

# Forces and States

Name: \_\_\_\_\_

Date: \_\_\_\_\_

$\text{F} \cdot \cdot \text{F}$ Fluorine Gas Molar mass = 38.0 g	$\text{Cl} \cdot \cdot \text{Cl}$ Chlorine Gas Molar mass = <u>71.0g</u>	$\text{Br} \cdot \cdot \text{Br}$ Bromine Liquid Molar mass = <u>159.8g</u>	$\text{I} \cdot \cdot \text{I}$ Iodine Solid Molar mass = <u>253.8g</u>
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## Critical Thinking Questions

- What type of force exists between two  $\text{F}_2$  molecules—dispersion, dipolar, or hydrogen bonds?  
**Dispersion ( $\text{F}_2$  is nonpolar)**
- What type of force exists between two  $\text{Cl}_2$  molecules—dispersion, dipolar, or hydrogen bonds?  
**Dispersion ( $\text{Cl}_2$  is nonpolar)**
- Recall the trend in sizes as one proceeds down a column of the periodic table. Do atoms get larger or smaller? Rank the sizes of fluorine, chlorine, bromine, and iodine in order from smallest to largest.  
**Atoms get larger going down a column.**  
**Smallest to largest: fluorine, chlorine, bromine, iodine**
- The forces between chlorine molecules cause them to be a gas at room temperature. The forces between bromine molecules cause them to be liquid at room temperature.
  - Do chlorine or do bromine molecules have stronger forces of attraction between them?  
**Bromine because in liquids, the molecules are attracted to each other more than in gases.**
  - True or False: If two different kinds of molecules have dispersion forces, then the dispersion forces are equal in strength.  
**No,  $\text{Cl}_2$  and  $\text{Br}_2$  have dispersion forces but  $\text{Br}_2$ 's are evidently stronger.**
- Considering your answers to questions 2 and 3, complete the following:  
 The larger the molecules are, the stronger the intermolecular forces between them.
- The states of the substances are given in the table above. Which kind of substance have the strongest intermolecular forces: solids, liquids, or gases?

**SOLIDS**

7. The molar mass of fluorine is given in the table above, but the molar masses for chlorine and others are not given. Use your periodic table to calculate the masses and place them in the blanks provided.

See the table.

8. In general, are lighter molecules more likely to be gases or solids?

Lighter molecules are more likely to be gases.

9. Propane's formula is  $C_3H_8$  and octane's formula is  $C_8H_{18}$ . Propane is a gas at room temperature, but octane is a liquid.

a. Which molecule has the strongest intermolecular forces: propane or octane?

Octane, since it is a liquid. It's mass is also greater than that of propane.

b. Would you expect  $C_2H_6$  to be a solid, liquid or a gas at room temperature?

A gas, since its mass is less than  $C_3H_8$ , which is a gas.

10. Consider two substances—one that has dipolar intermolecular forces and one that has London dispersion forces.

a. Which has the strongest intermolecular forces? The substance with dipolar forces

b. Which is most likely to be a gas at room temperature? The one with London dispersion forces.

11. What determines whether a substance will be a solid, liquid or a gas at room temperature?

The strength of the intermolecular forces between the molecules.

12. Which of the following describes what happens to the molecules when water changes from a liquid to a gas?

- i. The molecules get closer together
- ii. The molecules become farther apart.
- iii. The molecules slow down.
- iv. The molecules break up into atoms.

13. It takes a lot of heat energy to boil a certain liquid. What can we say about the intermolecular forces in the liquid—are the forces strong or weak? The forces must be strong because the molecules are sticking together so much that it takes a lot of energy to separate them by boiling.

14. Water boils at a temperature of  $100^\circ\text{C}$ . Acetone boils at  $50.5^\circ\text{C}$ . Ethyl alcohol boils at  $79^\circ\text{C}$ . Acetaldehyde boils at  $20.8^\circ\text{C}$ . Rank the four substances in order from the strongest intermolecular forces to the weakest.

They should be ranked from highest boiling point (strongest forces) to lowest boiling point (weakest forces): Water, Ethyl alcohol, Acetone, Acetaldehyde.

15. Which substance from question 14 is a gas at room temperature ( $25^\circ\text{C}$ )?

Acetaldehyde

## Information: Freezing Points of Some Substances

Substance	Freezing Point (degrees Kelvin)
Acetone	179
Ethyl Alcohol	158.6
Carbon dioxide	194.5
Hexane	178
Water	273

## Critical Thinking Questions

16. Two of the substances in the table have nearly the same strength of intermolecular forces. Name these two substances.

Hexane and Acetone since their freezing points are nearly the same.

17. If a substance has a low freezing point, then you must cool it down a lot before the molecules will stick together enough to become a solid. Therefore, if a substance has a low freezing point would you say that the intermolecular forces are strong or weak?

Weak because they do not want to attract to each other enough so it is difficult to freeze them

18. Rank the substances in the table in order from strongest to weakest intermolecular forces.

Should be ranked from highest freezing point to lowest freezing point.

Water, Carbon dioxide, Acetone, Hexane, Ethyl alcohol

19. True or False: A substance's freezing point and its melting point are at the same temperature.

True. For example, at zero Celsius  $H_2O$  will both melt and freeze at the same time.

20. Substance A is very polar. Substance B is nonpolar. Which substance would require the most energy to melt? Explain.

Substance A because polar substances have stronger intermolecular forces and therefore stick together better.

21. Water's melting and boiling point is very high. What does this fact tell you about water's intermolecular forces?

Water's intermolecular forces are relatively strong compared to many other substances

22. Use what you know about intermolecular forces to explain why a water bug can walk on water, but it can't walk on ethyl alcohol.

Water's molecules stick together because they have stronger intermolecular forces than ethyl alcohol. The alcohol molecules don't stick to each other as well.

23. Consider the previous question. We say that water has a stronger "surface tension" than ethyl alcohol. Do your best to define surface tension.

Surface tension is a measure of how strongly molecules attract each other at the surface of a liquid.

24. Chemists have a saying: "Like dissolves like." This means that polar substances dissolve other polar substances, and nonpolar substances dissolve nonpolar substances. Permanent ink can't be removed (dissolved) with water, but it can be removed with hexane. Based on this information, do you think permanent ink is polar or nonpolar? Explain.

Permanent ink is nonpolar since it can't be dissolved by water, a polar liquid.