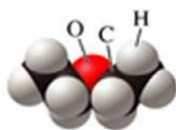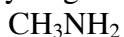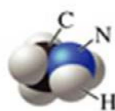1. Which of the following statements is correct?
    A. Since acetone (nail polish remover) evaporates more readily than water, one would assume that acetone has weaker intermolecular forces.
    B. The phase change from solid to gas is exothermic.
    C. Evaporation is an exothermic process, since heat is given off when a substance vaporizes.
    D. A liquid which has a high boiling point has a higher vapor pressure at a given temperature than a liquid with a low boiling point.
    E. Liquids boil at higher temperatures in the mountains due to the higher altitude.

2. Which of the following is **not** an attractive force that acts *between* the individual molecules of CH_3OH?
    A. covalent bonds
    B. London dispersion forces
    C. dipole-dipole forces
    D. hydrogen-bonding forces
    E. none of these is correct

3. The physical properties of a substance that are influenced by the strength of intermolecular forces include all of the following **except**:
    A. melting point.
    B. vapor pressure.
    C. mass.
    D. boiling point.
    E. viscosity.

4. Which of the following substances is most likely to be a gas at room temperature and atmospheric pressure?
    A. Pb
    B. C_8H_{18}
    C. I_2
    D. CCl_4
    E. Ar

5. Rank the following substances in order of increasing boiling point: Cl_2, Ar, Ne, Br_2
    A. Ne < Ar < Cl_2 < Br_2
    B. Ne < Ar < Br_2 < Cl_2
    C. Cl_2 < Br_2 < Ar < Ne
    D. Cl_2 < Ar < Ne < Br_2
    E. Ar < Ne < Br_2 < Cl_2

6. Which of the following molecules experience dipole-dipole forces?
    A. CCl_4
    B. H_2S
    C. SO_2
    D. CO_2
    E. both SO_2 and H_2S

7. Which of the molecules in the figure has hydrogen bonding in the pure liquid state?

$$CH_3CH_2OCH_2CH_3 \qquad CH_3NH_2 \qquad H_2S$$


    A. II only
    B. I only
    C. II and III
    D. III only
    E. I and II

8. A solid substance has a high melting point, is hard, brittle, and conducts electricity when molten. This substance is probably a(n)_____ solid.
    A. polar molecular
    B. nonpolar molecular
    C. metallic
    D. ionic
    E. network

9. Which of the following statements regarding the solution process is **incorrect**?
    A. Some of the hydrogen bonds among the water molecules must break.
    B. Hydration is the process whereby water molecules surround solute particles.
    C. In a sodium chloride solution, the ions interact with the water molecules through ion-dipole forces.
    D. When an ionic compound dissolves, the ionic bonds break.
    E. A hydrated cation is surrounded by the partially positive end of the water molecules.

10. When potassium nitrate is dissolved in water, the resulting solution feels cool to the touch. This means that:
    A. there is a decrease in entropy for the solution.
    B. hydrogen bonds must be broken, which is an exothermic process.
    C. the strength of attraction between the solute and solvent particles is greater than that of the attraction between the solute particles.
    D. the strength of attraction between the solute particles is greater than that of the attraction between the solute and solvent.
    E. the strength of attraction between the solute particles is equal to that of the attraction between the solute and solvent.

11. What will happen to a blood cell that is placed in pure water?
    A. The cell will shrink because there will be a net flow of water to the outside of the cell.
    B. Nothing will happen because the cell is impermeable.
    C. The cell will shrink because there will be a net flow of electrolytes to the outside of the cell.
    D. The cell will expand because there will be a net flow of water to the inside of the cell.
    E. The cell will expand because there will be a net flow of electrolytes to the inside of the cell.

