

※ 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(70%，每題 2%)

(1) Which of the following compound(s) is thermodynamically more stable than a N_2 molecule? a) N_2O
b) NO c) NO_2 d) N_2H_4 e) NH_3

(2) A certain metal fluoride crystallizes in such a way that the fluoride ions occupy simple cubic lattice sites, while the metal atoms occupy the body centers of half the cubes. What is the formula for this metal fluoride?
a) MF_2 b) M_2F c) MF d) MF_6 e) M_2F_3

(3) Which of the following is the correct order of boiling points for KNO_3 , CH_3OH , C_2H_6 , and Ne ?

a) $KNO_3 < CH_3OH < C_2H_6 < Ne$ b) $CH_3OH < Ne < C_2H_6 < KNO_3$

c) $Ne < C_2H_6 < KNO_3 < CH_3OH$ d) $Ne < C_2H_6 < CH_3OH < KNO_3$

e) $C_2H_6 < Ne < CH_3OH < KNO_3$

(4) Consider two liquids, A and B. Liquid A exhibits stronger intermolecular forces than liquid B. Which of the following statements is true?

a) The surface tension and viscosity of liquid A are greater than those of liquid B.

b) The surface tension of liquid A is greater than that of liquid B; the viscosity of liquid B is greater than that of liquid A.

c) The surface tension of liquid B is greater than that of liquid A; the viscosity of liquid A is greater than that of liquid B.

d) The surface tension and viscosity of liquid B are greater than those of liquid A.

e) The surface tension of liquid A is greater than liquid B, but the viscosity of two liquids are the same.

(5) Which one of the following is the strongest intermolecular force experienced by noble gases?

a) Hydrogen bonding b) Dipole-dipole interactions c) London dispersion forces d)
Ion-ion interactions e) Covalent bonding

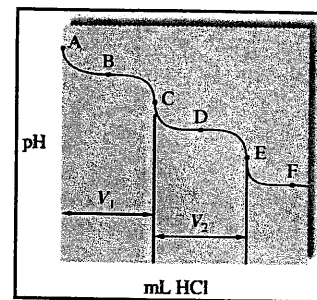
(6) Boron naturally occurs in two isotopic forms. The more common isotope is ^{11}B (atomic mass 11.01 amu), which is 80.00% abundant. The average atomic mass of boron is 10.81. What is the mass of the other isotope? a) 10.91 amu. b) 10.01 amu. c) 11.00 amu. d) 11.01 amu. e) 10.81 amu.

(7) The K_w of water at $25^\circ C$ is 1×10^{-14} . If the autoionization of water is endothermic, which of the following statements is correct for water at $50^\circ C$.

a) K_w is larger than 1×10^{-14} b) K_w is smaller than 1×10^{-14} c) K_w is 1×10^{-14} d) pH value is larger than 7 e) pH value is 7

(8) Which of the following solutions has the titration curve on the right?

- a) NH_3 b) CO_3^{2-} c) HCN d) PO_4^{3-} e) NaOH



(9) How many of the following oxides are amphoteric? Al_2O_3 , Ga_2O_3 , BeO , MgO , CaO , SrO , BaO , RaO

- a) 1 b) 2 c) 3 d) 4 e) 5

(10) How many of the following processes involve an increase in the entropy of the system? Melting of a solid, sublimation, freezing, diffusion, evaporation of a liquid

- a) 1 b) 2 c) 3 d) 4 e) 5

(11). A certain first-order reaction has a half-life of 40 mins. How much time is required for this reaction to be 87.5 % complete?

- a) 20 mins b) 40 mins c) 80 mins d) 120 mins e) 160 mins

(12). For the reaction $\text{A} + \text{B} \rightarrow \text{products}$, the following data were obtained:

Initial rate (mol/L•s)	0.030	0.059	0.060	0.090	0.090
$[\text{A}]_0$ (mol/L)	0.10	0.20	0.20	0.30	0.30
$[\text{B}]_0$ (mol/L)	0.20	0.20	0.30	0.30	0.50

What is the experimental rate law?

