※ 注意：請於試卷上「非選擇題作答區」依序作答，並應註明作答之題號。

多重選擇題(50%) – 總分50分(答錯選項扣分，至多扣到多重選擇題爲0分)

1. Which of the following pairs of compounds can be used to illustrate the law of multiple proportions?
   A) H_2S and HCl
   B) SO_2 and H_2SO_4
   C) NH_4 and NH_4Cl
   D) CH_4 and CO_2
   E) NO and NO_2
   F) none of the above

2. Which of the following combinations of names and formulas is (are) *incorrect*?
   A) PCl_5 Phosphorus pentachloride
   B) NO_2^- nitrate
   C) $NaHCO_3$ sodium carbonate
   D) ClO_4^- perchlorate
   E) $[Pt(NH_2CH_2CH_2NH_2)_3]Br_4$ Tris(ethylenediamine)platinum(IV)

3. Arginine contains 41.36% C, 18.37% O, 32.17% N, and 8.10% H by mass. What is its empirical formula?
   A) $C_4H_8N_{32}O_{18}$
   B) $C_4H_{10}N_3O_2$
   C) $C_6H_{14}N_4O_2$
   D) $C_4H_{10}N_3O_3$
   E) $C_3H_7N_2O$
   F) none of the above

4. To separate positive ions from each other, dilute solutions of Na_2S, NaCl, and Na_2SO_4 are available. What is the order in which the solution should be added in order to separate Ag^+, Pb^{2+}, and Ni^{2+} ions present in a sample solution?
   A) Na_2S, NaCl, Na_2SO_4
   B) NaCl, Na_2SO_4, Na_2S
   C) Na_2SO_4, NaCl, Na_2S
   D) Na_2SO_4, Na_2S, NaCl
   E) NaCl, Na_2S, Na_2SO_4
   F) none of the above

5. Which of the following statements is(are) *true*?
   A) Oxidation occurs at the positive electrode in the voltaic cell.
   B) Oxidation and reduction accompany all chemical changes.
   C) Oxidation and reduction describe the loss and gain of electron(s), respectively.
   D) Oxidation and reduction result in a change in the oxidation states of the species involved.
   E) For silver electroplating, a pure silver metal is the cathode.
   F) The net reaction in a hydrogen-oxygen fuel cell is the conversion of H_2 and O_2 to water

6. Three gases are placed separately in three closed, glass vessels at STP. Vessel X contains NH_3 gas, vessel Y contains NO_2 gas, and vessel Z contains N_2 gas.
   A) The molecules in vessel Z are most ideal in gas behavior.
   B) The molecules in vessel X have the highest average velocity.
   C) All vessels have the same number of molecules.
   D) The number of the molecules in one of the three vessels will decrease as the vessel temperature is decreased to -50℃.
   E) none of the above

7. Which of the following order of increasing pHs is correct for 0.10 M solutions of KOH, HCN, HNO_3, C_5H_5NHCl, NaF, and $NaC_2H_3O_2$? (K_a for HCN is 6.2×10^{-10}; K_a for HF is 7.2×10^{-4}; K_a for H $C_2H_3O_2$ is 1.8×10^{-5}; and K_b for C_5H_5N is 1.7×10^{-9})
   A) NaF, HNO_3, $NaC_2H_3O_2$, HCN, C_5H_5NHCl, KOH
   B) KOH, $NaC_2H_3O_2$, NaF, HCN, C_5H_5NHCl, HNO_3
   C) HNO_3, C_5H_5NHCl, HCN, NaF, $NaC_2H_3O_2$, KOH
   D) HNO_3, HCN, C_5H_5NHCl, NaF, $NaC_2H_3O_2$, KOH
   E) HNO_3, HCN, NaF, C_5H_5NHCl, $NaC_2H_3O_2$, KOH
   F) none of the above

8. The titration of 100.0 mL of a 0.100 M solution of weak acid H_3A with 0.200 M NaOH is carried out. What are the major species (except water) at each of the following specified points in the titration?
   A) HA^{2-}, after 100.0 mL NaOH is added
   B) H_2A^- and HA^{2-}, after 40.0 mL NaOH is added
   C) HA^{2-} and A^{3-}, after 120.0 mL NaOH is added
   D) HA^{2-}, after 50.0 mL NaOH is added
   E) H_2A^- and HA^{2-}, after 85.0 mL NaOH is added
   F) none of the above

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9. Which of the following involve(s) in an increase in the entropy of the system?

