Chemistry 1010

Solids, Liquids, and Gases



Introduction

What is dry ice? solid carbon dioxide (CO_2)

How cold is dry ice? -78.5° C, -109.8° F

What happens when you put dry ice in water?

solid turns to a gas – called sublimation

What do you see coming out?

not carbon dioxide – it is an invisible gas!
water vapor which has condensed to fog

What would you feel if you put your hand on it?

pressure of CO_2 building up

What would it taste like?

carbonated water (soda with no flavor)

In this lecture, we will talk about the three common states of matter – solids, liquids, and gases.

1. **How do the states of matter behave?**

2. **What happens when matter changes state?**

3. **At what temperatures do changes of state happen?**

1. How do the states of matter behave?

solid

liquid

gas

Do they change shape?

solid – no
liquid – yes
gas – yes

Do they change volume?

solid – no
liquid – no
gas – yes

solid remains the same shape and size no matter what container it is in

liquid flows to take the shape of the container, but doesn't expand, can't be compressed

gas expands to take the shape and volume of the container; can be compressed

To understand what these three states would look like at an atomic level, we will compare them to:

a pile of tangerines

a bucket of snakes

a jar of fireflies

Which of these seems most like a solid?

Which is most like a liquid?

Which is most like a gas?

How do fireflies behave like a gas?

they spread out to fill the container

How fast are they moving? pretty fast

How much space is between them? pretty far apart

Are they organized? no, moving randomly

How does a pile of tangerines act like a solid?

it doesn't change size or shape

How fast are they moving? not moving at all

How much space is between them? quite close together

Are they organized? they are arranged in rows

How is a liquid like a bucket of snakes?

they spread out to take the shape of the container, but don't expand

How fast are they moving? moving, but not as fast as in a gas

How much space is between them? more space than in a solid, but not as much as in a gas

Are they organized? there isn't much order

What evidence is there that the molecules in a liquid and a gas are moving?

look at how quickly they to mix together

different colors of sand

very slowly if at all

a drop of food coloring in a glass of water

a few minutes

the odor of cinnamon in air

a few seconds

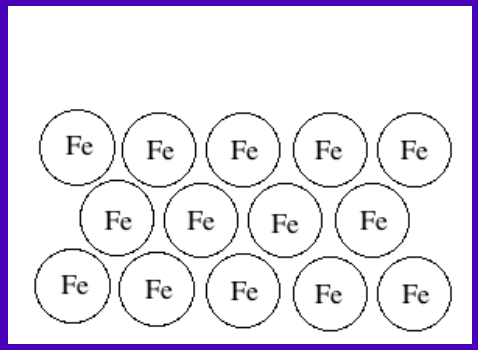
How would hot water compare to cold water?

hot water would mix faster than cold water

What would this look like with actual atoms?

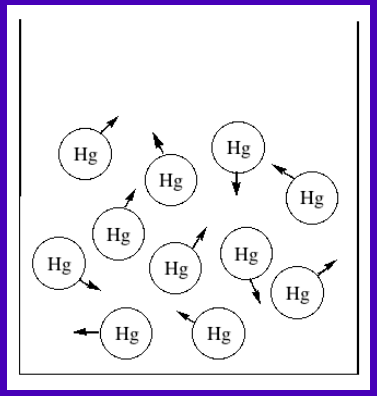
iron (Fe)

solid



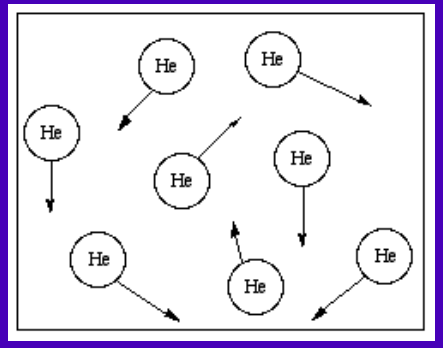
mercury (Hg)

liquid



helium (He)

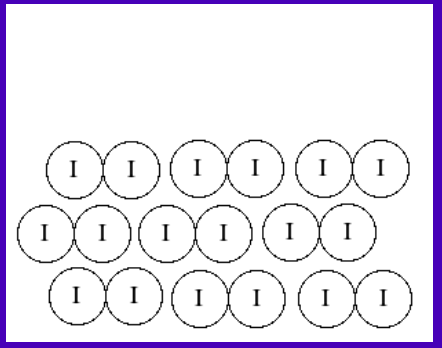
gas



What would it look like with diatomic molecules?

