113BE02

國立臺北科技大學113學年度碩士班招生考試

系所組別：3602

化學工程與生物科技系生化與生醫工程碩士班

第一節　普通化學　試題（選考）

注意事項：

1. 本試題共40題，每題2.5分共100分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. Atom is constructed of different types of components. Which of the following is not a fundamental component to consist of an atom? (A) proton (B) neutron (C) electron (D) anion (E) quark.

2. The anomalous properties of the second period elements compared to the rest of their groups (e.g., lithium compared to other alkali metals) can be attributed to which of the following factors?
   (A) Lithium is absence of d-orbitals in the valence shells
   (B) Lithium have relatively larger atomic radii than the other alkali metals
   (C) The other alkali metals have higher electronegativities than lithium
   (D) Lithium atomic configuration is presence of half-filled p-orbitals
   (E) Lithium has lower ionization energy than the other alkali metals

3. Which of the following electron configurations corresponds to an excited state of an oxygen atom? (A) $1s^2 2s^2 2p^3 3s^1$ (B) $1s^2 2s^2 2p^6$ (C) $1s^2 2s^2 2p^4$ (D) $1s^2 2s^2 2p^3$ (E) $1s^2 2s^2 2p^6 3s^1$

4. If 4 moles of hydrogen react with 1 mole of oxygen to form water, what is the limiting reactant? (A) oxygen (B) hydrogen (C) water (D) dihydrogen monoxide (E) hydrogen peroxide

5. Which type of reaction is represented by: $AB \rightarrow A+B$?
   (A) synthesis (B) decomposition (C) single replacement (D) double replacement (E) combustion

6. Which pair of solutions will form a precipitate when mixed?
   (A) $AgNO_3$ and NaCl (B) NaCl and KNO_3 (C)HCl and NaOH
   (D)Na_2SO_4 and H_2O (E)$MgCl_2$ and KNO_3

7. According to the ideal gas law, what happens to the pressure of a gas when its volume is halved while keeping temperature constant?
   (A) pressure is halved (B) pressure remains the same (C) pressure is doubled
   (D) pressure is quadrupled (E) pressure will decrease to 1/4 of the initial pressure

8. Which gas deviates most from ideal behavior under conditions of 25 °C and 100 atm?
   (A) H_2 (B)He (C) CO_2 (D)N_2 (E) O_2

9. Which change in the equilibrium position will shift the equilibrium of the exothermic reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ to the right? (A)increasing the temperature (B)decreasing the pressure (C)adding a catalyst (D)removing some hydrogen (E)decreasing the volume

10. Which of the following is a weaker acid in aqueous solution? (A) HF (hydrofluoric acid) (B) HCl (hydrochloric acid) (C) $HClO_4$ (perchloric acid) (D) HBr (hydrobromic acid) (E) HI (hydroiodic acid)

11. Which of the following is a buffer solution?
    (A)0.1M HCl and 0.1M NaCl
    (B)0.1M CH_3COOH and 0.1M CH_3COONa
    (C)0.1M NaOH and 0.1M NaCl
    (D)0.1M HNO_3 and 0.1M $NaNO_3$
    (E)0.1M H_2SO_4 and 0.1M $KHSO_4$

12. What is the pOH of a 0.01 M aqueous solution of HCl at 25 °C? (A) 14 (B) 13 (C) 12 (D) 2 (E) 1

13. Which ion is most likely to precipitate first from a solution containing Ag^+, Ca^{2+}, NH_4^+, K^+ and Ba^{2+} when sulfate ion (SO_4^{2-}) is gradually added?
    (A) Ag^+ (B) Ca^{2+} (C) Ba^{2+} (D) NH_4^+ (E) K^+

14. Which process is an exothermic process?

    (A) combustion of methane

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(B) evaporation of water

(C) dissolving sugar in water

(D) melting of ice

(E) sublimation of dry ice

15. Which of the following processes have a positive change in enthalpy (ΔH)?

(A) freezing of water (B) combustion of buthane (C) formation of ozone (O_3) from oxygen (O_2) (D) condensation of steam (E) dissolution of NaOH in water

16. In which case is the change in free energy (ΔG) negative at all temperatures?

(A) ΔH positive, ΔS positive (B) ΔH negative, ΔS negative (C) ΔH positive, ΔS negative (D) ΔH negative, ΔS positive (E) ΔH and ΔS are zero

17. What is the standard electrode potential for a hydrogen electrode with $[H^+] = 0.1$ M, H_2 pressure in 1atm at 298 K?

