

- 說明: 1. 請標明題號, 依序作答, 答案一律以橫式寫在答案卷上。  
 2. 20題選擇題請用橫式一行寫在答案卷最前面。  
 3. 參考數據如下:

(1) Atomic mass (weight): H 1.008, C 12.011, O 15.9994, P 30.9738,  
 Cl 35.4257, Ni 58.69,  ${}^3\text{Li}$  7.0160,  ${}^4\text{Be}$  7.0169,  $e^-$   $5.486 \times 10^{-4}$

(2) Acidity:	pKa	Acidity:	pKa
	HNO <sub>2</sub>		HOCl
	3.34		7.46
	HOAc		NH <sub>4</sub> <sup>+</sup>
	4.74		9.24
	H <sub>2</sub> CO <sub>3</sub>		HCO <sub>3</sub> <sup>-</sup>
	6.36		10.33
	H <sub>2</sub> S		HS <sup>-</sup>
	7.0		19

(3) Thermodynamic data:

	$\Delta H_f^\circ$ (KJ/mol)	$S^\circ$ (J/Kmol)
CaCO <sub>3</sub>	-1207	93
CaO	-634	40
CO <sub>2</sub>	-394	214
Cu <sup>2+</sup>	65	-100
Zn <sup>2+</sup>	-154	-112

(4)  $K_{sp}$  of Ag<sub>2</sub>S =  $8 \times 10^{-58}$ ,  $K_{sp}$  of CoS =  $4.5 \times 10^{-27}$

(5)  $\log 2=0.30$ ,  $\log 3=0.48$ ,  $\log 4=0.60$ ,  $\log 5=0.70$ ,  
 $\log 6=0.78$ ,  $\log 7=0.85$ ,  $\log 8=0.90$ ,  $\log 9=0.95$

1. Select the best answer (40%)

(1) Which contains the greatest mass of oxygen in one molecule of (a) ethanol (C<sub>2</sub>H<sub>5</sub>OH) (b) glucose (c) water (d) carbon dioxide (e) tetraphosphorus hexaoxide.

(2) Which force makes the most important contribution to the lattice energy of solid argon? (a) van de Waal's force (b) ionic bonding (c) covalent bonding (d) metallic bonding (e) hydrogen bonding.

(3) Which compound would you expect to have the highest boiling point? (a) methane (b) chloromethane (c) dichloromethane (d) chloroform (e) carbon tetrachloride.

(4) Which of the following is the strongest reducing agent? (a) HCl (b) H<sub>2</sub> (c) H<sub>2</sub>O<sub>2</sub> (d) NaH (e) Na<sup>+</sup>

(5) Which of the following compounds is an amine? (a) C<sub>2</sub>H<sub>5</sub>CONH<sub>2</sub> (b) CH<sub>3</sub>COOCH<sub>3</sub> (c) C<sub>7</sub>H<sub>15</sub>NH<sub>2</sub> (d) CHCH (e) CH<sub>3</sub>COCH<sub>3</sub>

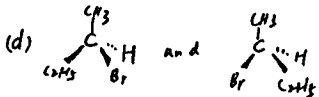
(6) In which of the following compounds is there a carbon atom in the +3 oxidation state. (a) CH<sub>3</sub>CH<sub>2</sub>OH (b) CH<sub>3</sub>OCH<sub>3</sub> (c) CH<sub>3</sub>CHO (d) CH<sub>3</sub>COCH<sub>3</sub> (e) CH<sub>3</sub>COOH

(7) Arrange the following ions and molecules in increasing order of their carbon-oxygen bond order: 1.  $\text{CO}_3^-$  2.  $\text{HCOO}^-$  3.  $\text{HCHO}$  4.  $\text{CH}_3\text{OH}$  (a)  $1=2=3>4$  (b)  $3>1=2>4$  (c)  $2>3>1>4$  (d)  $3>1>4>2$  (e)  $3>2>1>4$

(8) What hybrid orbital is found on the central atom in  $\text{TeCl}_4$  (a)  $\text{SP}^3$  (b)  $\text{P}^2$  (c)  $\text{dsp}^3$  (d)  $\text{d}^2\text{sp}^3$  (e)  $\text{dsp}^2$

(9) Which of the following sets of quantum numbers describes the most easily removed electron in a boron atom in its ground state? (a)  $n=1, l=0, m=0, s=1/2$  (b)  $n=2, l=1, m=0, s=-1/2$  (c)  $n=2, l=0, m=0, s=1/2$  (d)  $n=3, l=1, m=1, s=-1/2$  (e)  $n=4, l=1, m=1, s=1/2$

