CSCA Chemistry · Sample Paper

48 questions · 60 minutes · single choice, exactly one correct option · answer key and worked solutions at the end

1. The reaction type of $\mathrm{HCl + NaOH = NaCl + H_2O}$ is

A. Combination reaction
B. Displacement reaction
C. Decomposition reaction
D. Double displacement reaction

2. The Qing dynasty Chinese work Bencao Gangmu Shiyi (Supplement to the Compendium of Materia Medica) records 335 kinds of inorganic medicines. Under the entry "strong water" it writes: "Its nature is most fierce, and it can corrode the five metals... The water is so strong that all metals and minerals can be eaten through by it, and only glass can hold it." The "strong water" here refers to

A. Aqueous ammonia
B. Nitric acid
C. Vinegar
D. Brine

3. Which of the following dispersions can exhibit the Tyndall effect?

A. Dilute sulfuric acid
B. Copper sulfate solution
C. Ferric hydroxide colloid
D. Alcohol solution

4. Which of the following exhibits the Tyndall effect?

A. Saturated salt water
B. $\mathrm{Fe(OH)_3}$ colloid
C. Hydrochloric acid
D. Copper sulfate solution

5. Which of the following gases can turn moist red litmus paper blue?

A. $\mathrm{NH_3}$
B. $\mathrm{SO_3}$
C. HCl
D. $\mathrm{CO_2}$

6. Which of the following is a non-electrolyte?

A. Copper
B. Potassium nitrate
C. Sodium hydroxide
D. Sucrose

7. When diluting concentrated sulfuric acid to prepare dilute sulfuric acid, which personal protective equipment is not necessary?

A. Lab coat
B. Rubber gloves
C. Safety goggles
D. Gas mask

8. Which of the following does not form a precipitate when reacted with hydrogen sulfide?

A. $Pb(NO_3)_2$ solution
B. Na_2S solution
C. $CuSO_4$ solution
D. H_2SO_4 solution

9. The chemical formula of the highest-valence oxyacid of boron cannot be

A. HBO_2
B. H_2BO_3
C. H_3BO_3
D. $H_2B_4O_7$

10. Among the following separation methods, which one is independent of solubility?

A. Sublimation
B. Extraction
C. Paper chromatography
D. Recrystallization

11. The Tianwen-1 lander reached Mars and Chang'e-5 collected lunar soil samples. Chemistry is indispensable to China's space exploration. The fuels used in the Long March series of rockets include liquid hydrogen and kerosene among other chemical substances. Which of the following statements is correct?

A. Kerosene is a renewable energy source
B. During the combustion process of H_2, thermal energy is converted to chemical energy
C. The mass number of ^{20}Ne in Martian meteorites is 20
D. The ^{3}He in lunar soil and ^{3}H on Earth are isotopes of each other

12. Which of the following is a displacement reaction?

A. $4NH_3 + 5O_2 \xrightarrow{\text{catalyst},\Delta} 4NO + 6H_2O$
B. $2Na_2SO_3 + O_2 = 2Na_2SO_4$
C. $2Na_2O_2 + 2CO_2 = 2Na_2CO_3 + O_2$
D. $2KI + Cl_2 = 2KCl + I_2$

13. Which group of ions can coexist in large amounts in aqueous solution?

A. Na^+, Ba^{2+}, Cl^-, NO_3^-
B. Pb^{2+}, Hg^{2+}, S^{2-}, SO_4^{2-}
C. NH_4^+, H^+, $S_2O_3^{2-}$, PO_4^{3-}
D. Ca^{2+}, Al^{3+}, Br^-, CO_3^{2-}

14. Which of the following classifications of substances is correct?

A. SO_2, SiO_2, and CO are all acidic oxides

B. Soy milk, silicic acid, and ferric chloride solution are all colloids

C. Sodium hydroxide, glacial acetic acid, and carbon tetrachloride are all electrolytes

D. Formalin, water glass, and ammonia water are all mixtures

15. Which of the following is a weak electrolyte?

A. $NH_3 \cdot H_2O$

B. $NaOH$

C. $NaCl$

D. CH_3CH_2OH

16. Which of the following is a physical change?

A. Gasification of coal

B. Combustion of natural gas

C. Cracking of hydrocarbons

D. Fractional distillation of petroleum

17. Among the following reactions, which are substitution reactions? ① $CH_3CH=CH_2+Br_2 \xrightarrow{CCl_4} CH_3CHBrCH_2Br$ ② $CH_3CH_2OH \xrightarrow[\Delta]{\text{concentrated sulfuric acid}} CH_2=CH_2+H_2O$ ③ $CH_3COOH+CH_3CH_2OH \xrightarrow[\Delta]{\text{concentrated sulfuric acid}} CH_3COOCH_2CH_3+H_2O$ ④ $C_6H_6+HNO_3 \xrightarrow[\Delta]{\text{concentrated sulfuric acid}} C_6H_5NO_2+H_2O$

A. ① and ②

B. ③ and ④

C. ① and ③

D. ② and ④

18. The substances in parentheses are impurities. Which of the following methods for removing impurities using a reagent is correct?

A. Ferric chloride (with copper chloride as impurity): iron powder

B. Ethane (with ethylene as impurity): hydrogen/catalyst

C. Acetaldehyde (with acetic acid as impurity): saturated sodium carbonate solution

D. Carbon dioxide (with sulfur dioxide as impurity): acidic potassium permanganate

19. Given that $_{33}As$ and $_{35}Br$ are in the same period. Which of the following relationships is correct?

A. Atomic radius: $r(As) > r(Cl) > r(P)$

B. Thermal stability: $HCl > AsH_3 > HBr$

C. Reducing power: $As^{3-} > S^{2-} > Cl^-$

D. Acidity: $H_3AsO_4 > H_2SO_4 > H_3PO_4$

20. Which of the following ionic equations for the designated reactions is correct?

A. Cu dissolved in dilute HNO_3: $Cu+2H^++NO_3^-=Cu^{2+}+NO_2\uparrow+H_2O$

B. Reaction of $(NH_4)_2Fe(SO_4)_2$ solution with excess $NaOH$ solution to prepare $Fe(OH)_2$: $Fe^{2+}+2OH^-=Fe(OH)_2\downarrow$

C. Dissolving $CaCO_3$ with CH_3COOH: $CaCO_3+2H^+=Ca^{2+}+H_2O+CO_2\uparrow$

D. Passing excess CO_2 into $NaAlO_2$ solution to prepare $Al(OH)_3$: $CO_2+AlO_2^-+2H_2O=Al(OH)_3\downarrow+HCO_3^-$

21. Which of the following statements is correct?

A. An addition reaction occurs during the hydrogenation of vegetable oil

B. Starch and cellulose are isomers of each other

C. Cyclohexane and benzene can be distinguished using acidic $\mathrm{KMnO_4}$ solution

D. Water can be used to separate a mixture of bromobenzene and benzene

22. Which of the following statements is incorrect?

A. Both ethene and benzene can decolorize bromine water, and the reasons for decolorization are the same.

B. Starch, oils, and proteins can all undergo hydrolysis, but their hydrolysis products are different.

C. Kerosene can be obtained from fractional distillation of petroleum and can be used as a fuel and to preserve a small amount of metallic sodium.

D. Ethanol, acetic acid, and ethyl acetate can all undergo substitution reactions; the small amount of acetic acid in ethyl acetate can be removed using a saturated $\mathrm{Na_2CO_3}$ solution.

