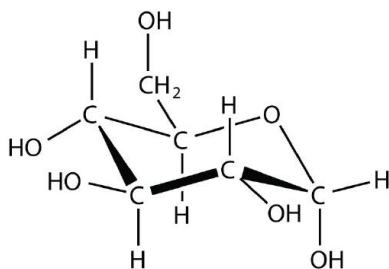


## 10.E: Solids and Liquids (Exercises)

### Exercises (Intermolecular Forces)

- What type of intermolecular force do all substances have?
- What is necessary for a molecule to experience dipole-dipole interactions?
- What is necessary for a molecule to experience hydrogen bonding?
- How does varying the temperature change the preferred phase of a substance?
- Identify the strongest intermolecular force present in each substance.
  - He
  - $\text{CHCl}_3$
  - $\text{HOF}$
- Identify the strongest intermolecular force present in each substance.
  - $\text{CH}_3\text{OH}$
  - $(\text{CH}_3)_2\text{CO}$
  - $\text{N}_2$
- Identify the strongest intermolecular force present in each substance.
  - $\text{HBr}$
  - $\text{C}_6\text{H}_5\text{NH}_2$
  - $\text{CH}_4$
- Identify the strongest intermolecular force present in each substance.
  - $\text{C}_{10}\text{H}_{22}$
  - $\text{HF}$
  - glucose



### Answers

- dispersion force
- An H atom must be bonded to an N, O, or F atom.
- dispersion forces
  - dipole-dipole interactions
  - hydrogen bonding

- 7.
- dipole-dipole interactions
  - hydrogen bonding
  - dispersion forces

### Exercises (Phase Transitions - Melting, Boiling, and Subliming)

- What is the difference between *melting* and *solidification*?
- What is the difference between *boiling* and *condensation*?
- Describe the molecular changes when a solid becomes a liquid.
- Describe the molecular changes when a liquid becomes a gas.
- What is the energy change when 78.0 g of Hg melt at  $-38.8^{\circ}\text{C}$ ?
- What is the energy change when 30.8 g of Al solidify at  $660^{\circ}\text{C}$ ?
- What is the energy change when 111 g of  $\text{Br}_2$  boil at  $59.5^{\circ}\text{C}$ ?
- What is the energy change when 98.6 g of  $\text{H}_2\text{O}$  condense at  $100^{\circ}\text{C}$ ?
- Each of the following statements is incorrect. Rewrite them so they are correct.
  - Temperature changes during a phase change.
  - The process of a liquid becoming a gas is called sublimation.
- Each of the following statements is incorrect. Rewrite them so they are correct.
  - The volume of a gas contains only about 10% matter, with the rest being empty space.
  - $\Delta H_{\text{sub}}$  is equal to  $\Delta H_{\text{vap}}$ .
- Write the chemical equation for the melting of elemental sodium.
- Write the chemical equation for the solidification of benzene ( $\text{C}_6\text{H}_6$ ).
- Write the chemical equation for the sublimation of  $\text{CO}_2$ .
- Write the chemical equation for the boiling of propanol ( $\text{C}_3\text{H}_7\text{OH}$ ).
- What is the  $\Delta H_{\text{sub}}$  of  $\text{H}_2\text{O}$ ? (Hint: see Table 10.3.1 "Enthalpies of Fusion for Various Substances" and Table 10.3.2 "Enthalpies of Vaporization for Various Substances".)
- The  $\Delta H_{\text{sub}}$  of  $\text{I}_2$  is 60.46 kJ/mol, while its  $\Delta H_{\text{vap}}$  is 41.71 kJ/mol. What is the  $\Delta H_{\text{fus}}$  of  $\text{I}_2$ ?

### Answers

- Melting is the phase change from a solid to a liquid, whereas solidification is the phase change from a liquid to a solid.
- The molecules have enough energy to move about each other but not enough to completely separate from each other.
- 890 J
- 10.7 kJ
- Temperature does not change during a phase change.
  - The process of a liquid becoming a gas is called boiling; the process of a solid becoming a gas is called sublimation.