- a) Rate = $k[\text{A}]$
 b) Rate = $k[\text{B}]$
 c) Rate = $k[\text{A}][\text{B}]$
 d) Rate = $k[\text{A}]^2[\text{B}]$
 e) Rate = $k[\text{A}][\text{B}]^2$

(13). The following are produced by radioactive processes. Which one has mass but no charge? a) alpha particle, b) beta particle, c) gamma ray, d) neutron, e) positron

(14) How many of the following molecules have a free radical? Superoxide, peroxide, nitric oxide, carbon monoxide, nitrous oxide, ozone

- a) 1 b) 2 c) 3 d) 4 e) 5

(15) A chemist needs to prepare a buffered solution using one of the following acids (and its sodium salt):

HA ($K_a = 1.35 \times 10^{-3}$), HB ($K_a = 1.1 \times 10^{-5}$), HC ($K_a = 6.4 \times 10^{-5}$), HD ($K_a = 3.5 \times 10^{-7}$), HE ($K_a = 1.89 \times 10^{-8}$). To prepare a solution buffered at $\text{pH} = 5.10$, which system will work best?

- a) HA and its sodium salt, b) HB and its sodium salt, c) HC and its sodium salt, d) HD and its sodium salt e) HE and its sodium salt

(16) Regarding a B₂ molecule, which of the following statements is true?

- a) The bond order of B₂ molecule is two
- b) The highest occupied molecular orbital (HOMO) is σ_{2p}
- c) The lowest unoccupied molecular orbital (LUMO) is σ_{2p}^*
- d) B₂ molecule is a paramagnetic species
- e) The lowest unoccupied molecular orbital (LUMO) is π_{2p}^*

(17) How many "three-center bond" does a diborane molecule (B₂H₆) have?

- a) 1 b) 2 c) 3 d) 4 e) 5

(18) Please indicate the order of wavelength for the following radiation (in a decreasing order)?

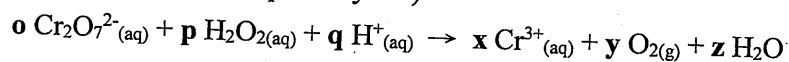
(I) Microwave frequency, (II) Radio frequency, (III) Infrared light, (IV) γ -ray frequency,

- a) I, II, III, IV b) IV, III, I, II c) II, I, III, IV d) III, IV, I, II e) IV, III, II, I

(19). Which of the following statements is NOT true?

- a) the reaction constant might change when the reaction temperature change
- b) the reaction constant won't change when the concentration of reactants change
- c) the reaction constant might change when the catalyst is added to the reaction
- d) the activation of energy for a reaction might change when the catalyst is added
- e) the activation of energy for a reaction might change when the reaction temperature change

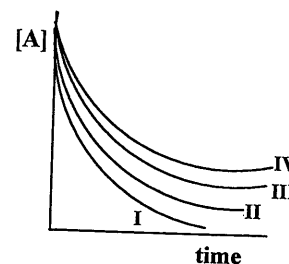
(20) Please balance the following equation (o, p, q, x, y, z are reaction coefficients). What is the sum of all coefficients (o + p + q + x + y + z)



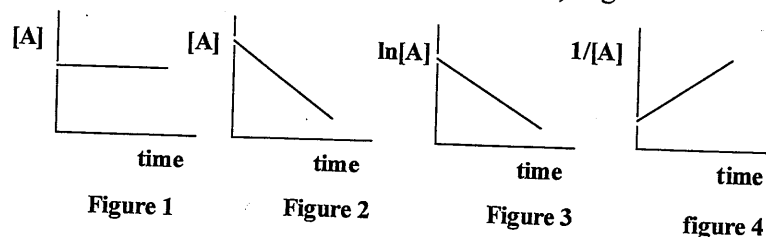
- a) 18 b) 20 c) 22 d) 24 e) 26

(21) The graph shows the concentration of reactants versus reaction time in four different first-order reactions. Which reaction has the largest reaction rate constant?