(A) 0.00 V (B) 0.118 V (C) -0.760 V (D) -0.059 V (E) -1.00 V

18. Which statement is true for a galvanic cell operating under standard conditions?

(A) The anode is where reduction occurs

(B) The cell potential is zero

(C) The flow of electrons is from cathode to anode

(D) Ions get reduced by taking up electrons from the cathode

(E) The electrolyte concentrations change and the cell is a constant voltage during cell operation

19. Which principle states that no two electrons in an atom can have the same set of four quantum numbers?

(A) Aufbau principle (B) Hund's rule (C) Bohr model (D) Heisenberg uncertainty principle (E) Pauli exclusion principle

20. Considering the principles and typical electron configurations, which of the following transition metals demonstrate an exception to the expected electron configuration, but still represents a correct arrangement in accordance with the principles?

(A) Vanadium (V) atom with an electron configuration of [Ar] $3d^4 4s^1$, deviating from the expected full 4s-orbital

(B) Chromium (Cr) atom with an electron configuration of [Ar] $3d^5 4s^1$ due to half-filled d-orbital stability

(C) Manganese (Mn) atom with an electron configuration of [Ar] $3d^6 4s^1$, showing an unusual 4s-orbital occupancy

(D) Cobalt (Co) atom with an electron configuration of [Ar] $3d^6 4s^2$, not following the typical d-orbital filling order

(E) Nickel (Ni) atom with an electron configuration of [Ar]$3d^9 4s^1$, which is not in line with expected electron filling patterns

21. Which of the following statements about the first ionization energy of elements in the first five periods of the periodic table is correct?

(A) The first ionization energy decreases from lithium to neon in the second period.

(B) Magnesium has a lower first ionization energy than aluminum.

(C) Potassium has a higher first ionization energy than argon.

(D) The first ionization energy generally decreases from left to right across a period and increases from top to bottom in a group.

(E) The second ionization energy of an element is always larger than the first ionization energy

22. Which of the following statements accurately describes an aspect of ionic bonding and bonding energy in relation to the duet or octet rule?

(A) The formation of an ionic bond between sodium (Na) and chlorine (Cl) involves Na achieving a duet configuration by gaining an electron, resulting in a high bonding energy.

(B) In an ionic bond, magnesium (Mg) attains an octet by sharing two electrons with oxygen (O), leading to a moderate bonding energy.

(C) Fluorine (F) forms an ionic bond with sodium (Na) by transferring two electrons to Na, allowing both to satisfy the octet rule with low bonding energy.

(D) In a covalent bond, the atoms are bound by attraction of opposite ions, whereas in an ionic bond, atoms are bound by sharing electrons.

(E) The bonding energy in the ionic bond of sodium chloride (NaCl) is high due to the transfer of one electron from Na to Cl, allowing both to achieve stable electronic configurations.

23. Which of the following molecules correctly matches its description based on Lewis structure and the VSEPR model?

(A) CH_4 has a Lewis structure with four single bonds and no lone pairs on the carbon atom, leading to a linear molecular geometry.

(B) NH_3 possesses a trigonal planar structure with three single bonds and one lone pair on the nitrogen atom.

(C) BF_3 features a tetrahedral geometry with three single bonds and one lone pair on the boron atom.

(D) CO_2 has a linear structure with two double bonds to oxygen and two lone pairs on the carbon atom.

(E) H_2O has a bent molecular geometry with two single bonds and two lone pairs on the oxygen atom, and an approximate bond angle of 104.5°.

24. Which of the description matches a spectroscopic technique with its application for a specific compound?

(A) Using electronic spectroscopy to determine the exact mass of benzene (C_6H_6) by observing its absorption of UV-visible light.

(B) Applying vibrational spectroscopy (Infrared spectroscopy) to identify the presence of carbonyl groups in acetone (CH_3COCH_3) based on characteristic absorption bands.

