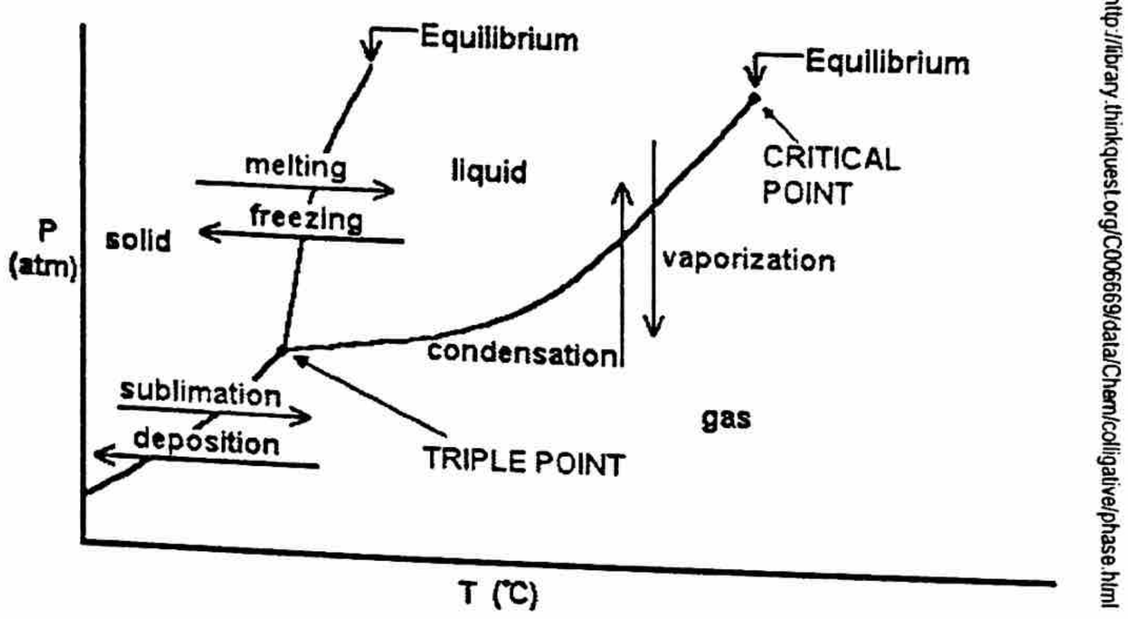
Phase Diagram POGIL

Name:_____ Date:_____

Model 1



http://library.thinkquest.org/C006669/data/Chem/colligative/phase.html

A phase diagram is a graphical way to summarize the conditions under which equilibria exist between the different states of matter. It also allows us to predict the phase of a substance that is stable at any given temperature and pressure.

Critical Thinking Questions

1. What Label is on the x-axis?

   temperature

2. What Label is on the y-axis?

   pressure

3. List the three phases of matter that are on the diagram.

   solid, liquid, gas

4. At which point do all three phases on the diagram meet?

   triple point

5. In your own words, define what you think the triple point is.

   the point where all three states of matter are in equilibrium

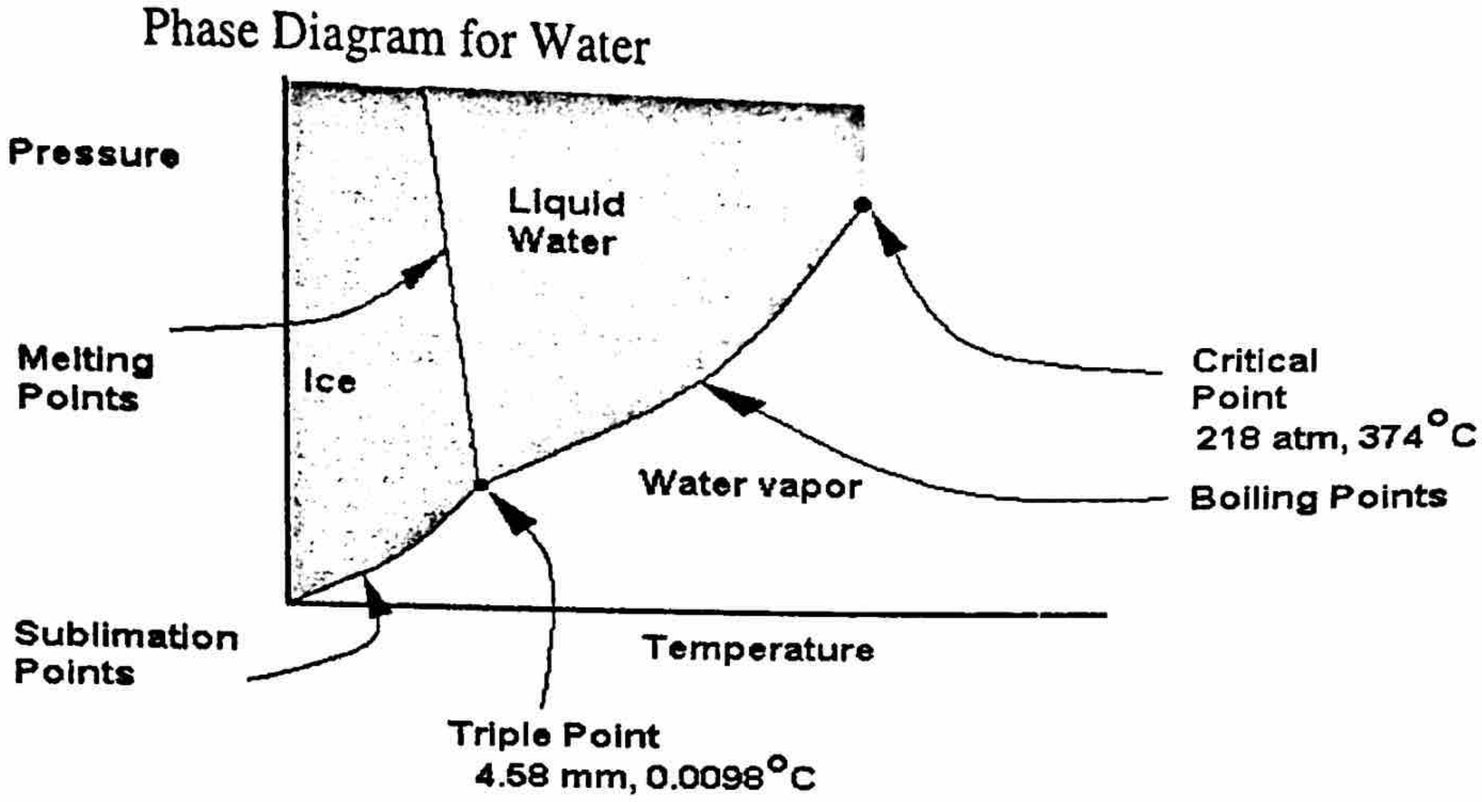
6. The line extending from the triple point to the critical point stops. What does this mean in terms of phase change?