23. Magnesium burns in $\mathrm{CO_2}$ to produce MgO and C. Which of the following statements is correct?

A. Element C exists only as diamond and graphite allotropes

B. Magnesium particle radius in Mg and MgO: $r(Mg^{2+}) > r(Mg)$

C. Under these reaction conditions, the reducing ability of Mg is stronger than that of C

D. In this reaction, all chemical energy is converted to thermal energy

24. X and Y are both short-period metal elements. At the same temperature and pressure, $0.1\ \mathrm{mol}$ of element X reacts with excess dilute hydrochloric acid to produce $\mathrm{V_1}$ L of $\mathrm{H_2}$; $0.1\ \mathrm{mol}$ of element Y reacts with excess dilute sulfuric acid to produce $\mathrm{V_2}$ L of $\mathrm{H_2}$. Which of the following statements is incorrect?

A. The molar ratio of $\mathrm{H_2}$ generated from X and Y is necessarily $\frac{\mathrm{V_1}}{\mathrm{V_2}}$

B. The molar ratio of acid consumed by X and Y is necessarily $\frac{2\mathrm{V_1}}{\mathrm{V_2}}$

C. The oxidation state ratio of X and Y in the products is necessarily $\frac{\mathrm{V_1}}{\mathrm{V_2}}$

D. The oxidation states of X and Y in the products can definitely be determined from $\frac{\mathrm{V_1}}{\mathrm{V_2}}$

25. For the reaction $X(g) + Y(g) \rightleftharpoons 2Z(g)$ with $\triangle H < 0$, which of the following statements is correct when equilibrium is reached?

A. Decreasing container volume shifts equilibrium to the right

B. Adding a catalyst increases the yield of Z

C. Increasing $c(X)$ increases the conversion rate of X

D. Lowering temperature increases the conversion rate of Y

26. The electrolyte that produces a precipitate when reacting with hydrogen sulfide is

A. copper sulfate

B. sodium hydroxide

C. ferrous sulfate

D. sulfur dioxide

27. Which of the following descriptions of substance properties and applications is incorrect?

A. Alum hydrolyzes to form $\mathrm{Al(OH)_3}$ colloid and can be used as a water purifier

B. $\mathrm{FeCl_3}$ solution can react with Cu and can be used to etch printed circuit boards

C. $\mathrm{SO_2}$ has oxidizing properties and can be used to bleach paper pulp

D. Zn has reducing and conducting properties and can be used as the negative electrode material in zinc–manganese dry cells

28. Which of the following methods for preparing the gas in the laboratory is feasible? | | Gas | Method | |---|---|---| | A | Ammonia | Heating solid ammonium chloride | | B | Nitrogen dioxide | Adding aluminum sheet to cold concentrated nitric acid | | C | Hydrogen sulfide | Adding concentrated sulfuric acid dropwise to solid sodium sulfide | | D | Oxygen | Heating a mixture of potassium chlorate and manganese dioxide |

A. A

B. B

C. C

D. D

29. The laboratory needs to handle small amounts of pollutants. Which of the following treatment methods and corresponding reaction equations are both incorrect?

A. Using sulfur to treat spilled mercury on the ground: $\mathrm{S + Hg = HgS}$

B. Using hydrochloric acid to treat metallic silver on the tube wall after the silver mirror reaction: $\mathrm{2Ag + 2H^+ = 2Ag^+ + H_2}$

C. Using NaOH solution to absorb the irritating gas produced from the reaction of sucrose with concentrated sulfuric acid: $\mathrm{SO_3 + 2OH^- = SO_4^{2-} + H_2O}$

D. Using NaOH solution to absorb the gas produced at the anode during electrolysis of saturated salt solution: $\mathrm{Cl_2 + 2OH^- = Cl^- + ClO^- + H_2O}$

30. In a closed container at constant temperature and volume, $2\ \mathrm{mol}\ \mathrm{SO_2}$ and $1\ \mathrm{mol}\ \mathrm{O_2}$ are introduced. After the reaction $\mathrm{2SO_2}(g) + \mathrm{O_2}(g) \rightleftharpoons \mathrm{2SO_3}(g)$ reaches equilibrium, a certain amount of $\mathrm{O_2}$ is introduced again. When the new equilibrium is reached, which of the following judgments is incorrect?

A. The equilibrium concentration of $\mathrm{SO_3}$ increases

B. The reaction equilibrium constant increases

C. The rate of the forward reaction increases

D. The total amount of $\mathrm{SO_2}$ converted increases

31. $\mathrm{N_2}$ is an important raw material in ammonia synthesis. $\mathrm{NH_3}$ can not only be used to manufacture fertilizers, but also can be used to produce $\mathrm{HNO_3}$ through catalytic oxidation. $\mathrm{HNO_3}$ can dissolve metals such as Cu and Ag, and can also react with many organic compounds. Under high temperature or discharge conditions, $\mathrm{N_2}$ reacts with $\mathrm{O_2}$ to generate NO, which is further oxidized to produce $\mathrm{NO_2}$. $\mathrm{2NO(g) + O_2(g) = 2NO_2(g)}\quad \Delta H = -116.4\ \mathrm{kJ \cdot mol^{-1}}$. Excessive $\mathrm{NO_x}$ in the atmosphere and excessive $\mathrm{NH_4^+}$ and $\mathrm{NO_3^-}$ in water bodies are both pollutants. Through catalytic reduction methods, NO in flue gas and vehicle exhaust can be converted to $\mathrm{N_2}$, and $\mathrm{NO_3^-}$ in water bodies can also be converted to $\mathrm{N_2}$. Which of the following statements about $\mathrm{NH_3}$, $\mathrm{NH_4^+}$, and $\mathrm{NO_3^-}$ is correct?

A. $\mathrm{NH_3}$ can form intermolecular hydrogen bonds

B. $\mathrm{NO_3^-}$ has a pyramidal molecular geometry

C. The bond angles in $\mathrm{NH_3}$ and $\mathrm{NH_4^+}$ are equal

D. There are 6 coordinate covalent bonds in $\mathrm{[Ag(NH_3)_2]^+}$ formed between $\mathrm{NH_3}$ and $\mathrm{Ag^+}$

32. At room temperature, $1\ \mathrm{mol}$ of $\mathrm{C_2H_5OH}$ and hydrabromic acid containing $1\ \mathrm{mol}\ \mathrm{HBr}$ are added to a round-bottom flask. In solution, the reaction occurs: $\mathrm{C_2H_5OH + HBr \rightleftharpoons C_2H_5Br + H_2O}$. Upon reaching equilibrium after sufficient reaction, given that at atmospheric pressure, the boiling points of $\mathrm{C_2H_5Br}$ and $\mathrm{C_2H_5OH}$ are $38.4^\circ\mathrm{C}$ and $78.5^\circ\mathrm{C}$, respectively. Which of the following statements is incorrect?

