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考試科目: 普通化學   考試日期:0223,節次:2

※ 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. 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 the number of neutrons are always the same in the neutral atom.

2. Compound X_2Y is 60% X by mass.   Calculate the percent Y by mass of the compound X_2Y_2.
   A)   23.5%   B)   35.2%   C)   41.5%   D)   57.1%   E)   57.5%

3. Which statement about kinetic energy (K.E.) is true?
   A)   All objects moving with the same velocity have the same K.E.
   B)   As the velocity of a body increases, its K.E. decreases.
   C)   The K.E. of a body will double if its velocity doubles.
   D)   The K.E. of a body is independent of its mass.
   E)   None of these statements is true.

4. How is the observed pressure of a gas related to the ideal pressure?
   A)   The observed pressure is less than the ideal pressure.
   B)   The observed pressure is greater than the ideal pressure.
   C)   They are equal.
   D)   The relationship depends on the gas.
   E)   none of these

5. Given the reaction $A(g) + B(g) \rightleftharpoons C(g) + D(g)$.   You have the gases A, B, C, and D at equilibrium. Upon adding gas A, the value of K
   A)   increases because when A is added, more products are made, increasing the ratio of product to reactant.
   B)   decreases because A is a reactant, so the ratio of product to reactant decreases.
   C)   does not change because A does not figure in the ratio of product to reactant.
   D)   does not change as long as the temperature is constant.
   E)   depends on whether the reaction is endothermic or exothermic.

6. For a particular system at a particular temperature, there are _____ equilibrium constant(s) and _____ equilibrium position(s).
   A)   an infinite number of, one   B)   one, an infinite number of
   C)   one, one   D)   an infinite number of, an infinite number of
   E)   none of these

7. For a neutral solution, it must be true that
   A)   pH = 7.00.   B) $[H^+] = 0\ M$ C) $[H^+] = [OH^-]$.
   D) $[H_2O] = 1 \times 10^{-14}$ E)   At least two of these must be true.

8. The salt BX, when dissolved in water, produces an acidic solution. Which of the following could be true?
   A)   HX is a weak acid.   B)   HX is a strong acid.
   C)   The cation B^+ is a weak acid.   D)   All of these could be true.
   E)   Both HX and the cation B^+ are weak acids.

(背面仍有題目,請繼續作答)

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9. Which of the following solutions will be the best buffer at a pH of 9.26? (K_a for $HC_2H_3O_2$ is 1.8×10^{-5}; K_b for NH_3 is 1.8×10^{-5}.)
   A)　0.20 M $HC_2H_3O_2$ and 0.20 M $NaC_2H_3O_2$　　B)　0.20 M NH_3 and 0.20 M NH_4Cl
   C)　3.0 M $HC_2H_3O_2$ and 3.0 M NH_4Cl　　D)　3.0 M NH_3 and 3.0 M NH_4Cl
   E)　3.0 M $HC_2H_3O_2$ and 3.0 M NH_3

10. The pH at the equivalence point of a titration of a weak acid with a strong base is
    A)　less than 7.00　　　B)　equal to 7.00　　　C)　greater than 7.00
    D)　More data are needed to answer this question.

11. Which of the following are state functions?
    A)　work, heat　　　B)　work, heat, enthalpy, energy　　　C)　enthalpy, energy
    D)　work, heat, enthalpy　E)　heat, enthalpy, energy

12. Consider the dissociation reaction of the acid HF.
    $$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$$
    Why is ΔS negative?
    A)　Each HF molecule produces two ions when it dissociates.
    B)　The ions are hydrated.
    C)　The reaction is expected to be exothermic, and ΔS thus should be negative.
    D)　The reaction is expected to be endothermic, and thus ΔS should be negative.
    E)　none of these
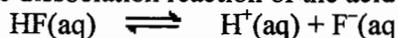
13. Which of the following is true?
    A)　As long as the disorder of the surroundings is increasing, a process will be spontaneous.
    B)　For any process, ΔS_{surr} and ΔS_{sys} have opposite signs.
    C)　If $\Delta S_{surr} = -\Delta S_{sys}$, the process is at equilibrium.
    D)　$H°$ is zero for a chemical reaction at constant temperature.
    E)　none of these

14. From the following list of observations, choose the one that most clearly supports the conclusion that electrons have wave properties.
    A)　the emission spectrum of hydrogen　　B)　the photoelectric effect
    C)　the scattering of alpha particles by metal foil　　D)　diffraction
    E)　cathode "rays"

15. Which of the following shows these molecules in order from most polar to least polar?
    A)　$CH_4 > CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2$
    B)　$CH_4 > CF_2H_2 > CF_2Cl_2 > CCl_4 > CCl_2H_2$
    C)　$CF_2Cl_2 > CF_2H_2 > CCl_2H_2 > CH_4 = CCl_4$
    D)　$CF_2H_2 > CCl_2H_2 > CF_2Cl_2 > CH_4 = CCl_4$
    E)　$CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2 > CH_4$

