

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

一單選題 70% (每題 2.5 分，共 28 題)

1. 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 less than 2 times.  
B) The volume of the balloon expands by more than 2 times.  
C) The balloon doubles in volume.  
D) The balloon stays the same size, but the pressure increases. E) none of these

2. Which of the following statements is true concerning ideal gases?

- A) The temperature of the gas sample is directly related to the average velocity of the gas particles.  
B) At STP, 1.0 L of Ar(g) contains about twice the number of atoms as 1.0 L of Ne(g) because the molar mass of Ar is about twice that of Ne.  
C) A gas exerts pressure as a result of the collisions of the gas molecules with the walls of the container.  
D) The gas particles in a sample exert attraction on one another.  
E) All of these statements are false.

3. A sample of solid  $\text{NH}_4\text{NO}_3$  was placed in an evacuated container and then heated so that it decomposed explosively according to the following reaction:



At equilibrium, the total pressure in the container was found to be 2.25 atm at a temperature of  $500^\circ\text{C}$ . Calculate  $K_p$ .

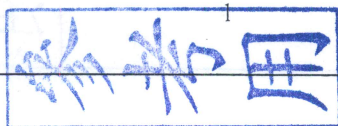
- A) 45.6 B) 5.06 C) 2.25 D) 22.5 E) 1.69

4. Calculate the pH of a solution made by a mixture of the following acids: 0.40 M  $\text{HC}_2\text{H}_3\text{O}_2$  ( $K_a = 1.8 \times 10^{-5}$ ;  $\log 1.8 = -0.255$ ), 0.10 M  $\text{HOCl}$  ( $K_a = 3.5 \times 10^{-8}$ ;  $\log 3.5 = 0.544$ ), and 0.20 M  $\text{HCN}$  ( $K_a = 6.2 \times 10^{-10}$ ;  $\log 6.2 = 0.792$ ).

- A) 2.57 B) 3.49 C) 3.92 D) 4.23 E) 4.95

5. In the titration of a weak acid HA with 0.100 M NaOH, the stoichiometric point is known to occur at a pH value of approximately 10. Which of the following indicator acids would be best to use to mark the endpoint of this titration?

- A) indicator A,  $K_a = 10^{-14}$  B) indicator B,  $K_a = 10^{-11}$  C) indicator C,  $K_a = 10^{-8}$   
D) indicator D,  $K_a = 10^{-6}$  E) indicator D,  $K_a = 10^{-3}$



注意：背面有試題

類組：化學類 科目：綜合化學(1001)

共 8 頁 第 2 頁

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

6. A student titrates an unknown weak acid, HA, to a pale pink phenolphthalein endpoint with 25.0 mL of 0.100 M NaOH. The student then adds 13.0 mL of 0.100 M HCl. The pH of the resulting solution is 4.7. Which of the following statements is true?
- A) At pH 4.7, half of the conjugate base,  $A^-$ , has been converted to HA.  
 B) The pKa of the acid is 4.7.  
 C) The pKa of the acid is less than 4.7.  
 D) The pKa of the acid is greater than 4.7.  
 E) More than one of the above statements are correct.
7. Consider a solution made by mixing 500.0 mL of 4.0 M  $NH_3$  and 500.0 mL of 0.40 M  $AgNO_3$ .  $Ag^+$  reacts with  $NH_3$  to form  $AgNH_3^+$  and  $Ag(NH_3)_2^+$ :
- $$Ag^+ + NH_3 \rightleftharpoons AgNH_3^+ ; K_1 = 2.1 \times 10^3$$
- $$AgNH_3^+ + NH_3 \rightleftharpoons Ag(NH_3)_2^+ ; K_2 = 8.2 \times 10^3$$
- The concentration of  $Ag^+$  at equilibrium is
- A) 2.0 M. B)  $1.2 \times 10^{-8}$  M. C)  $4.5 \times 10^{-9}$  M. D) 1.6 M. E)  $4.5 \times 10^{-8}$
8. Which statement is true of a process in which 1 mol of a gas is expanded from state A to state B?
- A) When the gas expands from state A to state B, the surroundings are doing work on the system.  
 B) The amount of work done in the process must be the same, regardless of the path.  
 C) It is not possible to have more than one path for a change of state.  
 D) The final volume of the gas will depend on the path taken.  
 E) The amount of heat released in the process will depend on the path taken.
9. When a student performs an endothermic reaction in a calorimeter, how (if any) does the calculated value of  $\Delta H$  differ from the actual value if the heat exchanged with the calorimeter is not taken into account?
- A)  $\Delta H_{calc}$  is more negative because the calorimeter always absorbs heat from the reaction.  
 B)  $\Delta H_{calc}$  is less negative because the calorimeter absorbs heat from the reaction.  
 C)  $\Delta H_{calc}$  is more positive because the reaction absorbs heat from the calorimeter.  
 D)  $\Delta H_{calc}$  is less positive because the reaction absorbs heat from the calorimeter.  
 E)  $\Delta H_{calc}$  equals the actual value because the calorimeter does not absorb heat.



