

選擇題，共40題，每題2.5分，共100分，答錯不倒扣。請在答案卷上作答。

- You take an aspirin tablet (a compound consisting solely of carbon, hydrogen, and oxygen) with a mass of 1.00 g, burn it in air, and collect 2.20 g of carbon dioxide and 0.400 g water. The molar mass of aspirin is between 170 and 190 g/mol. The molecular form of aspirin is  
(a)  $C_6H_8O_5$ , (b)  $C_9H_8O_4$ , (c)  $C_8H_{10}O_5$ , (d)  $C_{10}H_6O_4$ , (e) none of these.
- What is the coefficient for oxygen when the following equation is balanced?  
$$NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O(g)$$
  
(a) 3, (b) 6, (c) 7, (d) 12, (e) 14.
- Consider the following reaction:  $2A + B \rightarrow 3C + D$   
3.0 mol  $A$  and 2.0 mol  $B$  react to form 4.0 mol  $C$ . What is the percent yield of this reaction?  
(a) 50%, (b) 67%, (c) 75%, (d) 89%, (e) 100%.
- Which of the following statements correctly describes the signs of  $q$  and  $w$  for the following exothermic process at  $P = 1$  atm and  $T = 370$  K?  $H_2O(g) \rightarrow H_2O(l)$   
(a)  $q$  and  $w$  are negative, (b)  $q$  is positive,  $w$  is negative, (c)  $q$  is negative,  $w$  is positive, (d)  $q$  and  $w$  are both positive, (e)  $q$  and  $w$  are both zero.
- Which of the following properties is (are) intensive properties?  
I. Mass II. Temperature III. Volume IV. Concentration V. Energy  
(a) I, III, and V, (b) II only, (c) II and IV, (d) III and IV, (e) I and V
- Using the following data, calculate the standard heat of formation of the compound  $ICl$  in kJ/mol:  

|                                   | $H^\circ$ (kJ/mol) |
|-----------------------------------|--------------------|
| $Cl_2(g) \rightarrow 2Cl(g)$      | 242.3              |
| $I_2(g) \rightarrow 2I(g)$        | 151.0              |
| $ICl(g) \rightarrow I(g) + Cl(g)$ | 211.3              |
| $I_2(s) \rightarrow I_2(g)$       | 62.8               |

  
(a) -211 kJ/mol, (b) -14.6 kJ/mol, (c) 16.8 kJ/mol, (d) 245 kJ/mol, (e) 439 kJ/mol.
- Which of the following statements is (are) true?  
I. An excited atom can return to its ground state by absorbing electromagnetic radiation.  
II. The energy of an atom is increased when electromagnetic radiation is emitted from it.  
III. The energy of electromagnetic radiation increases as its frequency increases.  
IV. An electron in the  $n = 4$  state in the hydrogen atom can go to the  $n = 2$  state by emitting electromagnetic radiation at the appropriate frequency.  
V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.  
(a) II, III, IV, (b) III, V, (c) I, II, III, (d) III, IV, V, (e) I, II, IV.
- Which of these is an isoelectronic series?  
(a)  $Na^+$ ,  $K^+$ ,  $Rb^+$ ,  $Cs^+$ , (b)  $K^+$ ,  $Ca^{2+}$ , Ar,  $S^{2-}$ , (c)  $Na^+$ ,  $Mg^{2+}$ ,  $S^{2-}$ ,  $Cl^-$ , (d) Li, Be, B, C, (e) none of these.
- Which of the following molecules has a bond order of 1.5?

(a)  $O_2^+$ , (b)  $N_2$ , (c)  $O_2^-$ , (d)  $C_2$ , (e) none of these.

10. The average rate of disappearance of ozone in the reaction  $2O_3(g) \rightarrow 3O_2(g)$  is found to be  $9.0 \times 10^{-3}$  atm over a certain interval of time. What is the rate of appearance of  $O_2$  during this interval?

(a)  $1.3 \times 10^{-2}$  atm/s, (b)  $9.0 \times 10^{-3}$  atm/s, (c)  $6.0 \times 10^{-3}$  atm/s, (d)  $3.0 \times 10^{-5}$  atm/s, (e)  $2.7 \times 10^{-5}$  atm/s.

11. For a reaction in which A and B react to form C, the following initial rate data were obtained:

| [A]<br>(mol/L) | [B]<br>(mol/L) | Initial Rate of Formation of C<br>(mol/L.s) |
|----------------|----------------|---|
| 0.10           | 0.10           | 1.00  |
| 0.10           | 0.20           | 4.00  |
| 0.20           | 0.20           | 8.00  |

What is the rate law for the reaction?