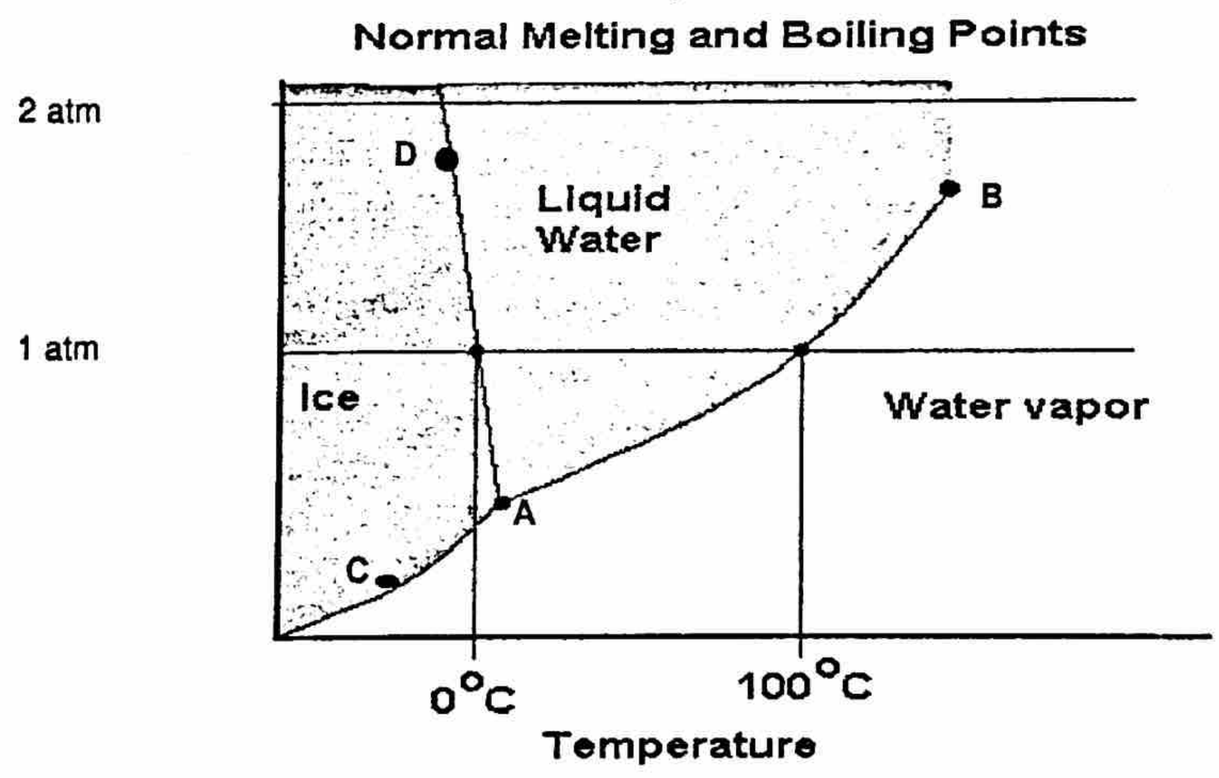
   after this point liquid and gas can no longer change phases

7. In your own words, define what you think the critical point is.

   the point at which liquid will longer no longer be convert to a gas

Model 2





Critical Thinking Questions

8. Identify the following points: A, B, C, D

A = triple point
B = critical point
C = sublimation points
D = melting points

9. If the line AD represents the melting/freezing line for water, what would the AB line represent? What would the AC line represent?

AB = evaporation / condensation line
AC = sublimation / deposition line

10. Given the phase diagram above, what phase would water be in if it had the following properties:

a. 50 °C, and 0.5 atm pressure

gas

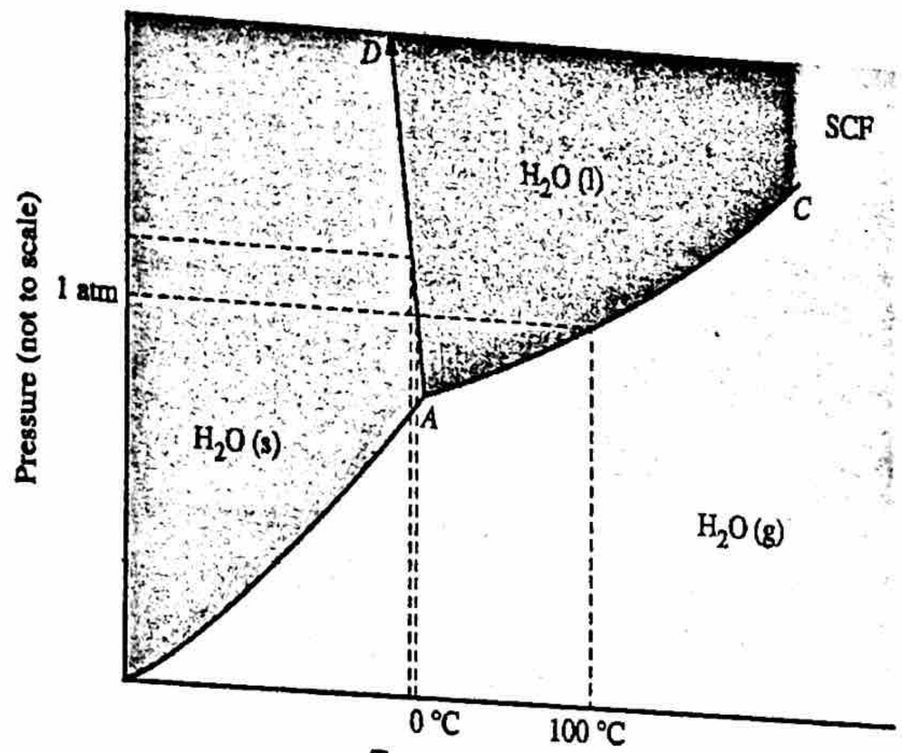
b. -50°C, and 0.5 atm pressure

solid

c. 125 °, and 1.0 atm pressure

gas

Model 3



11. In the diagram above, what do (s), (l), and (g) represent?

(s) = solid (ℓ) = liquid (g) = gas

Using the phase diagram of the liquid above, describe any changes in phase present when H_2O is:

12. kept at 0°C while the pressure is increased from 1 atm to 5atm (vertical line)