※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

10. In a certain reversible expansion, a system at 300. K absorbs exactly  $6.00 \times 10^2$  J of heat. In the irreversible recompression to the original state of the system, twice as much work is done on the system as is performed on the surroundings in the expansion. What is the entropy change of the system in the recompression step?  
A)  $-4.00$  J/K B)  $-2.00$  J/K C)  $0.00$  J/K D)  $2.00$  J/K E)  $4.00$  J/K

11. In which of the following changes is the work done by the system the largest at  $25^\circ\text{C}$ ?

- A) an isothermal free expansion of an ideal gas from 1 L to 10 L
- B) an isothermal expansion of an ideal gas from 1 L to 10 L against an opposing pressure of 1 atm
- C) an isothermal expansion of an ideal gas from 1 L to 10 L against an opposing pressure of 5 atm
- D) an isothermal reversible expansion of an ideal gas from 1 L to 10 L
- E) The work is the same for all these processes.

12. Which of the following statements is true?

- A) We can determine the exact location of an electron if we know its energy.
- B) Ni has 2 unpaired electrons in its 3d orbitals.
- C) An electron in a 2s orbital can have the same n, l, and ml quantum numbers as an electron in a 3s orbital.
- D) In building up of atoms, electrons occupy the 4f orbitals before the 6s orbitals.
- E) Only three quantum numbers are needed to uniquely describe an electron.

13. An electron in a one-dimensional box requires energy with wavelength 8080 nm to excite it from the  $n = 2$  energy level to the  $n = 3$  energy level. Calculate the length of the box. ( $m_e = 9.11 \times 10^{-31}$  kg;  $h = 6.626 \times 10^{-34}$  kg.m<sup>2</sup>.s<sup>-1</sup>)

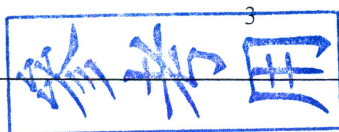
- A) 1.00 nm B) 1.50 nm C) 2.50 nm D) 3.00 nm E) 3.50 nm

14. How many of the following molecules have all of their atoms in the same plane?



- A) 3 B) 4 C) 5 D) 6 E) 7

15. Consider the second-order reaction  $a\text{A} \rightarrow \text{products}$  (which has a first half-life of 24 s). If the concentration of A after 15.4 s is 0.40 M, determine the initial concentration of A. A) 0.61 M, B) 0.15 M C) 0.30 M D) 0.20 M E) 0.66 M



注意：背面有試題

類組：化學類 科目：綜合化學(1001)

共 8 頁 第 4 頁

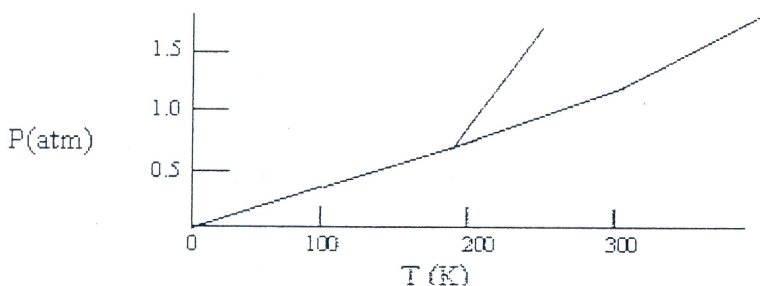
※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

16. Consider the molecular-orbital energy-level diagrams for  $O_2$  and  $NO$ . Which of the following is true?
- Both molecules are paramagnetic.
  - The bond strength of  $O_2$  is greater than the bond strength of  $NO$ .
  - $NO$  is an example of a homonuclear diatomic molecule.
  - The ionization energy of  $NO$  is smaller than the ionization energy of  $NO^+$ .
- A) I and II only B) I and IV only C) I only D) II and III E) I, II, and IV

17. Choose the electron dot formula that most accurately describes the bonding in  $CS_2$ . (Hint: Consider formal charges.)

- A)  $:\ddot{S}=C=\ddot{S}:$  B)  $:\ddot{C}=S=\ddot{S}:$  C)  $:\ddot{S}-C-\ddot{S}:$  D)  $:\ddot{S}-\ddot{C}=\ddot{S}:$  E)  $:\ddot{S}-C\equiv S:$

18. Below is a phase diagram for compound X. You wish to purify a sample of X that was collected at  $P = 1.0$  atm and  $T = 100$  by subliming it. In order to sublime the sample, you should



- increase  $P$  to 1.5 atm and then increase  $T$  to 300 K.
- increase  $T$  to 300 K, keeping  $P = 1.0$  atm.
- lower  $P$  to 0.5 atm and then increase  $T$  to 200 K.
- increase  $T$  to 300 K and then lower  $P$  to 0.5 atm.
- abandon the attempt to sublime X.

