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CHAPTER 10 REVIEW

States of Matter

SECTION 1

SHORT ANSWER **Answer the following questions in the space provided.**

1. Identify whether the descriptions below describe an ideal gas or a real gas.

ideal gas **a.** The gas will not condense because the molecules do not attract each other.

ideal gas **b.** Collisions between molecules are perfectly elastic.

real gas **c.** Gas particles passing close to one another exert an attraction on each other.

2. The formula for kinetic energy is $KE = \frac{1}{2}mv^2$.

a. As long as temperature is constant, what happens to the kinetic energy of the colliding particles during an elastic collision?

The energy is transferred between them.

b. If two gases have the same temperature and share the same energy but have different molecular masses, which molecules will have the greater speed?

Those with the lower molecule mass.

3. Use the kinetic-molecular theory to explain each of the following phenomena:

a. A strong-smelling gas released from a container in the middle of a room is soon detected in all areas of that room.

Gas molecules are in constant, rapid, random motion.

b. As a gas is heated, its rate of effusion through a small hole increases if all other factors remain constant.

As a gas is heated, each molecule's speed increases; therefore, the molecules pass through the small hole more frequently.

4. **a.** b, d, c, a List the following gases in order of rate of effusion, from lowest to highest. (Assume all gases are at the same temperature and pressure.)

(a) He **(b)** Xe **(c)** HCl **(d)** Cl_2

SECTION 1 continued

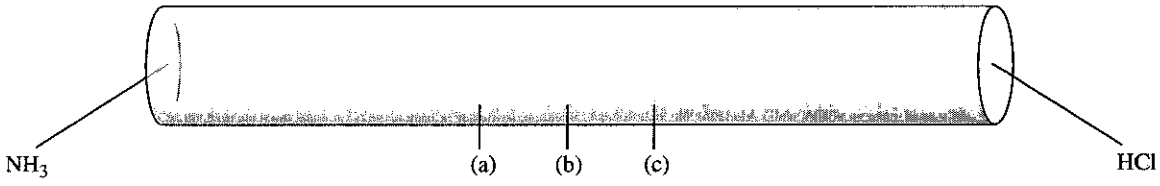
b. Explain why you put the gases in the order above. Refer to the kinetic-molecular theory to support your explanation.

All gases at the same temperature have the same average kinetic energy. Therefore, heavier molecules have slower average speeds. Thus, the gases are ranked from heaviest to lightest in molar mass.

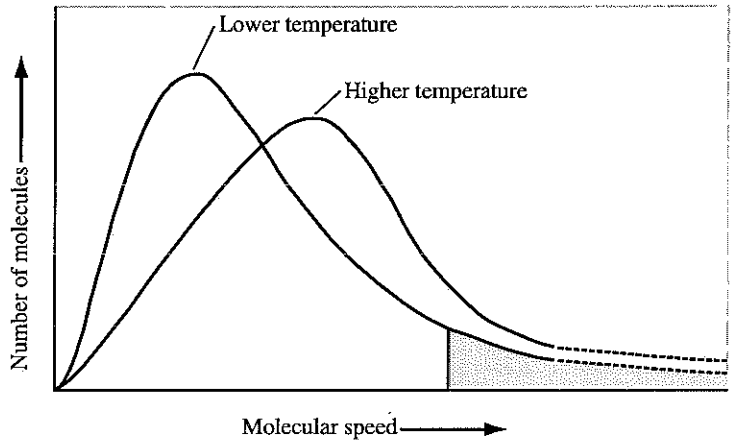
5. Explain why polar gas molecules experience larger deviations from ideal behavior than nonpolar molecules when all other factors (mass, temperature, etc) are held constant.

Polar molecules attract neighboring polar molecules and often move out of their straight-line paths because of these attractions.

6. **c** The two gases in the figure below are simultaneously injected into opposite ends of the tube. The ends are then sealed. They should just begin to mix closest to which labeled point?



7. Explain the difference in the speed-distribution curves of a gas at the two temperatures shown in the figure below.



In both cases the average speed of the molecules is proportional to temperature. The distribution of molecules becomes broader as the temperature increases. This means that there are a greater number of molecules traveling within a greater range of higher speeds as the temperature increases.

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CHAPTER 10 REVIEW

States of Matter

SECTION 2

SHORT ANSWER **Answer the following questions in the space provided.**

1. ___a___ Liquids possess all the following properties *except*

(a) relatively low density.
(b) the ability to diffuse.
(c) relative incompressibility.
(d) the ability to change to a gas.

2. **a.** Chemists distinguish between intermolecular and intramolecular forces. Explain the difference between these two types of forces.

Intermolecular forces are between separate molecules; intramolecular forces are within individual molecules.

