

※ 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 (50%，每題 2 分)

1. The oxidation state of the sulfur atom in sulfuric acid is:

- (A) +2 ; (B) +4 ; (C) +5 ; (D) +6 ; (E) -2

2. Choose the element with the smallest electronegativity.

- (A) N ; (B) P ; (C) As ; (D) Sb ; (E) O

3. The ion  $^{127}\text{I}^-$  has:

- (A) 53 protons, 74 neutrons, 54 electrons ; (B) 53 protons, 74 neutrons, 53 electrons ;  
(C) 53 protons, 74 neutrons, 52 electrons ; (D) 53 protons, 127 neutrons, 54 electrons ;  
(E) 53 protons, 53 neutrons, 54 electrons

4. What is the correct formula for chromium(VI) oxide?

- (A)  $\text{CrO}_6$  ; (B)  $\text{Cr}_6\text{O}$  ; (C)  $\text{CrO}_3$  ; (D)  $\text{Cr}_2\text{O}_3$  ; (E)  $\text{CrO}_2$

5. Which of the following contains the greatest percentage of nitrogen by mass?

- (A)  $\text{NO}_2$  ; (B)  $\text{NH}_3$  ; (C)  $\text{N}_2\text{O}$  ; (D)  $\text{C}_6\text{H}_4\text{N}_3\text{O}_6$  ; (E)  $\text{HCN}$

6. Give (in order) the correct coefficients to balance the following reaction:



- (A) 1, 2, 2, 2 ; (B) 1, 1, 1, 6 ; (C) 1, 1, 2, 6 ; (D) 2, 4, 2, 6 ; (E) 1, 2, 1, 6

7. Which pair of ions would *not* be expected to form a precipitate when dilute solutions of each are mixed?

- (A)  $\text{Al}^{3+}$ ,  $\text{S}^{2-}$  ; (B)  $\text{Ag}^+$ ,  $\text{Cl}^-$  ; (C)  $\text{Co}^{2+}$ ,  $\text{PO}_4^{3-}$  ; (D)  $\text{Mn}^{2+}$ ,  $\text{OH}^-$  ; (E)  $\text{Ni}^{2+}$ ,  $\text{SO}_4^{2-}$

8. In the reaction  $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$ , which element, if any, is oxidized?

- (A) hydrogen ; (B) zinc ; (C) sulfur ; (D) oxygen ; (E) zinc sulfate

9. Balance the reaction below in acidic aqueous solution, using the oxidation number method. In the balanced equation, what is the coefficient of  $\text{Fe}^{2+}$ ?



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

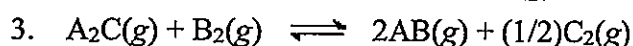
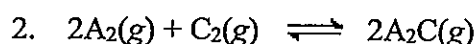
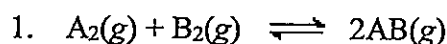
10. For which gas do the molecules have the highest average velocity at 25°C?  
(A) Cl<sub>2</sub>; (B) NH<sub>3</sub>; (C) CH<sub>4</sub>; (D) He; (E) The molecules of all the gases have the same average velocity

11. How many of the following gases at STP are less dense than air at STP?

NH<sub>3</sub>, He, Kr, and F<sub>2</sub>

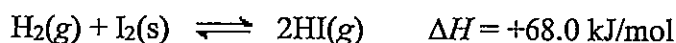
(A) 0; (B) 1; (C) 2; (D) 3; (E) 4

12. For the hypothetical reactions 1 and 2,  $K_1 = 10^2$  and  $K_2 = 10^{-4}$



(A) 1; (B) 10<sup>2</sup>; (C) 10<sup>4</sup>; (D) 10<sup>6</sup>; (E) 10<sup>-2</sup>

13. Consider the following equilibrium:



Which of the following statements about the equilibrium is *false*?

- (A) If the system is heated, the right side is favored. ;
- (B) This is a heterogeneous equilibrium. ;
- (C) If the pressure on the system is increased by changing the volume, the left side is favored. ;
- (D) Adding more H<sub>2</sub>(g) increases the equilibrium constant. ;
- (E) Removing HI as it forms forces the equilibrium to the right.

14. In deciding which of two acids is the stronger, one must know

- (A) the concentration of each acid solution only. ; (B) the equilibrium constant of each acid only. ;
- (C) the pH of each acid solution only. ; (D) all of the these. ;
- (E) both the concentration and the equilibrium constant of each acid.

15. Calculate  $\Delta E$  for a system that releases 30 J of heat while 60 J of work is done on it.

(A) 30 J; (B) 60 J; (C) 90 J; (D) -30 J; (E) -60 J

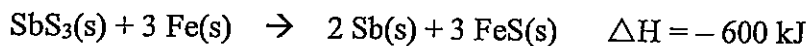
16. The molar solubility in moles per liter of Fe<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> is  $x$ , What is  $K_{sp}$  for Fe<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>?