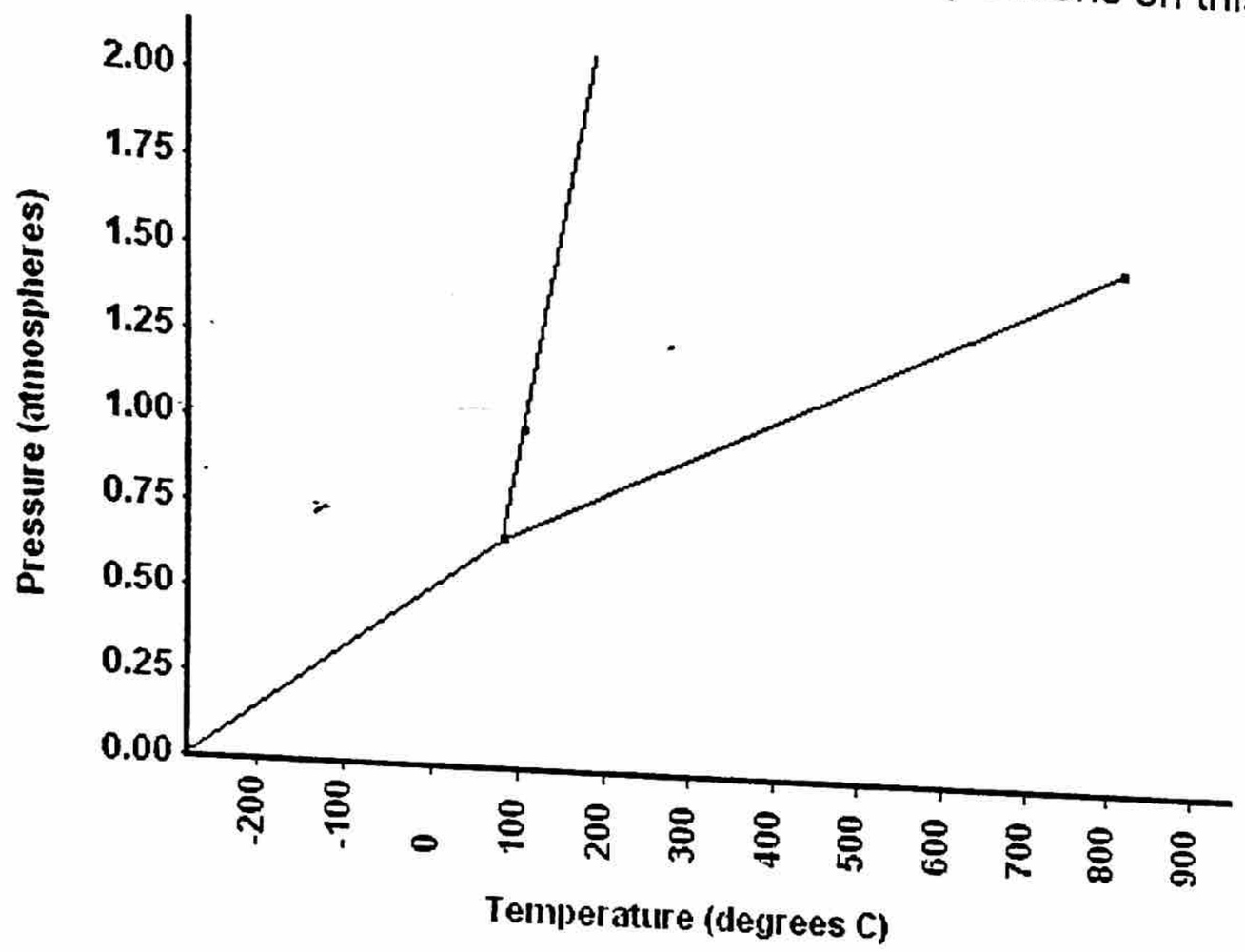
melting

13. Kept at 1.00 atm while the temperature is increased from 0 °C to 125 °C. (horizontal line)

melting + evaporation

Phase Diagram Worksheet

Refer to the phase diagram below when answering the questions on this worksheet:



1) What is the normal freezing point of this substance? 100°C

2) What is the normal boiling point of this substance? 400°C

3) What is the triple point of this substance? .65 atm, 100°C

4) If I had a quantity of this substance at a pressure of 1.25 atm and a temperature of 300° C and lowered the pressure to 0.25 atm, what phase transition(s) would occur?

evaporation

5) At what temperature do the gas and liquid phases become indistinguishable from each other? 900°C

6) If I had a quantity of this substance at a pressure of 0.75 atm and a temperature of -100° C, what phase change(s) would occur if I increased the temperature to 600° C? At what temperature(s) would they occur?

melting, evaporation

Phase Diagram Worksheet

Name: _____

A **phase diagram** is a graphical way to depict the effects of **pressure** and **temperature** on the phase of a substance:

The CURVES indicate the conditions of temperature and pressure under which "equilibrium" between different phases of a substance can exist. BOTH phases exist on these lines:

Melting/Freezing: Any point on this line (pressure & temperature) the substance is both **solid** and **liquid**

Sublimation/Deposition: Any point on this line (pressure & temperature) the substance is both **solid** and **gas**

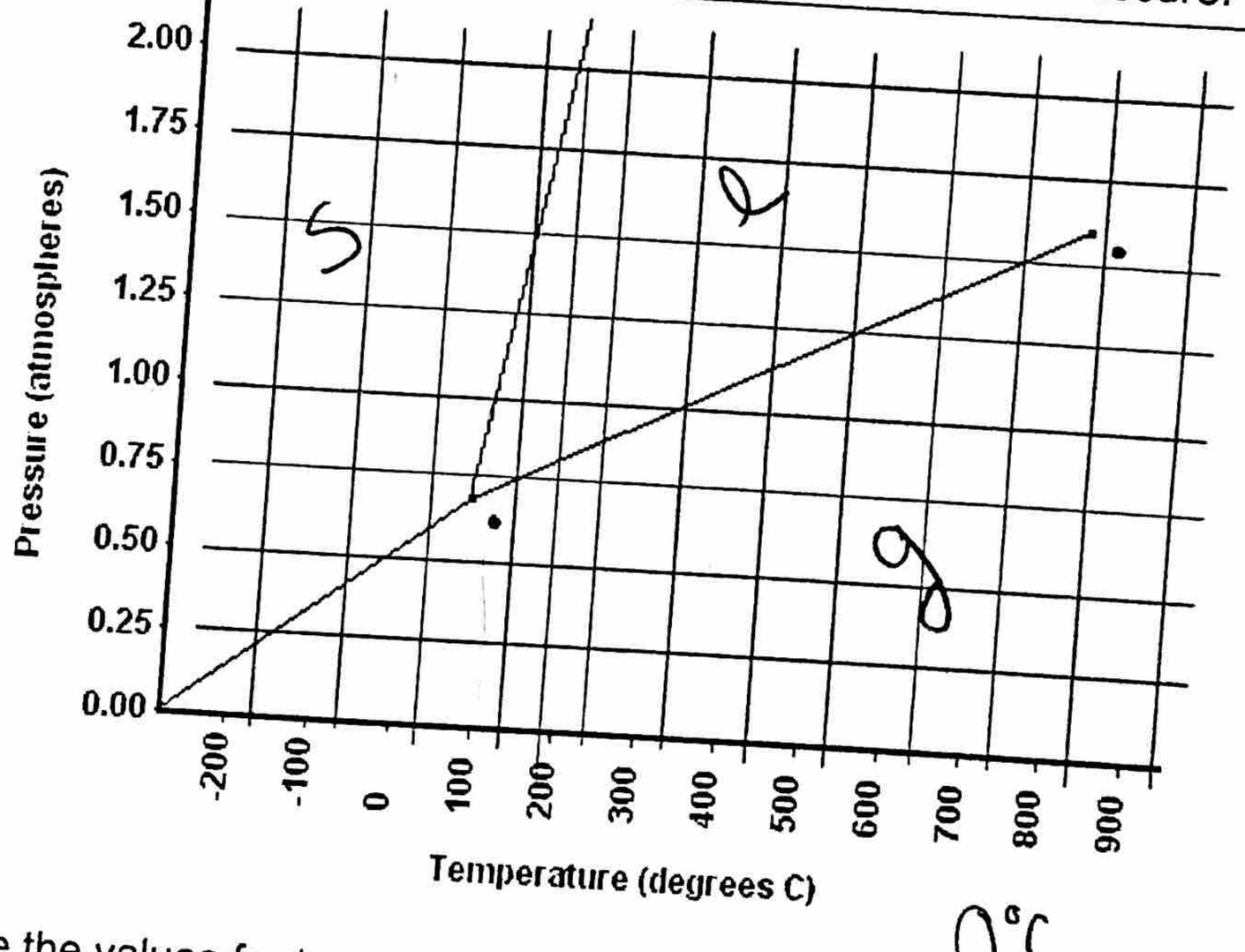
Vaporization/Condensation: Any point on this line (pressure & temperature) the substance is both **liquid** and **gas**

NOTE: the vapor pressure curve ends at the **critical point,** the temperature above which the gas cannot be liquefied no matter how much pressure is applied (the kinetic energy simply is too great for attractive forces to overcome). Any substance beyond this critical point is called a **supercritical fluid** – *indistinguishable* between gas or liquid (*neither one*)

The **TRIPLE POINT** is the condition of temperature and pressure where ALL THREE phases exist in equilibrium (solid, liquid, gas)

Remember that pressure can be expressed in many units where: **1 atm = 101.3 kpa = 760 mmHg**

Refer to the phase diagram below when answering the questions *on the back* of this worksheet:
NOTE: "*Normal*" refers to STP – Standard Temperature and Pressure.