Classify each of the following as intramolecular or intermolecular:

intermolecular **b.** hydrogen bonding in liquid water

intramolecular **c.** the O—H covalent bond in methanol, CH_3OH

intermolecular **d.** the bonds that cause gaseous Cl_2 to become a liquid when cooled

3. Explain the following properties of liquids by describing what is occurring at the molecular level.

a. A liquid takes the shape of its container but does not expand to fill its volume.

Liquid molecules are very mobile. This mobility allows a liquid to take the shape of its container. In liquids, molecules are in contact with adjacent molecules, allowing intermolecular forces to have a greater effect than they do in gases. The molecules in a liquid will therefore not necessarily spread out to fill a container's entire volume.

b. Polar liquids are slower to evaporate than nonpolar liquids.

Polar molecules are attracted to adjacent molecules and are therefore less able to escape from the liquid's surface than are nonpolar molecules.

Name _____ Date _____ Class _____

SECTION 2 continued

4. Explain briefly why liquids tend to form spherical droplets, decreasing surface area to the smallest size possible.

An attractive force pulls adjacent parts of a liquid's surface together, thus decreasing surface area to the smallest possible size. A sphere offers the minimum surface area for a given volume of liquid.

5. Is freezing a chemical change or a physical change? Briefly explain your answer.

Freezing is a physical change. The substance solidifying is changing its state, which is a physical change. It is still the same substance so it has not changed chemically.

6. Is evaporation a chemical or physical change? Briefly explain your answer.

Evaporation is a physical change because it involves a change of physical state. There is no change in the chemical makeup of the substance, which would be necessary for a chemical change.

7. What is the relationship between vaporization and evaporation?

Evaporation is a form of vaporization. It occurs only in nonboiling liquids when some liquid particles enter the gas state. Vaporization is a more general term that refers to either a liquid or a solid changing to a gas.

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CHAPTER 10 REVIEW

States of Matter

SECTION 3

SHORT ANSWER **Answer the following questions in the space provided.**

1. Match description on the right to the correct crystal type on the left.

b	ionic crystal	(a)	has mobile electrons in the crystal
c	covalent molecular crystal	(b)	is hard, brittle, and nonconducting
a	metallic crystal	(c)	typically has the lowest melting point of the four crystal types
d	covalent network crystal	(d)	has strong covalent bonds between neighboring atoms

2. For each of the four types of solids, give a specific example other than one listed in Table 1 on page 340 of the text.

some possible answers:

ionic solid: MgO, CaO, KI, $CuSO_4$

covalent network solid: graphite, silicon carbide

covalent molecular solid: dry ice (CO_2), sulfur, iodine

metallic solid: any metal from the far left side of the periodic table

3. A chunk of solid lead is dropped into a pool of molten lead. The chunk sinks to the bottom of the pool. What does this tell you about the density of the solid lead compared with the density of the molten lead?

Solid lead is denser than the liquid form.

4. Answer *amorphous solid* or *crystalline solid* to the following questions:

crystalline solid	**a.** Which is less compressible?
crystalline solid	**b.** Which has a more clearly defined shape?
amorphous solid	**c.** Which is sometimes described as a supercooled liquid?
amorphous solid	**d.** Which has a less clearly defined melting point?

Name _____ Date _____ Class _____

SECTION 3 continued

5. Explain the following properties of solids by describing what is occurring at the atomic level.

a. Metallic solids conduct electricity well, but covalent network solids do not.

Metals have many electrons that are not bound to any one atom; therefore they are able to move throughout the crystal. In covalent network solids, all atoms (and electrons) are strongly bound in place and are not free to move.

b. The volume of a solid changes only slightly with a change in temperature or pressure.

Solids have definite volume because their particles are packed very close together. There is very little empty space into which the particles can be compressed. Even at high temperatures their particles are held in relatively fixed positions.

c. Amorphous solids do not have a definite melting point.

In amorphous solids, particles are arranged randomly; no specific amount of kinetic energy is needed to overcome the attractive forces holding the particles together. Thus, they do not have a point at which they melt, but melt over a range of temperatures.

d. Ionic crystals are much more brittle than covalent molecular crystals.

Ionic crystals have strong binding forces between the positive and negative ions in the crystal structure. Covalent molecular crystals have weaker bonds between the molecules.

6. Experiments show that it takes 6.0 kJ of energy to melt 1 mol of water ice at its melting point but only about 1.1 kJ to melt 1 mol of methane, CH_4, at its melting point. Explain in terms of intermolecular forces why it takes so much less energy to melt the methane.

The attractive forces between CH_4 molecules are weak (dispersion forces). Little energy is needed to separate the molecules. Melting water ice involves the breaking of many hydrogen bonds between molecules, which requires more energy.