A) grinding a large crystal of KCl to powder　　B) $Br_2(g) \rightarrow Br_2(l)$

C) $O_2(298\ K) \rightarrow O_2(373\ K)$　　D) $NH_3(1\ atm, 298\ K) \rightarrow NH_3(3\ atm, 298\ K)$

E) mixing benzene with toluene (Both have similar intermolecular forces.)

10. What is the minimum energy required to excite an electron in a one-dimensional box from the ground state?

A) $\frac{h^2}{8\ mL^2}$　　B) $\frac{2h^2}{8\ mL^2}$

C) $\frac{3h^2}{8\ mL^2}$　　D) $\frac{4h^2}{8\ mL^2}$

E) $\frac{5h^2}{8\ mL^2}$　　F) none of the above

11. Which of the following exhibits the correct order for increasing wavelength of electromagnetic radiation?

A) gamma rays, infrared, radio, ultraviolet　　B) radio, infrared, ultraviolet, gamma rays

C) radio, ultraviolet, infrared, gamma rays　　D) gamma rays, ultraviolet, infrared, radio

E) gamma rays, radio, ultraviolet, infrared

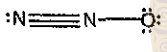
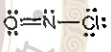
12. Which of the following sets of quantum numbers can correctly represent a 3p orbital?

A) $n = 3, l = 1, m_l = 2$　　B) $n = 3, l = 1, m_l = -1$

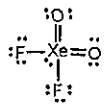
C) $n = 1, l = 3, m_l = 3$　　D) $n = 3, l = 2, m_l = 1$

E) $n = 3, l = 1, m_l = 0$　　F) $n = 3, l = 0, m_l = 1$

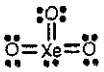
13. Which of the following molecular shapes of the specified molecules (or their general formula) is (are) correct, as predicted by the VSEPR theory?

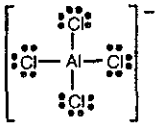
A)  linear　　B)  linear

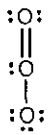
C) CCl_2CH_2 trigonal bipyramidal　　D) AX_3E_2 trigonal bipyramidal

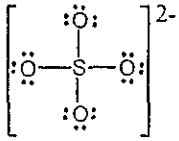
E)  octahedral　　F)  octahedral

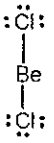
14. In which one(s) of the following structures does the central atom have a formal charge of +2?

A) XeO_3 

B) $AlCl_4^-$ 

C) O_3 

D) SO_4^{2-} 

E) $BeCl_2$ 

F) none of the above

15. The hybridization of the Cl atom in ClF_2^+ is

A) dsp^2　　B) d^2sp^3

C) sp　　D) sp^2

E) sp^2d　　F) none of the above

16. Which of the following statements is (are) true?

A) O_2^+ would give a bond order of 2.5　　B) C_2 is diamagnetic.

C) Six electrons are involved in pi bonding in benzene, C_6H_6　　D) N-O bond length: $NO^+ < NO_2^-$

E) The carbon-carbon bond in C_2^{2-} is stronger than the one in CH_3CH_3.

接次頁

17. The reaction $2A + B \rightarrow C$ has the following proposed mechanism:

Step 1: $A + B \rightleftharpoons D$ (fast equilibrium)
Step 2: $D + B \rightarrow E$
Step 3: $E + A \rightarrow C + B$

If step 2 is the rate-determining step, then the rate of formation of C should equal:

A) $k[A]$
B) $k[A][B]$
C) $k[A]^2[B]$
D) $k[A][B]^2$
E) $k[A]^2[B]^2$
F) none of the above

18. Which of the following statements is (are) correct?

A) Hydrogen is produced when zinc metal is immerged in hydrochloric acid.
B) Hydrogen can react with active metals to form compounds which contain H^+.
C) Aluminum metal can react with hot, concentrated $NaOH_{(aq)}$ to produce hydrogen.
D) Combustion takes place when hydrogen and oxygen are mixed at room temperature.
E) Pure hydrogen can be collected when water steam passes through hot coal.
F) Hydrogen is produced at the positive electrode when $NaH_{(l)}$ is electrolyzed.

19. Which of the following statements related to alkali metals and alkaline earth metals are *incorrect*?

A) They can all be obtained via electrolysis of their molten salts.
B) Their oxides can all be dissolved in the strong acid.
C) Their carbonate salts are all fairly soluble in water.
D) Their ions present in water are all colorless and not reactive.
E) Alkaline earth metals can form compounds of oxidation numbers +1 and +2, because of the presence of ns^2 electrons in their outer shells.