(a) Rate =  $k[A][B]$ , (b) Rate =  $k[A]^2[B]$ , (c) Rate =  $k[A][B]^2$ , (d) Rate =  $k[A]^2[B]^2$ , (e) Rate =  $k[A]^3$ .

12. The reaction  $2NO \rightarrow N_2 + O_2$  has the following rate law:

$$-\frac{D[NO]}{Dt} = 2k[NO]^2.$$

After a period of  $2.0 \times 10^3$  s, the concentration of NO falls from an initial value of  $2.8 \times 10^{-3}$  mol/L to  $2.0 \times 10^{-3}$  mol/L. What is the rate constant,  $k$ ?

(a)  $7.2 \times 10^{-2} M^{-1}/s$ , (b)  $1.7 \times 10^{-4} M^{-1}/s$ , (c)  $4.0 \times 10^{-4} M^{-1}/s$ , (d)  $4.0 \times 10^{-7} M^{-1}/s$ , (e)  $3.6 \times 10^{-2} M^{-1}/s$ .

13. Consider the gaseous reaction  $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ . What is the expression for  $K_p$  in terms of  $K$ ?

(a)  $K(RT)$ , (b)  $K/(RT)$ , (c)  $K(RT)^2$ , (d)  $K/(RT)^2$ , (e)  $1/K(RT)$ .

14. A 100-mL sample of water is placed in a coffee cup calorimeter. When 1.0 g of an ionic solid is added, the temperature decreases from  $21.5^\circ C$  to  $20.8^\circ C$  as the solid dissolves. For the dissolving of the solid

(a)  $H < 0$ , (b)  $S_{univ} > 0$ , (c)  $S_{sys} < 0$ , (d)  $S_{surr} > 0$ , (e) none of these.

15. Which statement below is not upheld by the second law of thermodynamics?

(a) The change of entropy of the universe is always positive. (b) The entropy of a perfect crystal at 0 K is zero. (c) Machines always waste some energy. (d) A machine is never 100% efficient. (e) All of these.

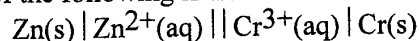
16. For the dissociation reaction of the acid HF



$\Delta S$  is observed to be negative. The best explanation is:

(a) This is the expected result since each HF molecule produces two ions when it dissociates.  
 (b) Hydration of the ions produces the negative value of  $\Delta S$ .  
 (c) The reaction is expected to be exothermic and thus  $\Delta S$  should be negative.  
 (d) The reaction is expected to be endothermic and thus  $\Delta S$  should be negative.  
 (e) None of these can explain the negative value of  $\Delta S$ .

17. Which of the following is true for the cell shown here?



(a) The electrons flow from the cathode to the anode.  
 (b) The electrons flow from the zinc to the chromium.  
 (c) The electrons flow from the chromium to the zinc.

- (d) The chromium is oxidized.  
 (e) The zinc is reduced.

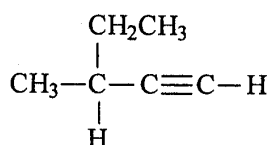
18. Which has the greatest number of unpaired electrons ?

- (a) The square planar complex  $\text{Ni}(\text{CN})_4^{2-}$ . (b) The tetrahedral complex  $\text{FeCl}_4^-$ . (c) Neither of these have any unpaired electrons. (d) Both (a and b) have the same number (non-zero) of unpaired electrons. (e) More information is needed.

19. How many unpaired electrons are there in the complex ion  $[\text{Co}(\text{NO}_3)_6]^{4-}$ ? For this ion the nitrate ligands produce a very strong crystal field.

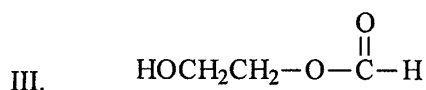
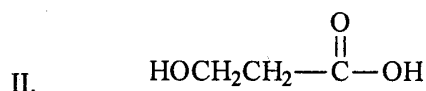
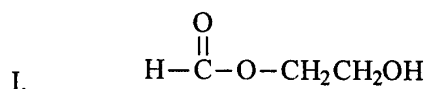
- (a) 1, (b) 2, (c) 3, (d) 4, (e) 5.

20. Name the following:



- (a) 1-hexyne, (b) 2-ethynyl butane, (c) 2-ethyl-3-butyne, (d) 3-methyl-1-pentyne, (e) 3-methyl-4-pentyne.