12. What happens to the vapor pressure, boiling point, and freezing point of a liquid when a solute is dissolved in the liquid to form a solution?
    A. vapor pressure increases, boiling point decreases, and freezing point increases
    B. vapor pressure increases, boiling point increases, and freezing point increases
    C. vapor pressure decreases, boiling point increases, and freezing point decreases
    D. vapor pressure increases, boiling point decreases, and freezing point decreases
    E. vapor pressure decreases, boiling point decreases, and freezing point decreases

13. The images represent a solution of NaCl, a solution of glucose, and a more dilute solution of glucose. Rank the aqueous solutions in order of highest to lowest freezing point.
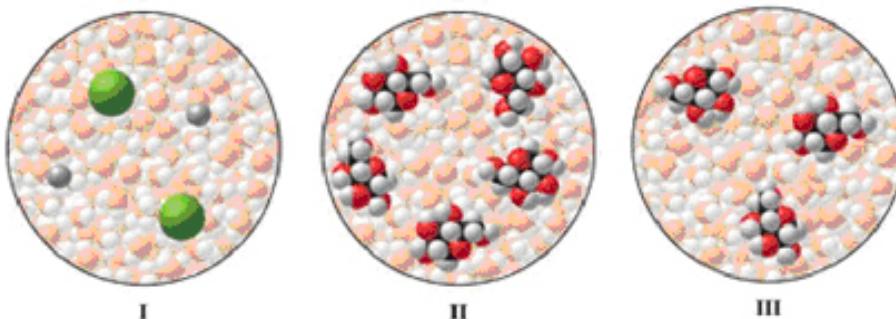
I   II   III

    A. II > I > III
    B. II > III > I
   C. I > II > III
    D. III > II > I
    E. III > I > II

14. The rate of a reaction can be increased by all of the following **except**:
    A. increasing the concentration of the reactants.
    B. increasing the surface area of the reactants.
    C. increasing the volume of the reaction vessel.
    D. increasing the temperature.
    E. adding a catalyst.

15. Which of the following statements regarding catalysts is **incorrect**?
    A. A catalyst increases the rate of a reaction by giving the reaction an alternate pathway with a lower activation energy.
    B. In a chemical reaction, the catalyst is shown on the reactant side of the equation.
    C. The shape of an active site on an enzyme is unique, allowing it to react with only one substrate.
    D. Enzymes act as catalysts in our bodies.
   E. Catalysts need not be present in large amounts because they are regenerated during the reaction.

16. If the following reaction is carried out in a sealed container:

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$
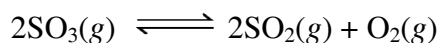
a state of equilibrium can be reached if the container initially contains:
- A. SO_3 only.
- B. SO_3, SO_2, and O_2.
- C. SO_3 and O_2 only.
- D. SO_2 and O_2 only.
- E. any of these combinations of reactants and products.

17. Select the correct equilibrium constant expression for the reaction:

$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$
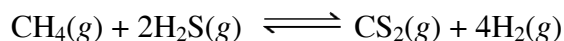
- A. $K_{eq} = \dfrac{[CS_2][H_2]}{[CH_4][H_2S]}$

- B. $K_{eq} = \dfrac{[CS_2][H_2]^4}{[CH_4][H_2S]^2}$

- C. $K_{eq} = \dfrac{[CH_4][H_2S]}{[CS_2][H_2]}$

- D. $K_{eq} = [CS_2][H_2]^4 - [CH_4][H_2S]^2$
- E. $K_{eq} = [CS_2][H_2]^4 + [CH_4][H_2S]^2$

18. Consider the following system at equilibrium:

$$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$
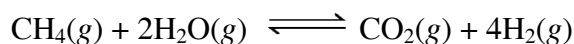
What change will cause the equilibrium to shift to form more CO_2?
- A. add a catalyst
- B. decrease $[H_2O]$
- C. decrease the volume of the reaction vessel
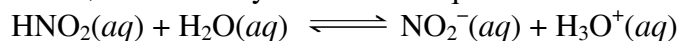- D. decrease $[H_2]$
- E. decrease $[CH_4]$

19. Ethane, C_2H_6, can be formed by reacting acetylene, C_2H_2, with hydrogen gas as follows:

$$C_2H_2(g) + H_2(g) \rightleftharpoons C_2H_6(g) \text{ Exothermic}$$

What change will be observed if the temperature of the reaction mixture at equilibrium were increased?
- A. The concentration of C_2H_6 will increase.
- B. The concentration of both C_2H_2 and H_2 will increase.
- C. There will be no change in the equilibrium concentrations.
- D. The concentration of both C_2H_2 and H_2 will decrease.
- E. The concentration of H_2 only will decrease.