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CHAPTER 10 REVIEW

States of Matter

SECTION 4

SHORT ANSWER **Answer the following questions in the space provided.**

1. __a__ When a substance in a closed system undergoes a phase change and the system reaches equilibrium,

(a) the two opposing changes occur at equal rates.
(b) there are no more phase changes.
(c) one phase change predominates.
(d) the amount of substance in the two phases changes.

2. Match the following definitions on the right with the words on the left.

__b__ equilibrium	**(a)** melting
__c__ volatile	**(b)** opposing changes occurring at equal rates in a closed system
__a__ fusion	**(c)** readily evaporated
__d__ deposition	**(d)** a change directly from a gas to a solid

3. Match the process on the right with the change of state on the left.

__c__ solid to gas	**(a)** melting
__d__ liquid to gas	**(b)** condensation
__b__ gas to liquid	**(c)** sublimation
__a__ solid to liquid	**(d)** vaporization

4. Refer to the phase diagram for water in Figure 16 on page 347 of the text to answer the following questions:

__A__ **a.** What point represents the conditions under which all three phases can coexist?

__C__ **b.** What point represents a temperature above which only the vapor phase exists?

__it decreases__ **c.** Based on the diagram, as the pressure on the water system increases, what happens to the melting point of ice?

d. What happens when water is at point A on the curve and the temperature increases while the pressure is held constant?

ice and liquid water will vaporize, forming water vapor

Name _____ Date _____ Class _____

SECTION 4 continued

5. Use this general equilibrium equation to answer the following questions:

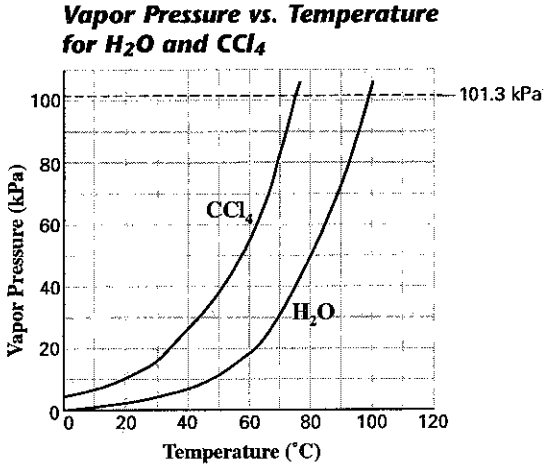
reactants ⇄ products + energy

decrease **a.** If the forward reaction is favored, will the concentration of reactants increase, decrease, or stay the same?

reverse reaction **b.** If extra product is introduced, which reaction will be favored?

forward reaction **c.** If the temperature of the system decreases, which reaction will be favored?

6. Refer to the graph below to answer the following questions:



about 75°C **a.** What is the normal boiling point of CCl_4?

about 85°C **b.** What would be the boiling point of water if the air pressure over the liquid were reduced to 60 kPa?

about 38 kPa **c.** What must the air pressure over CCl_4 be for it to boil at 50°C?

d. Although water has a lower molar mass than CCl_4, it has a lower vapor pressure when measured at the same temperature. What makes water vapor less volatile than CCl_4?

Based solely on molar mass, CCl_4 would be expected to be less volatile than water. However, CCl_4 is nonpolar and thus has weak intermolecular forces of attraction. Water is polar and contains strong hydrogen bonds between molecules. Thus, water is less volatile despite its smaller molar mass.

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CHAPTER 10 REVIEW

States of Matter

SECTION 5

SHORT ANSWER **Answer the following questions in the space provided.**

1. Indicate whether each of the following is a *physical* or *chemical* property of water.

physical **a.** The density of ice is less than the density of liquid water.

chemical **b.** A water molecule contains one atom of oxygen and two atoms of hydrogen.

chemical **c.** There are strong hydrogen bonds between water molecules.

physical **d.** Ice consists of water molecules in a hexagonal arrangement.

2. Compare a polar water molecule with a less-polar molecule, such as formaldehyde, CH_2O. Both are liquids at room temperature and 1 atm pressure.

water **a.** Which liquid should have the higher boiling point?

formaldehyde **b.** Which liquid is more volatile?

water **c.** Which liquid has a higher surface tension?

water **d.** In which liquid is NaCl, an ionic crystal, likely to be more soluble?

3. Describe hydrogen bonding as it occurs in water in terms of the location of the bond, the particles involved, the strength of the bond, and the effects this type of bonding has on physical properties.

Hydrogen bonding in water occurs between a hydrogen atom of one water molecule and the unshared pair of electrons of an oxygen atom of an adjacent water molecule. It is a particularly strong type of dipole-dipole force. Hydrogen bonding causes the boiling point of water and its molar enthalpy of vaporization to be relatively high. The water's high surface tension is also a result of hydrogen bonding.