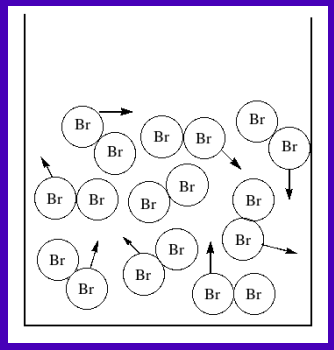
iodine (I_2)

solid



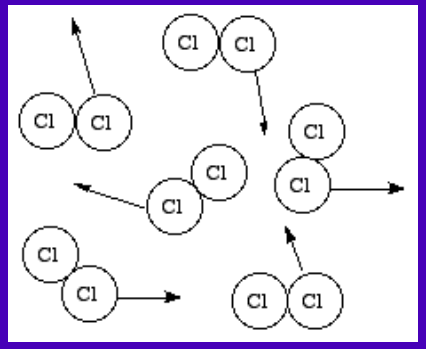
bromine (Br_2)

liquid



chlorine (I_2)

gas



2. What happens when matter changes state?

What can happen to the state of matter of a substance if the temperature changes?

it can change from one state to another
the molecules change speed, spacing, organization

What are the following changes called?

solid to liquid:

melting

liquid to gas:

evaporating
boiling

solid to gas:

subliming

liquid to solid:

freezing

gas to liquid:

condensing

gas to solid:

depositing

Knowing what the molecules in a solid, liquid, and gas are doing, we can predict what changes need to occur in order for a substance to change states.

snakes asleep in rows

snakes flying around

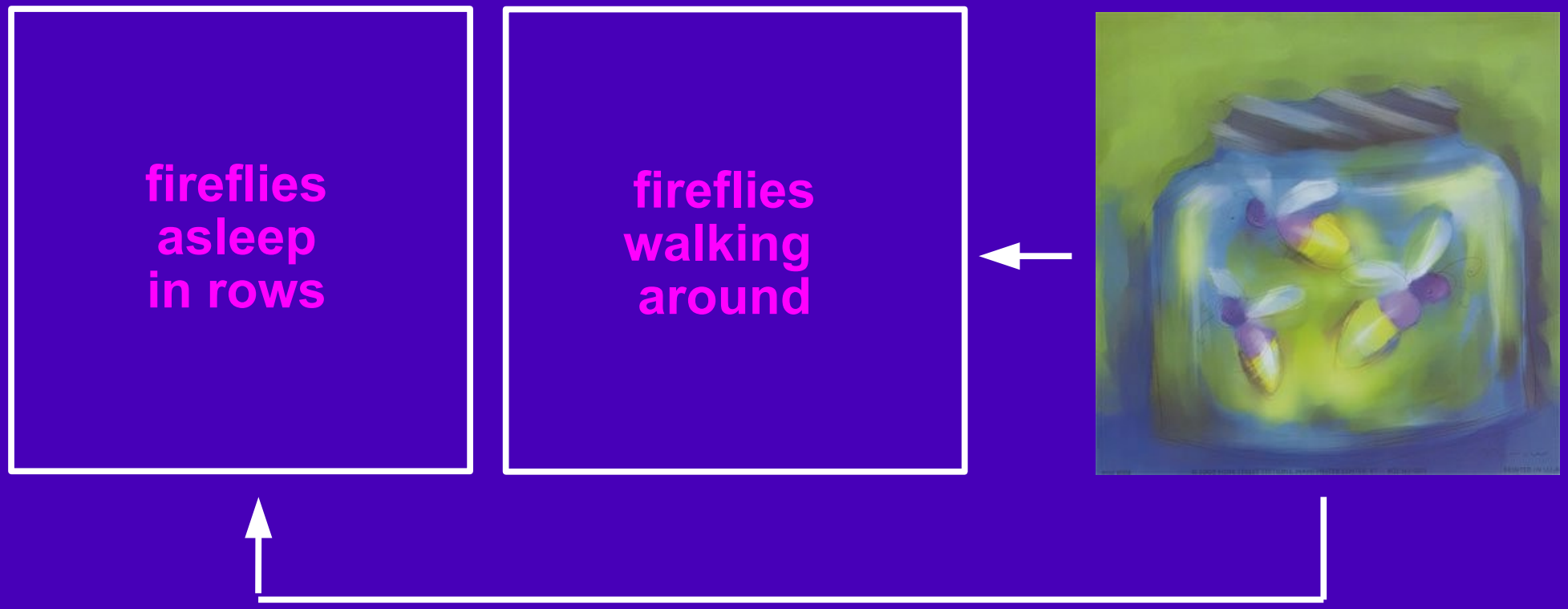
solid liquid gas

Freezing: What must happen for the snakes to change to a solid?