20. Select the two Brønsted-Lowry acids in the equation:

$$HNO_2(aq) + H_2O(aq) \rightleftharpoons NO_2^-(aq) + H_3O^+(aq)$$

- A. NO_2^- and H_3O^+
- B. HNO_2 and H_2O
- C. H_2O and H_3O^+
- D. HNO_2 and H_3O^+
- E. HNO_2 and NO_2^-

21. Select the pair that consists of an acid and its conjugate base *in that order.*
    A. CO_3^{2-} / CO_2^{2-}
    B. CO_3^{2-}/HCO_3^-
    C. H_2CO_3/HCO_3^-
    D. NH_3/NH_4^+
    E. HPO_4^{2-}/H_3PO_4

22. Which of the following is the strongest acid?
    A. HCN, $K_a = 6.2 \times 10^{-10}$
    B. HF, $K_a = 6.3 \times 10^{-4}$
    C. HOCl, $K_a = 4.0 \times 10^{-8}$
    D. CH_3CO_2H, $K_a = 1.8 \times 10^{-5}$
    E. HCO_2H, $K_a = 1.8 \times 10^{-4}$

23. Select the solution below that is the most acidic.
    A. $[H_3O^+] = 1.0 \times 10^{-10}\ M$
    B. $[H_3O^+] = 1.0 \times 10^{-6}\ M$
    C. $[H_3O^+] = 1.0 \times 10^{-8}\ M$
    D. $[H_3O^+] = 1.0 \times 10^{-7}\ M$
    E. $[H_3O^+] = 1.0 \times 10^{-4}\ M$

24. Calculate the pH of a solution that has $[H_3O^+] = 1.0 \times 10^{-7}M$.
    A. pH = 1.00
    B. pH = 14.00
    C. pH = 7.00
    D. pH = 6.00
    E. pH = 8.00

25. Calculate the pH of a solution that has $[OH^-] = 1.0 \times 10^{-6}\ M$.
    A. pH = 7.00
    B. pH = 14.00
    C. pH = 1.00
    D. pH = 6.00
    E. pH = 8.00

Exam 4 Version 1 Key

1.A

2.A

3.C

4.E

5.A

6.E

7.A

8.D

9.E

10.D

11.D

12.C

13.E

14.C

15.B

16.E

17.B

18.D

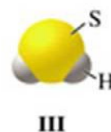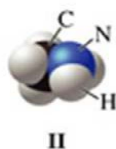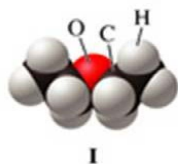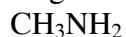19.B

20.D

21.C

22.B

23.E

24.C

25.E

1. Which of the following statements is correct?
    A. Since acetone (nail polish remover) evaporates more readily than water, one would assume that acetone has weaker intermolecular forces.
    B. A liquid which has a high boiling point has a higher vapor pressure at a given temperature than a liquid with a low boiling point.
    C. Evaporation is an exothermic process, since heat is given off when a substance vaporizes.
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2. Which of the following is **not** an attractive force that acts *between* the individual molecules of CH_3OH?
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    E. mass.

4. Which of the following substances is most likely to be a gas at room temperature and atmospheric pressure?
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    B. Ar
    C. C_8H_{18}
    D. CCl_4
    E. I_2

5. Rank the following substances in order of increasing boiling point: Cl_2, Ar, Ne, Br_2
    A. $Cl_2 < Br_2 < Ar < Ne$
    B. $Ne < Ar < Cl_2 < Br_2$
    C. $Ar < Ne < Br_2 < Cl_2$
    D. $Ne < Ar < Br_2 < Cl_2$
    E. $Cl_2 < Ar < Ne < Br_2$