1) What are the values for temperature and pressure at STP? 0°C 273 K, P= 1.00 atm

2) What is the *normal* freezing point of this substance? 100°C

3) What is the *normal* boiling point of this substance? 330°C

4) What is the *normal* melting point of this substance? 100°C

For chemistry help, visit www.chemfiesta.com

5) What is the phase (s, l, g) of a substance at **2.0 atm** and 100 °C? S

6) What is the phase (s, l, g) of a substance at **0.75 atm** and 100 °C? l

7) What is the phase (s, l, g) of a substance at **0.5 atm** and 100 °C? g

8) What is the phase (s, l, g) of a substance at 1.5 atm and **50 °C**? g s

9) What is the phase (s, l, g) of a substance at 1.5 atm and **200 °C**? l

10) What is the phase (s, l, g) of a substance at 1.5 atm and **800 °C**? g

11) What is the condition of the **triple point** of this substance? T= 100°C, P= 0.65 atm

12) If a quantity of this substance was at an initial pressure of 1.25 atm and a temperature of **300° C** was lowered to a pressure of 0.25 atm, what phase transition(s) would occur? evaporation

13) If a quantity of this substance was at an initial pressure of 1.25 atm and a temperature of **0° C** was lowered to a pressure of 0.25 atm, what phase transition(s) would occur? sublimation

14) If a quantity of this substance was at an initial pressure of **1.0 atm** and a temperature of 200° C was lowered to a temperature of **-200° C**, what phase transition(s) would occur? freezing

15) If a quantity of this substance was at an initial pressure of **0.5 atm** and a temperature of 200° C was lowered to a temperature of **-200° C**, what phase transition(s) would occur? deposition

16) If this substance was at a pressure of 2.0 atm, at what temperature would it **melt**? 190°C

17) If this substance was at a pressure of 2.0 atm, at what temperature would it **boil**? it wouldn't

18) If this substance was at a pressure of 0.75 atm, at what temperature would it **melt**? 95°C

19) If this substance was at a pressure of 0.75 atm, at what temperature would it **boil**? 120°C

20) At what temperature do the gas and liquid phases become indistinguishable from each other? 810°C

21) At what pressure would it be possible to find this substance in the gas, liquid, **and** solid phase? .65 atm

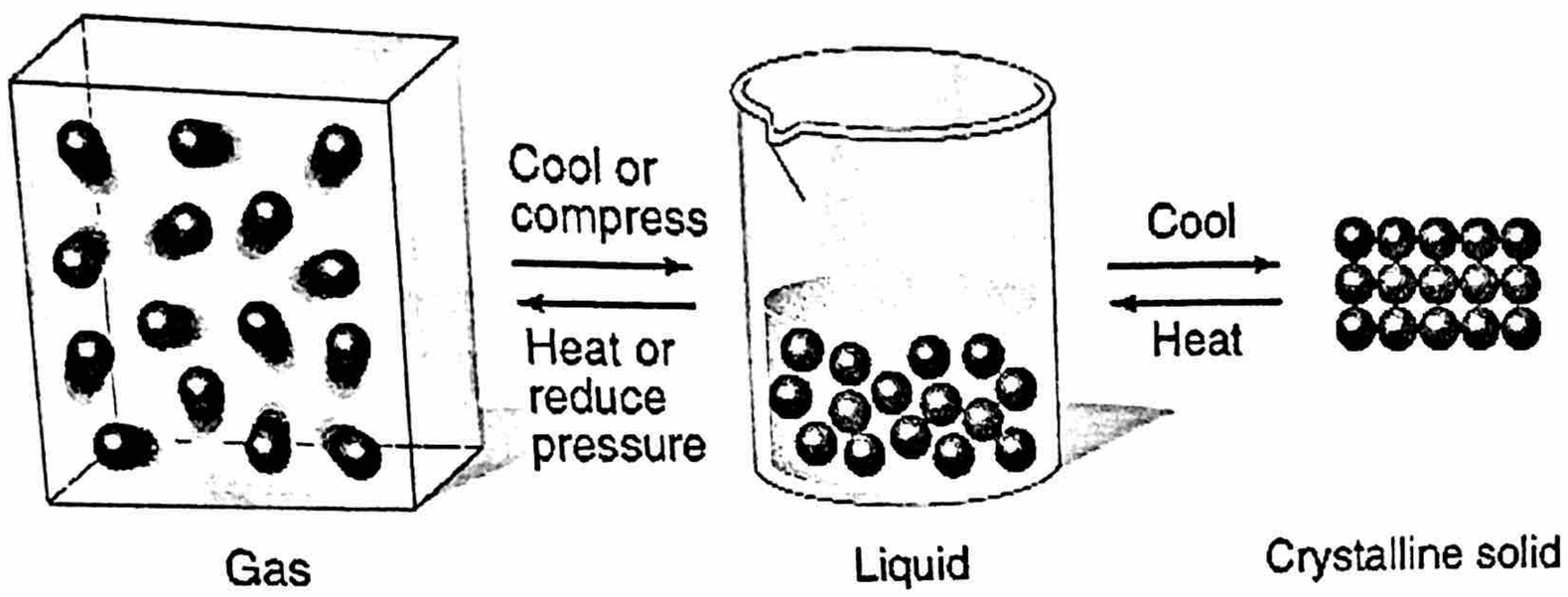
22) If I had a quantity of this substance at a pressure of 1.00 atm and a temperature of -100° C, what phase change(s) would occur if I **increased the temperature** to 600° C? At what temperature(s) would they occur? (***NOTE**: multiple answers needed for this question*)

melting, then, evaporation

22) If I had a quantity of this substance at a pressure of 2.00 atm and a temperature of -150° C, what phase change(s) would occur if I **decreased the pressure** to 0.25 atm? At what pressure(s) would they occur? (***NOTE**: multiple answers needed for this question*)

Sublimation, 0.35 atm

Model 1 Representation of Atoms in Different Phases



http://itl.chem.ufl.edu/2045_s00/lectures/lec_f.html

Key Questions

1. What are the key characteristics of atoms and molecules in gases, liquids, and solids? In Table 1 below, describe the characteristics of particles for each phase of matter based on Model 1. Be specific with regard to spacing, the potential of particles for movement, and whether or not the particles will fill the container.

Table 1. Characteristics of the Phases of Matter

	SOLID	LIQUID	GAS
SPACING	close	medium	far
POTENTIAL FOR MOVEMENT	vibration	Kinetic Sliding	fast movement
FILLING A CONTAINER	NO	NO	yes

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2. In which phase of matter is there the least spacing between particles?

Solid

3. In which phase of matter is there the most potential for movement?

solid / gas

4. Which phase of matter does not have a definite shape yet the particles will not fill the container?

liquid

5. In terms of spacing, what would be necessary to change from a solid to a liquid? What is this process called and how is this accomplished?

spread out → add heat , melting / fusion

6. In terms of spacing, what would be necessary to change a liquid to a gas? What is this process called and how is this accomplished?

spread out → add heat , evaporation

7. In terms of spacing, what would be necessary to change a liquid to a solid? What is this process called and how is this accomplished?

condense → remove heat , freezing / solidification

important

Model 2

POSTULATES OF THE KINETIC MOLECULAR THEORY

1. Gases consist of tiny particles (atoms or molecules).
2. These particles are so small, compared with the distances between them that the volume (size) of the individual particles can be assumed to be negligible (zero).
3. The particles are in constant random motion, colliding with the walls of the container. These collisions with the walls cause the pressure exerted by the gas.
4. The particles are assumed to not attract nor repel each other.
5. The average kinetic energy of the gas particles is directly proportional to the Kelvin temperature of the gas.