19. 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 if the vapor above the solution is 30% A?

- $0.3y/(0.7x + 0.3y)$  B)  $0.7y/(0.3x + 0.7y)$  C)  $0.3x/(0.3x + 0.7y)$
- $0.7x/(0.7x + 0.3y)$  E)  $0.7x/(0.3x+0.3y)$

注意：背面有試題

參考用



※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

20. When a nonvolatile solute is added to a volatile solvent, the solution vapor pressure \_\_\_\_\_, the boiling point \_\_\_\_\_, the freezing point \_\_\_\_\_, and the osmotic pressure across a semipermeable membrane \_\_\_\_\_.

- A) decreases, increases, decreases, decreases
- B) increases, increases, decreases, increases
- C) increases, decreases, increases, decreases
- D) decreases, decreases, increases, decreases
- E) decreases, increases, decreases, increases

21. The deciding factor that makes HF a weak acid is that

- A) the entropy for hydration of  $F^-$  is a large negative value.
- B) HF has a large bond energy.
- C) the enthalpy of hydration of  $F^-$  is negative.
- D)  $F_2$  has a small bond energy.
- E)  $F^-$  has the largest ionization energy of all the halide ions.

22. Which of the following statements about the complex ion  $Co(en)_2Cl_2^+$  is true? (en = ethylenediamine,  $NH_2CH_2CH_2NH_2$ )

- A) The complex ion contains Co(I).
- B) The complex ion exhibits two geometric isomers (cis and trans) and two optical isomers.
- C) The complex ion exhibits cis and trans geometric isomers, but no optical isomers.
- D) Because en is a strong field ligand (large  $\Delta$ ), the complex ion is paramagnetic.
- E) The geometric isomers of the complex ion have identical chemical properties.

23. The complex ions of  $Zn^{2+}$  are all colorless. The most likely explanation for this is that

- A)  $Zn^{2+}$  is paramagnetic.
- B)  $Zn^{2+}$  exhibits "d orbital" splittings in its complexes such that they absorb all wavelengths in the visible region.
- C) because  $Zn^{2+}$  is a  $d^{10}$  ion, it does not absorb visible light even though the "d orbital" splittings are correct for absorbing visible wavelengths.
- D)  $Zn^{2+}$  is not a transition metal ion.
- E) because  $Zn^{2+}$  is a  $d^8$  ion, it does not absorb visible light even though the "d orbital" splitting are correct for absorbing visible wavelengths.

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

24. It is desired to determine the concentration of arsenic in a lake sediment sample by means of neutron activation analysis. The nuclide  $^{75}_{33}\text{As}$  captures a neutron to form

$^{76}_{33}\text{As}$ , which in turn undergoes  $\beta$  decay. The daughter nuclide produces the characteristic  $\gamma$  rays used for the analysis. What is the daughter nuclide?

- A)  $^{75}_{34}\text{Se}$  B)  $^{76}_{32}\text{Ge}$  C)  $^{74}_{31}\text{Ga}$  D)  $^{76}_{34}\text{Se}$  E)  $^{74}_{34}\text{Se}$

25. What is the complementary nucleic acid sequence for the DNA sequence GAC TAC GTT GGC?

- A) GAC TAC GTT GGC  
B) TCA GCA TGG CTA  
C) CGA GTG CAT CAG  
D) GCG AAG GGG TTG  
E) CTG ATG CAA CCG

26. The diffusion rate of  $\text{N}_2$  gas is 1.73 times as great as that of a certain noble gas (both gases are at the same temperature). What is the noble gas?

- A)Xe B)Kr C)Ar D)Ne E)He

27. The uncertainty in the velocity of an electron is  $1 \times 10^5 \text{ m s}^{-1}$ . What is the minimum uncertainty in its position? ( $m_e = 9.11 \times 10^{-31} \text{ kg}$ ;  $\hbar(h/2\pi) = 1.06 \times 10^{-34} \text{ kg.m}^2.\text{s}^{-1}$ )

- A)  $5.79 \times 10^{-10} \text{ m}$  B)  $5.79 \times 10^{-5} \text{ m}$  C)  $2.31 \times 10^{-9} \text{ m}$  D)  $2.31 \times 10^{-10} \text{ m}$  E)  $1.08 \times 10^{-10} \text{ m}$

28. A strip of copper is placed in a 1 M solution of copper nitrate, and a strip of silver is placed in a 1 M solution of silver nitrate. The two metal strips are connected to a voltmeter by wires, and a salt bridge connects the solutions. The following standard reduction potentials apply:



When the voltmeter is removed and the two electrodes are connected by a wire, which of the following does *not* take place?