6. Which of the following molecules experience dipole-dipole forces?
    A. H_2S
    B. SO_2
    C. CO_2
    D. CCl_4
    E. both SO_2 and H_2S

7. Which of the molecules in the figure has hydrogen bonding in the pure liquid state?

$CH_3CH_2OCH_2CH_3$ CH_3NH_2 H_2S

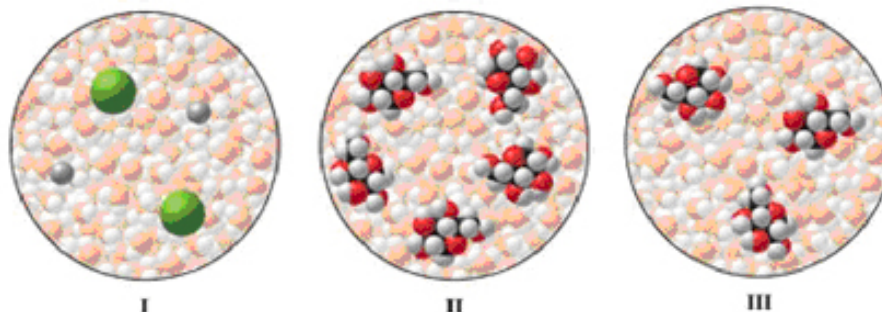   **I**   **II**   **III**

    A. I only
    B. II and III
    C. II only
    D. I and II
    E. III only

8. A solid substance has a high melting point, is hard, brittle, and conducts electricity when molten. This substance is probably a(n)_____ solid.
    A. nonpolar molecular
    B. polar molecular
    C. ionic
    D. metallic
    E. network

9. Which of the following statements regarding the solution process is **incorrect**?
    A. When an ionic compound dissolves, the ionic bonds break.
    B. Hydration is the process whereby water molecules surround solute particles.
    C. In a sodium chloride solution, the ions interact with the water molecules through ion-dipole forces.
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10. When potassium nitrate is dissolved in water, the resulting solution feels cool to the touch. This means that:
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11. What will happen to a blood cell that is placed in pure water?
    A. Nothing will happen because the cell is impermeable.
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    C. The cell will expand because there will be a net flow of water to the inside of the cell.
    D. The cell will expand because there will be a net flow of electrolytes to the inside of the cell.
    E. The cell will shrink because there will be a net flow of electrolytes to the outside of the cell.

12. What happens to the vapor pressure, boiling point, and freezing point of a liquid when a solute is dissolved in the liquid to form a solution?
    A. vapor pressure decreases, boiling point increases, and freezing point decreases
    B. vapor pressure increases, boiling point decreases, and freezing point increases
    C. vapor pressure increases, boiling point decreases, and freezing point decreases
    D. vapor pressure increases, boiling point increases, and freezing point increases
    E. vapor pressure decreases, boiling point decreases, and freezing point decreases

13. The images represent a solution of NaCl, a solution of glucose, and a more dilute solution of glucose. Rank the aqueous solutions in order of highest to lowest freezing point.

    A. I > II > III
    B. II > III > I
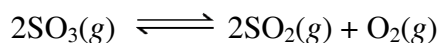   C. III > II > I
    D. II > I > III
    E. III > I > II

14. The rate of a reaction can be increased by all of the following **except**:
    A. increasing the volume of the reaction vessel.
    B. increasing the concentration of the reactants.
    C. increasing the surface area of the reactants.
    D. increasing the temperature.
    E. adding a catalyst.

15. Which of the following statements regarding catalysts is **incorrect**?
    A. Catalysts need not be present in large amounts because they are regenerated during the reaction.
    B. The shape of an active site on an enzyme is unique, allowing it to react with only one substrate.
    C. Enzymes act as catalysts in our bodies.
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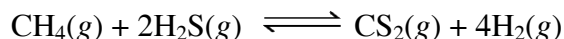
16. If the following reaction is carried out in a sealed container:
$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$
a state of equilibrium can be reached if the container initially contains:
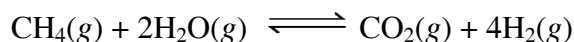   A. SO_2 and O_2 only.
    B. SO_3, SO_2, and O_2.
    C. SO_3 only.
    D. SO_3 and O_2 only.
    E. any of these combinations of reactants and products.