Key Questions

1. What causes a gas to exert pressure when confined in a container?

Collisions with walls of container

2. How does the total volume of gas particles compare to the volume of the space between the gas particles?

Space between gas particles is basically zero

3. As the temperature of a gas decreases, what change occurs in the amount of kinetic energy?

it decreases (direct relationship)

4. What property of gas particles is measured by temperature?

average kinetic energy

5. What is the relationship between temperature and molecular motion?

direct

6. In terms of the kinetic-molecular theory of gases, how can increase in the temperature of a gas confined in a rigid container cause an increase in the pressure of the gas?

the molecules speed up, meaning they will hit into the walls of the container more often, increasing the pressure

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Applications

1. There is a government warning on all aerosol cans that states: Do not store at a temperature above 120° F (50°C).

a) Explain why this warning is required in terms of the relationship between temperature and pressure and the kinetic molecular theory.

As the temperature increases the molecules more more quickly, hitting the walls of the container more often, increasing the pressure

b) What could happen if the can were to be heated above 120° F (50°C)?

It would explode

2. What would happen to a completely inflated balloon if it were taken from inside a house to the outside in the middle of January in Minnesota? Explain this prediction in terms of the Kinetic Molecular Theory.

It would decrease in volume because the particles slow down, hitting the walls of the balloon less often, making inside pressure lower than outside pressure, allowing the balloon to shrink

3. Why do the manufacturers of tires suggest that tire pressure be checked before a car has been driven any distance?

If the tire is too full, driving long distances will cause the tires to heat up, causing too much pressure on the inside, causing a blown tire

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http://www.stbedes.school.nz/wp-content/uploads/2012/02/Intermolecular_Forces_C1YvM.pdf

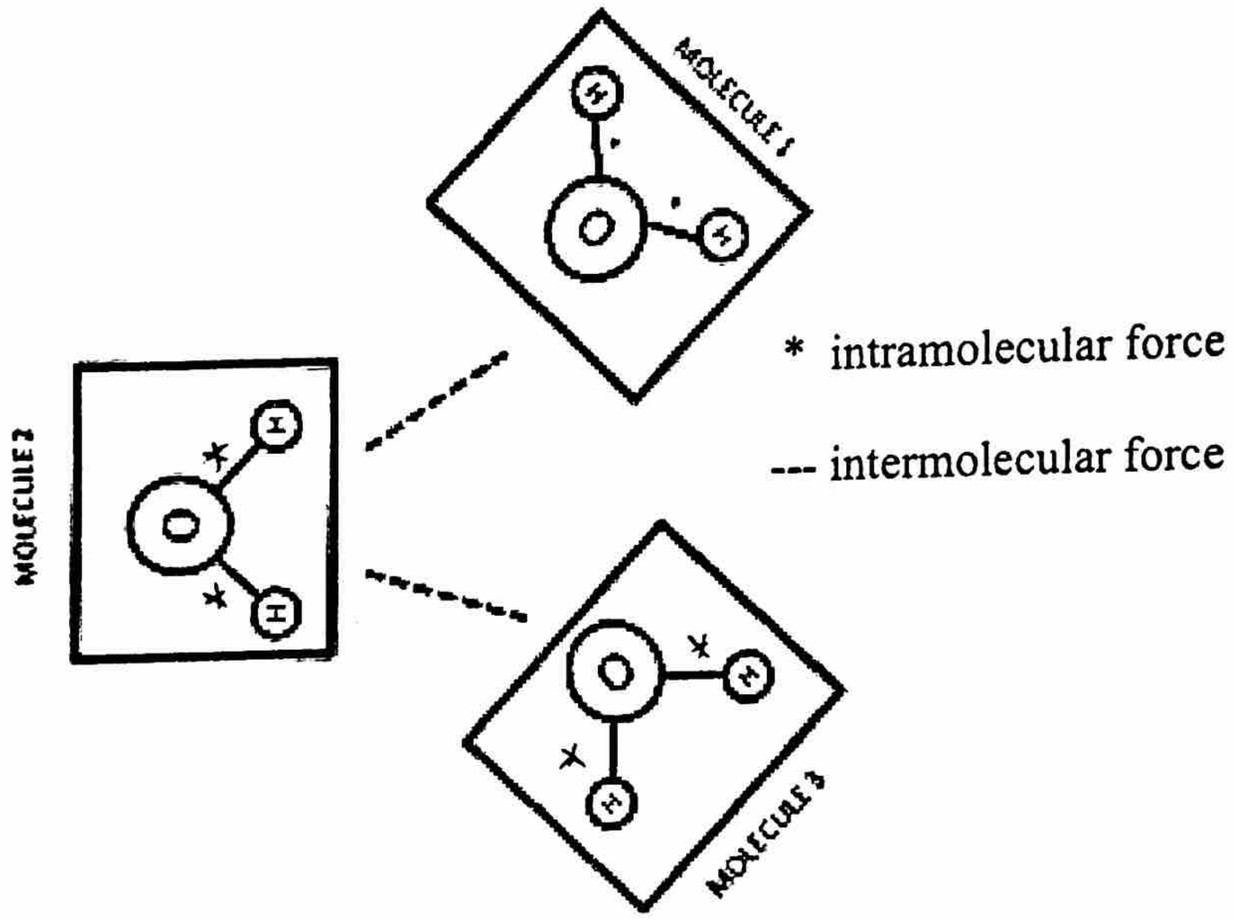
Name _____ Date _____ Block _____

POGIL: Intermolecular Forces

Model 1: What is an intermolecular force?

As you have learned, matter is made up of discrete particles called **atoms**, which chemically combine to form **molecules.** Molecules do not exist as independent units: in fact, groups of molecules "stick together" in order to form liquids and solids. The forces that hold groups of molecules together are **intermolecular forces**. Without intermolecular forces, the world as we know it would not be the same.

Figure 1: Intramolecular and Intermolecular Forces



Critical Thinking Questions:

