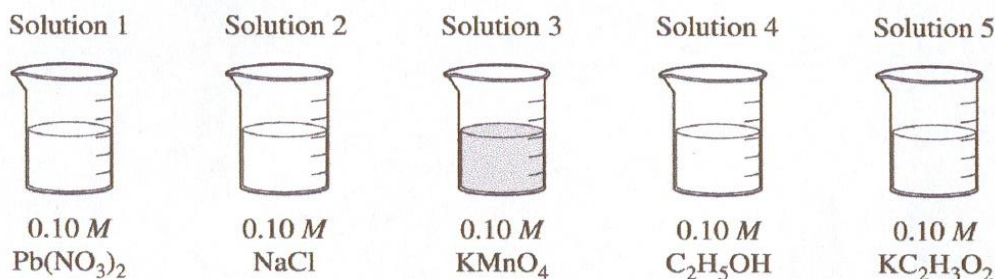
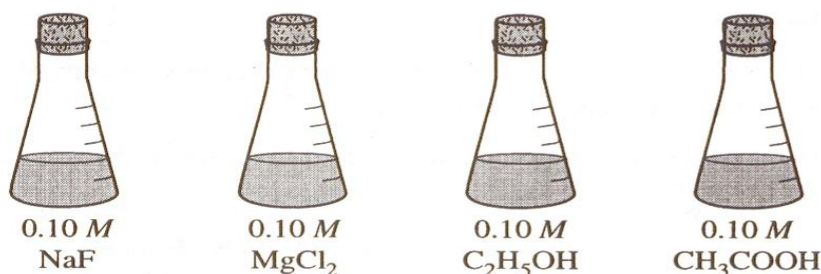


Use separate paper. Do essays in order. Answering these questions provides an opportunity to demonstrate your ability to present your material in logical, coherent, and convincing English. Your responses will be judged on the basis of accuracy and importance of the detail cited and on the appropriateness of the descriptive material used. Specific answers are preferable to broad, diffuse responses. Illustrative examples and equations may be helpful.



- Answer the questions below that relate to the five aqueous solutions at 25°C shown above.
  - Which solution has the highest pH? Explain.
  - Which solution would be the least effective conductor of electricity? Explain.
  - Which solution has the highest boiling point? Explain.
  - Identify a pair of the solutions that would produce a precipitate when mixed together. Write the formula of the precipitate.
  - Which solution could be used to oxidize the Cl<sup>-</sup> (aq) ion? Identify the product of the oxidation.
- Using principles of chemical bonding and molecular geometry, explain each of the following observations. Lewis electron-dot diagrams and sketches of molecules may be helpful as part of your explanations. For each observation, your answer must include references to both substances.
  - The bonds in nitrite ion, NO<sub>2</sub><sup>-</sup>, are shorter than the bonds in nitrate ion, NO<sub>3</sub><sup>-</sup>.
  - The CH<sub>2</sub>F<sub>2</sub> molecule is polar, whereas the CF<sub>4</sub> molecule is not.
  - The atoms in a C<sub>2</sub>H<sub>4</sub> molecule are located in a single plane, whereas those in a C<sub>2</sub>H<sub>6</sub> molecule are not.
  - The shape of a PF<sub>5</sub> molecule differs from that of an IF<sub>5</sub> molecule.
  - HClO<sub>3</sub> is a stronger acid than HClO.
- Use your knowledge of the principles of atomic structure and periodic trends to account for each of the following.
  - The first ionization energy of potassium is less than the first ionization energy of sodium.
  - The second ionization energy of potassium is approximately seven times greater than its first ionization energy.
  - The atomic radius of potassium is greater than the atomic radius of bromine.
  - The atomic radius of K<sup>+</sup> is smaller than the atomic radius of Cl<sup>-</sup>.