21. Referring to the structures below, which statement is true ?



- (a) I and II have different molecular formulas. (b) I and III are structural isomers of each other. (c) II and III are stereoisomers of each other. (d) II and III are different conformations of the same compound. (e) I and III are the same compound.

22. Naturally occurring copper exists in two isotopic forms:  $^{63}\text{Cu}$  and  $^{65}\text{Cu}$ . The atomic mass of copper is 63.55 amu. What is the approximate natural abundance of  $^{63}\text{Cu}$  ?

- (a) 63%, (b) 90%, (c) 70%, (d) 50%, (e) 30%.

23. You heat 3.970 g of a mixture of  $\text{Fe}_3\text{O}_4$  and  $\text{FeO}$  to form 4.195 g  $\text{Fe}_2\text{O}_3$ . The mass percent of  $\text{FeO}$  originally in the mixture was:

- (a) 12.1%, (b) 28.7%, (c) 71.3%, (d) 87.9%, (e) none of these.

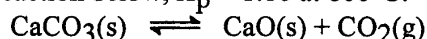
24. Consider two organic molecules, ethanol and benzene. One dissolves in water and the other does not. Why ?

- (a) They have different molar masses. (b) One is ionic, the other is not. (c) One is an electrolyte, the other is not. (d) Ethanol contains a polar O—H bond, and benzene does not. (e) Two of these.

25. A solution contains the ions  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ , and  $\text{Ni}^{2+}$ . Dilute solutions of  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ , and  $\text{Na}_2\text{S}$  are available to separate the positive ions from each other. In order to effect separation, the solutions should be added in which order?

(a)  $\text{Na}_2\text{SO}_4$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$ , (b)  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$ , (c)  $\text{Na}_2\text{S}$ ,  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ , (d)  $\text{NaCl}$ ,  $\text{Na}_2\text{S}$ ,  $\text{Na}_2\text{SO}_4$ , (e)  $\text{NaCl}$ ,  $\text{Na}_2\text{SO}_4$ ,  $\text{Na}_2\text{S}$

26. For the reaction below,  $K_p = 1.16$  at  $800^\circ\text{C}$ .



If a 20.0-gram sample of  $\text{CaCO}_3$  is put into a 10.0-liter container and heated to  $800^\circ\text{C}$ , what percent of the  $\text{CaCO}_3$  will react to reach equilibrium?

(a) 14.6%, (b) 65.9%, (c) 34.1%, (d) 100.0%, (e) none of these.

27. A 0.10-mol sample of a diprotic acid,  $\text{H}_2\text{A}$ , is dissolved in 250 mL of water. The  $K_{a1}$  of this acid is  $1.0 \times 10^{-5}$  and  $K_{a2}$  is  $1.0 \times 10^{-10}$ . Calculate the concentration of  $\text{A}^{2-}$  in this solution.

(a)  $1.0 \times 10^{-5}$  M, (b)  $2.0 \times 10^{-3}$  M, (c)  $4.0 \times 10^{-6}$  M, (d)  $1.0 \times 10^{-10}$  M, (e) 0.40 M.

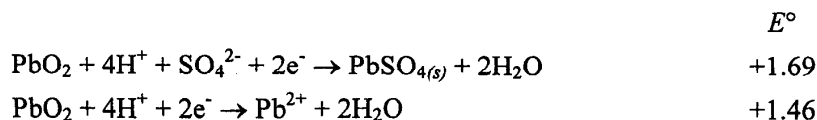
28. A 0.240 M solution of the salt  $\text{NaA}$  has a pH of 8.40. Calculate the  $K_a$  value of the acid  $\text{HA}$ .

(a)  $6.60 \times 10^{-17}$ , (b)  $1.05 \times 10^{-5}$ , (c)  $3.80 \times 10^{-4}$ , (d)  $2.63 \times 10^{-11}$ , (e) none of these.

29. Of energy, work, enthalpy, and heat, how many are state functions?

(a) 0, (b) 1, (c) 2, (d) 3, (e) 4.

30. Using the following data



calculate the  $K_{sp}$  value at  $25^\circ\text{C}$  for  $\text{PbSO}_4(\text{s})$ .

(a)  $1.7 \times 10^{-9}$ , (b)  $1.7 \times 10^{-10}$ , (c)  $1.7 \times 10^{-7}$ , (d)  $1.7 \times 10^{-8}$ , (e)  $1.7 \times 10^{-6}$ .

31. What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from  $n = 5$  to  $n = 2$ ?

(a)  $5.12 \times 10^{-7}$  m, (b)  $4.34 \times 10^{-7}$  m, (c)  $6.50 \times 10^{-7}$  m, (d)  $5.82 \times 10^{-7}$  m, (e) none of these.