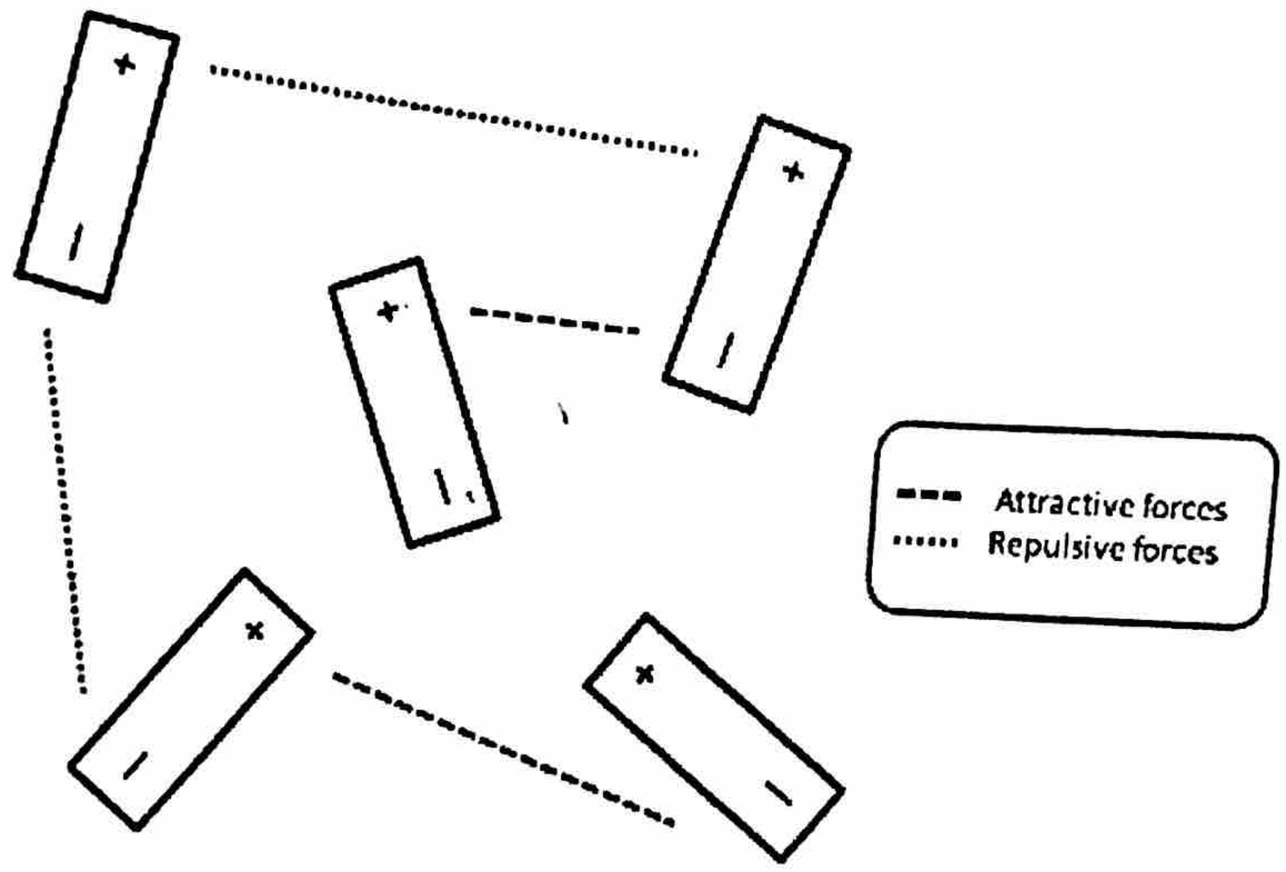
1. What specific molecule is represented inside each box in Figure 1? water
2. In relation to the box for molecule 1, where do the intramolecular forces exist in Figure 1 – inside the boxes or outside the boxes? inside
3. Based on the intramolecular forces for molecule 1, draw similar asterisks (*) for the intramolecular forces on the diagram for molecules 2 and 3.
4. In relation to the molecule, where do ~~intramolecular~~ intermolecular forces tend to occur – within the molecule or outside of the molecule? outside
5. Two intermolecular forces exist in Figure 1. Where are they positioned relative to the molecules – within the molecules or between the molecules? between
6. State the difference between intermolecular and intramolecular forces in terms of where they occur on the molecular level.

intra → within inter → between

20

Model 2: What are the three types of intermolecular forces?
There are three different types of intermolecular forces: **dipole-dipole interactions**, **hydrogen bonding** (although technically this is not a bond because it does not involve electrons being shared or transferred), and **dispersion forces.**

Figure 2: Dipole-Dipole Interactions



Critical Thinking Questions:

7. Figure 2 represents an arrangement of five molecules. What is the difference between the two ends of each molecule?

   + , −

8. Molecules with the property you identified in #7 are known as ***dipoles***. Consult with your group and reach a consensus on what you think a dipole is. Write down this definition.

   A dipole is a difference in charged ends of the molecule

9. Consider the attractive forces shown in Figure 2. In terms of the positive and negative ends of the dipoles, where do attractive forces occur?

   between molecules + and − ends

10. Consider the repulsive forces shown in Figure 2. In terms of the positive and negative ends of the dipoles, where do repulsive forces occur?

    between molecules − and − or + and +

11. The forces described in #9 and #10 are called **dipole-dipole interactions**. How might dipole-dipole interactions help many molecules attract each other?

    like a magnet, + + − attraction

Read This!

A dipole is most often found in *polar* molecules, in which the electrons are unevenly shared. This uneven sharing gives one side of the molecule a partially positive charge (δ+) and the other side a partially negative charge (δ–).

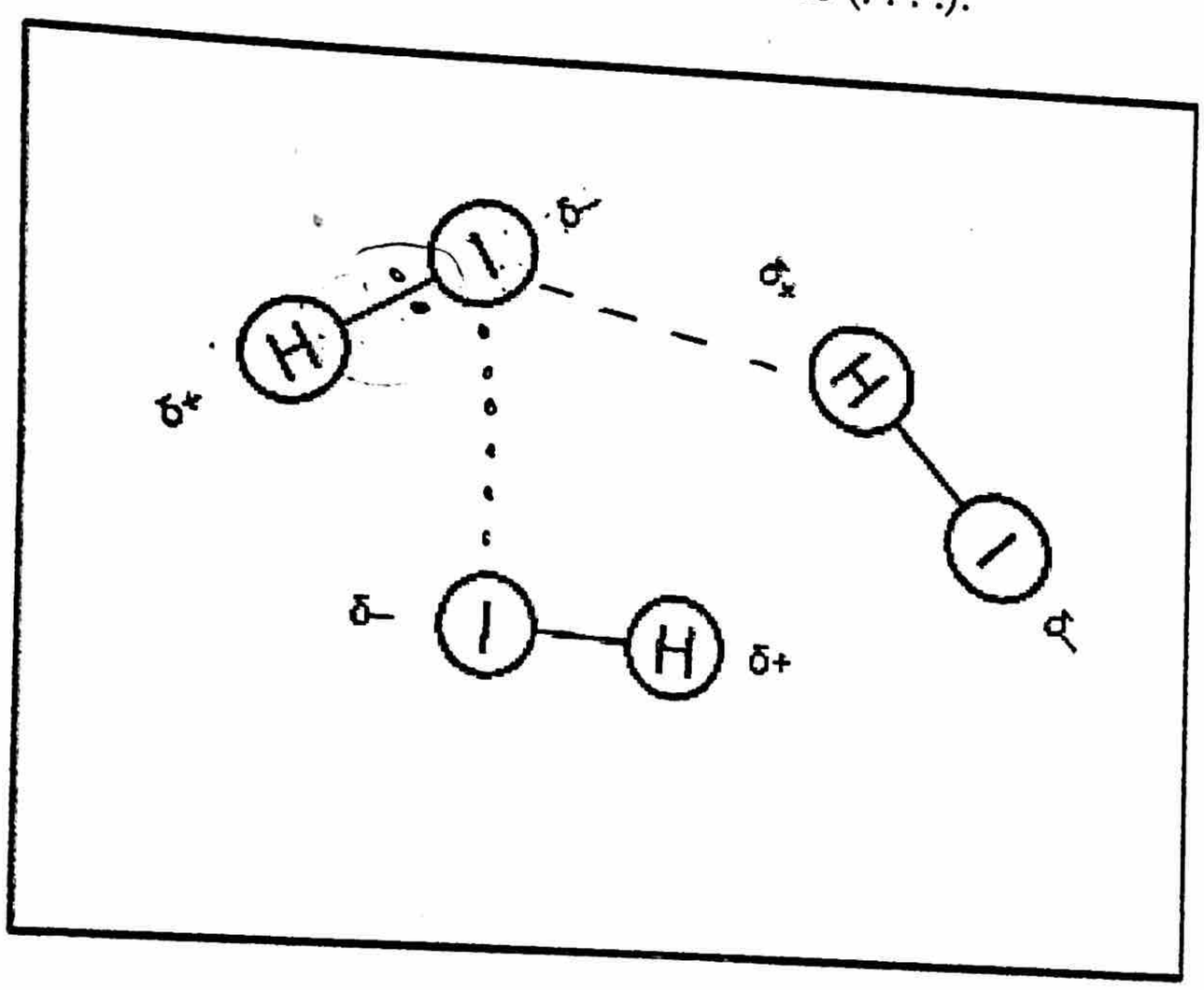
12. What causes the dipole in polar molecules?

uneven sharing of electrons

13. What symbols are used to represent the partial charges at the ends of polar molecules?

δ – δ +

14. In the diagram below, a hydrogen iodide molecule has been drawn with its partial positive and partial negative charges. Using the three molecules in the box, draw an attractive force between two HI molecules using a dashed line (- - -) and a repulsive force between two HI molecules using a dotted line (. . . .).