20. Which of the following orders of increasing intermolecular force is correct?

A) hydrogen-bonding, dipole-dipole, London dispersion, and ionic
B) London dispersion, ionic, dipole-dipole, and hydrogen-bonding
C) dipole-dipole, ionic, London dispersion, and hydrogen-bonding
D) dipole-dipole, London dispersion, ionic, and hydrogen-bonding
E) London dispersion, dipole-dipole, hydrogen-bonding, ionic

21. The freezing point for 4.6 g of formic acid (HCOOH) dissolved in 1.0 kg of benzene (C_6H_6) is depressed by 0.26 ℃, whereas that for the same amount of HCOOH dissolved in 1.0 kg of water is lowered by 0.19℃. ($K_{f,\,C_6H_6}$ = 5.12℃-kg/mol; $K_{f,\,H_2O}$ = 1.86℃-kg/mol) In order to explain these observations, one needs to assume that HCOOH is

A) associated in C_6H_6 and monomeric in water.
B) monomeric in C_6H_6 and associated in water.
C) associated in C_6H_6 and dissociated in water.
D) dissociated in C_6H_6 and monomeric in water.
E) monomeric in C_6H_6 and dissociated in water.
F) none of the above

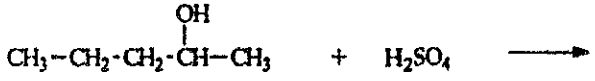
22. Which of the following are structural isomers?

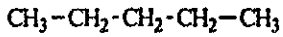
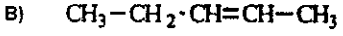
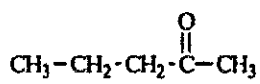
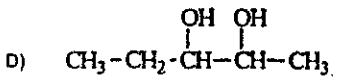
A) optical isomers
B) geometric isomers
C) coordination isomers
D) linkage isomers
E) stereoisomers
F) enantiomers

23. $^{11}_{6}C$ is an unstable isotope. Which radioactive decay would be expected?

A) β^- B) α C) β^+ D) α^- E) $^{1}_{0}n$

24. The main organic compound produced when 2-pentanol reacts with sulfuric acid is



A) 
B) 
C) 
D) 

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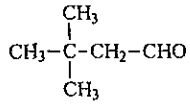
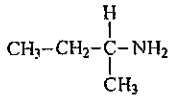
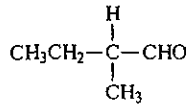
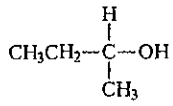
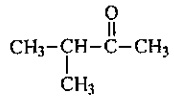
25. Which of the following compounds is (are) optically active aldehyde?

A) 

B) 

C) 

D) 

E) 

F) none of the above

26.(19%) Iron (II) sulfate is added to a sample solution of 100.0 mL such that the solution prepared contains 0.100 M in $Ag^{+}_{(aq)}$, 0.0100 M in $Fe^{3+}_{(aq)}$ and 0.100 M in $Fe^{2+}_{(aq)}$. (a) Calculate the equilibrium constant, based on the electrochemical data shown below, for the reaction ($Ag^{+}_{(aq)} + Fe^{2+}_{(aq)} \leftrightarrows Ag_{(s)} + Fe^{3+}_{(aq)}$) that will take place in the solution at 25.0 °C. (b) Calculate $\Delta G°$ for the reaction. (c) Calculate $\Delta G_f°$ for $Fe^{2+}_{(aq)}$. (d) When equilibrium for the reaction is established at 25 °C, how many moles of solid silver will be present? ($\Delta G_f°$ = -4.7 kJ/mol for $Fe^{3+}_{(aq)}$, $\Delta G_f°$ = 77.11 kJ/mol for $Ag^{+}_{(aq)}$)

$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$ $\quad E^0 = 0.799$ V

$Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$ $\quad E^0 = 0.771$ V

27.(13%) 50.0 mL of 0.100 M HOAc is titrated with 0.100 M NaOH. Calculate the pH at the start of the titration and after the addition of 15.0, 50.0, and 50.1 mL of titrant. ($K_aHOAc = 1.75 \times 10^{-5}$)

28.(8%) Bohr found that the energy of the electron in a hydrogen atom was quantized. The energy of an electron in its third energy level (n=3) is -2.421×10^{-19} J. (a) Calculate the constant which relates the energy value to the specified energy level. (b) Calculate the energy produced per gram of hydrogen for H atoms undergoing an electronic transition from the n=4 level to the n=1 level. (H=1.00794)

29.(10%) Derive to prove that for the ideal gas in the isothermal process $q = n R T \ln\frac{V_2}{V_1}$

試題隨卷繳回