國　立　清　華　大　學　命　題　紙

96 學年度___工學院分子工程學程___系（所）_____組碩士班入學考試

科目__普通物理及普通化學__ 科目代碼__0902__共___11__頁第__1__頁 *請在【答案卷卡】內作答

General Chemistry

40 simple-choice questions for 50%

1. Bromine exists naturally as a mixture of bromine-79 and bromine-81 isotopes. An atom of bromine-79 contains
   (A) 35 protons, 44 neutrons, 35 electrons.
   (B) 34 protons and 35 electrons, only.
   (C) 44 protons, 35 neutrons, 44 electrons.
   (D) 35 protons, 79 neutrons, 35 electrons.
   (E) 79 protons, 79 neutrons, 35 electrons.

2. Which one of the following statements about atomic structure is false?
   (A) The electrons occupy a very large volume compared to the nucleus.
   (B) Almost all of the mass of the atom is concentrated in the nucleus.
   (C) The protons and neutrons in the nucleus are very tightly packed.
   (D) The number of protons and neutrons is always the same in the neutral atom.

3. Which among the following represent a set of isotopes? Atomic nuclei containing:
   I. 20 protons and 20 neutrons.
   II. 21 protons and 19 neutrons.
   III. 22 neutrons and 18 protons.
   IV. 20 protons and 22 neutrons.
   V. 21 protons and 20 neutrons.
   (A) I, II, III
   (B) III, IV
   (C) I, V
   (D) I, IV, and II, V
   (E) No isotopes are indicated.

4. Roundup, an herbicide manufactured by Monsanto, has the formula $C_3H_8NO_5P$. How many moles of molecules are there in a 500 g sample of Roundup?
   (A) 0.338
   (B) 1.75
   (C) 2.96
   (D) 84.5
   (E) None of these.

5. Which of the following solutions contains the greatest total ion concentration?
   (A) One mole of potassium chloride dissolved in 1.0 L of solution.
   (B) One mole of iron(II) nitrate dissolved in 1.0 L of solution.
   (C) One mole of potassium hydroxide dissolved in 1.0 L of solution.
   (D) One mole of sodium phosphate dissolved in 1.0 L of solution.
   (E) At least two of the above solutions have an equal number of ions, and these contain the greatest total ion concentration.

6. You dissolve a 1.28 g sample of NaCl in a total volume of 125 mL solution. Your lab partner has 1.5 M aqueous NaCl and wants to make a solution with the same concentration and volumes as yours. How much of the solution does your lab partner need to use?
   (A) 1.83mL
   (B) 14.6mL
   (C) 107mL
   (D) 125mL
   (E) None of these.

7. Which of the following relationships is not true?
   (A) PV=constant when temperature and moles of gas are held constant.
   (B) V/T=constant when pressure and moles of gas are held constant.
   (C) nT=constant when pressure and volume are held constant.
   (D) P/n=constant when volume and temperature are held constant.
   (E) All of the above are true.

8. Into a 3.0 liter container at 25°C are placed 1.23 moles of O_2 gas and 3.2 moles of solid C (graphite). If the carbon and oxygen react completely to form CO(g), what will be the final pressure in the container at 25°C.
   (A) 20.1 atm
   (B) 26.1 atm
   (C) 10.2 atm
   (D) 1.68 atm
   (E) None of these

9. For the reaction $2H_2(g) + O_2(g) \longleftrightarrow 2H_2O(g)$, what is the relationship between K and K_p at temperature T?
   (A) $K=K_p$
   (B) $K=K_p (RT)^2$
   (C) $K_p=K(RT)^2$
   (D) $K=K_p (RT)$
   (E) $K_p=K(RT)$

10. The following reaction is investigated (assume an ideal gas mixture):
    $2N_2O(g) + N_2H_4(g) \longleftrightarrow 3N_2(g) + 2H_2O(g)$
    Initially ther are 0.1 moles of N_2O and 0.25 moles of N_2H_4, in a 10 L container. If there are 0.06 moles of N_2O at equilibrium, how many moles of N_2 are present at equilibrium.
    (A) 0.39 moles/liter
    (B) 0.65 moles/liter
    (C) 0.82 moles/liter
    (D) 7.5 moles/liter
    (E) None of these.