they would have to stop moving and line up

Boiling: What must happen for the snakes to change to a gas?

they would have to fly up into the air



Condensation: What must happen for the fireflies to change to a liquid?

they would have to land but keep moving

Deposition: What must happen for the fireflies to change to a solid?

they would have to land, hold still, and line up

tangerines rolling around

tangerines flying everywhere

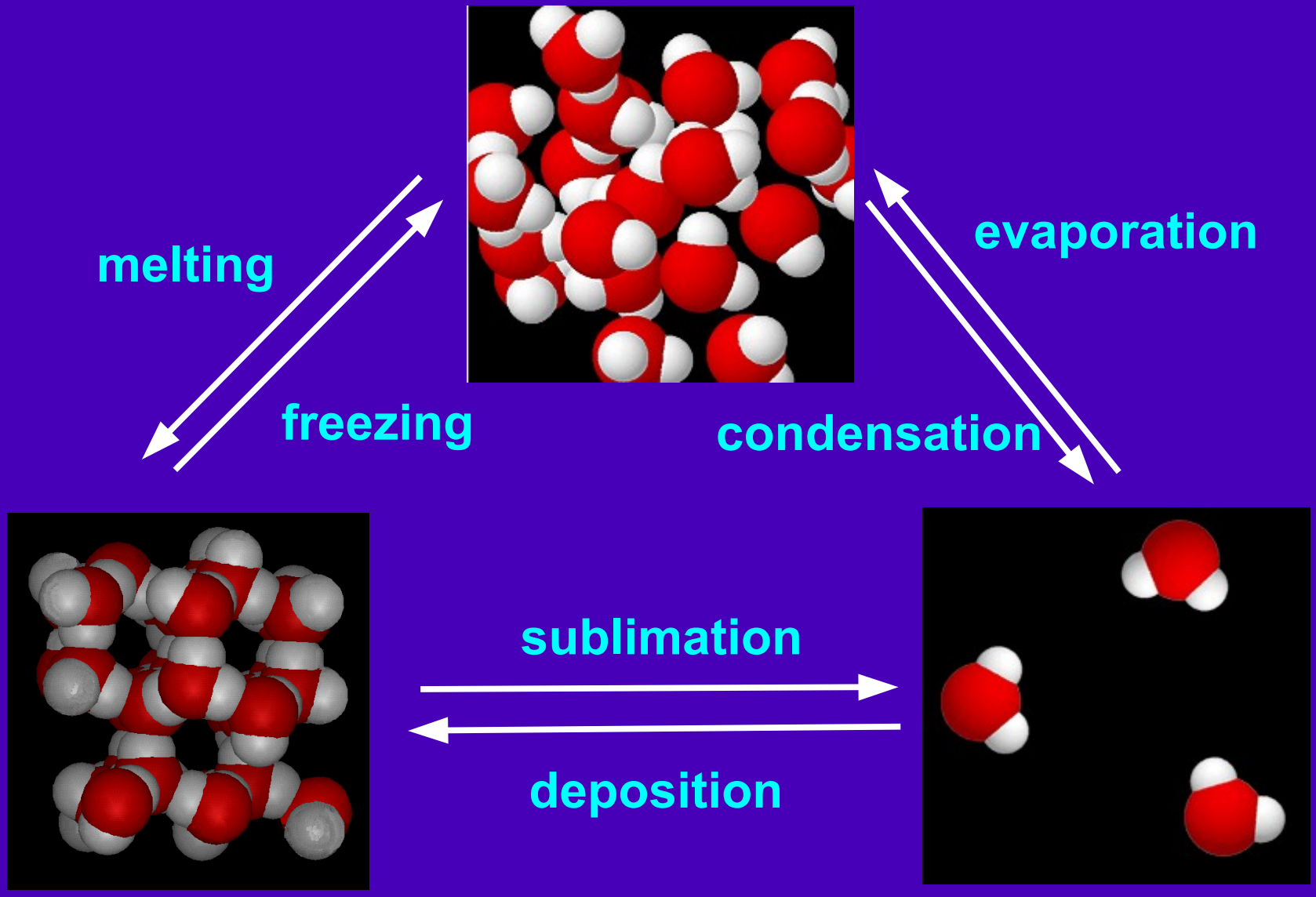
Melting: What must happen for the tangerines to change to a liquid?

they would have to break the pattern and start rolling around

Sublimation: What must happen for the tangerines to change to a gas?

they would have to break the pattern and start flying around

Label the changes of state that are occurring at each arrow.



