

※ 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。

I 單選題 (60 分, 每題 3 分)

(1). Three solutions have violet, blue and yellow color.

Each solution has one of the following compounds: (a) $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$, (b) $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$, and (c) $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$. Which compound has the color of yellow (please use the table in the following) ? a) $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$, b) $[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$, and c) $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$ d) can not be determined.

Absorbed wavelength in nm (color)	Observed color
400 violet	Greenish yellow
450 blue	yellow
570 yellow-green	Violet
580 yellow	Dark blue
600 orange	blue
650 red	green

(2). Consider the complex ions $\text{Co}(\text{NH}_3)_6^{3+}$, $\text{Co}(\text{CN})_6^{3-}$, CoF_6^{3-} and CoCl_6^{3-} . The wavelengths of absorbed electromagnetic radiation for these compounds are 770 nm, 680 nm, 440 nm, and 290 nm (in no specific order). Which is the complex that absorbs electromagnetic radiation of 440 nm? a) $\text{Co}(\text{NH}_3)_6^{3+}$, b) $\text{Co}(\text{CN})_6^{3-}$, c) CoF_6^{3-} and d) CoCl_6^{3-} .

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

(4) A metal complex has a trigonal bipyramidal geometry. Which d orbital has the highest energy?

a) d_{xy} b) d_{xz} c) d_{yz} d) d_z^2 e) $d_{x^2-y^2}$

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

- a) $\text{KNO}_3 < \text{CH}_3\text{OH} < \text{C}_2\text{H}_6 < \text{Ne}$
- b) $\text{CH}_3\text{OH} < \text{Ne} < \text{C}_2\text{H}_6 < \text{KNO}_3$
- c) $\text{Ne} < \text{C}_2\text{H}_6 < \text{KNO}_3 < \text{CH}_3\text{OH}$
- d) $\text{Ne} < \text{C}_2\text{H}_6 < \text{CH}_3\text{OH} < \text{KNO}_3$
- e) $\text{C}_2\text{H}_6 < \text{Ne} < \text{CH}_3\text{OH} < \text{KNO}_3$

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(6) 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.

(7) 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

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

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

(9) 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.

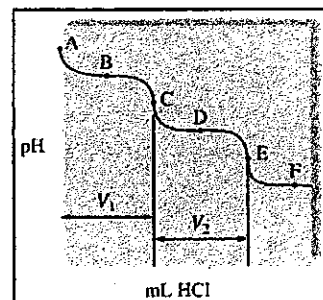
(10) The K_w of water at 25°C is 1×10^{-14} . If the autoionization of water is endothermic., which of the following statement is correct for water at 50°C .

- 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

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(11) Which of the following solution will have the titration curve on the right?

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



(12) How many of the following oxides are amphoteric? Al_2O_3 ,

- Ga_2O_3 , BeO , MgO , CaO , SrO , BaO , and RaO a) 1 b) 2 c) 3 d) 4 e) 5

(13) 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

(14). A certain first-order reaction has a half-life of 40.0 mins. How much time is required for this reaction to be 75 % complete?

- a) 20 mins b) 40 mins c) 80 min d) 160 min e) 320 min

(15). 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) $\text{Rate} = k[\text{A}]$
 b) $\text{Rate} = k[\text{B}]$
 c) $\text{Rate} = k[\text{A}][\text{B}]$
 d) $\text{Rate} = k[\text{A}]^2[\text{B}]$
 e) $\text{Rate} = k[\text{A}][\text{B}]^2$

(16). 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

(17) How many of the following molecules have free radical? superoxide peroxide

nitric oxide ozone

- a) 1 b) 2 c) 3 d) 4 e) none

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(18) 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 ($K_a = 6.4 \times 10^{-5}$), (Ka = 3.5×10^{-7}), HD ($K_a = 1.89 \times 10^{-8}$). To prepare a solution buffered at 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.

(19). What oxidation state of metal does not exist?

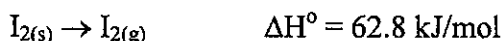
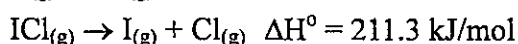
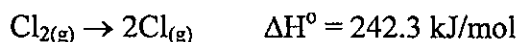
a) Fe^{2+} b) Mn^{+7} c) Zn^{3+} d) Ni^{2+} e) Cr^{3+}

(20) How many "three-center bond" does diborane molecule have?

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

II 簡答題 (24 分, 每題 3 分)

(1). Calculate the standard enthalpy of formation of the compound ICl in kJ/mol



(2). What amount in gram of Al(s) can be produced from Al_2O_3 if 5 mol e^- is supplied?

The atomic mass of Al is 26.98

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

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

(5) Please write down the chemical reaction for the preparation of methanol in industry.

(6) Please draw the molecular structure for toluene

(7) Please draw the molecular structure for the cis form of dibromoethene

(8) Please draw the molecular structure of Isopropylethanoate

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III 簡答題 (16 分, 每題 2 分)

Please answer questions about molecular orbital Model of He_2 , He_2^{1+} , or He_2^{2+} .

1. Please draw the MO energy-level diagram for the He_2^{1+} .
You have to label bonding orbital (σ) and antibonding orbital (σ^*). You have also to fill electrons in molecular orbitals.
2. If atomic orbitals of two He atoms are $1s_A$ and $1s_B$, what are wave functions of two resulted molecular orbitals (MOs)?
3. Please draw the shapes of two molecular orbitals (MOs).
4. What is bond order of He_2^{1+} ?
5. Is He_2^{1+} paramagnetic or diamagnetic?
6. Write electron configuration for He_2^{+} ?
7. What is order of the bond strength for He_2 , He_2^{1+} , He_2^{2+} (in a increasing order)?
8. What is order of the bond distance for He_2 , He_2^{1+} , He_2^{2+} (in a increasing order)?