A. Adding NaOH can increase the amount of ethanol

B. Increasing HBr concentration favors formation of $\mathrm{C_2H_5Br}$

C. If both reactants are increased to $2\ \mathrm{mol}$, the ratio of conversion rates of the two reactants does not change

D. If the initial temperature is raised to $60^\circ\mathrm{C}$, the time to reach equilibrium can be shortened

33. At room temperature, which of the following relationships about particle concentrations in solution is correct?

A. Solid NaOH added to fresh chlorine water: $c(\mathrm{Na^+}) = c(\mathrm{Cl^-}) + c(\mathrm{ClO^-}) + c(\mathrm{OH^-})$

B. In a pH = 8.3 $\mathrm{NaHCO_3}$ solution: $c(\mathrm{Na^+}) > c(\mathrm{HCO_3^-}) > c(\mathrm{CO_3^{2-}}) > c(\mathrm{H_2CO_3})$

C. Equal volumes of pH = 11 ammonia solution and pH = 3 hydrochloric acid solution are mixed: $c(\mathrm{Cl^-}) = c(\mathrm{NH_4^+}) > c(\mathrm{OH^-}) = c(\mathrm{H^+})$

D. Equal volumes of $0.2\ \mathrm{mol/L}\ \mathrm{CH_3COOH}$ solution and $0.1\ \mathrm{mol/L}\ \mathrm{NaOH}$ solution are mixed: $2c(\mathrm{H^+}) - 2c(\mathrm{OH^-}) = c(\mathrm{CH_3COO^-}) - c(\mathrm{CH_3COOH})$

34. Silver articles gradually darken on the surface after long use, which is due to the formation of $\mathrm{Ag_2S}$. According to electrochemical principles, the following treatment can be carried out: add salt solution to an aluminum container, then immerse the darkened silver article in this solution; after a period of time the black color fades. Which of the following statements is correct?

A. The silver article maintains constant mass during the treatment process

B. The silver article is the positive electrode, and $\mathrm{Ag_2S}$ is reduced to form metallic silver

C. The overall reaction in this process is $\mathrm{2Al + 3Ag_2S = 6Ag + Al_2S_3}$

D. The reason the black color fades is that black $\mathrm{Ag_2S}$ converts to white AgCl

35. At 25 degrees Celsius, the concentration of $\mathrm{H^+}$ in $0.005\ \mathrm{mol/L}\ \mathrm{Ba(OH)_2}$ is

A. 1×10^{-12} mol/L

B. 1×10^{-13} mol/L

C. 5×10^{-12} mol/L

D. 5×10^{-13} mol/L

36. N_A is the value of Avogadro's constant. Which of the following statements is correct?

A. When 2.4 g of magnesium burns in excess $\mathrm{O_2}$, the number of electrons transferred is $0.1N_A$

B. At standard conditions, 5.6 L of $\mathrm{CO_2}$ gas contains $0.5N_A$ oxygen atoms

C. Hydrogen atoms number $0.4N_A$ in a $\mathrm{CH_3OH}$ molecule, the number of sigma bonds is $0.4N_A$

D. In a 0.1 L of $0.5\ \mathrm{mol/L}\ \mathrm{CH_3COOH}$ solution, the number of $\mathrm{H^+}$ is $0.05N_A$

37. Let N_A denote the Avogadro constant. Which of the following statements is correct?

A. The number of oxygen atoms in 1.6 g of a mixture of oxygen and ozone is $0.1N_A$

B. The number of double bonds in $0.1\ \mathrm{mol}$ of acrylic acid is $0.1N_A$

C. At standard conditions, the number of molecules in 11.2 L of benzene is $0.5N_A$

D. In the reaction of sodium peroxide with water, when $0.1\ \mathrm{mol}$ of oxygen gas is produced, the number of electrons transferred is $0.4N_A$

38. Let $\mathrm{N_A}$ denote Avogadro's constant. The Hou's process involves substances such as NaCl, $\mathrm{NH_4Cl}$, and $\mathrm{NaHCO_3}$. Which of the following descriptions is correct?

A. 1 mol of $\mathrm{NH_4Cl}$ contains $5N_A$ covalent bonds

B. When 1 mol of $\mathrm{NaHCO_3}$ completely decomposes, the number of $\mathrm{CO_2}$ molecules obtained is $2N_A$

C. In 1 L of 1 $\mathrm{mol \cdot L^{-1}}$ $\mathrm{NaHCO_3}$ solution, the number of $\mathrm{HCO_3^-}$ ions is N_A

D. In a mixture of NaCl and $\mathrm{NH_4Cl}$ containing 1 mol of $\mathrm{Cl^-}$, the number of protons is $28N_A$

39. Solutions of NaOH and HCl with equal molar concentration are mixed in a 3:2 volume ratio, and the resulting solution has pH = 12. Then the molar concentration of the original solutions is

A. $0.01\mathrm{mol \cdot L^{-1}}$

B. $0.017\mathrm{mol \cdot L^{-1}}$

C. $0.05\mathrm{mol \cdot L^{-1}}$

D. $0.50\mathrm{mol \cdot L^{-1}}$

40. If the products of the decomposition of $\mathrm{(NH_4)_2SO_4}$ under strong heating are $\mathrm{SO_2}$, $\mathrm{N_2}$, $\mathrm{NH_3}$ and $\mathrm{H_2O}$, then the ratio of the number of N atoms whose oxidation state changes to the number of N atoms whose oxidation state does not change in this reaction is

A. $1:4$

B. $1:2$

C. $2:1$

D. $4:1$

41. How many organic compounds have the molecular formula $\mathrm{C_5H_{10}O_2}$ and can react with sodium bicarbonate solution to release a gas?

A. 3 kinds

B. 4 kinds

C. 5 kinds

D. 6 kinds

42. Under certain conditions, the alcoholysis reaction of acetic anhydride $[\mathrm{(CH_3CO)_2O}]$ is $\mathrm{(CH_3CO)_2O + ROH \longrightarrow CH_3COOR + CH_3COOH}$, which can proceed to completion. Using this reaction to quantitatively measure the hydroxyl content in organic alcohols (ROH), the hydrolysis of esters can be neglected in the experiment. The experimental steps are as follows: ① Prepare an acetic anhydride–benzene solution with a certain concentration; ② Measure a certain volume of acetic anhydride–benzene solution into a conical flask, add m g ROH sample, react fully, then add appropriate water to completely hydrolyze the remaining acetic anhydride: $\mathrm{(CH_3CO)_2O + H_2O \longrightarrow 2CH_3COOH}$; ③ Add indicator and titrate with a standard NaOH solution in methanol of concentration $c\,\mathrm{mol \cdot L^{-1}}$ to the endpoint, consuming $\mathrm{V_1}$ mL of standard solution; ④ Under identical conditions, measure the same volume of acetic anhydride–benzene solution, add only appropriate water to completely hydrolyze the acetic anhydride; add indicator and titrate with a standard NaOH solution in methanol of concentration $c\,\mathrm{mol \cdot L^{-1}}$ to the endpoint, consuming $\mathrm{V_2}$ mL of standard solution. The correct calculation for the mass fraction of hydroxyl content in the ROH sample is

A. $\frac{c(V_2-V_1)\times 17}{1000m}\times 100\%$

B. $\frac{c(V_1-V_2)\times 17}{1000m}\times 100\%$

C. $\frac{0.5c(V_2-V_1)\times 17}{1000m}\times 100\%$

D. $\frac{c(0.5V_2-V_1)\times 17}{1000m}\times 100\%$

43. Under acidic conditions, the following reaction occurs: $\mathrm{ClO_3^- + 2M^{3+} + 4H_2O = M_2O_7^{n-} + Cl^- + 8H^+}$. The oxidation state of M in $\mathrm{M_2O_7^{n-}}$ is

A. +4

B. +5

C. +6

D. +7

44. When V L of ammonia gas dissolves in 1 L of water (with water density approximately 1 g/mL), the density of the resulting solution is ρ g/mL, the mass percentage is ω, and the molar concentration is c mol/L. Which of the following relationships is incorrect?