- a) I b) II c) III d) IV e) the same



(22) Which of the following plots shows that the reaction $A \rightarrow B$ is a second order reaction? [A]: the concentration of A



(23) The formation rate of dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ions is $0.32 \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$ in the reaction $2\text{CrO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$. What is the reaction rate of chromate ions (CrO_4^{2-}) in the reaction?

- a) $0.16 \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$ b) $0.32 \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$ c) $0.64 \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$ d) $1.28 \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$

(24). Which of the following is NOT determined by the principal quantum number n of the electron in a hydrogen atom?

- a) the energy of the electron
b) the minimum wavelength of the light needed to remove the electron from the atom
c) the size of the corresponding atomic orbital(s)
d) the shape of the corresponding atomic orbital(s)
e) all of these are determined by n

(25) The observed osmotic pressure for 0.10 M solution of FeCl_3 at 27°C is 7.38 atm. What are the expected and experimental values for i (van't Hoff factor)? Gas law constant is $0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$

- a) expected value is 4, experimental value is 3.8
b) expected value is 4, experimental value is 3.6
c) expected value is 4, experimental value is 3.0
d) expected value is 3, experimental value is 3.8
e) expected value is 3, experimental value is 3.6

(26). Which of the following statements is NOT true?

- a) The 2s and 2p orbitals are degenerate in a hydrogen atom.
b) The 2s orbital has two nodes which are areas of zero electron probability.
c) The d orbital has 5 subshells.
d) The dependence of the wave function on the angular momentum quantum number determines the shapes of the atomic orbital.
e) The d orbitals are degenerate in Fe^{2+} free ion, but not in $[\text{FeCl}_4]^{2-}$ complex.

(27). For an unstable proton-rich nuclide, which of the following decay processes is most unlikely to occur in order to reach a stable nucleus? a) β^- emission b) proton emission c) positron production
d) electron capture e) α -particle production

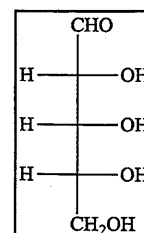
(28). Which of the following is a buffer solution with the best capacity?

- a) 1.0 L solution containing 0.50 M NaOH and 0.50 M HCl
b) 1.0 L solution containing 0.05 M NaOCl and 0.50 M HOCl
c) 1.0 L solution containing 0.50 M NH_4OH and 0.50 M NH_4Cl
d) 1.0 L solution containing 0.50 M NaCl and 0.50 M HCl
e) 1.0 L solution containing 0.50 M NaF and 0.05 M HF

(29) Mixing 500 mL of 0.20 M CH_3COOH solution and 500 mL of 0.20 M CH_3COONa solution, what is the final pH value? (K_a for $\text{CH}_3\text{COOH} = 1.8 \times 10^{-5}$) 分。

- a) 6.25 b) 4.85 c) 3.75 d) 5.25 e) 5.75

(30) The structure of pentose is shown on the right figure. How many carbon atoms with chirality in this molecule?



- a) 1 b) 2 c) 3 d) 4 e) 5

(31) What amount of $\text{Al}_{(s)}$ can be produced from Al_2O_3 if 5 moles of electrons are supplied? The atomic mass of Al is 26.98

- a) 135 g b) 67 g c) 45 g d) 81 g e) 54 g

(32) Which of the following solution has the better solubility for $\text{Ag}_3\text{PO}_4(s)$?

- (a) a solution buffered at pH 4.2 (b) a solution buffered at pH 7.0 (c) a solution buffered at pH 8.2 (d) a AgNO_3 solution (e) a Na_3PO_4 solution

(33) The Effusion rate for a gas is R_1 at 25°C and R_2 at 323°C . The Average kinetic energy for a gas is E_1 at 25°C and E_2 at 323°C . The Mean free path for a gas is λ_1 at 25°C and λ_2 at 323°C . Which of the following statements is true?