11.  $\text{Na(s)} \rightarrow \text{Na(l)}$
13.  $\text{CO}_2\text{(s)} \rightarrow \text{CO}_2\text{(g)}$
15. 46.69 kJ/mol

### Exercises (Properties of Liquids)

1. What is the difference between evaporation and boiling?
2. What is the difference between a gas and vapor?
3. Define *normal boiling point* in terms of vapor pressure.
4. Is the boiling point higher or lower at higher environmental pressures? Explain your answer.
5. Referring to Fig. 10.4.3, if the pressure is 400 torr, which liquid boils at the lowest temperature?
6. Referring to Fig. 10.4.3, if the pressure is 100 torr, which liquid boils at the lowest temperature?
7. Referring to Fig. 10.4.3, estimate the boiling point of ethanol at 200 torr.
8. Referring to Fig. 10.4.3, at approximately what pressure is the boiling point of water 40°C?
9. Explain how surface tension works.
10. From what you know of intermolecular forces, which substance do you think might have a higher surface tension—ethyl alcohol or mercury? Why?
11. Under what conditions would a liquid demonstrate a capillary rise?
12. Under what conditions would a liquid demonstrate a capillary depression?

### Answers

1. Evaporation occurs when a liquid becomes a gas at temperatures below that liquid's boiling point, whereas boiling is the conversion of a liquid to a gas at the liquid's boiling point.
3. the temperature at which the vapor pressure of a liquid is 760 torr
5. diethyl ether
7. 48°C
9. Surface tension is an imbalance of attractive forces between liquid molecules at the surface of a liquid.
11. Adhesion must be greater than cohesion.

### Exercises (Solids)

1. What is the difference between a crystalline solid and an amorphous solid?
2. What two properties do solids have in common? What two properties of solids can vary?
3. Explain how the bonding in an ionic solid explains some of the properties of these solids.
4. Explain how the bonding in a molecular solid explains some of the properties of these solids.
5. Explain how the bonding in a covalent network solid explains some of the properties of these solids.
6. Explain how the bonding in a metallic solid explains some of the properties of these solids.
7. Which type(s) of solid has/have high melting points?

8. Which type(s) of solid conduct(s) electricity in their solid state? In their liquid state?
9. Which type of solid(s) is/are considered relatively soft?
10. Which type of solid(s) is/are considered very hard?
11. Predict the type of solid exhibited by each substance.
  - a. Hg
  - b.  $\text{PH}_3$
  - c.  $\text{CaF}_2$
12. Predict the type of solid exhibited by each substance.
  - a.  $(\text{CH}_2)_n$  (polyethylene, a form of plastic)
  - b.  $\text{PCl}_3$
  - c.  $\text{NH}_4\text{Cl}$
13. Predict the type of solid exhibited by each substance.
  - a.  $\text{SO}_3$
  - b.  $\text{Br}_2$
  - c.  $\text{Na}_2\text{SO}_3$
14. Predict the type of solid exhibited by each substance.
  - a. BN (boron nitride, a diamond-like compound)
  - b.  $\text{B}_2\text{O}_3$
  - c.  $\text{NaBF}_4$
15. Predict the type of solid exhibited by each substance.
  - a.  $\text{H}_2\text{S}$
  - b. Si
  - c. CsF
16. Predict the type of solid exhibited by each substance.
  - a. Co
  - b. CO
  - c.  $\text{CaCO}_3$

### Answers

1. At the atomic level, a crystalline solid has a regular arrangement of atoms, whereas an amorphous solid has a random arrangement of atoms.
3. The oppositely charged ions are very strongly held together, so ionic crystals have high melting points. Ionic crystals are also brittle because any distortion of the crystal moves same-charged ions closer to each other, so they repel.
5. The covalent network solid is essentially one molecule, making it very hard and giving it a very high melting point.
7. ionic solids, covalent network solids
9. molecular solids
11.
  - a. metallic
  - b. molecular solid
  - c. ionic crystal
- 13.

- a. molecular solid
- b. molecular solid
- c. ionic crystal

15.

- a. molecular solid
- b. molecular solid
- c. ionic crystal

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