What change of state is occurring in each of the following?

dew: condensation

frost: deposition

puddle: evaporation

clouds: condensation (or deposition)

snowflakes: deposition

hail: freezing

fog: condensation

ice fog: deposition

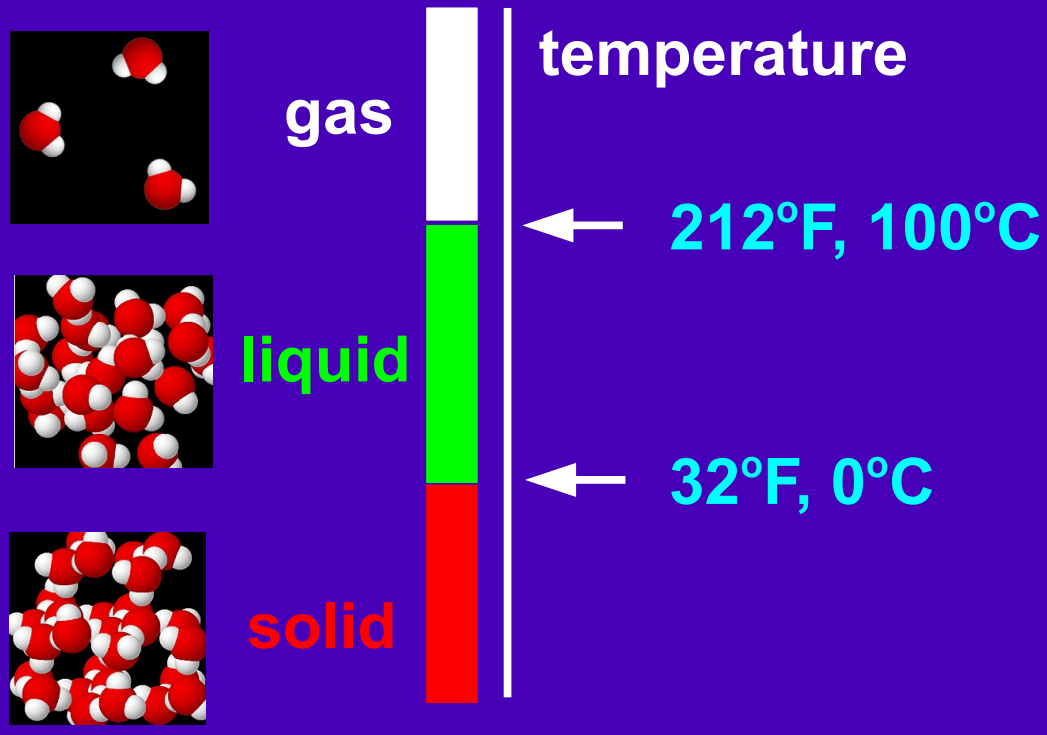
sleet: freezing

freezing rain: freezing

3. At what temperatures do changes of state happen?

Different substances have different temperatures at which these changes occur.

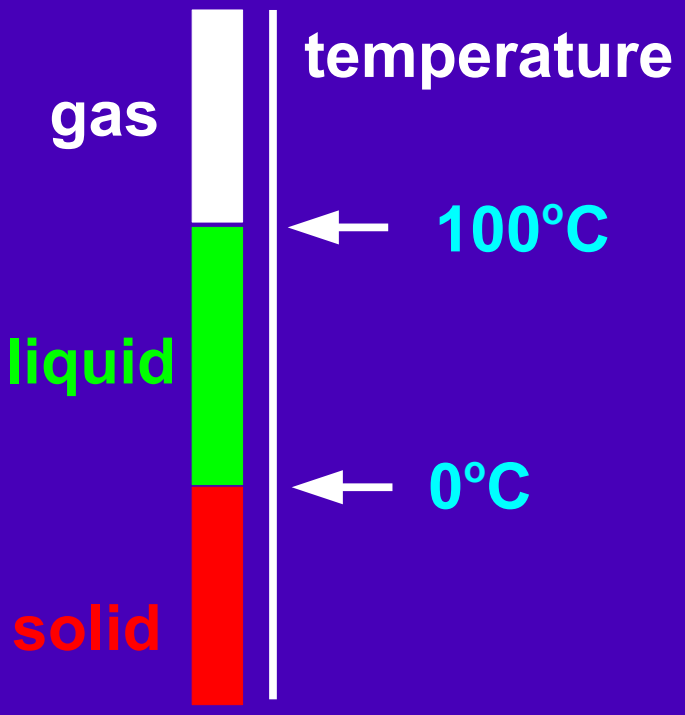
water:



