

共五十題單選題，答對一題計二分，答錯一題倒扣0.5分，請將題號及答案寫在答案紙上，否則不予計分。

1. An atom that has the same number of neutrons as  $^{85}\text{Rb}$  is (A)  $^{85}\text{Kr}$  (B)  $^{87}\text{Rb}$  (C)  $^{85}\text{Sr}$  (D)  $^{86}\text{Sr}$  (E)  $^{86}\text{Kr}$
2. Which of the following substances is commonly called laughing gas? (A)  $\text{N}_2\text{O}$  (B)  $\text{NO}_2$  (C)  $\text{NO}$  (D)  $\text{N}_2\text{O}_4$  (E)  $\text{Mg}_3\text{N}_2$
3. In the compound sodium oxalate, the molar ratio of sodium to carbon atoms is (A) 1 : 1 (B) 2 : 1 (C) 1 : 2 (D) 1 : 3 (E) 2 : 3
4. The name of the  $\text{SO}_3^{2-}$  ion is (A) sulfite (B) sulfate (C) sulfide (D) thiosulfate (E) bisulfide ion
5. At 27 °C and 1.00 atm, the density of a gaseous hydrocarbon is 1.22 g/L. The hydrocarbon is (A)  $\text{CH}_4$  (B)  $\text{C}_2\text{H}_4$  (C)  $\text{C}_2\text{H}_6$  (D)  $\text{C}_3\text{H}_8$  (E)  $\text{C}_3\text{H}_6$
6. What is the partial pressure of  $\text{SO}_2$  in millimeters of mercury, if 100 g of  $\text{O}_2$  are mixed with 100 g of  $\text{SO}_2$ , and the total pressure is 600 mmHg? (A) 500 (B) 400 (C) 300 (D) 200 (E) 100
7. A sample of gas in closed container of fixed volume is at 250 K and 400-mmHg pressure. If the gas is heated to 375 K, its pressure increases to 600 mmHg. By what factor will the average speed of the molecules increase? (A) 1.22 (B) 1.50 (C) 2.25 (D) 2.00 (E) 2.75
8. If the rate of effusion of ammonia,  $\text{NH}_3$ , is 3.32 times faster than that of an unknown gas when both gases are at 350 K, what is the molecular weight of the unknown gas? (A) 31.0 (B) 45.5 (C) 56.5 (D) 112 (E) 188
9. Which of the following substances is most likely to exist as a gas at 25 °C and 1-atm pressure? (A)  $\text{MgO}$  (B)  $\text{C}_7\text{H}_{16}$  (C)  $\text{B}_2\text{H}_6$  (D)  $\text{AsI}_3$  (E)  $\text{LiF}$
10. At a specified value of pressure and of temperature, which of the following gases will show the greatest deviation from the ideal gas law? (A)  $\text{N}_2$  (B)  $\text{NH}_3$  (C)  $\text{NO}$  (D)  $\text{Ne}$  (E)  $\text{NF}_3$
11. The boiling point of a 1.00 m solution of  $\text{CaCl}_2$  should be elevated by (A) exactly 0.51 °C (B) some what less than 1.02 °C (C) exactly 1.02 °C (D) somewhat less than 1.53 °C (E) exactly 1.53 °C
12. How many grams of potassium permanganate,  $\text{KMnO}_4$ , are needed to prepare 250.00 mL of a 0.1000 M solution? (A) 3.951 g (B) 9.877 g (C) 15.80 g (D) 39.51 g (E) 158.0 g (K = 39, Mn = 55)
13. What volume of 0.125 N  $\text{HNO}_3$  is required to completely neutralize 25.00 mL of 0.108 M  $\text{Ba}(\text{OH})_2$ ? (A) 14.47 mL (B) 21.60 mL (C) 28.94 mL (D) 43.20 mL (E) 64.80 mL
14. In which of the following liquids would you expect the solubility of  $\text{NaCl}$  to be the smallest? (A)  $\text{HF}$  (B)  $\text{CH}_3\text{OH}$  (C)  $\text{CH}_3\text{COCH}_3$  (D)  $\text{H}_2\text{O}$  (E)  $\text{CCl}_4$