- A) There is a net general movement of silver ions through the salt bridge to the copper half-cell.

類組：化學類 科目：綜合化學(1001)

共 8 頁 第 7 頁

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

- B) The silver electrode increases in mass as the cell operates.
- C) Electrons flow in the external circuit from the copper electrode to the silver electrode.
- D) Negative ions pass through the salt bridge from the silver half-cell to the copper half-cell.
- E) Some positive copper ions pass through the salt bridge from the copper half-cell to the silver half-cell.

二 計算與問答題(30%，共五題) • 計算題應詳列計算過程，無計算過程者不給分。

1. (6pts) From the ionization energies, as shown in the following table, we might expect lithium to be weakest of alkali metals as a reducing agent in water. However, the standard reduction potentials indicate that Li is the stronger. Please explain why? (3pts) Also, Why Lithium reacts more slowly with water than sodium and potassium? (3pts)

Properties of Five Alkali Metals

Element	Valence Electron Configuration	Density at 25°C (g/cm <sup>3</sup> )	mp (°C)	bp (°C)	First Ionization Energy (kJ/mol)	Atomic (covalent) Radius (pm)	Ionic (M <sup>+</sup> ) Radius (pm)
Li	2s <sup>1</sup>	0.53	180	1330	520	152	60
Na	3s <sup>1</sup>	0.97	98	892	495	186	95
K	4s <sup>1</sup>	0.86	64	760	419	227	133
Rb	5s <sup>1</sup>	1.53	39	688	409	247	148
Cs	6s <sup>1</sup>	1.87	29	690	382	265	169

2. (6pts) The compounds Na<sub>2</sub>O, CdS, and ZrI<sub>4</sub> all can be described as cubic closest packed anions with the cations in the tetrahedral holes. What fraction of the tetrahedral holes is occupied for each case?

注意：背面有試題

參考用



類組：化學類 科目：綜合化學(1001)

共 8 頁 第 8 頁

※選擇題請在答案卡內作答，非選擇題請在答案卷內作答

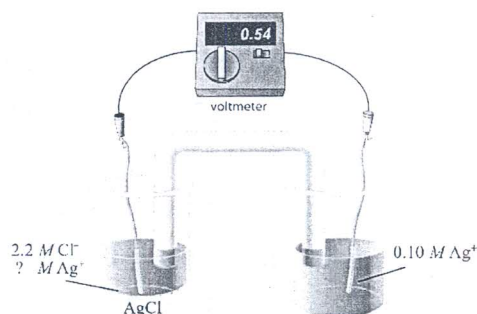
3. (6pts) A silver concentration cell is set up at 25 °C as shown below:

The  $\text{AgCl}_{(s)}$  is in excess in the left compartment.

a. Label the anode and cathode(1pts), and describe the direction of the electron flow(1pts)

b. Determine the value of  $K_{sp}$  for  $\text{AgCl}$  at 25 °C. (4pts)

(Hint:  $10^{-0.9137} \sim 1.22 \times 10^{-1}$ ;  $10^{-9.137} \sim 7.3 \times 10^{-10}$ ;  $10^{-8.137} \sim 7.3 \times 10^{-9}$ ;  $10^{0.9137} \sim 8.19$ )

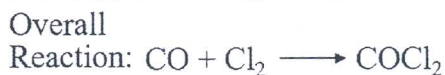
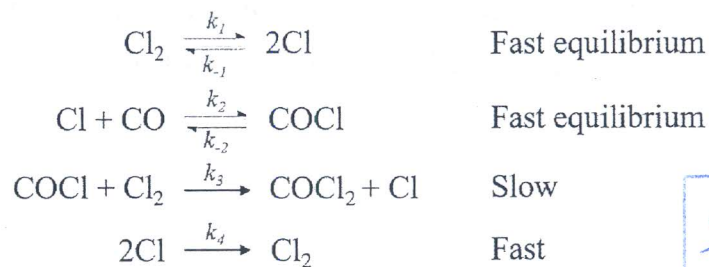


4. (6pts) What is the total probability of finding a particle in a one-dimensional box in level  $n=3$  between  $x=0$  and  $x=L/6$ ? (3pts) And explain why a function of the type  $A \cos(Lx)$  is not an appropriate solution for the particle in a one-dimensional box(3pts)

5.(6pts) In the gas phase, the production of phosgene from chlorine and carbon monoxide is assumed to proceed by the following mechanism:

a. Write the rate law for this reaction. (4pts)

b. Which species are intermediates?(2pts)



注意：背面有試題

參考用