A. $\rho = (17V + 22400)/(22.4 + 22.4V)$

B. $\omega = 17c/(1000\rho)$

C. $\omega = 17V/(17V + 22400)$

D. $c = 1000V\rho/(17V + 22400)$

45. $\mathrm{(NH_4)_2SO_4}$ decomposes at high temperature, producing $\mathrm{SO_2}$, $\mathrm{H_2O}$, $\mathrm{N_2}$, and $\mathrm{NH_3}$. In the chemical equation for this reaction, the products arranged by increasing stoichiometric coefficients are

A. $\mathrm{SO_2}$, $\mathrm{H_2O}$, $\mathrm{N_2}$, $\mathrm{NH_3}$

B. $\mathrm{N_2}$, $\mathrm{SO_2}$, $\mathrm{H_2O}$, $\mathrm{NH_3}$

C. $\mathrm{N_2}$, $\mathrm{SO_2}$, $\mathrm{NH_3}$, $\mathrm{H_2O}$

D. $\mathrm{H_2O}$, $\mathrm{NH_3}$, $\mathrm{SO_2}$, $\mathrm{N_2}$

46. A monofunctional organic compound contains only carbon, hydrogen, and oxygen with a relative molecular mass of 58. Complete combustion produces equal amounts of $\mathrm{CO_2}$ and $\mathrm{H_2O}$. The number of possible structural isomers (not considering stereoisomerism) is

A. 4

B. 5

C. 6

D. 7

47. Based on the following experiments, which of the predicted experimental phenomena is correct?

A. When NaOH solution is added dropwise to $\mathrm{MgCl_2}$ solution in excess, the white precipitate disappears after formation

B. When KSCN solution is added dropwise to $\mathrm{FeCl_2}$ solution, the solution turns blood red

C. When NaCl solution is added in excess to AgI suspension, the yellow precipitate is completely converted to white precipitate

D. When ethanol is added in excess to acidic $\mathrm{KMnO_4}$ solution, the purple–red color of the solution fades

48. The atomic numbers of short-period elements W, X, Y, and Z increase in order. Among them, the number of electrons in the anion of W equals the number of inner-shell electrons in atoms X, Y, and Z. One isotope of X is commonly used in archaeology to determine the ages of artifacts. Industrially, the single substance of Y is produced by liquid air fractional distillation. Z cannot form diatomic molecules. Based on the above statements, which of the following is correct?

A. The atomic radii are ordered as $W < X < Y < Z$

B. The sum of the valence electrons of W, X, Y, and Z is 20

C. W and Y can form a compound containing both polar and nonpolar covalent bonds

D. The boiling point of compounds formed by W and X is always lower than that of compounds formed by W and Y

Answer key

1 D	2 B	3 C	4 B	5 A	6 D	7 D	8 B
9 B	10 A	11 C	12 D	13 A	14 D	15 A	16 D
17 B	18 D	19 C	20 D	21 A	22 A	23 C	24 D
25 D	26 A	27 C	28 D	29 B	30 B	31 A	32 D
33 D	34 B	35 A	36 B	37 A	38 D	39 C	40 B
41 B	42 A	43 C	44 A	45 C	46 B	47 D	48 C

Worked solutions

1. D From the chemical reaction $\mathrm{HCl + NaOH = NaCl + H_2O}$, we can see that: sodium hydroxide is a base, hydrochloric acid is an acid, and the reaction between an acid and a base is a neutralization reaction, which belongs to a double displacement reaction, so the answer is D.

2. B A. Aqueous ammonia is a weak base and does not react with metals, so it does not fit the description, and A is incorrect. B. Nitric acid has strong oxidizing power and strong acidity; it can corrode most metals and can also react with the $\mathrm{CaCO_3}$ in rocks, but it cannot react with the silicates that make up glass, so it fits the description, and B is correct. C. Acetic acid is a weak electrolyte; it can corrode relatively active metals but not less active metals such as Cu, so it does not fit the description, and C is incorrect. D. The main components of brine are magnesium chloride, sodium chloride, and some metal cations, and it does not react with most metals, so it does not fit the description, and D is incorrect. The answer is B.

3. C The Tyndall effect is a property unique to colloids, which are dispersions with dispersed particles having diameters between 1 and 100 nm. A. Dilute sulfuric acid is a solution, not a colloid, so it does not exhibit the Tyndall effect; B. Copper sulfate solution is a solution, not a colloid, so it does not exhibit the Tyndall effect; C. Ferric hydroxide colloid is a colloid and exhibits the Tyndall effect; D. Alcohol solution is a solution, not a colloid, so it does not exhibit the Tyndall effect. Therefore, C is correct.

4. B A. Saturated salt water is a solution and does not exhibit the Tyndall effect, so A is incorrect. B. $\mathrm{Fe(OH)_3}$ colloid is a colloid and exhibits the Tyndall effect, so B is correct. C. Hydrochloric acid is a solution and does not exhibit the Tyndall effect, so C is incorrect. D. Copper sulfate solution is a solution and does not exhibit the Tyndall effect, so D is incorrect. Answer: B.

5. A A gas that turns moist red litmus paper blue is a basic gas. A. Ammonia dissolves in water to form aqueous ammonia, a weak base, which can turn moist red litmus paper blue; B. SO_3 reacts with water to form sulfuric acid, an acidic gas, which turns moist red litmus paper red; C. HCl is an acidic gas, which turns moist red litmus paper red; D. CO_2 reacts with water to form carbonic acid, an acidic gas, which turns moist red litmus paper red. Therefore, A is correct.

6. D A non-electrolyte is a compound that does not conduct electricity in aqueous solution or in the molten state. A: Copper is a metal (element) and not a compound, so it is neither an electrolyte nor a non-electrolyte; B: Potassium nitrate solution or molten potassium nitrate contains free mobile ions and conducts electricity, so it is an electrolyte; C: Sodium hydroxide is a compound that dissociates into ions in aqueous solution or molten state, conducting electricity, so it is an electrolyte; D: Sucrose exists as molecules in aqueous solution or molten state and does not conduct electricity, so it is a non-electrolyte. Therefore, the answer is D.

7. D Concentrated sulfuric acid is not toxic, so a gas mask is not necessary; option D is selected.

8. B Option A produces $\mathrm{PbSO_4}$ precipitate. Option C produces CuS precipitate. Option D undergoes a redox reaction to form elemental sulfur precipitate. Therefore, the correct answer is B.

9. B The boron atom has 3 electrons in its outermost shell, so its highest oxidation state is +3. According to the rule that the algebraic sum of positive and negative oxidation states in a compound is zero, B in H_2BO_3 has an oxidation state of +4, which does not match the highest state of +3, so boron's highest-valence oxyacid cannot be H_2BO_3. Meanwhile, in HBO_2, H_3BO_3, and $H_2B_4O_7$, B has an oxidation state of +3 in all cases, and they can all possibly exist. Therefore B is correct.