15. All of the following species can exist in aqueous solution EXCEPT (A)  $\text{NH}_4^+$  (B)  $\text{NO}_3^-$  (C)  $\text{NO}_2^-$  (D)  $\text{NH}_3$  (E)  $\text{NH}_2^-$
16. The pH of a 0.050 N HA solution is 5.35 What is  $K_a$  for HA? (A)  $2.0 \times 10^{-11}$  (B)  $4.0 \times 10^{-10}$  (C)  $4.5 \times 10^{-6}$  (D)  $8.9 \times 10^{-5}$  (E)  $5.0 \times 10^{-2}$
17. A flask contains 100 ml of 0.10 F HOAc. To prepare a buffer with pH = 4.75, which of the following samples of barium acetate solution should be added to the flask? ( $K_a$  of HOAc =  $1.8 \times 10^{-5}$ ) (A) 50 mL of 0.40 F  $\text{Ba}(\text{OAc})_2$  (B) 25 mL of 0.20 F  $\text{Ba}(\text{OAc})_2$  (C) 50 mL of 0.20 F  $\text{Ba}(\text{OAc})_2$  (D) 100 mL of 0.10 F  $\text{Ba}(\text{OAc})_2$  (E) 200 mL of 0.10 F  $\text{Ba}(\text{OAc})_2$
18. A weak base, B, has basicity constant  $K_b = 2 \times 10^{-5}$ . The pH of any solution in which  $[\text{B}] = [\text{BH}^+]$  is (A) 4.7 (B) 7.0 (C) 9.3 (D) 9.7 (E) 10.3
19. At the temperature at which the  $K_{sp}$  of  $\text{PbSO}_4$  is  $1.7 \times 10^{-8}$ , the molar solubility of  $\text{PbSO}_4$  in pure water is (A)  $1.7 \times 10^{-7}$  M (B)  $1.7 \times 10^{-8}$  M (C)  $1.3 \times 10^{-4}$  M (D)  $1.7 \times 10^{-9}$  M (E)  $1.3 \times 10^{-8}$  M
20. When 60 mL of 0.10 F  $\text{Pb}(\text{NO}_3)_2$  and 40 mL of 0.125 F  $\text{Na}_2\text{CO}_3$  are mixed,  $\text{CaCO}_3$  precipitates. If  $K_{sp}(\text{CaCO}_3) = 5 \times 10^{-9}$ , the  $[\text{CO}_3^{2-}]$  in the resulting solution is (A) 0.10 M (B) 0.05 M (C)  $5 \times 10^{-7}$  M (D)  $8 \times 10^{-8}$  M (E)  $5 \times 10^{-8}$  M

21. Which of the following statements best describes the emission spectrum of atomic hydrogen? (A) A discrete series of lines of equal intensity and equally spaced with respect to wavelength. (B) A series of only four lines. (C) A continuous emission of radiation of all frequencies. (D) Several discrete series of lines with both intensity and spacings between lines decreasing as the wave number increases within each series. (E) A discrete series of lines with both intensity and spacings between lines decreasing as the wavelength increases.
22. Which of the following statements about Millikan's oil drop experiment is TRUE? (A) When the electric field is turned on, all the oil drops move toward the positively charged plate. (B) The charge on each oil drop is the electronic charge. (C) In the absence of the electric field, the speed with which the drop falls depends only upon the acceleration of gravity. (D) Oil drops, rather than water drops, were used because oil is easier to see. (E) Some oil drops become positively charged and some become negatively charged after colliding with gaseous ions.