(10) Which of the following represent resonance forms of the same species  
 (a)  $\text{:N}\equiv\text{C}-\ddot{\text{O}}^-$  and  $\text{:}\ddot{\text{N}}=\text{C}=\ddot{\text{O}}:$  (b)  $\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\ddot{\text{O}}-\text{H}$  and  $\text{H}-\overset{\text{O}}{\parallel}{\text{C}}-\ddot{\text{O}}-\text{H}$  (c)  $\text{:}\ddot{\text{N}}=\text{N}=\ddot{\text{O}}:$  and  $\text{:}\ddot{\text{N}}\equiv\text{O}-\ddot{\text{N}}:$

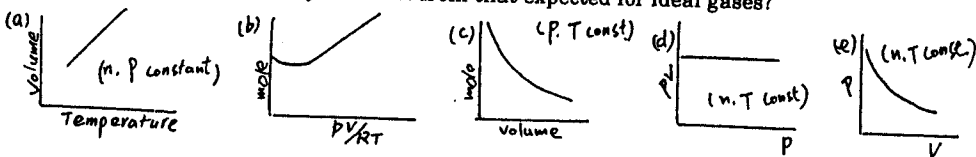
(d)  and (e)  $(\text{:}\ddot{\text{N}}=\text{C}=\ddot{\text{S}}:)$  and  $(\text{:}\ddot{\text{S}}=\text{C}=\ddot{\text{N}}:)$

(11) Which of the following is exception to the Lewis octet rule? (a)  $\text{IF}_3$  (b)  $\text{H}_3\text{O}^+$  (c)  $\text{H}_2\text{CO}$  (d)  $\text{CO}_2$  (e)  $\text{PCl}_3$

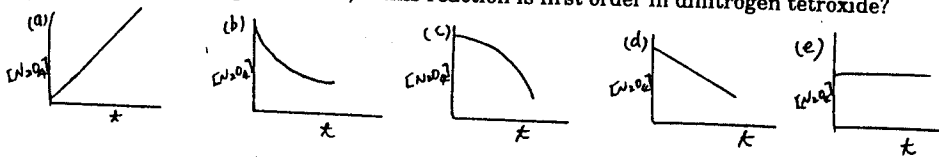
(12) Which of the following is nonpolar, but contains polar bonds? (a) hydrogen chloride (b) water (c) sulfur trioxide (d) nitrogen dioxide (e) sulfur dioxide

(13) Of the five  $\Delta H$  values needed to calculate a lattice energy using the Born-Haber cycle, the one that is most difficult to measure is (a) the heat of sublimation of the metal (b) the heat of formation of gaseous atoms of the nonmetal (c) the ionization energy of the metal (d) the electron affinity of the nonmetal (e) the standard heat of formation of the crystal

(14) Graphs showing the behavior of several different gases follow. Which of these gases exhibits behavior significantly different from that expected for ideal gases?



(15) Which of the following graphs best describes the rate at which dinitrogen tetroxide decomposes to nitrogen dioxide, if this reaction is first order in dinitrogen tetroxide?

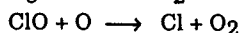
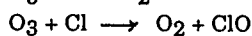
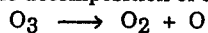


(16) For the reaction:  $2\text{NO}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{NOCl}(\text{g})$ , the following initial rates of reaction have been observed for certain reactant concentrations

[NO]	[Cl <sub>2</sub> ]	rate, -d[Cl <sub>2</sub> ]/dt
0.50 M	0.50 M	1.14 M/min
1.00 M	0.50 M	4.56 M/min
1.00 M	1.00 M	9.12 M/min

then the rate equation,  $d[\text{NOCl}]/dt =$  (a)  $k[\text{NO}][\text{Cl}_2]$  (b)  $k[\text{NO}]^2[\text{Cl}_2]$  (c)  $k[\text{NO}][\text{Cl}_2]^2$  (d)  $k[\text{NO}]^3[\text{Cl}_2]$  (e)  $k[\text{NO}][\text{Cl}_2]^3$

(17) The decomposition of ozone in the ozone layer of the earth's atmosphere:



Which of the following statements is wrong? (a) The overall reaction is  $2\text{O}_3 \rightarrow 3\text{O}_2$  (b)  $\text{O}_2$  is a product (c)  $\text{ClO}$  is an intermediate (d)  $\text{Cl}$  is a reactant (e) This is a catalyzed reaction by  $\text{Cl}$

(18) To prepare a buffer with pH close to 3.4, you could use a mixture of (a)  $\text{NH}_4\text{NO}_3$  and  $\text{NH}_3$  (b)  $\text{HOCl}$  and  $\text{NaOCl}$  (c)  $\text{HOAc}$  and  $\text{NaOAc}$  (d)  $\text{HNO}_2$  and  $\text{KNO}_2$  (e)  $\text{NaHCO}_3$  and  $\text{Na}_2\text{CO}_3$