15. Nonpolar molecules do not form dipoles, because electrons are shared evenly. Would you expect nonpolar molecules to "stick together" more or less effectively than polar molecules?

less

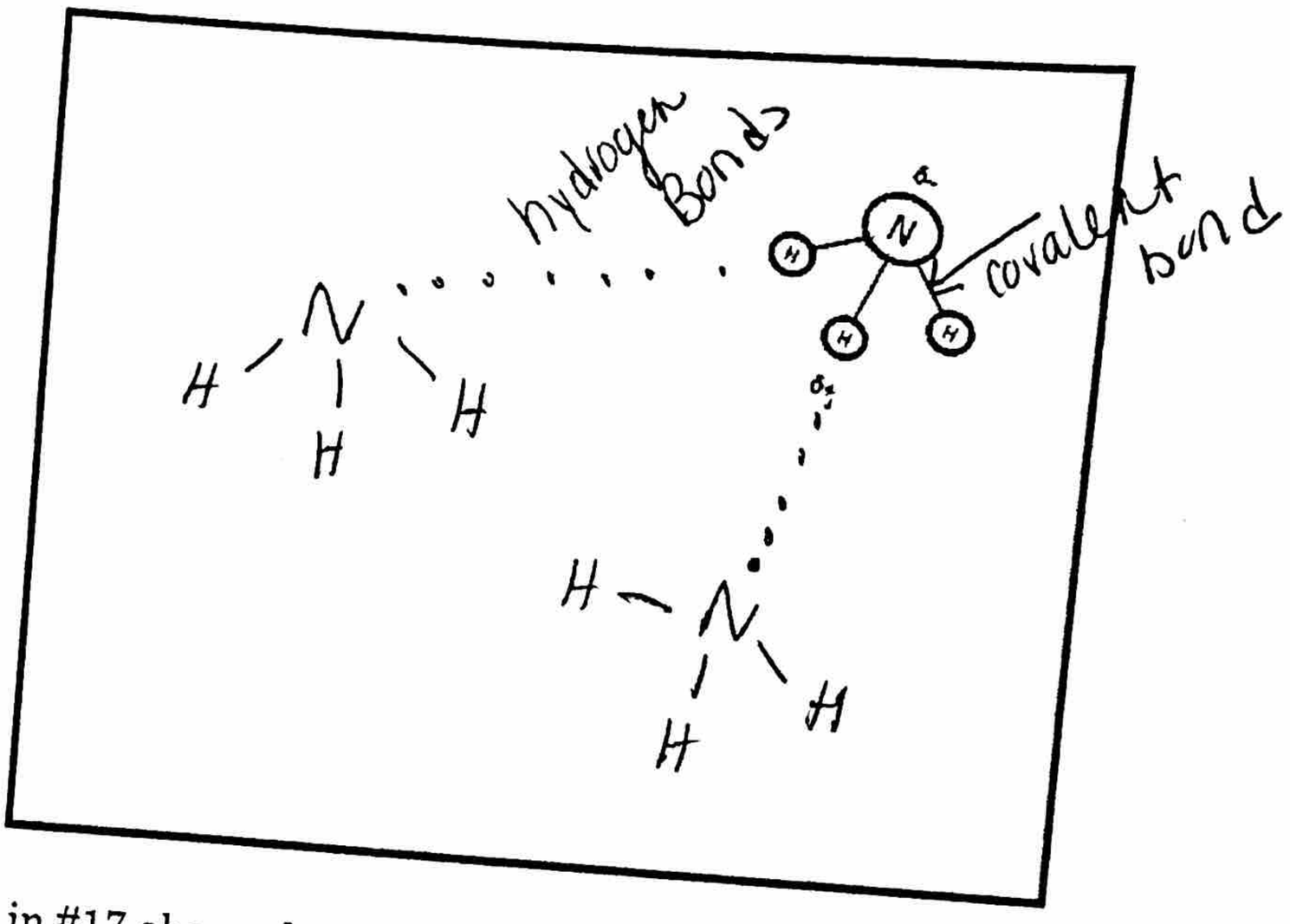
16. Explain your answer to #15 in terms of dipole-dipole interactions.

if there are not strong "magnets" they will not be very attracted to each other

Read This!

When a hydrogen atom is covalently bonded to nitrogen, oxygen, or fluorine, a very strong dipole is formed. The dipole-dipole interactions that result from these dipoles are known as **hydrogen bonding**. Hydrogen bonding is an especially strong form of dipole-dipole interaction.

17. Below is a diagram of ammonia. Draw two more ammonia molecules in the box, indicating the partial positive and partial negative ends for each molecule.



18. In the diagram in #17 above, draw the attractive forces between the ammonia molecules with a dotted line (. . .). Label these forces **hydrogen bonds**.

19. Indicate and label one covalent bond in the diagram in #17.

20. Is a hydrogen bond the same as a covalent bond?

No

21. With your group, explain your answer to #20, including:

a. How a covalent bond is formed.

Sharing of elections

b. How a hydrogen bond is formed.