- a) $R_1:R_2 = 1:1.414$ $E_1:E_2 = 1:2$ $\lambda_1:\lambda_2 = 1:1$
 b) $R_1:R_2 = 1:2$ $E_1:E_2 = 1:2$ $\lambda_1:\lambda_2 = 1:1$
 c) $R_1:R_2 = 1:2$ $E_1:E_2 = 1:2$ $\lambda_1:\lambda_2 = 1:1.414$
 d) $R_1:R_2 = 1:1.414$ $E_1:E_2 = 1:1.414$ $\lambda_1:\lambda_2 = 1:2$
 e) $R_1:R_2 = 1:1.414$ $E_1:E_2 = 1:1.414$ $\lambda_1:\lambda_2 = 1:1$

(34) When 2.00 mol of $\text{SO}_{2(g)}$ reacts completely with 1.00 mole of $\text{O}_{2(g)}$ to form 2.00 mol of $\text{SO}_{3(g)}$ at 27°C and a constant pressure of 1.00 atm, 150 kJ of energy is released as heat. Calculate ΔE (the change in system's internal energy) for this process. ($R = 8.3145 \text{ J K}^{-1} \text{ mole}^{-1}$)

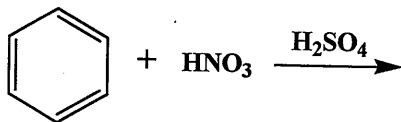
- a) $\Delta E = -152.5 \text{ kJ}$ b) $\Delta E = -155.0 \text{ kJ}$ c) $\Delta E = -145.0 \text{ kJ}$ d) $\Delta E = -147.5 \text{ kJ}$ e) $\Delta E = -150 \text{ kJ}$

(35) The spontaneous process from liquid phase to gas phase for a molecule X_2 at 1 atm has ΔH° of 38.0 kJ/mol and ΔS° of $90.0 \text{ J K}^{-1} \text{ mol}^{-1}$. What is the normal boiling point of liquid X_2 ?

- a) 273 K b) 333 K c) 375 K d) 422 K e) 298 K

二.非選擇題

(1) Please write the product for the following reaction. (2%)



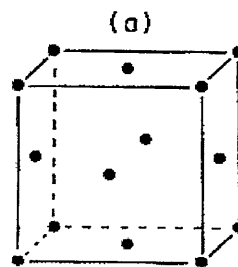
(2) Please draw the molecular structure for the cis form of 1,2-dibromoethene. (2%)

(3) Please write down the chemical reaction for the preparation of ammonia gas in industry. (2%)

(4) An metal atom crystallizes in a cubic closest packed structure, shown on the right.

The radius of this atom is 1.44 Å. Calculate the density of solid silver.

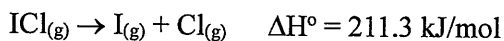
What is the net number in a unit cell (z value)? (2%)



(5) Following the question “4”, what is the fraction of the space occupied by the atom spheres in a cubic closest packed structure? (2%)

(6). What amount in gram of Al(s) can be produced from Al₂O₃ if 5 mol e⁻ is supplied? The atomic mass of Al is 26.98 (2%)

(7) Calculate the standard enthalpy of formation of the compound ICl in kJ/mol. (2%)



(8) Please draw the d orbital splitting for [Fe(CN)₆]³⁻ in an octahedral geometry. (2%)

(9) Followed the question “(8), please label the orbitals and fill the d electrons. (2%)

(10) Predict the number of unpaired electron in [Fe(CN)₆]³⁻ (2%)

Please answer questions “11-15” about molecular orbital Model of He₂¹⁺⁺.

(11) Please draw the MO energy-level diagram for the He₂¹⁺. (2%)

You have to label bonding orbital (σ) and antibonding orbital (σ*). You have also to fill electrons in molecular orbitals.

(12) If atomic orbitals of two He atoms are 1s_A and 1s_B, what are wave functions of two resulted molecular orbitals (MOs)? (2%)

(13) Please draw the shapes of two molecular orbitals (MOs). (2%)

(14) What is bond order of He_2^{1+} ? (2%)

(15) Is He_2^{1+} paramagnetic or diamagnetic? (2%)