4. Use chemical principles to explain the following.
- A soda fizzes with bubbles of  $\text{CO}_2$  when the bottle top is removed. More bubbles form with warm soda as compared to cold soda.
  - Before Freon was developed, many refrigerators used sulfur dioxide as a refrigerant. Repairmen always carried a bottle of concentrated ammonia with them. Why?
  - Powdered platinum is a more effective catalyst than the same amount of platinum in a single crystal.
  - A mixture of compounds has a lower melting point than the pure compounds.
  - Helium-filled party balloons deflate more quickly than air-filled balloons.
5. Use the principles of bonding and intermolecular forces to describe the following.
- The difference between real and ideal gases
  - The experimental evidence for hydrogen bonding
  - The reaction between  $\text{Cu}^{2+}$  and  $\text{NH}_3$
  - The reason why  $\text{NO}_2$  forms dimers and  $\text{CO}_2$  does not
  - The reason why  $\text{NaCl}$  dissolves in water and  $\text{AgCl}$  does not
6. Account for each of the following observations about pairs of substances. In your answers, use appropriate principles of chemical bonding and/or intermolecular forces. In each part, your answer must include references to both substances.
- Even though  $\text{NH}_3$  and  $\text{CH}_4$  have similar molecular masses,  $\text{NH}_3$  has a much higher boiling point ( $-33^\circ\text{C}$ ) than  $\text{CH}_4$  ( $-164^\circ\text{C}$ ).
  - At  $25^\circ\text{C}$  and 1.0 atm, ethane ( $\text{C}_2\text{H}_6$ ) is a gas and hexane ( $\text{C}_6\text{H}_{14}$ ) is a liquid.
  - Si melts at a much higher temperature ( $1,410^\circ\text{C}$ ) than  $\text{Cl}_2$  ( $-101^\circ\text{C}$ ).
  - $\text{MgO}$  melts at a much higher temperature ( $2,852^\circ\text{C}$ ) than  $\text{NaF}$  ( $993^\circ\text{C}$ ).
7. Account for the following observations using principles of atomic structure and/or chemical bonding. In each part, your answer must include specific information about both substances.
- The  $\text{Ca}^{2+}$  and  $\text{Cl}^-$  ions are isoelectronic, but their radii are not the same. Which ion has the larger radius? Explain.
  - Carbon and lead are in the same group of elements, but carbon is classified as a nonmetal and lead is classified as a metal.
  - Compounds containing Kr have been synthesized, but there are no known compounds that contain He.
  - The first ionization energy of Be is  $900 \text{ kJ mol}^{-1}$ , but the first ionization energy of B is  $800 \text{ kJ mol}^{-1}$ .



8. Answer the following questions, which refer to the 100 mL samples of aqueous solutions at 25°C in the stoppered flasks shown above.
- Which solution has the lowest electrical conductivity? Explain.
  - Which solution has the highest pH? Explain.
  - Above which solution is the pressure of water vapor greatest? Explain.
  - Which solution has the lowest freezing point? Explain.
9. Use the principles of atomic structure and/or chemical bonding to explain each of the following. In each part, your answer must include references to both substances.
- The atomic radius of Li is larger than that of Be.
  - The second ionization energy of K is greater than the second ionization energy of Ca.
  - The carbon-to-carbon bond energy in C<sub>2</sub>H<sub>4</sub> is greater than it is in C<sub>2</sub>H<sub>6</sub>.
  - The boiling point of Cl<sub>2</sub> is lower than the boiling point of Br<sub>2</sub>.
10. Consider five unlabeled bottles, each containing 5.0 g of one of the following pure salts.
- AgCl   BaCl<sub>2</sub>   CoCl<sub>2</sub>   NaCl   NH<sub>4</sub>Cl
- Identify the salt that can be distinguished by its appearance alone. Describe the observation that supports your identification.
  - Identify the salt that can be distinguished by adding 10 mL of H<sub>2</sub>O to a small sample of each of the remaining unidentified salts. Describe the observation that supports your identification.
  - Identify the chemical reagent that could be added to the salt identified in part (b) to confirm the salt's identity. Describe the observation that supports your confirmation.
  - Identify the salt that can be distinguished by adding 1.0 M Na<sub>2</sub>SO<sub>4</sub> to a small sample of each of the remaining unidentified salts. Describe the observation that supports your identification.
  - Identify the salt that can be distinguished by adding 1.0 M NaOH to a small sample of each of the remaining unidentified salts. Describe the observation that supports your identification.

11. Explain each of the following using your knowledge of intermolecular forces and molecular structure.
- $\text{Br}_2$  has a higher boiling point than  $\text{Cl}_2$ .
  - $\text{F}_2$  has a greater bond length than  $\text{O}_2$ .
  - $\text{LiF}$  has a higher melting point than  $\text{NaCl}$ .
  - $\text{C}_4\text{H}_{10}$  has a higher boiling point than  $\text{CH}_4$ .
12. Use chemical principles to explain each of the following.
- A pressure cooker is used to cook food at higher temperatures than can be achieved using a regular pot.
  - Iron nails that are to be used outdoors are coated with zinc.
  - Food kept in a refrigerator takes longer to spoil than food left out on a kitchen table.
  - When water is left standing in plumbing during extremely cold weather, there is a danger that the pipes will burst.



13. Aqueous solutions of equal concentration of the three compounds listed above are prepared. What would an experimenter expect to observe when each of the following procedures is performed on each of the solutions?
- The pH of each solution is measured.
  - $\text{Pb}^{2+}$  ions are introduced into each solution.
  - $\text{SO}_4^{2-}$  ions are introduced into each solution.
  - The freezing point of each solution is measured and the three temperatures are compared.
14. For each of the following, use appropriate chemical principles to explain the observation. Include chemical equations as appropriate.
- In areas affected by acid rain, statues and structures made of limestone (calcium carbonate) often show signs of considerable deterioration.
  - When table salt ( $\text{NaCl}$ ) and sugar ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ) are dissolved in water, it is observed that
    - both solutions have higher boiling points than pure water, and
    - the boiling point of  $0.10\text{ M NaCl (aq)}$  is higher than that of  $0.10\text{ M C}_{12}\text{H}_{22}\text{O}_{11 (aq)}$ .
  - Methane gas does not behave as an ideal gas at low temperatures and high pressures.
  - Water droplets form on the outside of a beaker containing an ice bath.