(C) Utilizing rotational spectroscopy to determine the three-dimensional structure of insulin, a protein hormone.

(D) Employing nuclear magnetic resonance (NMR) spectroscopy to measure the speed of electrons moving around atomic nuclei in glucose ($C_6H_{12}O_6$).

(E) Using electronic spectroscopy to identify the presence of isotopes in carbon tetrachloride (CCl_4) by observing microwave radiation absorption.

25. Which of the following examples correctly illustrates the application of molecular orbital theory in a compound with a specific number of electron pairs?

(A) CO_2 (Carbon Dioxide) demonstrating molecular orbital arrangement for four electron pairs, resulting in a linear shape due to dsp^2 hybridization

(B) PF_5 (Phosphorus Pentafluoride) showing molecular orbital configuration for six electron pairs, leading to a trigonal bipyramidal shape due to sp^3d^2 hybridization

(C) H_2O (Water) with molecular orbitals for four electron pairs, leading to a bent shape due to dsp^2 hybridization and two lone pairs

(D) CH_4 (Methane) exhibiting molecular orbital characteristics of five electron pairs, achieving a tetrahedral shape due to sp^3 hybridization

(E) SF_6 (Sulfur Hexafluoride) with molecular orbitals for six electron pairs, forming an octahedral shape due to sp^3d^2 hybridization

26. Which of the following description correctly applies the concept of reaction order or the Arrhenius equation to a specific compound or reaction, along with a measurement scenario?

(A) The decomposition of hydrogen peroxide (H_2O_2) in the presence of iodide ion is a zero-order reaction because its rate is independent of the concentration of H_2O_2, typically observed by measuring the pressure change of H_2O_2 over time

(B) The hydrolysis of ethyl acetate ($CH_3COOC_2H_5$) in an acidic medium follows a first-order reaction, as its rate depends linearly on the concentration of ethyl acetate, observed through conductivity measurements

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(C) The reaction between hydrogen gas (H_2) and iodine gas (I_2) to form hydrogen iodide (HI) is a second-order reaction, with its rate proportional to the reactants of the concentrations of H_2 and I_2, monitored via instrumental methods of analysis

(D) The rate of an enzyme-catalyzed reaction following Michaelis-Menten kinetics is best described by the Arrhenius equation, where temperature changes affect the rate constant, measured using absorbance readings

(E) In the nitrogen dioxide (NO_2) dimerization reaction to form N_2O_4, the reaction follows a zero-order process, with the rate of reaction is solely dependent on the concentration of NO_2 , observed by color intensity changes at different temperatures

27. Which of the following scenarios correctly associates a specific type of intermolecular force or surface tension with a compound?

(A) The high boiling point of water (H_2O) is attributed to London dispersion forces, which are significant due to the small size and high polarity of the water molecule, observed by measuring its boiling point at different altitudes

(B) The tendency of carbon dioxide (CO_2) to dissolve in water is mainly due to strong hydrogen bonding between the CO_2 molecules and water, facilitating its absorption, observed in carbonated beverages

(C) Acetone (CH_3COCH_3) exhibits a higher surface tension compared to water due to its dipole-dipole interactions, which is observable through capillary action in thin tubes

(D) The high surface tension of water (H_2O) results primarily from hydrogen bonding, which leads to water forming droplets on non-polar surfaces, observed in the beading of water on waxy leaves

(E) The ability of iodine (I_2) crystals to sublime easily is due to hydrogen bonding, which results in its low vapor pressure and high sublimation rate, observed during the crystallization process

28. Which of the following description matches a material with its properties and a practical application or characteristic?