23. The amount of energy required to remove the electron from a  $\text{Li}^{2+}$  ion in its ground state is how many times greater than the amount of energy needed to remove the electron from an H atom in its ground state? (A) 2 (B) 3 (C) 4 (D) 6 (E) 9
24. Which of the following series of elements have most nearly the same atomic radius? (A) Ne, Ar, Kr, Xe (B) Mg, Ca, Sr, Ba (C) B, C, N, O (D) Ga, Ge, As, Se (E) Cr, Mn, Fe, Co
25. The ground state electronic configuration of  $\text{Fe}^{+3}$  is (A)  $(\text{Ar})1^83d^34s^2$  (B)  $(\text{Ar})1^83d^64s^2$  (C)  $(\text{Ar})1^83d^5$  (D)  $(\text{Ar})1^83d^44s$  (E)  $(\text{Ar})1^83d^6$
26. Which hybrids can be used for bonding in a square-planar molecule or ion? (A)  $sp^3$  (B)  $dsp^2$  (C)  $sp^2$  (D)  $d^2sp^3$  (E)  $sp^3d$
27. Which of the following diatomic species do you expect to have the longest bond length? (A)  $\text{NO}^+$  (B)  $\text{O}_2^-$  (C) CO (D)  $\text{O}_2^+$  (E)  $\text{N}_2^+$
28. A sulfur-containing species that cannot be a reducing agent is (A)  $\text{SO}_2$  (B)  $\text{SO}_3^{2-}$  (C)  $\text{SO}_4^{2-}$  (D)  $\text{S}^{2-}$  (E)  $\text{S}_2\text{O}_3^{2-}$
29. When  $\text{PbS}_{(s)}$  is reacted with warm dilute nitric acid, the products will most likely be (A)  $\text{Pb}^{2+}$ ,  $\text{S}_{(s)}$ , and  $\text{NO}_{2(g)}$  (B)  $\text{Pb}^{2+}$ ,  $\text{S}_{(s)}$ , and  $\text{NO}_{(g)}$  (C)  $\text{PbO}_{(s)}$ ,  $\text{S}_{(s)}$ , and  $\text{NO}_{(g)}$  (D)  $\text{PbO}_{2(s)}$ ,  $\text{SO}_4^{2-}$ , and  $\text{N}_{2(g)}$  (E)  $\text{Pb}^{2+}$ ,  $\text{H}_2\text{S}$ , and  $\text{NO}_{2(g)}$
30. An adiabatic process is one in which there is no transfer of heat across the boundary between system and surroundings. For such a process (A)  $P_{\text{ext}}\Delta V = 0$  (B)  $q = w$  (C)  $\Delta E = w$  (D)  $\Delta H = 0$  (E)  $\Delta E = q$
31. If a process is both endothermic and spontaneous then (A)  $\Delta S > 0$  (B)  $\Delta S < 0$  (C)  $\Delta H < 0$  (D)  $\Delta G > 0$  (E)  $\Delta E = 0$
32. For the gas-phase decomposition  $\text{PCl}_{5(g)} \rightarrow \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$  (A)  $\Delta H < 0$  and  $\Delta S < 0$  (B)  $\Delta H > 0$  and  $\Delta S > 0$  (C)  $\Delta H > 0$  and  $\Delta S < 0$  (D)  $\Delta H < 0$  and  $\Delta S > 0$  (E)  $\Delta H = 0$  and  $\Delta S > 0$
33. How many faradays are required to reduce a mole of  $\text{MnO}_4^-$  to  $\text{Mn}^{2+}$ ? (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
34. Which of the following statements about the order of a reaction is TRUE? (A) The order of a reaction must be a positive integer (B) A second-order reaction is also bimolecular. (C) We can determine the order of the reaction from the correctly balanced net ionic equation for the reaction. (D) The order of a reaction increases with increasing temperature. (E) The order of a reaction can only be determined by experiment.
35. Which of the following statements is TRUE? (A) endothermic reactions have higher activation energies than exothermic reactions. (B) The rate law for a reaction depends on the concentrations of all reactants that appear in the stoichiometric equation. (C) The rate of a catalyzed reaction is independent of the concentration of the catalyst (D) The specific rate constant for a reaction is independent of the concentrations of the reacting species (E) There is a single rate-determining step in any reaction mechanism.