16. Which statement is correct?
    A)　H_2O is linear.
    B)　The molecule ClO_2 cannot be accurately described by a Lewis structure consistent with the octet rule.
    C)　The diatomic molecule Cl_2 is an example of a polar molecule.
    D)　The bonds in LiF have a more covalent character than those in F_2.
    E)　none of these

17. Which of the following has a central atom that is dsp^3 hybridized?
    A)　SCl_4^-　　B)　SF_4　　C)　CBr_4　　D)　SBr_6　　E)　SO_3

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18. If the reaction $2HI \rightarrow H_2 + I_2$ is second order, which of the following will yield a linear plot?
    A) log [HI] vs. time　　B) 1/[HI] vs. time　　C) [HI] vs. time
    D) ln [HI] vs. time

19. Identify the major attractive force in H_2S.
    A) London dispersion forces　　B) dipole-dipole interactions
    C) hydrogen bonding　　D) ionic bonding
    E) none of these

20. A solution of two liquids, A and B, shows negative deviation from Raoult's law. This means that
    A) molecules of A interact strongly with other A-type molecules.
    B) the two liquids have a positive heat of solution.
    C) molecules of A interact weakly, if at all, with B molecules.
    D) the molecules of A hinder the strong interaction between B molecules.
    E) molecules of A interact more strongly with B than with A or and more strongly than B with B.

21. What reason is given for the stability of C—C, N—N, and O—O bonds compared to the instability of Si—Si, P—P, and S—S bonds?
    A) Their metallic character varies greatly.
    B) There are large differences in their ionization energies.
    C) There are large differences in their electronegativities.
    D) There are large differences in their abilities to form strong pi bonds.
    E) none of these

22. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of $AgNO_3$?
    A) $[Cr(NH_3)_3Cl_3]$　　B) $[Cr(NH_3)_6]Cl_3$　　C) $Na_3[Cr(CN)_6]$
    D) $[Na_3CrCl_6]$　　E) all of these

23. Which of the metal ions in the following complex ions has a d^5 electron configuration?
    A) $[Ti(H_2O)_6]^{2+}$　　B) $[Ni(NH_3)_6]^{3+}$　　C) $[Cr(CN)_6]^{3-}$
    D) $[Fe(CN)_6]^{3-}$　　E) $[FeCl_6]^{4-}$

24. The most likely decay mode (or modes) of the unstable nuclide $_6C^{11}$ would be
    A) positron production.　　B) α-particle production.　　C) electron capture.
    D) β-emission　　E) either positron production or electron capture or both.

25. Which of the following molecules exhibits chirality?
    A) CH_2Cl_2　　B) CH_3NH_2　　C) $CH_3CH_2OCH_3$
    D) $CH_3CClFOH$　　E) CH_3CH_2OH

二、非選擇題 (50%)

1. Are solutions of the following salts acidic, basic, or neutral? Account for your answer. (K_a for HCN is 6.2×10^{-10}; K_a for HF is 7.2×10^{-4}; K_a for $HC_2H_3O_2$ is 1.8×10^{-5}; K_b for C_5H_5N is 1.7×10^{-9}; K_b for NH_3 is 1.8×10^{-5}; K_b for $C_2H_5NH_2$ is 5.6×10^{-4} and K_{a1} for H_2CO_3 is 4.3×10^{-7}) (5%)
    a. $Sr(NO_3)_2$　　b. $C_2H_5NH_3CN$　　c. C_5H_5NHF
    d. $NH_4C_2H_3O_2$　　e. $NaHCO_3$

(背面仍有題目，請繼續作答)

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2. The $Co(NH_3)_6^{3+}$ is diamagnetic, but $Fe(H_2O)_6^{2+}$ is paramagnetic. Explain. (6%)

3. Consider the following pH curves for 100.0 mL of two different acids with the same initial concentration each titrated by 0.10 M NaOH:
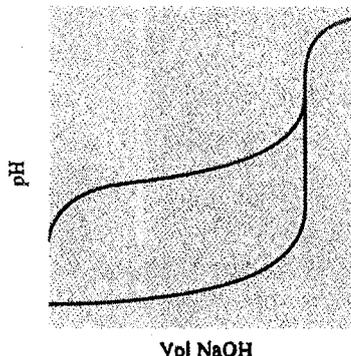
Which plot represents a pH curve of a weak acid and which plot is for a strong acid? (2%) How can you tell? Cite three differences between the plots that help you decide. (6%)

4. A galvanic cell is shown below. The contents of each half-cell are written beneath each compartment.

0.01 M MnO_4^-	0.40 M Cr^{3+}
0.2 M Mn^{2+}	0.30 M $Cr_2O_7^{2-}$
0.010 M H^+	0.010 M H^+
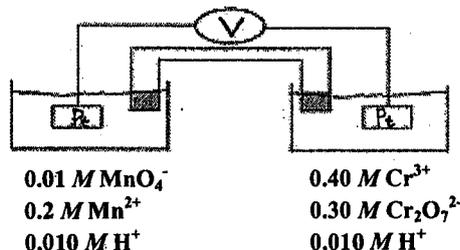
The standard reduction potentials are as follows:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O \qquad E = 1.51\ V$$