10. A Sublimation is the direct phase transition of a solid to a gas without passing through the liquid state; it is related to melting and boiling points, not solubility, so A is correct. Extraction utilizes the difference in solubility of a solute in different solvents, so it depends on solubility. Paper chromatography utilizes the differences in solubility (distribution ratio) of components in the mixture between the stationary phase and the mobile phase, so it depends on solubility. Recrystallization exploits the different ways solubility changes with temperature for different solutes, so it depends on solubility. The answer is A.

11. C A. Kerosene comes from petroleum, which is a non-renewable energy source. Therefore A is incorrect. B. The combustion of hydrogen releases heat, converting chemical energy into thermal energy. Therefore B is incorrect. C. The number in the upper left of the element symbol is the mass number, so the mass number of $^{20}\mathrm{Ne}$ in Martian meteorites is 20. Therefore C is correct. D. Isotopes must be of the same element. $^{3}\mathrm{He}$ and $^{3}\mathrm{H}$ have different numbers of protons, so they cannot be isotopes of each other. Therefore D is incorrect. The answer is C.

12. D A displacement reaction is defined as a reaction in which a simple substance reacts with a compound to produce another simple substance and another compound. This is a redox reaction, but not all redox reactions are displacement reactions. A is a redox reaction but not a displacement reaction; B is a combination reaction, not a displacement reaction; C is a redox reaction but not a displacement reaction; D fits the definition of a displacement reaction (a more active nonmetal displaces a less active nonmetal), so the answer is D.

13. A A. The four ions in this group do not react with each other and can coexist in large amounts. B. In this group, Pb^{2+} and Hg^{2+} each react with S^{2-} to form PbS and HgS precipitates, so they cannot coexist in large amounts. C. In this group, H^{+} reacts with $S_2O_3^{2-}$ and PO_4^{3-}, so they cannot coexist in large amounts. D. In this group, Ca^{2+} and CO_3^{2-} form a precipitate, and Al^{3+} and CO_3^{2-} undergo mutually promoted hydrolysis reaction, so neither can coexist in large amounts. Therefore, the answer is A. This question tests the concept of ion coexistence.

14. D CO is a non-salt-forming oxide and does not belong to acidic oxides, so A is incorrect. Ferric chloride solution is a true solution rather than a colloid, so B is incorrect. Carbon tetrachloride is a non-electrolyte, so C is incorrect. Formalin is an aqueous solution of formaldehyde, water glass is an aqueous solution of sodium silicate, and ammonia water is an aqueous solution of ammonia gas; all three are mixtures, so D is correct. This question tests the classification of substances.

15. A $\mathrm{NH_3 \cdot H_2O}$ (aqueous ammonia) is a weak electrolyte. NaOH and NaCl are both strong electrolytes. $\mathrm{CH_3CH_2OH}$ (ethanol) is a non-electrolyte. Answer: A.

16. D A physical change produces no new substances, while a chemical change produces new substances. Option A: gasification of coal is the process where coal reacts with water at high temperatures to produce CO and H_2, which is a chemical change, so A is incorrect; option B: combustion of natural gas produces carbon dioxide and water, which is a chemical change, so B is incorrect; option C: cracking of hydrocarbons uses heavy oil as raw material to produce short-chain alkenes such as ethylene, producing new substances, which is a chemical change, so C is incorrect; option D: fractional distillation of petroleum uses the different boiling points of components in petroleum and heating to separate the components, producing no new substances, which is a physical change, so D is correct. The answer is D.

17. B Analysis: ① Alkene carbon–carbon double bond reacts with bromine in an addition reaction; ② ethanol undergoes an intramolecular elimination reaction to form ethene and water when heated with concentrated sulfuric acid; ③ acetic acid and ethanol undergo an esterification reaction when heated with concentrated sulfuric acid, which is a substitution reaction; ④ benzene and concentrated nitric acid undergo a nitration reaction when heated with concentrated sulfuric acid, which is also a substitution reaction. Answer: ① is an addition reaction, ② is an elimination reaction, neither is a substitution reaction; ③ is an esterification reaction, which is a substitution reaction; ④ is a nitration reaction, which is also a substitution reaction. Therefore substitution reactions are ③ and ④. Answer: B.

18. D A. Iron powder will preferentially react with ferric chloride, and only then with the impurity copper chloride, making it impossible to remove copper chloride while retaining ferric chloride; B. Although adding excess hydrogen can react with ethylene, the excess hydrogen itself becomes a new impurity and is difficult to completely remove; D. Sulfur dioxide can be oxidized and absorbed by acidic potassium permanganate, while carbon dioxide does not react with acidic potassium permanganate, allowing for effective impurity removal. Therefore, the answer is D.

19. C In the same period, atomic radius decreases with increasing atomic number, so the radius order is As > P > Cl, making A incorrect. Nonmetallic character increases with stability of the corresponding hydride; nonmetallic character order is Cl > Br > As, so stability order is HCl > HBr > AsH_3, making B incorrect. In the same period, stronger nonmetallic character corresponds to stronger oxidizing power of the element and weaker reducing power of the anion; nonmetallic character order is $Cl_2 > S > As$, so reducing power order is $As^{3-} > S^{2-} > Cl^-$, making C correct. Stronger nonmetallic character corresponds to stronger acidity of the highest oxidation state oxyacid; nonmetallic character order is S > P > As, so acidity order is $H_2SO_4 > H_3PO_4 > H_3AsO_4$, making D incorrect. Therefore, the answer is C.

20. D A. Cu reacts with dilute nitric acid to produce NO, not NO_2. The correct ionic equation should be $3Cu + 8H^+ + 2NO_3^- = 3Cu^{2+} + 2NO\uparrow + 4H_2O$. Statement A is incorrect. B. When $(NH_4)_2Fe(SO_4)_2$ reacts with excess NaOH, NH_4^+ also reacts with OH^- to form $NH_3 \cdot H_2O$. The correct equation is $2NH_4^+ + Fe^{2+} + 4OH^- = Fe(OH)_2\downarrow + 2NH_3 \cdot H_2O$. Statement B is incorrect. C. CH_3COOH is a weak electrolyte and should be written in molecular form. The correct equation is $CaCO_3 + 2CH_3COOH = Ca^{2+} + H_2O + CO_2\uparrow + 2CH_3COO^-$. Statement C is incorrect. D. Sodium aluminate reacting with excess CO_2 produces $Al(OH)_3$ and $NaHCO_3$; the ionic equation is written correctly. Statement D is correct. Answer: D.

21. A A. The hydrogenation of vegetable oil is an addition reaction with hydrogen, in which unsaturated hydrocarbyl groups become saturated, so A is correct. B. Starch and cellulose are both polymer compounds whose degrees of polymerization vary over a wide range and have no definite value, so their molecular formulas are different and they are not isomers of each other, so B is incorrect. C. Cyclohexane is a saturated hydrocarbon and benzene is chemically stable; neither reacts with acidic $\mathrm{KMnO_4}$ solution, so the two cannot be distinguished this way, so C is incorrect. D. Bromobenzene and benzene are miscible with each other and neither dissolves in water, so water cannot be used to separate the mixture, so D is incorrect. The answer is A.