36. Which of the following complexes is diamagnetic? (A)  $\text{Fe}(\text{CN})_6^{4-}$  (B)  $\text{Cu}(\text{NH}_3)_4^{2+}$  (C)  $\text{Ti}(\text{H}_2\text{O})_6^{3+}$  (D)

- $\text{Ni(en)}_6^{2+}$  (E)  $\text{Co(py)}_6^{2+}$
37. The crystal field stabilization energy of low-spin octahedral complex of a  $d^7$  ion is (A)  $1.6 \Delta_o$  (B)  $1.8 \Delta_o$  (C)  $2.0 \Delta_o$  (D)  $2.2 \Delta_o$  (E)  $2.4 \Delta_o$
38. Which of the following crystals has the largest lattice energy? (A) KCl (B) RbI (C) LiBr (D) MgO (E) NaF
39. Which of the following statements best describes what happens when  $\text{MgCl}_2$  is electrolyzed? (A) Mg metal forms at the anode. (B)  $\text{Mg}^{+2}$  ions are oxidized at the cathode. (C)  $\text{Cl}_2$  gas is formed at the anode by the oxidation of  $\text{Cl}^-$ . (D)  $\text{Cl}^-$  ions flow toward the cathode. (E) none of the above
40. Assume that aqueous solutions of the following salts are electrolyzed for 20.0 minutes with a 10.0-amp current. Which solution will deposit the most grams of metal at the cathode? (A)  $\text{ZnCl}_2$  (B)  $\text{ZnBr}_2$  (C)  $\text{WCl}_6$  (D)  $\text{ScBr}_3$  (E)  $\text{HfCl}_4$
41. The product of the reaction of 2-butene with HBr is (A) 1-bromobutane (B) 2-bromobutane (C) 3-bromobutane (D) 1,3-dibromobutane (E) 2,3-dibromobutane
42. If an ideal gas is expanded at constant temperature, (A)  $\Delta E > 0$  and  $\Delta S > 0$  (B)  $\Delta E = 0$  and  $\Delta S = 0$  (C)  $\Delta E = 0$  and  $\Delta S < 0$  (D)  $\Delta E < 0$  and  $\Delta S > 0$  (E)  $\Delta E = 0$  and  $\Delta S > 0$
43. Which equation describes the relationship between the rates at which  $\text{Cl}_2$  is consumed and  $\text{ClF}_3$  is produced in the following reaction
- $$\text{Cl}_2(\text{g}) + 3 \text{F}_2(\text{g}) \rightarrow 2 \text{ClF}_3(\text{g})$$
- (A)  $-\text{d}(\text{Cl}_2)/\text{dt} = \text{d}(\text{ClF}_3)/\text{dt}$  (B)  $-\text{d}(\text{Cl}_2)/\text{dt} = 2[-\text{d}(\text{ClF}_3)/\text{dt}]$  (C)  $2[-\text{d}(\text{Cl}_2)/\text{dt}] = -\text{d}(\text{ClF}_3)/\text{dt}$  (D)  $-\text{d}(\text{Cl}_2)/\text{dt} = 2[\text{d}(\text{ClF}_3)/\text{dt}]$  (E)  $2[-\text{d}(\text{Cl}_2)/\text{dt}] = \text{d}(\text{ClF}_3)/\text{dt}$
44. The reaction  $\text{A}(\text{g}) + 2 \text{B}(\text{g}) \rightarrow \text{C}(\text{g}) + \text{D}(\text{g})$  is an elementary process. In an experiment, the initial partial pressures of A and B are  $P_A = 0.60$  atm and  $P_B = 0.80$  atm. When  $P_C = 0.20$  atm, the rate of the reaction, relative to the initial rate, is (A)  $1/48$  (B)  $1/24$  (C)  $9/16$  (D)  $3/4$  (E)  $1/6$
45. Which of the following nuclides are most likely to be neutron-poor? (A)  $^{11}\text{C}$  (B)  $^{24}\text{Na}$  (C)  $^{26}\text{Si}$  (D)  $^{27}\text{Al}$  (E)  $^{31}\text{P}$
46. Which isotope of carbon is most likely to decay by positron emission? (A)  $^{11}\text{C}$  (B)  $^{12}\text{C}$  (C)  $^{13}\text{C}$  (D)  $^{14}\text{C}$  (E) none of the above
47. Which of the following does not react with  $\text{Br}_2$  dissolved in  $\text{CCl}_4$  (A) pentane (B) 1-pentene (C) 2-pentene (D) 1-pentyne (E) 2-pentyne
48. Which of the following can be oxidized to form a ketone? (A)  $\text{CH}_3\text{CH}_2\text{OH}$  (B)  $(\text{CH}_3)_2\text{CHOH}$  (C)  $\text{CH}_3\text{OCH}_3$  (D)  $\text{CH}_3\text{CHO}$  (E)  $\text{CH}_3\text{COOH}$
49. Which of the following is not a plastic?
- (A) The celluloid used for ping-pong balls (B) the polyethylene in sandwich bags and garbage bags (C) The rubber in an eraser (D) The polystyrene in the cups used for beer and soft drinks (E) The polystyrene in disposable coffee cups
50. A racemic mixture contains (A) equal amounts of cis and trans isomers. (B) Both straight-chain and branched-chain alkanes. (C) A catalyst to increase the rate of reaction. (D) Equal amounts of a primary and a secondary amine. (E) Equal amounts of a pair of enantiomers.