17. Select the correct equilibrium constant expression for the reaction:
$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$

    A. $K_{eq} = [CS_2][H_2]^4 - [CH_4][H_2S]^2$
    B. $K_{eq} = [CS_2][H_2]^4 + [CH_4][H_2S]^2$
    C. $K_{eq} = \dfrac{[CS_2][H_2]^4}{[CH_4][H_2S]^2}$
    D. $K_{eq} = \dfrac{[CS_2][H_2]}{[CH_4][H_2S]}$
    E. $K_{eq} = \dfrac{[CH_4][H_2S]}{[CS_2][H_2]}$

18. Consider the following system at equilibrium:
$$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$
What change will cause the equilibrium to shift to form more CO_2?
    A. decrease $[H_2O]$
    B. add a catalyst
    C. decrease $[H_2]$
    D. decrease the volume of the reaction vessel
    E. decrease $[CH_4]$

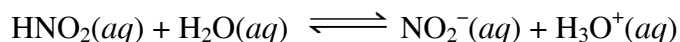19. Ethane, C_2H_6, can be formed by reacting acetylene, C_2H_2, with hydrogen gas as follows:
$$C_2H_2(g) + H_2(g) \rightleftharpoons C_2H_6(g) \text{ Exothermic}$$
What change will be observed if the temperature of the reaction mixture at equilibrium were increased?
    A. The concentration of C_2H_6 will increase.
    B. The concentration of both C_2H_2 and H_2 will increase.
    C. There will be no change in the equilibrium concentrations.
    D. The concentration of both C_2H_2 and H_2 will decrease.
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$$HNO_2(aq) + H_2O(aq) \rightleftharpoons NO_2^-(aq) + H_3O^+(aq)$$
    A. HNO_2 and H_2O
    B. NO_2^- and H_3O^+
    C. HNO_2 and H_3O^+
    D. HNO_2 and NO_2^-
    E. H_2O and H_3O^+

21. Select the pair that consists of an acid and its conjugate base *in that order.*
      A. CO_3^{2-} / CO_2^{2-}
      B. HPO_4^{2-}/H_3PO_4
      C. NH_3/NH_4^+
      D. CO_3^{2-}/HCO_3^-
      E. H_2CO_3/HCO_3^-

22. Which of the following is the strongest acid?
      A. HF, $K_a = 6.3 \times 10^{-4}$
      B. CH_3CO_2H, $K_a = 1.8 \times 10^{-5}$
      C. HCO_2H, $K_a = 1.8 \times 10^{-4}$
      D. HCN, $K_a = 6.2 \times 10^{-10}$
      E. HOCl, $K_a = 4.0 \times 10^{-8}$

23. Select the solution below that is the most acidic.
      A. $[H_3O^+] = 1.0 \times 10^{-6} \, M$
      B. $[H_3O^+] = 1.0 \times 10^{-7} \, M$
      C. $[H_3O^+] = 1.0 \times 10^{-4} \, M$
      D. $[H_3O^+] = 1.0 \times 10^{-8} \, M$
      E. $[H_3O^+] = 1.0 \times 10^{-10} \, M$

24. Calculate the pH of a solution that has $[H_3O^+] = 1.0 \times 10^{-7} M$.
      A. pH = 1.00
      B. pH = 6.00
      C. pH = 14.00
      D. pH = 7.00
      E. pH = 8.00

25. Calculate the pH of a solution that has $[OH^-] = 1.0 \times 10^{-6} \, M$.
      A. pH = 1.00
      B. pH = 14.00
      C. pH = 6.00
      D. pH = 7.00
      E. pH = 8.00

Exam 4 Version 2 Key

1.A

2.A

3.E

4.B

5.B

6.E

7.C

8.C

9.E

10.C

11.C

12.A

13.E

14.A

15.D

16.E

17.C

18.C

19.B

20.C

21.E

22.A

23.C

24.D

25.E