32. The number of orbitals having a given value of  $l$  is equal to

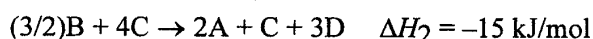
(a)  $2l + 1$ , (b)  $2n + 2$ , (c)  $3l$ , (d)  $l + m_l$ , (e) the number of lobes in each orbital

33. Which of the following combinations of quantum numbers is not allowed?

|           | $n$ | $l$ | $m(l)$ | $m(s)$ |
|-----------|-----|-----|--------|--------|
| Option 1: | 1   |     | 0      | 1/2    |
| Option 2: | 3   | 0   | 0      | -1/2   |
| Option 3: | 2   | 1   | -1     | 1/2    |
| Option 4: | 4   | 3   | -2     | -1/2   |
| Option 5: | 4   | 2   | 0      | 1/2    |

(a) Option 1, (b) Option 2, (c) Option 3, (d) Option 4, (e) Option 5.

34. Consider the following processes:



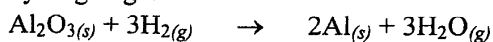


$$\Delta H_3 = 10 \text{ kJ/mol}$$

Calculate  $\Delta H$  for :  $C \rightarrow E + 3D$

(a) 0 kJ/mol, (b) 10 kJ/mol, (c) -10 kJ/mol, (d) -20 kJ/mol, (e) 20 kJ/mol.

35. Calculate  $\Delta S^\circ$  for the reduction of aluminum oxide by hydrogen gas :



using the following standard entropy values.

(a) 159 J/K, (b) 179 J/K, (c) 199 J/K, (d) 209 J/K, (e) 229 J/K.

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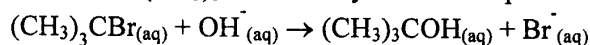
| Substance                          | $S^\circ$ (J K <sup>-1</sup> mol <sup>-1</sup> ) |
|------------------------------------|--|
| Al <sub>2</sub> O <sub>3</sub> (s) | 51   |
| H <sub>2</sub> (g)                 | 131  |
| Al(s)                              | 28   |
| H <sub>2</sub> O(g)                | 189  |

36. In the cyanide ion (CN<sup>-</sup>), the nitrogen has a formal charge of  
(a) -2, (b) -1, (c) 0, (d) 1, (e) 2.

37. The configuration  $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^1(\pi_{2p}^*)^1$  is the molecular orbital description for the ground state of

(a) Li<sub>2</sub><sup>+</sup>, (b) Be<sub>2</sub>, (c) B<sub>2</sub>, (d) B<sub>2</sub><sup>2-</sup>, (e) C<sub>2</sub>.

38. The reaction of (CH<sub>3</sub>)<sub>3</sub>CBr with hydroxide ion proceeds with the formation of (CH<sub>3</sub>)<sub>3</sub>COH.



The following data were obtained at 55°C.

| Exp. | $[(\text{CH}_3)_3\text{CBr}]_0$<br>(mol/L) | $[\text{OH}^-]_0$<br>(mol/L) | Initial Rate<br>(mol/L·s) |
|------|--|------------------------------|---------------------------|
| 1    | 0.10                                       | 0.10                         | $1.0 \times 10^{-3}$      |
| 2    | 0.20                                       | 0.10                         | $2.0 \times 10^{-3}$      |
| 3    | 0.10                                       | 0.20                         | $1.0 \times 10^{-3}$      |
| 4    | 0.30                                       | 0.20                         | ?                         |

What will the initial rate (in mol/L·s) be in Experiment 4 ?

(a)  $3.0 \times 10^{-3}$ , (b)  $6.0 \times 10^{-3}$ , (c)  $9.0 \times 10^{-3}$ , (d)  $18 \times 10^{-3}$ , (e) none of these.

39. 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. The formula for the metal fluoride is:

(a) MF<sub>2</sub>, (b) M<sub>2</sub>F, (c) MF, (d) MF<sub>8</sub>, (e) none of these.

40. Which of the following statements is (are) false ?

I. The hexagonal closest-packed structure is ABAB ---.

II. A body-centered cubic unit cell has four atoms per unit cell.

III. For unit cells having the same edge length, a simple cubic structure would have a smaller density than a body-centered cube.

IV. Atoms in a solid consisting of only one element would have six nearest neighbors if the crystal structure were a simple cubic array.

(a) I, (b) II, (c) II, III, (d) I, IV, (e) II, III, IV.