aq) + 2H_2O(l)$ (c) $2HNO_3(aq) + Cu(OH)_2(s) \rightarrow Cu(NO_3)_2(s) + 2H_2O(l)$ (d) $2H^+(aq) + 2NO_3^-(aq) + Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(NO_3)_2(s) + 2H_2O(l)$.
32. Which substances, $BaCl_2$, Ne, CO, and HF, own the highest and lowest boiling points? (a) $BaCl_2$ and HF. (b) HF and CO. (c) CO and Ne. (d) $BaCl_2$ and Ne.
33. The organic starting materials for the preparation of an ester could be _____. (a) an acid and an alcohol (b) a ketone and an alcohol (c) an alkane and a ketone (d) an amine and an acid.

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34. In order to increase the solubility of a selected solute, (a) increasing temperature is always an effective method. (b) finding the solvent with disparate polarity is always an effective method. (c) increasing the volume of solvent is always an effective method. (d) finding the solvent with similar electronegativity is always an effective method.

35. Which terminology is NOTHING to do with the so-called stereochemistry: (a) stereoisomer (b) enantiomer (c) chirality (d) polarizer.

36. In a chamber separated by a wall with a very small hole, we put four gases, CO_2, NH_3, O_2, and N_2, into one of the two separated rooms, which one of the four gases will effuse the largest amount into the empty room? **Note:** the probability of a gas molecule going through the small hole is proportional to the rate (1/second) hitting the wall. To calculate the effusion probability, you can use the kinetic energy of gases $\frac{3}{2}RT$ at constant environment temperature and assume both rooms have a fixed volume/dimension. (a) CO_2 (b) NH_3 (c) O_2 (d) N_2.

37. If you are designing a polymeric resin to filter mineral cations in hard water, such as Ca^{2+} and Mg^{2+}, which of the following functional groups may not be your first choice? **Note:** Please refer to the solubility table and find out your answer. (a) $-CO_2^-$ (b) $-PO_3^-$ (c) $-SO_3^-$ (d) $-NO_2^-$.

Unit: g/100 mL	carbonate	phosphate	sulfate	nitrate
Calcium	6.2×10^{-4}	0.002	0.255	121.2
Magnesium	0.039	2.6×10^{-4}	35.1	69.5

38. Please rank the ionization energies of the following elements in an ascending sequence. Ionization energy

(1) $[Xe]6s^2$ (2) $[Ar]4s^2$ (3) $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^2$ (4) $1s^22s^22p^63s^2$

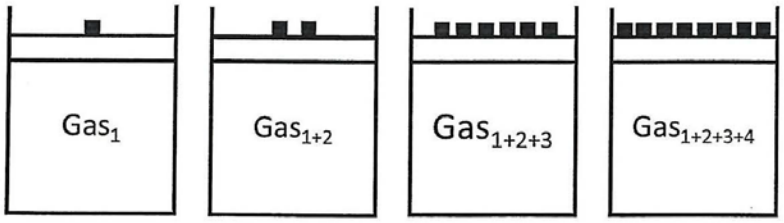
(a) (2)(1)(4)(3) (b) (1)(3)(2)(4) (c) (1)(2)(3)(4) (d) (4)(2)(3)(1).

39. Oxidized silver and marine materials fortunately have formed tightly bound adhesions that have protected silver coins for hundred years. To have higher market value, the oxidized silver and outer marine mineral must be removed for buyers' interests. You decide 1st, to slowly dissolve the outer shell and 2nd, to proceed electrolytic reaction on the oxidized silver. What is your "best" combination of the solutions in the 1st and 2nd steps? **Note:** The reduction potentials of silver, iron(III), sodium, potassium, and lithium are 0.80, 0.77, -2.71 and -3.04 V. (a) sulfuric acid and sodium hydroxide (b) hydrogen chloride and iron(III) chloride (c) potassium hydroxide and sodium hydroxide (d) sodium hydroxide and lithium hydroxide.

40. Bond order is defined as follows: bond order = ½ (number of bonding electrons – number of antibonding electrons). Please identify the bond order of the He_2^+ ion. (a) 1 (b) 2/3 (c) 1/2 (d) 2.

41. H_2SO_4 is a strong acid in its first dissociation step and has a dissociation constant of 1.2×10^{-2} in its second step. Calculate the pH of a 0.5 M H_2SO_4 solution. (a) 0.3 (b) 0.1 (c) 0 (d) -0.1.

42. A quantity of HI was sealed in a tube, heated to 425°C and held at this temperature until equilibrium was reached. The concentration of HI in the tube at equilibrium was found to be 0.0706 mol/L. Calculate the equilibrium concentration of H2 (and I2). For the gas-phase reaction, $H_2 + I_2 \rightleftharpoons 2HI$ Kc = 54.6 at 425°C (a) 9.55 x 10-3 M (b) 1.17 x 10-3 M (c) 1.85 x 10-4 M (d) 4.78 x 10-3 M.
43. Which of the following alcohols forms a ketone when oxidized? (a) 1-propanol (b) methanol (c) 2-methyl-2-propanol (d) 2-propanol.
44. Using the standard free energies of formation, calculate $\Delta G°$ for the following reaction at 298K: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$. $N_2(g)$: $\Delta G°_f = 0$, $H_2(g)$: $\Delta G°_f = 0$, $NH_3(g)$: $\Delta G°_f = -16.66$ kJ/mol. (a) 16.66 kJ (b) 33.32 kJ (c) -16.66 kJ (d) -33.32 kJ.
45. What is the oxidation state of Chromium (Cr) in the following compounds: $CrOCl_4^-$ and CrS? (a) +4 and +4 (b) +7 and +1 (c) +5 and +2 (d) -7 and -1.
46. Please arrange the following atoms and ions of Mg^{2+}, Ca^{2+}, and Ca in order of decreasing size. (a) $Ca^{2+} > Ca > Mg^{2+}$ (b) $Ca > Ca^{2+} > Mg^{2+}$ (c) $Mg^{2+} > Ca^{2+} > Ca$ (d) $Ca = Ca^{2+} = Mg^{2+}$.
47. Which description about entropy is CORRECT: (a) entropy is a measure of the amount of energy dispersal (b) entropy of the universe is at maximum at 0 K (c) entropy increases in a spontaneous process (d) total entropy of the universe always decreases.
48. Inside a piston at constant temperature, we put 4 kinds of gases into it. In order to keep piston volume constant, we must increase the counterweights above the piston as demonstrated in the below picture. Now we remove all the counterweights and decrease the piston volume to half of the original volume. Which kind of gas will experience the largest increase of pressure? (a) Gas1 (b) Gas2 (c) Gas3 (d) Gas4.



49. Which of the following atoms and ions of S^{2-}, S, and O^{2-} is largest? (a) O^{2-} (b) S (c) S^{2-} (d) The same.
50. In a sealed container enclosing a beaker of aqueous sugar solution and a beaker of pure water, (a) the volume of sugar solution increases gradually since the equilibrium vapor pressure of sugar solution is larger than that of pure water. (b) the volume of the pure water increases gradually since the equilibrium vapor pressure of sugar aqueous solution is larger than that of pure water. (c) the volume of sugar solution increases gradually since the equilibrium vapor pressure of sugar solution is smaller than that of pure water. (d) the volume of the pure water increases gradually since the equilibrium vapor pressure of sugar solution is smaller than that of sugar aqueous solution.