(A)  $6x^2$ ; (B)  $6x^5$ ; (C)  $12x^3$ ; (D)  $32x^5$ ; (E)  $108x^5$

17. For which of the following reaction (I, II, and III) is the enthalpy change for the reaction *not* equal to  $\Delta H_f^\circ$  of the product?  
I.  $2\text{H}(g) \rightarrow \text{H}_2(g)$ ; II.  $\text{H}_2(g) + \text{O}_2(g) \rightarrow \text{H}_2\text{O}_2(l)$ ; III.  $\text{H}_2\text{O}(l) + \text{O}(g) \rightarrow \text{H}_2\text{O}_2(l)$   
(A) I only; (B) II only; (C) III only; (D) II and III; (E) I and III
18. For a reaction in a 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)  $\Delta G^\circ > 0$  for all temperatures. ;  
(C)  $E^\circ_{\text{cell}}$  will decrease with an increase in temperature. ; (D)  $\Delta G^\circ < 0$  for all temperatures. ;  
(E)  $E^\circ_{\text{cell}}$  will not change when the temperature increases.
19. Consider an electrochemical cell with a copper electrode immersed in  $1.0\text{ M Cu}^{2+}$  and a silver electrode immersed in  $1.0\text{ M Ag}^+$ .  
$$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu} \quad E^\circ = 0.34\text{ V}$$
$$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag} \quad E^\circ = 0.80\text{ V}$$
  
(A) 1.48 V; (B) 1.26 V; (C) 1.14 V; (D) 0.46 V; (E) 1.94 V
20. The C—C—H bond angles in ethylene,  $\text{C}_2\text{H}_4$ , are  $120^\circ$ . What is the hybridization of the carbon orbitals?  
(A) sp; (B)  $\text{sp}^2$ ; (C)  $\text{sp}^3$ ; (D)  $\text{dsp}^3$ ; (E)  $\text{d}^2\text{sp}^3$
21. Which of the following species is paramagnetic?  
(A)  $\text{C}_2$ ; (B)  $\text{B}_2$ ; (C)  $\text{N}_2$ ; (D)  $\text{F}_2$ ; (E)  $\text{O}_2^{2+}$
22. How many isomers of  $\text{C}_4\text{H}_{10}$  are there?  
(A) 2; (B) 3; (C) 4; (D) 5; (E) 6
23. In which group are the elements listed in correct order of increasing first ionization energy?  
(A)  $\text{Na} > \text{P} > \text{Cl}$ ; (B)  $\text{Cs} > \text{Na} > \text{K}$ ; (C)  $\text{K} > \text{Ca} > \text{Ge}$ ; (D)  $\text{Na} > \text{Rb} > \text{Cs}$ ; (E)  $\text{Al} > \text{Si} > \text{P}$
24. Which of the compounds below is an example of a network solid?  
(A)  $\text{S}_8(s)$ ; (B)  $\text{SiO}_2(s)$ ; (C)  $\text{MgO}(s)$ ; (D)  $\text{NaCl}(s)$ ; (E)  $\text{C}_{25}\text{H}_{52}(s)$
25. What is the number of half-lives needed for a radioactive element to decay to one-eighth of its original activity? (Choose the nearest number.)  
(A) 1; (B) 2; (C) 3; (D) 4; (E) 5

## 二、非選擇題 (50%；計算題需寫過程否則不予計分)

1. (a) Iron is used to reduce antimony in sulfide ores:



Calculate the  $\Delta S_{\text{surr}}$  value for this reaction at 27 °C and 1 atm. (3 %)

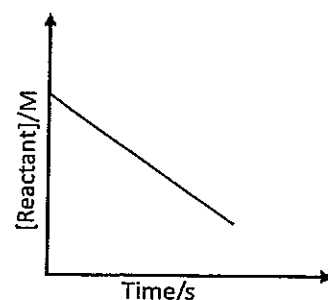
- (b). What is the normal boiling point of liquid
- $\text{Br}_2$
- ?



- (c) What is the third law of thermodynamics? (3 %)

2. (a) For a first-order reaction with rate constant of
- $100 \text{ s}^{-1}$
- , please calculate the half-life (
- $t_{1/2}$
- ) at initial concentration of 0.1 M. (4 %)

- (b) What is the reaction order in the right plot? Why? (5 %)



3. Give the Lewis structure for each of the following:

(1)  $\text{NO}^+$  ; (2)  $\text{KBr}$  ; (3)  $\text{NO}_2^-$  (resonance structures) (6 %)

4. A complex ion with a
- $d^8$
- electron configuration is a tetrahedral complex. Give the most reasonable crystal field diagram of the
- $d$
- orbitals for this complex?. Is this complex ion paramagnetic or diamagnetic? (6 %)

5. (a) Use the gas solubility to explain why the boiler scale(鍋垢) was generally formed in hot water? (4 %)

- (b) What is Henry's law? Use this law to explain the fizzing when opening a can of soda. (4%)

6. (a) How many degenerate orbitals are there in
- $\text{Li}^{2+}$
- ion with the principle quantum number
- $n = 5$
- ? (3 %)

- (b). Please write a mathematical representation to describe the probability of a wave function (
- $\psi$
- ) in a space of
- $dV$
- . (3 %)

- (c) Please derive an equation for the energies of a particle freely moving in a box.

(Length of the box =  $L$ ; mass of the particle =  $m$ ) (5 %)