(A) Silica (SiO_2) used in the manufacturing of optical fibers due to its electrical conductivity, making it suitable for use in electrical wiring

(B) Borosilicate glass used in cookware, chosen for its magnetic properties that allow it to heat up quickly on induction stoves

(C) Porcelain, a type of ceramic, used in knife blades due to its high flexibility and resistance to shattering

(D) A silicon-based p-n junction in solar cells, where the p-type semiconductor is doped with boron and the n-type with phosphorus, creating a junction that converts light into electrical energy

(E) An n-type semiconductor made of silicon, doped with boron, used in thermoelectric coolers due to its unique heating properties when an electric current is applied

29. Which of the following scenarios accurately applies the concept of a varied compound's phase diagram?

(A) The phase diagram of carbon dioxide (CO_2) shows its triple point occurring at room temperature and atmospheric pressure, where solid, liquid, and gas phases coexist in equilibrium

(B) The critical point of water (H_2O) is observed at a temperature of 0°C and a pressure of 1 atm, beyond which liquid and gas phases are indistinguishable

(C) Helium's (He) phase diagram indicates a critical temperature near -268°C under 1 atm, the temperature at which it transitions directly from solid to gas without passing through a liquid phase

(D) For carbon dioxide (CO_2), the critical temperature is about 31°C and critical pressure is about 73 atm, the liquid phase of CO_2 does not exist at 1 atm

(E) The triple point of nitrogen (N_2) occurs at high temperatures typical of combustion processes, allowing it to exist in solid, liquid, and gaseous states simultaneously in engines

30. Which of the following of the description is correct?

(A) A solution of salt (NaCl) in water demonstrates a higher freezing point than pure water due to the effect of freezing-point elevation, a colligative property dependent on the number of solute particles

(B) The boiling point of an aqueous sugar solution is observed to be lower than that of pure water, exemplifying boiling-point elevation due to the non-volatile nature of the solute

(C) Raoult's law states: It establishes that the vapour pressure of an ideal solution directly depends on the vapour pressure of each chemical component and the mole fraction of the components present in the solution

(D) A solution of glucose in water exhibits a higher osmotic pressure than pure water at the same temperature, due to the presence of glucose molecules, which can be calculated using the van't Hoff factor is equal 2

(E) The addition of antifreeze (ethylene glycol) to water in a car radiator causes the solution to boil at a lower temperature, helping prevent the engine from overheating

31. Which of the following statements accurately describes the properties or occurrences of representative elements (Group 1A and 2A)?

(A) Potassium (K), a Group 1A element, is less reactive than magnesium (Mg) due to its lower position in the periodic table, making it less common in Earth's crust

(B) Calcium (Ca), a Group 2A element, is one of the least abundant elements in the Earth's crust, primarily found in rare minerals like turquoise

(C) Sodium (Na), a Group 1A element, is known for its high reactivity with water, a characteristic that makes it the most abundant element in Earth's oceans

(D) Magnesium (Mg), a Group 2A element, is an abundant element in the Earth's crust, primarily found in minerals like dolomite and magnesite, and plays a crucial role in biological processes

(E) Rubidium (Rb), a Group 1A element, is the most abundant alkali metal in Earth's crust and is commonly used in consumer electronics due to its abundance

32. Which of the following statements correctly associates a concept of nitrogen or its compounds with their industrial or natural process?

(A) The Ostwald process for manufacturing nitric acid (HNO_3) primarily involves the reaction of nitrogen (N_2) with hydrogen (H_2) at high temperatures and pressures, in the presence of a catalyst

(B) Ammonia (NH_3) is a key component of the nitrogen cycle in nature, where it forms by direct combination of nitrogen and oxygen in the atmosphere under lightning conditions

(C) In the Haber process, nitrogen (N_2) from the air is combined with oxygen (O_2) to produce ammonia (NH_3), which is then used to manufacture fertilizers and explosives

(D) Nitric acid is an important industrial chemical used in the manufacture of many products, such as nitrogen-based explosives and ammonium nitrate for use as a fertilizer

(E) Nitrogen, in the form of nitrates, natural sources of nitrate is fixed from the atmosphere in the nitrogen cycle primarily by industrial processes like the Ostwald process, rather than by biological systems

33. Which of the following statements correctly describes a basic chemical property of a specific class of hydrocarbons?

(A) Ethane (C_2H_6), an alkane, characteristically undergoes addition reactions due to the presence of a double bond between the carbon atoms, making it highly reactive

(B) Ethene (C_2H_4), an alkene, features a double bond between carbon atoms, which imparts rigidity to its structure and makes it susceptible to addition reactions

(C) Acetylene (C_2H_2), an alkyne, is known for its triple bond between carbon atoms, making it less reactive than alkenes and alkanes due to increased bond strength

(D) Benzene (C_6H_6), an aromatic hydrocarbon, has a ring structure with alternating single and triple bonds, making it highly stable and resistant to addition reactions

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(E) Butane (C_4H_{10}), an alkane, is characterized by its linear structure and the presence of a triple bond, which makes it particularly reactive in substitution reactions

34. Which of the following statements accurately describes a characteristic or function of a specific protein structure or type?

