

注意事項：1. 答案一律寫在答案紙上，否則不予計分。

2. 請標明提號依序作答，答錯不倒扣。

3. 試題應隨同試卷繳回，不得攜出試場。

1. 至 10. 題為單選題每題四分，11. 至 20. 題為填充題（但必須列式計算）每題六分。

1. For a reaction in voltaic cell both  $\Delta H^\circ$  and  $\Delta S^\circ$  are positive. Which of the following statements is true?
  - (a)  $E^\circ_{\text{cell}}$  will increase with an increase in temperature.
  - (b)  $E^\circ_{\text{cell}}$  will decrease with an increase in temperature.
  - (c)  $E^\circ_{\text{cell}}$  will not change when the temperature increases.
  - (d)  $\Delta G^\circ > 0$  for all temperatures.
  - (e)  $\Delta G^\circ < 0$  for all temperatures.
2. Which form of electromagnetic radiation has the longest wavelengths?
  - (a) gamma rays (b) microwaves (c) radio waves (d) infrared radiation (e) x-rays
3. Which of the following compounds contains both polar and nonpolar covalent bonds?
  - (a)  $\text{NH}_4\text{Cl}$  (b)  $\text{CH}_4$  (c)  $\text{H}_2\text{O}_2$  (d)  $\text{HCN}$  (e)  $\text{NH}_3$ .
4. Which of the following statements about the thiocyanate ion  $\text{SCN}^-$ , is true?
  - (a) Its Lewis structure contains an unpaired electron.
  - (b) Its shape is bent like that of  $\text{H}_2\text{O}$
  - (c) Only one correct resonance structure can be drawn
  - (d) There are two sigma bonds in the ion.
  - (e) There are two pi electrons in the ion.
5. Calculate the pH of a  $5.0 \times 10^{-8}$  M HCl solution.
  - (a) 6.72 (b) 6.89 (c) 7.00 (d) 7.30 (e) 7.7
6. Which of the following statements is true?
  - (a) The exact location of an electron can be determined if we know its energy.
  - (b) An electron in a 2s orbital can have the same n, l, quanta numbers as an electron in 3s orbital.
  - (c)  ${}_{28}\text{Ni}$  has 2 unpaired electrons in its 3d orbitals.
  - (d) In the build-up of atom s electrons occupy the 4f orbitals before the 6s orbitals.
  - (e) Only three quantum numbers are needed to uniquely describe an electron.
7.  ${}^{11}\text{C}$  is unstable isotope. What type of radioactive decay would be expected?
  - (a)  $\beta^-$  (b)  $\alpha$  (c)  $\beta^+$  (d)  $\alpha$  (e) neutron
8. In the molecular orbital description of CO. Which of the following statements is true?
  - (a) the highest energy electrons occupy antibonding orbitals
  - (b) six molecular orbitals contain electrons
  - (c) there are two unpaired electrons
  - (d) the bond order is 3
  - (e) CO is paramagnetic

（背面仍有問題，請繼續作答）

9. In which of the following compounds does the bond between the central atom and fluorine have the greatest ionic character? (a)  $\text{OF}_2$  (b)  $\text{SF}_2$  (c)  $\text{SeF}_2$  (d)  $\text{AsF}_3$  (e)  $\text{SbF}_3$
10. The third law of thermodynamics states:  
 (a) The entropy of the universe is increasing.  
 (b) The entropy of the universe is constant.  
 (c) The entropy is zero at zero K for a perfect crystal.  
 (d) The absolute entropy of a substance decreases with increasing temperature.  
 (e) The entropy of the universe equals the sum of the entropy of system and surroundings.
11. A metal crystallizes with a face-Centered cubic lattice. The edge of the unit cell is 408 pm. The diameter of the metal atom is \_\_\_\_\_.
12. The decomposition of  $\text{N}_2\text{O}_5(\text{g})$  to  $\text{NO}_2(\text{g})$  and  $\text{O}_2(\text{g})$  obeys first-order kinetics.  $\text{Rate} = k[\text{N}_2\text{O}_5]$ , where  $k = 3.4 \times 10^{-5} \text{ s}^{-1}$  at  $25^\circ\text{C}$ . If initial concentration of  $\text{N}_2\text{O}_5$  is  $1.0 \times 10^{-3} \text{ M}$ , then the half-life for this reaction is \_\_\_\_\_ sec.
13. A reaction with the standard reaction free energy of  $+1.70 \text{ kJ/mol}$  at  $25^\circ\text{C}$ , the equilibrium constant of this reaction is \_\_\_\_\_. ( $R = 8.3123 \text{ J K}^{-1} \text{ mol}^{-1}$ )
14. The standard enthalpies of formation ( $\Delta H_f$ ,  $\text{kJ/mol}$ ) for  $\text{CO}_2(\text{g})$ ,  $\text{H}_2\text{O}(\text{l})$ , benzene $(\text{l})$  are  $-393.52$ ,  $-285.83$  and  $+49.0$ , respectively. The standard enthalpy of combustion of benzene is \_\_\_\_\_  $\text{kJ/mol}$ .
15. A 1.5 mol of gas was in 5.00 L of tank, if the van der Waals coefficients are  $a = 16.2 \text{ L}^2 \text{ atm mol}^{-2}$  and  $b = 8.4 \times 10^{-2} \text{ L mol}^{-1}$ , then the pressure of this tank is \_\_\_\_\_ atm.
16. A 5.00 mL of 0.150 M  $\text{NaOH}(\text{aq})$  is added to 25.00 mL of 0.100 M  $\text{HCOOH}$  ( $K_a = 1.8 \times 10^{-4}$ ), the pH of the resulting solution is \_\_\_\_\_.
17. A galvanic cell is constructed with copper electrodes and  $\text{Cu}^{2+}$ , in each compartment. In one compartment, the  $[\text{Cu}^{2+}] = 1.0 \times 10^{-3} \text{ M}$  and in the other compartment, the  $[\text{Cu}^{2+}] = 2.0 \text{ M}$ . The standard reduction potential for  $\text{Cu}^{2+}$  is  $+0.34 \text{ V}$ . The potential for this galvanic cell is \_\_\_\_\_.
18. Consider the following reaction (assume an ideal gas mixture):  $2\text{NOBr}(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{Br}_2(\text{g})$   
 A 1.0-liter vessel was initially filled with pure  $\text{NOBr}$ , at a pressure of 4.0 atm, at 300 K. After equilibrium was established, the partial pressure of  $\text{NOBr}$  was 2.5 atm. The  $K_p$  for this reaction is \_\_\_\_\_.
19. The  $K_a$ 's of  $\text{H}_3\text{PO}_4$  are  $K_{a1} = 7.6 \times 10^{-3}$ ,  $K_{a2} = 6.2 \times 10^{-8}$ ,  $K_{a3} = 2.1 \times 10^{-13}$   
 The concentration of  $[\text{H}_3\text{O}^+]$  in 0.010 M  $\text{H}_3\text{PO}_4(\text{aq})$  is \_\_\_\_\_.
20. The concentration of  $[\text{HPO}_4^{2-}]$  in 0.010 M  $\text{H}_3\text{PO}_4(\text{aq})$  is \_\_\_\_\_.