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O \qquad E = 1.33\ V$$
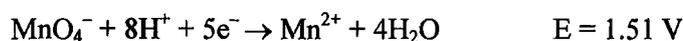
Please answer the following questions.
    a. When current is allowed to flow, which species is oxidized? (2%)
    b. When current is allowed to flow, which species is reduced? (2%)
    c. In which direction do electrons flow in the external circuit? (2%)
    d. What is the cell potential at 25°C as read on the digital voltmeter? (4%)

5. A second process called the carbon-nitrogen cycle occurs in the sun:
    1. $_1H^1 + _6C^{12} \rightarrow _7N^{13} + _0\gamma^0$　　2. $_7N^{13} \rightarrow _6C^{13} + _{+1}e^0$　　3. $_1H^1 + _6C^{13} \rightarrow _7N^{14} + _0\gamma^0$
    4. $_1H^1 + _7N^{14} \rightarrow _8O^{15} + _0\gamma^0$　　5. $_8O^{15} \rightarrow _7N^{15} + _{+1}e^0$　　6. $_1H^1 + _7N^{15} \rightarrow _6C^{12} + _2He^4 + _0\gamma^0$

Overall reaction: $4\,_1H^1 \rightarrow _2He^4 + 2_{+1}e^0$
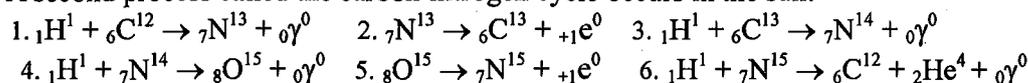
a. What is the catalyst in the above process? (2%)
b. What nucleons are intermediates? (2%)
c. How much energy is released per mole of hydrogen nuclei reacted in the overall reaction? The atomic masses are as follows: $_1H^1$, 1.00782 amu and $_2He^4$, 4.00260 amu. The mass of electron is 5.4858 x 10^{-4} amu. (4%)

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6. Consider the relationship

$$\ln(K) = -\Delta H^{o}/RT + \Delta S^{o}/R$$

The equilibrium constant for some hypothetical process was determined as a function of temperature (in Kelvins) with the results plotted below.
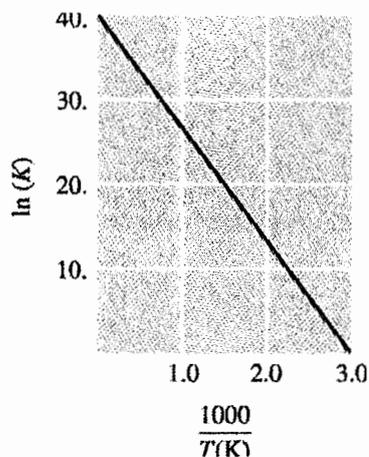
a. Determine the values of ΔH^{o} and ΔS^{o} for this process. (4%)

b. What would be the major difference in the $\ln(K)$ versus 1/T plot for an endothermic process as compared to an exothermic process? (4%)

7. In the gas phase, the production of phosgene from chlorine and carbon monoxide is assumed to proceed by the following mechanism:

$$Cl_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2Cl \qquad \text{Fast Equilibrium}$$

$$Cl + CO \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} COCl \qquad \text{Fast Equilibrium}$$

$$COCl_2 + Cl_2 \overset{k_3}{\longrightarrow} COCl_2 + Cl \qquad \text{Slow}$$

$$2Cl \overset{k_4}{\longrightarrow} Cl_2 \qquad \text{Fast}$$

Overall reaction: $\quad CO + Cl_2 \longrightarrow COCl_2$
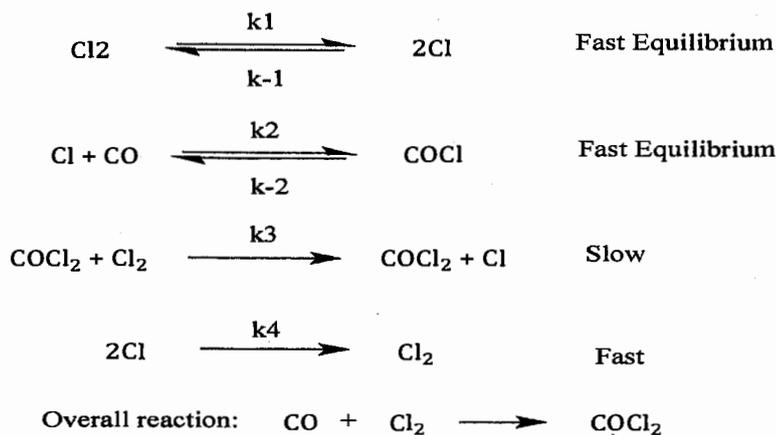
a. Write the rate law for this reaction. (3%)

b. Which species are intermediates? (2%)