Name _____ Date _____ Class _____

SECTION 5 continued

PROBLEMS **Write the answer on the line to the left. Show all your work in the space provided.**

4. The molar enthalpy of vaporization of water is 40.79 kJ/mol, and the molar enthalpy of fusion of ice is 6.009 kJ/mol. The molar mass of water is 18.02 g/mol.

68.6 kJ/mol **a.** How much energy is absorbed when 30.3 g of liquid water boils?

79.8 cal/g **b.** An energy unit often encountered is the calorie (4.18 J = 1 calorie). Determine the molar enthalpy of fusion of ice in calories per gram.

5. A typical ice cube has a volume of about 16.0 cm^3. Calculate the amount of energy needed to melt the ice cube. (Density of ice at 0.°C = 0.917 g/mL; molar enthalpy of fusion of ice = 6.009 kJ/mol; molar mass of H_2O = 18.02 g/mol.)

14.7 g **a.** Determine the mass of the ice cube.

0.814 mol **b.** Determine the number of moles of H_2O present in the sample.

4.89 kJ **c.** Determine the number of kilojoules of energy needed to melt the ice cube.

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CHAPTER 10 REVIEW

States of Matter

MIXED REVIEW

SHORT ANSWER **Answer the following questions in the space provided.**

1. __c__ The average speed of a gas molecule is most directly related to the

(a) polarity of the molecule.
(b) pressure of the gas.
(c) temperature of the gas.
(d) number of moles in the sample.

2. Use the kinetic-molecular theory to explain the following phenomena:

a. When 1 mol of a real gas is condensed to a liquid, the volume shrinks by a factor of about 1000.

Molecules in a gas are far apart. They are much closer together in a liquid. Molecules in a gas are easily squeezed closer together as the gas is compressed.

b. When a gas in a rigid container is warmed, the pressure on the walls of the container increases.

As the temperature increases, the molecules speed up. Thus, they collide with the walls more frequently than before and with a greater force per impact. For both of these reasons, the total force per unit area increases and the pressure increases.

3. __b__ Which of the following statements about liquids and gases is *not* true?

(a) Molecules in a liquid are much more closely packed than molecules in a gas.
(b) Molecules in a liquid can vibrate and rotate, but they are bound in fixed positions.
(c) Liquids are much more difficult to compress into a smaller volume than are gases.
(d) Liquids diffuse more slowly than gases.

4. Answer *solid* or *liquid* to the following questions:

solid **a.** Which is less compressible?

liquid **b.** Which is quicker to diffuse into neighboring media?

solid **c.** Which has a definite volume and shape?

solid **d.** Which has molecules that are rotating or vibrating primarily in place?

Name _____ Date _____ Class _____

MIXED REVIEW continued

5. Explain why almost all solids are denser than their liquid states by describing what is occurring at the molecular level.

In solids, particles are more closely packed than in liquids, due to stronger attractive forces between the particles of the solid.

6. A general equilibrium equation for boiling is

$$\text{liquid} + \text{energy} \rightleftarrows \text{vapor}$$

Indicate whether the forward or reverse reaction is favored in each of the following cases:

forward reaction **a.** The temperature of the system is increased.

reverse reaction **b.** More molecules of the vapor are added to the system.

reverse reaction **c.** The pressure on the system is increased.

7. **181 kJ** Freon-11, CCl_3F has been commonly used in air conditioners. It has a molar mass of 137.35 g/mol and its enthalpy of vaporization is 24.8 kJ/mol at its normal boiling point of 24°C. Ideally how much energy in the form of heat is removed from a room by an air conditioner that evaporates 1.00 kg of freon-11?

8. Use the data table below to answer the following:

Composition	Molar mass (g/mol)	Enthalpy vaporization (kJ/mol)	Normal boiling point (°C)	Critical temperature (°C)
He	4	0.08	−269	−268
Ne	20	1.8	−246	−229
Ar	40	6.5	−186	−122
Xe	131	12.6	−107	+17
H_2O	18	40.8	+100	+374
HF	20	25.2	+20	+188
CH_4	16	8.9	−161	−82
C_2H_6	30	15.7	−89	+32

higher **a.** Among *nonpolar* liquids, those with higher molar masses tend to have normal boiling points that are (higher, lower, or about the same).

higher **b.** Among compounds of approximately the same molar mass, those with greater polarities tend to have enthalpies of vaporization that are (higher, lower, or about the same).

c. Which is the only noble gas listed that is stable as a liquid at 0°C? Explain your answer using the concept of critical temperature.

Xe; a substance can exist only as a gas at temperatures above its critical temperature. Of the noble gases listed, only Xe has a critical temperature above 0°C.