22. A Analysis: Ethene contains a $C=C$ double bond and undergoes addition with bromine water, causing decolorization; benzene causes decolorization by extraction. Starch hydrolyzes to glucose, oil to fatty acids and glycerol, and protein to amino acids. Kerosene from petroleum distillation consists of alkanes with stable properties and lower density than sodium, suitable for preserving sodium. Acetic acid, ethanol, and ethyl acetate undergo substitution reactions; acetic acid is more acidic than carbonic acid and can be removed by Na_2CO_3. A: Ethene decolorizes bromine water by addition reaction, while benzene does so by extraction; the mechanisms differ, so A is incorrect. B: Starch hydrolyzes to glucose, proteins to amino acids, differing in products, so B is correct. C: Kerosene can be used as fuel and to preserve sodium, so C is correct. D: All three compounds undergo substitution; acetic acid can be removed by saturated Na_2CO_3, so D is correct. Answer: A.

23. C A. Carbon element exists not only as diamond and graphite but also as fullerene (C_{60}) and other allotropes, so A is incorrect. B. Mg has 3 electron shells; Mg^{2+} is a cation formed when Mg loses 2 electrons from its outermost shell, with only 2 electron shells, so radius $r(Mg^{2+}) < r(Mg)$, so B is incorrect. C. The reaction is $2Mg + CO_2 \xrightarrow{ignited} 2MgO + C$. Mg is the reducing agent and C is the product, so the reducing ability Mg > C, so C is correct. D. The reaction emits strong light, indicating that some chemical energy is converted to light energy, not all to thermal energy, so D is incorrect. Answer: C.

24. D Let the molar amount of HCl consumed when 1 mol of X reacts be a mol, and the molar amount of H_2SO_4 consumed when 1 mol of Y reacts be b mol. Based on electron transfer conservation and hydrogen atom conservation, we have $X \sim aHCl \sim \frac{a}{2}H_2 \sim X^{a+}$ and $Y \sim bH_2SO_4 \sim bH_2 \sim Y^{2b+}$. A. At the same temperature and pressure, the volume ratio of gases equals their molar ratio. Therefore, the molar ratio of H_2 generated from X and Y is $\frac{V_1}{V_2}$. A is correct. B. The molar ratio of acid consumed is $\frac{a}{b}$. Since $\frac{a/2}{b} = \frac{V_1}{V_2}$, we have $\frac{a}{b} = \frac{2V_1}{V_2}$. B is correct. C. The oxidation state ratio of X and Y in the products is $\frac{a}{2b} = \frac{V_1}{V_2}$. C is correct. D. The oxidation states of short-period metals in salts formed by reaction with acids can be +1, +2, or +3. When $a=1, b=0.5$ and when $a=2, b=1$, both give $\frac{V_1}{V_2}=1$, but the oxidation states of X and Y differ in these two cases. Therefore, the oxidation states cannot be determined solely from $\frac{V_1}{V_2}$. D is incorrect. The answer is D.

25. D Analysis: The reaction has no change in the number of gas molecules before and after; decreasing container volume increases pressure, but equilibrium does not shift. A catalyst changes reaction rate but does not change chemical equilibrium. For two reactants, increasing the amount of one substance increases the conversion rate of the other but decreases its own conversion rate. The reaction is exothermic, so lowering temperature favours the forward reaction. Resolution: Since the number of gas molecules does not change, decreasing container volume increases pressure but equilibrium does not shift; option A is incorrect. A catalyst changes reaction rate but does not change equilibrium, so the yield of Z does not change; option B is incorrect. Increasing $c(X)$ decreases the conversion rate of X; option C is incorrect. Since the reaction is exothermic, lowering temperature favours the forward reaction, increasing the conversion rate of Y; option D is correct. Answer: D.

26. A A. $CuSO_4$ is a salt and belongs to electrolytes. When hydrogen sulfide is added, the reaction $CuSO_4 + H_2S = CuS\downarrow + H_2SO_4$ occurs, producing a black precipitate, correct. B. Sodium hydroxide is a base and belongs to electrolytes. When it reacts with hydrogen sulfide: $2NaOH + H_2S = Na_2S + 2H_2O$, the product Na_2S is soluble, and no precipitate is produced, incorrect. C. Ferrous sulfate is a salt and belongs to electrolytes. Since the acidity of hydrosulfuric acid is weaker than that of sulfurous acid, the two cannot react, and no precipitate is produced, incorrect. D. Sulfur dioxide reacts with hydrogen sulfide: $SO_2 + 2H_2S = 3S\downarrow + 2H_2O$, producing a precipitate; however, SO_2 is a non-electrolyte, which does not match the question, incorrect.

27. C For A: The aluminum ions in alum hydrolyze to produce aluminum hydroxide colloid, which adsorbs suspended impurities, so the description is correct. For B: Iron(III) chloride solution dissolves copper, which is used to etch printed circuit boards, utilizing the reaction of $FeCl_3$ with Cu, so the description is correct. For C: The bleaching of paper pulp by SO_2 utilizes its bleaching property, not its oxidizing property, so the description is incorrect. For D: Zn has reducing property to serve as the negative electrode in a galvanic cell, and has conducting property, so it can be used as the negative electrode material in zinc-manganese dry cells. The description is correct. Answer: C.

28. D A. Ammonium chloride is unstable and decomposes on heating to produce ammonia and hydrogen chloride; however, the two recombine when cooled to reform ammonium chloride, so this method is not feasible for preparing ammonia, (A) is not feasible; B. Adding aluminum sheet to cold concentrated nitric acid causes the aluminum to undergo passivation, making it unsuitable for preparing nitrogen dioxide, (B) is not feasible; C. Hydrogen sulfide is a reducing gas, and concentrated sulfuric acid is a strong oxidizing agent. Concentrated sulfuric acid cannot be used to react with solid sodium sulfide to prepare hydrogen sulfide gas, as the gas would undergo a redox reaction with concentrated sulfuric acid, (C) is not feasible; D. Heating a mixture of potassium chlorate and manganese dioxide in the laboratory produces potassium chloride and oxygen, with manganese dioxide serving as a catalyst. This method is feasible for preparing oxygen, (D) is feasible; therefore (D) is correct.

29. B S and Hg undergo a combination reaction to form HgS; sulfur can be used to treat spilled mercury, and the equation $S + Hg = HgS$ is correct in both method and equation, not matching the question. Ag is not reactive and cannot react with hydrochloric acid to produce hydrogen gas; both the method and equation are incorrect, matching the question. The irritating gas produced from sucrose and concentrated sulfuric acid is SO_2, which can be absorbed by NaOH solution; the ionic equation should be $SO_2 + 2OH^- = SO_3^{2-} + H_2O$, so the given equation has both incorrect gas and products, meaning the method is correct but the equation is incorrect, not matching the question. The gas produced at the anode during electrolysis of saturated salt solution is Cl_2, which can be absorbed by NaOH solution; the ionic equation is $Cl_2 + 2OH^- = Cl^- + ClO^- + H_2O$, both method and equation are correct, not matching the question. Answer: B.

30. B A: After equilibrium, when a certain amount of O_2 is introduced, the equilibrium shifts forward, so the equilibrium concentration of SO_3 increases. A is correct. B: The equilibrium constant depends only on temperature. Since temperature is constant, the equilibrium constant remains unchanged. B is incorrect. C: When a certain amount of O_2 is introduced, the concentration of reactants increases, so the rate of the forward reaction increases. C is correct. D: When a certain amount of O_2 is introduced, it promotes the conversion of sulfur dioxide, so the total amount of SO_2 converted increases. D is correct. Answer: B.