(A) Collagen, a protein, is characterized by its globular structure and is primarily involved in the storage and transport of various molecules in the body

(B) Hemoglobin, a fibrous protein, consists of a β-helix structure that enables its role in oxygen transport, stabilized by disulfide linkages between its chains

(C) Insulin, a hormone protein, demonstrates a primary structure that includes a specific sequence of amino acids linked by glycoside linkages, crucial for its function in regulating blood glucose levels

(D) Myoglobin, a fibrous protein, exhibits a tertiary structure with a pleated sheet arrangement, enabling its function in oxygen storage in muscle tissues

(E) Keratin, a fibrous protein, α-keratin has a structure predominantly composed of α-helix arrangements, which contribute to the mechanical strength of hair and nails

35. Which of the following statements correctly matches a carbohydrate or nucleic acid with its structure or function?

(A) Starch, a polysaccharide, is composed of monosaccharide units linked by peptide bonds and serves as a key energy storage molecule in animal cells

(B) DNA, or deoxyribonucleic acid, each nucleotide subunit is composed of a pentose sugar (deoxyribose), a nitrogenous base, and a phosphate group

(C) Sucrose, a disaccharide, is formed by the glycoside linkage of two glucose and is used primarily in RNA synthesis in cells

(D) Cellulose, a polysaccharide found in plant cell walls, is made of glucose units linked by disulfide linkages, giving it structural rigidity

(E) Glycogen, the primary storage form of glucose in plant cells, is a polysaccharide composed of glucose units linked by glycoside linkages

36. The reaction A →B + C is known to be zero order in A and zero order overall with a rate constant of 3.8×10^{-7} mol/L • s at 25°C. An experiment was run at 25°C where $[A]_0 = 2.2 \times 10^{-3}$ M. What is the rate after 6.8 minutes?

(A)3.8×10^{-7} mol/L • s

(B)1.5×10^{-11} mol/L • s

(C)8.1×10^{-4} mol/L • s

(D)2.2×10^{-3} mol/L • s

(E)8.4×10^{-5} mol/L • s

37. If the reaction $2HI \rightarrow H_2 + I_2$ is second order in HI and second order overall, which of the following will yield a linear plot?

(A) log [HI] vs. time

(B) 1/[HI] vs. time

(C) [HI] vs. time

(D) ln[HI] vs. time

(E) $[HI]^2$ vs. time

38. How much water must be added to 100.0 mL of an aqueous NaOH solution to change the pH from 12.00 to 11.00 at 25°C ?

(A) 1000.0 mL　(B) 900.0 mL　(C) 500.0 mL　(D) 400.0 mL　(E) 100.0 mL

39. Which of the following is the strongest reducing agent based on the following data?

Reaction	E° (volts)
$Na^+ + e^- \rightarrow Na$	–2.71
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36
$F_2 + 2e^- \rightarrow 2F^-$	+2.87

(A) Cl_2　(B) F_2　(C) Na　(D) Na^+　(E) F^-

40. A mixture of hydrogen and chlorine remains unreacted until it is exposed to ultraviolet radiation at room temperature. After the exposure, then the following reaction occurs very rapidly, which can be described below:

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$　$\Delta G = -45.54$ kJ

$\Delta H = -44.12$ kJ

$\Delta S = -4.76$ J/K

Select the statement that best explains this behavior.

(A) The reactants are thermodynamically more stable than the products

(B) The reaction has a very small equilibrium constant

(C) The reaction is not spontaneous at room temperature, the ultraviolet light raises the temperature of the system and makes the reaction more favorable

(D) The negative value for ΔS slows down the reaction

(E) The reaction is spontaneous, but the reactants are kinetically stable at room temperature