11. The following acids are listed in order of decreasing acid strength in water
    $HI > HNO_2 > CH_3COOH > HClO > HCN$
    According to Bronsted-Lowry theory, which of the following ions is the weakest base?
    (A). I^-
    (B) NO_2^-
    (C) CH_3COO^-
    (D) ClO^-
    (E) CN^-

12. Identify the strongest base.
    (A) CH_3O^-
    (B) CH_3OH
    (C) CN^-
    (D) H_2O
    (E) NO_3^-

13. Which of the following will not produce a buffered solution?
    (A) 100mL of 0.1M Na_2CO_3 and 50 mL of 0.1M HCl
    (B) 100mL of 0.1M $NaHCO_3$ and 25 mL of 0.2M HCl
    (C) 100mL of 0.1M Na_2CO_3 and 75 mL of 0.2M HCl
    (D) 50mL of 0.2M Na_2CO_3 and 5 mL of 0.1M HCl
    (E) 100mL of 0.1M Na_2CO_3 and 50 mL of 0.1M NaOH

14. A 50.00 mL sample of 0.1 M KOH is titrated with 0.1 M HNO_3. Calculate the pH of the solution after the 52.00 mL is added.
    (A) 6.50
    (B) 3.01
    (C) 2.71
    (D) 2.41
    (E) None of these.

15. A 50.0 g sample of a metal is heated to 98.7°C and then placed in a calorimeter containing 395.0 g of water (c=4.18J/g°C) at 22.5 °C. The final temperature of the water is 24.5°C. Which metal was used?
    (A) Aluminum (c=0.89J/g°C)
    (B) Iron (c=0.45 J/g°C)
    (C) Copper (c=0.20 J/g°C)
    (D) Lead (c=0.14 J/g°C)
    (E) None of these.

16. For the reaction $A + B \rightarrow C + D$, $\Delta H^o = 40kJ$ and $\Delta S^o = 50kJ$. Therefore, the reaction under standard conditions is

(A) Spontaneous at temperatures less than 10K.

(B) Spontaneous at temperatures greater than 800K

(C) Spontaneous only at temperatures between 10K and 800K.

(D) Spontaneous at all temperatures.

(E) Non-spontaneous at all temperatures.

17. The reaction

$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$

Has a positive value of ΔG^o. Which of the following statements must be true?

(A) The reaction is slow.

(B) The reaction will not occur.

(C) The reaction is exothermic

(D) The equilibrium lies far to the right.

(E) None of these is true.

18. Which of the following is the best reducing agent?

$Cl_2 + 2e^- \rightarrow 2Cl^-$ $E^o = 1.36$ V

$Mg^{2+} + 2e^- \rightarrow Mg$ $E^o = -2.37$ V

$2H^+ + 2e^- \rightarrow H_2$ $E^o = 0.00$ V

(A) Cl2

(B) H2

(C) Mg

(D) Mg+2

(E) Cl-

19. A fuel cell designed to react grain alcohol with oxygen has the following net reaction:

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3HO_2(l)$

The maximum work one mole of alcohol can yield by this process is 1320 kJ. What is the theoretical maximum voltage this cell can achieve?

(A) 0.760 V

(B) 1.14 V

(C) 2.01 V

(D) 2.28 V

(E) 13.7 V

20. Which of the following statements is false?

(A) An orbital can accommodate at most two electrons.

(B) The electron density at a point is proportional to Ψ^2 at that point.

(C) The spin quantum number of an electron must be either +1/2 or -1/2.

(D) A 2p orbital is more penetrating than a 2s; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1s orbital.

(E) In the usual order of filling, the 6s orbital is filled before the 4f orbital.

21. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively?

(A) S, O, F and F, O, S

(B) F, S, O and O, S, F

(C) S, F, O and S, F, O

(D) F, O, S and S, O, F

(E) None of these

22. Which of the following molecules has a dipole moment?

(A) CH_4

(B) CCl_4

(C) CO_2

(D) SO_3

(E) None of these

23. Choose the molecule with the strongest bond.

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

24. As the bond order of a bond increases, its bond energy ------ and its bond length ------.

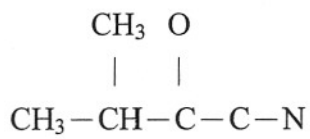
(A) increases, increases

(B) decreases, decreases

(C) increases, decreases

(D) decreases, decreases

25.Complete the Lewis structure for the following molecules:



This molecule has ------ sigma and ------ pi bonds.

(A) 4, 5
(B) 6, 3
(C) 11, 5
(D) 13, 2
(E) 13, 3

26.For a reaction: aA → Products, $[A]_o$=4.0M, and the first two half-lives are 48 and 96 minutes, respectively. Calculate k (without units)

(A) $8.3x10^{-2}$
(B) $2.6x10^{-3}$
(C) $4.1x10^{-3}$
(D) $1.4x10^{-2}$
(E) None of these

27.For which of the following is the half-life directly dependent on the concentration of the reactant?