31. A A. $\mathrm{NH_3}$ can form intermolecular hydrogen bonds. Ammonia molecules are polar molecules, with the nitrogen atom carrying a partial negative charge and the hydrogen atom carrying a partial positive charge. When ammonia molecules approach each other, they attract each other due to electrostatic interaction, A is correct. B. The nitrate ion has a planar trigonal geometry, with N and O both undergoing $\mathrm{sp^2}$ hybridization, B is incorrect. C. Both $\mathrm{NH_3}$ and $\mathrm{NH_4^+}$ undergo $\mathrm{sp^3}$ hybridization, but $\mathrm{NH_3}$ has a pair of lone electrons, resulting in a pyramidal geometry with a bond angle of approximately $107^\circ 18'$, while $\mathrm{NH_4^+}$ is tetrahedral with a bond angle of approximately $109^\circ 28'$, so the bond angles are not equal, C is incorrect. D. N–H bonds are sigma bonds, and coordinate covalent bonds are also sigma bonds. $[\mathrm{Ag(NH_3)_2}]^+$ contains 8 sigma bonds and 2 coordinate covalent bonds, not 6, D is incorrect. The answer is A.

32. D A. Adding NaOH consumes HBr, shifting equilibrium backward, increasing ethanol amount; A is correct. B. Increasing HBr concentration shifts equilibrium forward, increasing C_2H_5Br yield; B is correct. C. When both reactants increase to $2\,\mathrm{mol}$, equilibrium shifts forward. Initial concentrations are equal and consumed amounts are equal; conversion rate ratio unchanged; C is correct. D. Raising temperature causes ethanol to evaporate and C_2H_5Br to vaporize; solution concentrations of both decrease, reaction rate slows, equilibrium time increases rather than decreases; D is incorrect. Answer: D.

33. D When solid NaOH is added to fresh chlorine water, the charge balance equation is $c(Na^+) + c(H^+) = c(Cl^-) + c(ClO^-) + c(OH^-)$, so A is incorrect. In a $NaHCO_3$ solution, hydrolysis is more significant than ionization, so $c(H_2CO_3) > c(CO_3^{2-})$, making B incorrect. When equal volumes of pH = 11 ammonia solution and pH = 3 hydrochloric acid solution are mixed, ammonia is in excess and the solution is alkaline, so C is incorrect. For equal volumes of 0.2 mol/L CH_3COOH and 0.1 mol/L NaOH, the mixture contains equal concentrations of CH_3COOH and CH_3COONa. By charge conservation: $c(Na^+) + c(H^+) = c(CH_3COO^-) + c(OH^-)$ and by mass balance: $2c(Na^+) = c(CH_3COO^-) + c(CH_3COOH)$. Eliminating $c(Na^+)$ gives $2c(H^+) - 2c(OH^-) = c(CH_3COO^-) - c(CH_3COOH)$, so D is correct.

34. B Aluminum, silver, and electrolyte solution form a galvanic cell; aluminum is the negative electrode and silver is the positive electrode; aluminum loses electrons at the negative electrode undergoing oxidation, and silver ions gain electrons at the positive electrode undergoing reduction; analyze and solve accordingly. A: The silver article is placed in an aluminum container; since aluminum is more active than silver, aluminum is the negative electrode and loses electrons; the electrode reaction is $Al-3e^{-}=Al^{3+}$; silver is the positive electrode, and Ag_2S on the silver surface gains electrons and produces metallic silver; the electrode reaction is $Ag_2S+2e^{-}+2H_2O=2Ag+2OH^{-}+H_2S\uparrow$, so the silver article's mass decreases, thus A is incorrect. B: Silver serves as the positive electrode; Ag_2S at the positive electrode gains electrons acting as the oxidizing agent and is reduced in the reaction to form metallic silver, thus B is correct. C: Al_2S_3 cannot exist in solution; it undergoes double hydrolysis reaction to form H_2S and $Al(OH)_3$: $Al_2S_3+6H_2O=2Al(OH)_3\downarrow+3H_2S\uparrow$, thus C is incorrect. D: The black color fading is due to Ag_2S converting to Ag, not AgCl, thus D is incorrect.

35. A The concentration of hydroxide ions in the solution is 0.01 mol/L. Based on the ion product constant of water, the concentration of hydrogen ions is $\frac{1.0\times10^{-14}}{0.01}=10^{-12}\ \mathrm{mol/L}$.

36. B Analysis: A. The molar amount of 2.4 g magnesium is 2.4/24 = 0.1 mol. After burning, magnesium loses 2 electrons each, transferring a total of 0.2 mol electrons, incorrect; B. At standard conditions, the molar amount of 5.6 L CO_2 is 5.6/22.4 = 0.25 mol, containing 0.5 mol oxygen atoms, correct; C. When a CH_3OH molecule has $0.4N_A$ hydrogen atoms, its molar amount is 0.1 mol. Each molecule contains 5 sigma bonds, totaling 0.5 mol or $0.5N_A$ sigma bonds, incorrect; D. Acetic acid is a weak acid and cannot completely ionize, so the number of H^{+} is less than $0.05N_A$, incorrect. The answer is B.

37. A A. Both oxygen and ozone consist only of oxygen atoms. The mass of oxygen atoms in 1.6 g of the mixture is 1.6 g, i.e., 0.1 mol of oxygen atoms, with a count of $0.1N_A$. Statement A is correct. B. Acrylic acid contains one $C=C$ double bond and one $C=O$ double bond, a total of 2 double bonds; in 0.1 mol of acrylic acid, the number of double bonds should be $0.2N_A$. Statement B is incorrect. C. Benzene is a liquid at standard conditions and cannot be calculated using the gas molar volume formula; the molecular count is not $0.5N_A$. Statement C is incorrect. D. In sodium peroxide, oxygen is in the −1 oxidation state; when 0.1 mol of oxygen gas is produced from reaction with water, 0.2 mol of electrons are transferred, with a count of $0.2N_A$. Statement D is incorrect. Answer: A.

38. D A. The ammonium ion contains 4 N–H covalent bonds. 1 mol of $\mathrm{NH_4Cl}$ contains $4N_A$ covalent bonds, not $5N_A$, so A is incorrect. B. Sodium bicarbonate undergoes thermal decomposition to produce sodium carbonate, water, and carbon dioxide. 1 mol of $\mathrm{NaHCO_3}$ completely decomposes to produce 0.5 mol of $\mathrm{CO_2}$, which is $0.5N_A$ molecules, so B is incorrect. C. $\mathrm{NaHCO_3=Na^{+}+HCO_3^{-}}$. The $\mathrm{HCO_3^{-}}$ undergoes both hydrolysis and ionization, so the number of $\mathrm{HCO_3^{-}}$ ions in 1 mol of $\mathrm{NaHCO_3}$ solution is less than N_A, so C is incorrect. D. Both NaCl and $\mathrm{NH_4Cl}$ have a total proton number of 28 per formula unit. Regardless of how they are mixed, if the mixture contains 1 mol of $\mathrm{Cl^{-}}$, the total proton number is $28N_A$, so D is correct. The answer is D.

39. C Analyze by noting that pH = 12 indicates excess base, so $c(OH^{-})=0.01\ \mathrm{mol/L}$, and calculate accordingly. Solution: Let the molar concentration of both NaOH and HCl be x. If the volumes are $3V$ and $2V$ respectively, then $\frac{3Vx-2Vx}{5V}=0.01\ \mathrm{mol/L}$. Solving gives $x=0.05\ \mathrm{mol/L}$. Answer: C. This problem tests calculations for acid–base mixing; the key is recognizing that pH = 12 means base is in excess, and pay attention to the conversion between pH and concentration; the difficulty is not high.