attraction between δ- + δ+ of molecules

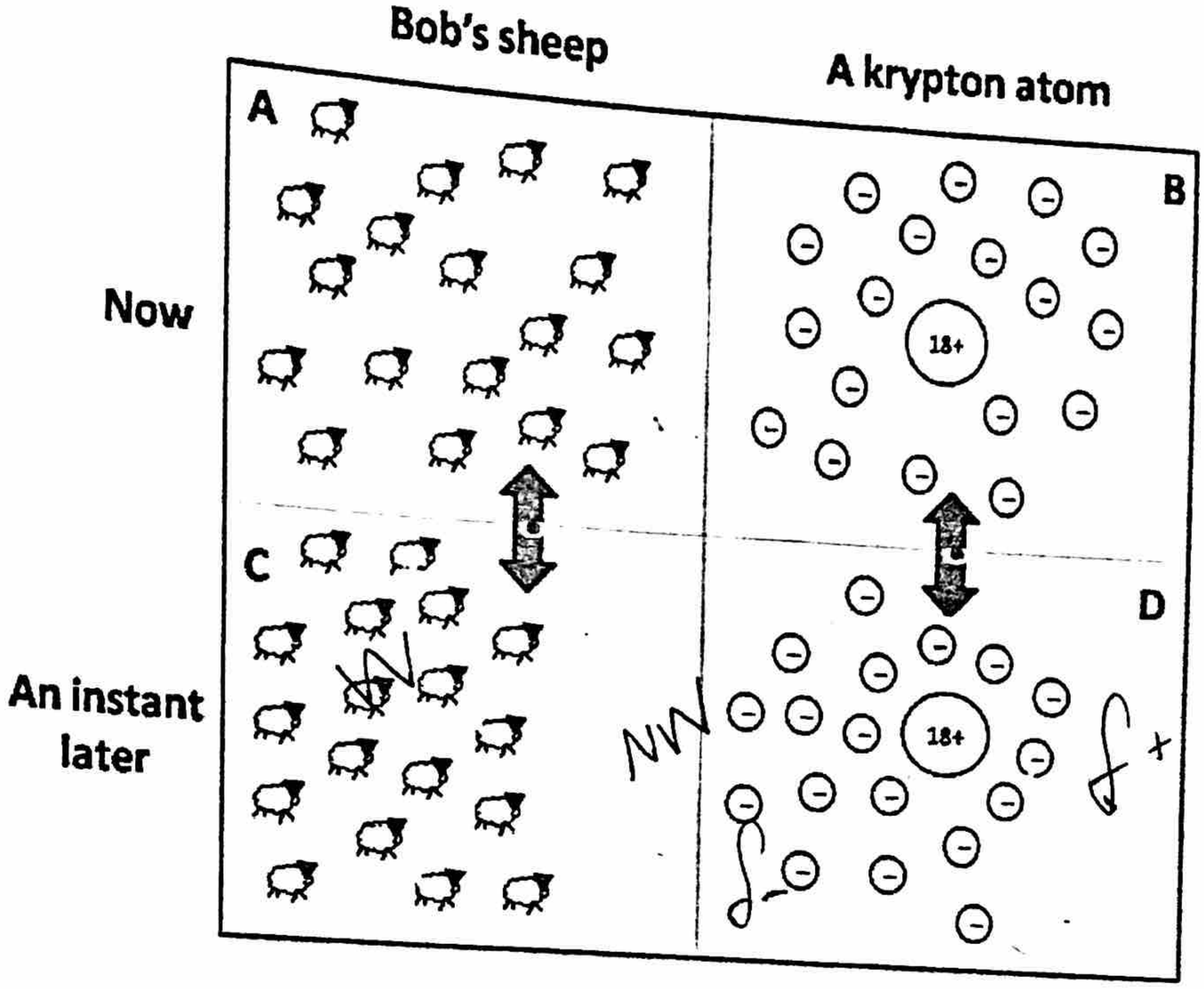
c. How covalent bonds and hydrogen bonds are similar.

between non-metals

d. How covalent bonds and hydrogen bonds are different.

within ↓ ↘ between

Figure 3: Dispersion Forces



22. Bob's sheep like to wander around the pasture. They could be found anywhere at any moment. How are Bob's sheep distributed in box A?

evenly

23. How are Bob's sheep distributed in box C? Are the woolly sheep evenly spread in the pasture?

unevenly

24. Looking at the sheep in box C, identify a "woolly" area and a "non-woolly" area. Lable the woolly area **W** and the non-woolly area **NW**.

25. Now let's look at the krypton atoms in boxes B and D. Electrons, like sheep, like to wander around the atom.

    a. How many protons are in the atom in each box? 18

    b. How many electrons are in the atom in each box? 18

26. Is each atom electrically neutral? Explain.

yes, $p^+ = e^-$

24

27. In box B, are the electrons evenly distributed around the nucleus? Explain.

yes

28. In box D, are the electrons evenly distributed around the nucleus? Explain.

No

29. In box D, indicate any area that is crowded with electrons with a "δ–", and any area where the nucleus is exposed with a "δ+".

30. Even though the krypton atom in #29 is electrically neutral, why could it be said to have a **"momentary" dipole**?

yes

31. Based on your answer to #30, what do you think helps neutral atoms and nonpolar molecules attract to each other?

momentary dipoles
→ constant movement of electrons

Read This!

Even though atoms by themselves are electrically neutral, a momentary imbalance of electrons can create a **momentary dipole.** The dipole-dipole interactions among these momentary dipoles are known as **dispersion forces**. These forces, also known as **van der Waals forces**, help neutral atoms and nonpolar molecules attract each other.

32. What causes a dispersion force to occur between two atoms or nonpolar molecules?

movements of electrons

33. How are dispersion forces similar to dipole-dipole interactions?

attraction between δ- + δ+

34. How are dispersion forces different to dipole-dipole interactions?

↓ nonpolar

↘ polar

25

Extension Questions – YES, you must answer these challenge questions as well! ☺

35. What is the difference between the formation of an ion and the formation of a momentary dipole?

Ion → transfer of electron

MD → movement of elections

36. The difference of electronegativity between hydrogen and bromine is 0.7, and the difference in electronegativity between hydrogen and chlorine is 0.9.
    a. Which would exhibit stronger dipole-dipole interactions, HBr or HCl?

HCl

    b. Justify your answer.

larger $\delta-$ + $\delta+$

37. Neon has 10 electrons, and krypton has 18 electrons.
    a. Which element do you think has a greater chance of forming a momentary dipole?

Krypton

    b. Explain your answer to part (a).

more elections to move

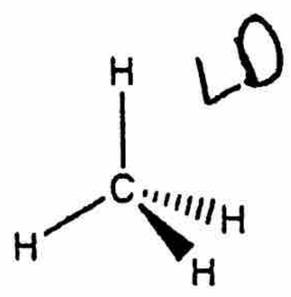
    c. Which element do you think exhibits greater dispersion forces?

Krypton

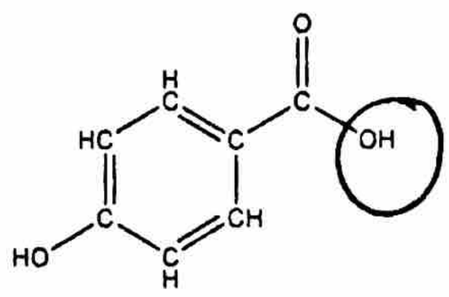
    d. Explain your answer to part (c).

more eletrons

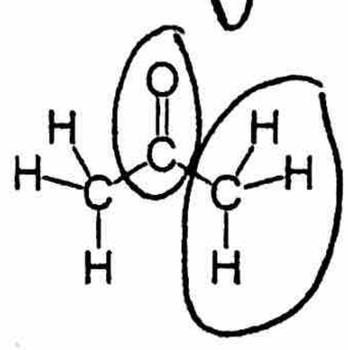
38. Which intermolecular forces can be found in the following molecules?



LD



Hydrogen



D-D

LD

26

Intermolecular Forces Worksheet

For each of the following compounds, determine the main intermolecular force. You may find it useful to draw Lewis structures for some of these molecules:

1) nitrogen gas London Dispersion

2) carbon tetrachloride London Dispersion

3) H_2S Dipole - Dipole

4) sulfur monoxide Dipole - Dipole

5) N_2H_2 Hydrogen Bonding

6) boron trihydride London- Dispersion

7) CH_4O hydrogen bonding

8) SiH_2O Dipole - Dipole

9) Explain why ethyl alcohol (C_2H_5OH) has a higher boiling point (78.4° C) than methyl alcohol (CH_3OH; 64.7° C).

Both have hydrogen bonding, so the one with the higher mass will have the higher boiling point.

10) Rank the following by from lowest to highest anticipated boiling point: C_2H_4, CH_4, Ne, H_3COCH_3.

London Dispersion

CH_4 , London dispersion , Ne , London dispersion C_2H_4 , Dipole-Dipole H_3COCH_3

11) Motor oil largely consists of molecules that consist of long chains of carbon atoms with hydrogen atoms attached to them. Using your knowledge of intermolecular forces, why wouldn't it be better to use a compound like glycerol. The formula of glycerol is $CHOH(CH_2OH)_2$.

Since glycerol has ~~more~~ Hydrogen bonds, the attractive forces are greater, making it more difficult for the oil to be converted to gas form.