(19) All of the following substances are water soluble except (a)  $\text{CH}_3\text{CH}_2\text{OCH}_3$  (b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$  (c)  $\text{Na}_2\text{CO}_3$  (d)  $\text{H}_2\text{SO}_4$  (e)  $\text{CH}_3\text{CH}_2\text{COOH}$

(20) Which of the following nuclei would you expect to be unstable and easily undergo  $\beta^-$  decay? (a)  $^{15}\text{P}^{29}$  (b)  $^{92}\text{U}^{238}$  (c)  $^{20}\text{Ca}^{40}$  (d)  $^1_1\text{H}^3$  (e)  $^{94}\text{Pu}^{247}$

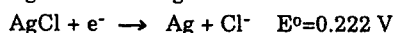
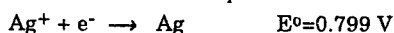
2. Give an example to explain the difference between molecularity and order of a reaction. 4%

3. Explain the difference in the color of aqueous solutions of the following ions: 4%  
 $[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]^{2+}$ ,  $[\text{Co}(\text{NH}_3)_5(\text{H}_2\text{O})]^{3+}$ ,  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$   
 yellow                      red                      violet

4. Ether,  $(\text{C}_2\text{H}_5)_2\text{O}$ , is prepared by the reaction of ethanol with sulfuric acid. What is the percent yield of the reaction that produces 12.5 g of ether from 36.0 g of ethanol. 4%

5. The osmotic pressure of human blood is 7.6 atm at 37 °C. What mass of glucose is required to make 1.00 L of aqueous solution for intravenous feeding if the solution must have the same osmotic pressure as blood at body temperature? 4%

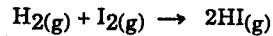
6. The standard reduction potentials for the reactions are:



Calculate the solubility product for  $\text{AgCl}$ . 4%

7. Trimethylphosphine,  $(\text{P}(\text{CH}_3)_3)$ , can act as a ligand. If trimethylphosphine is added to a solution of nickel(II) chloride in acetone, a blue compound that has a molecular mass of approximately 270 and contains 21.5% Ni, 26.0% Cl, and 52.5%  $\text{P}(\text{CH}_3)_3$  can be isolated. This blue compound does not have any isomeric forms. What is the molecular formula and geometry of this blue compound. 4%

8. The rate constant for the formation of HI from the elements:



is  $2.7 \times 10^{-4} \text{ L/mol}\cdot\text{s}$  at 600 K and  $3.5 \times 10^{-3} \text{ L/mol}\cdot\text{s}$  at 650 K. Find the activation energy of this reaction. 4%

9. A  ${}^7_4\text{Be}$  atom decays to a  ${}^7_3\text{Li}$  atom by electron capture. How much energy in MeV is produced by this reaction? 4%

10. For a reaction:  $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

When 1.00 mol of  $\text{CaCO}_3$  (volume=34.2 mL) decomposes at 25 °C and 1 atm to give solid CaO (volume=16.9 mL) and  $\text{CO}_2(\text{g})$ . What are  $w$  and  $\Delta G^\circ$  for this reaction? 4%

11. Write the Lewis structures and geometric shapes for the following species:  $\text{ClNO}$ ,  $\text{ICl}_4^-$ . 4%

12. Draw the structural formulas for the following compounds.

- (a) 1-bromo-4-methylpentane
- (b) 2,2,5-trimethylcyclohexene 4%

13. Write a balanced equation that can describe each of the following reactions. 4%

- (a) hot water vapor and hot carbon react to form water gas.
- (b)  ${}^{14}_6\text{C}$  undergoes  $\beta^-$  decay.

14. A solution containing 0.1 M  $\text{Co}(\text{NO}_3)_2$  and 0.1 M  $\text{AgNO}_3$  is saturated with  $\text{H}_2\text{S}$  ( $[\text{H}_2\text{S}]=0.10 \text{ M}$ ). What is the minimum  $[\text{H}^+]$  at which  $\text{Ag}_2\text{S}$  precipitates but  $\text{CoS}$  does not. 4%

15. From the following data about  $\text{CO}_2$ : Subliming point at -78 °C, Triple point at -57 °C and 5.11 atm, Critical point at 31 °C and 73 atm,

- (a) draw a phase diagram for  $\text{CO}_2$ .
- (b) Dry ice does not melt at atmospheric pressure. What is the lowest pressure at which  $\text{CO}_2(\text{s})$  will melt to give  $\text{CO}_2(\text{l})$ . 4%

16. List the advantages and disadvantages of nuclear energy as a source of electrical power. 4%