(A) Zero-order reaction
(B) First-order reaction
(C) Second-order reaction
(D) Two of the above
(E) All of the above (a-c)

28.Which of the following substances would you expect to have the lowest boiling point?

(A) Diamond
(B) Methane
(C) Sodium nitrate
(D) Glycerine
(E) Copper

29.Which of the following is the smallest hole in a closest-packed lattice of spheres?

(A) Trigonal
(B) Tetrahedral
(C) Cubic
(D) Octahedral
(E) None of these

30.Rank the following compounds according to increasing solubility in water.

I. CH_3--$CH_2-CH_2-CH_3$
II. $CH_3-CH_2-O-CH_2-CH_3$
III. CH_3-CH_2-OH
IV. CH_3-OH

(A) I < III < IV < II
(B) I < II < IV < III
(C) III < IV < II < I
(D) I < II < III < IV
(E) No order is correct.

31.Liquid A has vapor pressure x. Liquid B has vapor pressure y and x > y. What is the mole percent of the liquid mixture if the vapor above the solution is 50% A?

(A) y/(2x+2y)
(B) x/(2x+2y)
(C) x(x+y)
(D) y/(x+y)
(E) None of these

32.Ionic hydrides are formed when hydrogen combines with elements from:

I. Group 1A
II. Group 2A
III. Group 3A

(A) I, II, and III
(B) I and II
(C) I and III
(D) II and III
(E) None of these

33.Choose the metal that reacts least vigorously with water.

(A) Mg

(B) Ca

(C) Sr

(D) Ba

(E) All of these react equally vigorously with water.

34.Choose the element with smallest ionization energy.

(A) N

(B) P

(C) As

(D) Sb

(E) Bi

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

(A) +6

(B) +4

(C) +2

(D) 0

(E) -2

36.How many of the following compounds exhibit geometric isomers?

IV. $Pt(NH_3)_2Cl_2$ (square planar)

V. $[Co(H_2O)_2]Cl_3$

VI. $Ni(NH_3)_4(NO_2)_2$

VII. $K_2[CoCl_4]$

(A) 0

(B) 1

(C) 2

(D) 3

(E) 4

37.Give the number of geometrical isomers for the octahedral compound $[Ma_2B_2C_2]$, where A, B, and C represent ligands.

(A) 1
(B) 2
(C) 3
(D) 5
(E) None of these.

38.Which of the following processes decreases the atomic number by 1?

(A) Gamma-ray production
(B) Alpha-particle production
(C) Beta-particle production
(D) Positron production
(E) None of these

39.The number of half-lives needed for a radioactive element to decay to one-fourth of its original activity is (choose nearest number):

(A) 2
(B) 3
(C) 4
(D) 5
(E) None of these

40.Identify the type of organic compound shown:

$(CH_3)_2CHOH$

(A) Primary alcohol
(B) Secondary alcohol
(C) Tertiary alcohol
(D) Carboxylic acid
(E) None of these

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General Physics

1. Find the moments of inertia for a homogeneous circular disk of density ρ, radius R, and thickness h with respect to the following two axes of rotation.
   (1) The principal axis that pass through the center-of-mass and lies normal to the circular plane. [5%]
   (2) The principal axis that passes through the center-of-mass and lies parallel to the circular plane. [10%]

2. (1) Explain why soap bubbles often appears colored, although the soap water is nearly transparent and only slightly milky. [5%]
   (2) As the water within the bubble membrane drains, the membrane thins to an extent that it does not appear colored any more and is said to be "dark" (due to disappearance of the bright colors). Assuming that the refractive index of water is 1.33, give an estimate of the soap film thickness when the membrane becomes "dark". [5%]

3. Reflected sun light from a horizontal surface is more or less polarized. This is one reason that we wear sun glasses (which serve mainly as polarized filters) when we go to the beach in sun-shining days.
   (1) At a certain incident angle θ_B, the reflected light can be completely polarized. On the basis of Snell's law, derive an expression for θ_B in terms of refractive indices of air (n_1) and the reflecting substrate (i.e., water, n_2). [5%]
   (2) What should be the direction of polarization of the sun glasses, vertical or horizontal? Explain. [5%]

4. Consider an ideal gas at an initial state of p_1, T_1 and V_1. What would be its pressure and temperature if the gas is allowed to expand reversibly and adiabatically to V_2? [10%]

5. Show that an analogy may be drawn between an electric circuit of a resistor and a capacitor in series and a mechanical system of an elastic spring and a dashpot in series [5%]