40. B In this reaction, for $\mathrm{NH_4^{+}\rightarrow N_2}$ the oxidation state of nitrogen changes from −3 to 0. Forming one nitrogen molecule requires the ammonium ions to lose 6 electrons, and forming one sulfur dioxide molecule requires the sulfate ion to gain 2 electrons, so the least common multiple is 6. Balancing the other elements by atom conservation gives $3\left(\mathrm{NH_4}\right)_2\mathrm{SO_4}\overset{\text{strong heating}}{=}3\mathrm{SO_2}\uparrow+\mathrm{N_2}\uparrow+4\mathrm{NH_3}\uparrow+6\mathrm{H_2O}$. In this equation the oxidation state of the nitrogen atoms in the ammonium ions and in the ammonia molecules is −3 in both cases, unchanged, so the ratio of the number of N atoms whose oxidation state changes to the number of those whose oxidation state does not change is $1\times2:4\times1=1:2$. The answer is B.

41. B An organic compound with the molecular formula $\mathrm{C_5H_{10}O_2}$ that reacts with sodium bicarbonate solution to release a gas must contain $-\mathrm{COOH}$, so it is pentanoic acid. The number of pentanoic acid isomers equals the number of butyl isomers. The butyl group $(-\mathrm{C_4H_9})$ has the isomers $-\mathrm{CH_2CH_2CH_2CH_3}$, $-\mathrm{CH\left(CH_3\right)CH_2CH_3}$, $-\mathrm{CH_2CH\left(CH_3\right)CH_3}$, and $-\mathrm{C\left(CH_3\right)_3}$, so there are 4 such compounds. The answer is B.

42. A The standard NaOH solution in methanol titrates the acetic acid from complete hydrolysis of acetic anhydride in step ④, consuming V_2 mL. Thus the total amount of acetic anhydride is $\frac{V_2c\times10^{-3}}{2}$ mol. The remaining acetic anhydride in step ③ consumes V_1 mL of standard solution, with amount $\frac{V_1c\times10^{-3}}{2}$ mol. Let x mol be the acetic anhydride that underwent alcoholysis with ROH and y mol be the amount that underwent hydrolysis. Then $x+y=\frac{V_2c\times10^{-3}}{2}$ and $x+2y=\frac{V_1c\times10^{-3}}{2}$. Solving simultaneously gives $x=n(ROH)=(V_2-V_1)c\times10^{-3}$ mol. Thus the mass fraction of hydroxyl content is $\frac{(V_2-V_1)c\times10^{-3}\times17}{m}\times100\%=\frac{c(V_2-V_1)\times17}{1000m}\times100\%$. A is correct, so the answer is A.

43. C By charge conservation: reactant side charge is $2\times(+3)+(-1)=+5$; product side charge is $8\times(+1)+(-1)+(-n)=7-n$. Thus $5=7-n$, so $n=2$, giving $M_2O_7^{2-}$. Let M oxidation state be x; with 7 oxygen atoms each at −2, we have $2x+7\times(-2)=-2$, so $x=+6$. Therefore the oxidation state of M is +6. The answer is C.

44. A This problem tests the conversion relationships among mass percentage, density, and molar concentration. When solving, strictly follow the definition formulas of mass percentage, density, and molar concentration to derive and compare each expression. By carefully working through the derivations and understanding the conversion relationships among these quantities, you can identify the incorrect expression. Answer: A.

45. C Analyze by noting that in the reaction, N changes from -3 to 0 oxidation state (in N_2), with a total change of 6; S changes from $+6$ to $+4$ oxidation state (in SO_2), with a change of 2. The least common multiple is 6. Use this to balance SO_2 and N_2 coefficients, then balance remaining substances by atom conservation. Solution: The balanced equation is $3(NH_4)_2SO_4\xrightarrow{\Delta}4NH_3\uparrow+N_2\uparrow+3SO_2\uparrow+6H_2O$. The stoichiometric coefficients are: N_2 is 1, SO_2 is 3, NH_3 is 4, H_2O is 6. In increasing order: N_2, SO_2, NH_3, H_2O. Answer: C. This problem essentially tests balancing chemical equations; using oxidation state changes combined with atom conservation is the key to solving; difficulty is moderate.

46. B Analysis: From the given conditions, we can first determine the molecular formula. Let the compound be $C_nH_{2n}O_x$. If there is only one oxygen atom, then $58-16=42$, and the remaining mass for carbon and hydrogen is $14n=42$, so $n=3$, giving C_3H_6O with one degree of unsaturation. If there are two oxygen atoms, then $58-32=26$ and $14n=26$, which does not give an integer value for n; thus there cannot be two oxygen atoms. Based on functional group isomerism and carbon chain isomerism, determine the types of constitutional isomers. Resolution: From the condition that complete combustion produces equal molar amounts of CO_2 and H_2O, the molecular formula is C_3H_6O. Based on functional group isomerism and carbon chain isomerism, the constitutional isomers are: one aldehyde, one ketone, one enol, one three-membered oxacyclic compound, one three-membered carbon ring, and one four-membered heterocycle, totalling 6 types. However, since the compound is monofunctional, enol (containing both carbon–carbon double bond and hydroxyl group, actually tautomeric to a carbonyl compound) should be excluded, so there are actually 5 types. Answer: B.

47. D A. When NaOH solution is added in excess to $\mathrm{MgCl_2}$ solution, a white precipitate of magnesium hydroxide forms. Since magnesium hydroxide is a moderately strong base, it does not react with excess NaOH solution, so the precipitate does not disappear; A is incorrect. B. Only $\mathrm{FeCl_3}$ solution turns blood red when KSCN solution is added, which is used to test for $\mathrm{Fe^{3+}}$. $\mathrm{FeCl_2}$ solution does not change color when KSCN is added; B is incorrect. C. The solubility of AgI is much less than that of AgCl, so the yellow precipitate of AgI cannot be completely converted to white AgCl precipitate when NaCl solution is added; C is incorrect. D. Acidic $\mathrm{KMnO_4}$ solution is purple-red and has strong oxidizing power. Ethanol has strong reducing power, so when ethanol is added in excess, the purple-red color of the solution fades; D is correct. Therefore, the answer is D.

48. C Since one isotope of X is commonly used in archaeology to date artifacts, X is C (carbon-14). Since Y is produced by liquid air fractional distillation, Y is N (nitrogen). Z has an atomic number greater than X and Y and cannot form diatomic molecules, so Z is Ne (neon). The anion of W has a number of electrons equal to the inner-shell electrons of X, Y, and Z (which is 2), so W is H (hydrogen). For A: Within the same period, atomic radius decreases from left to right. Thus the radius order is C > N, and rare gas atomic radius is measured differently and is generally not compared with other atoms, so A is incorrect. For B: The valence electrons are W (1) + X (4) + Y (5) + Z (8) = 18, not 20, so B is incorrect. For C: H and N can form N_2H_4 (hydrazine), where N–N is a nonpolar covalent bond and N–H is a polar covalent bond, so C is correct. For D: C and H form various hydrocarbon compounds; those with larger relative molecular mass have higher boiling points and may not necessarily be lower than compounds formed by N and H, so D is incorrect. Answer: C.