The temperature where a substance changes from a solid to a liquid (or a liquid to a solid): melting point

The temperature where a substance changes from a liquid to a gas (or a gas to a liquid): boiling point

What state of matter be at in the following situations?



in a fire 900°C gas

in the oven 180°C gas

outside on a hot day 43°C liquid

room temperature 25°C liquid

the refrigerator 2°C liquid

the freezer -17°C solid

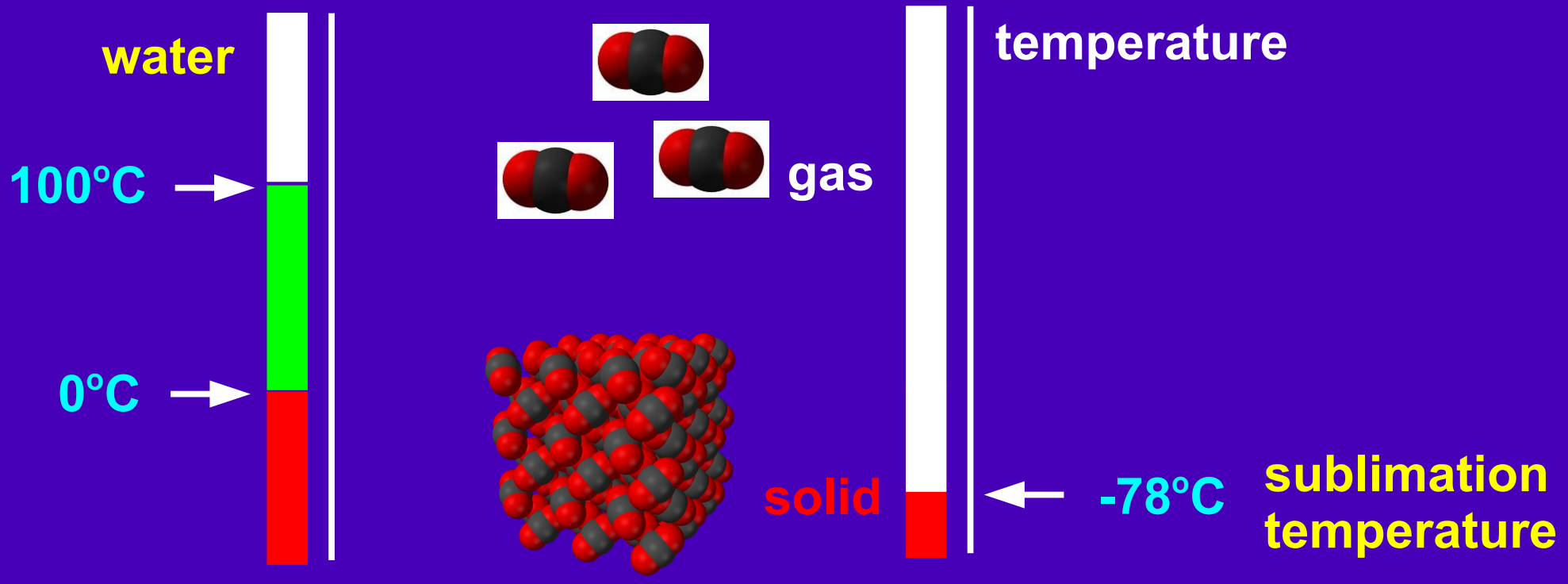
In general, what state of matter will a substance be in:

below the melting point: it will be a solid

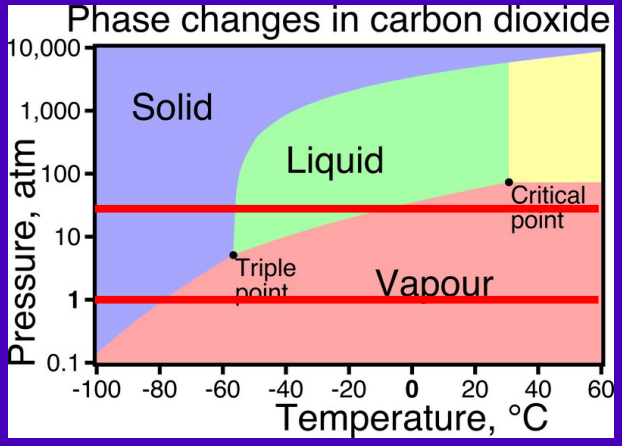
above the melting point but below the boiling point: it will be a liquid

above the boiling point: it will be a gas

What about carbon dioxide?



So, can carbon dioxide never be a liquid?



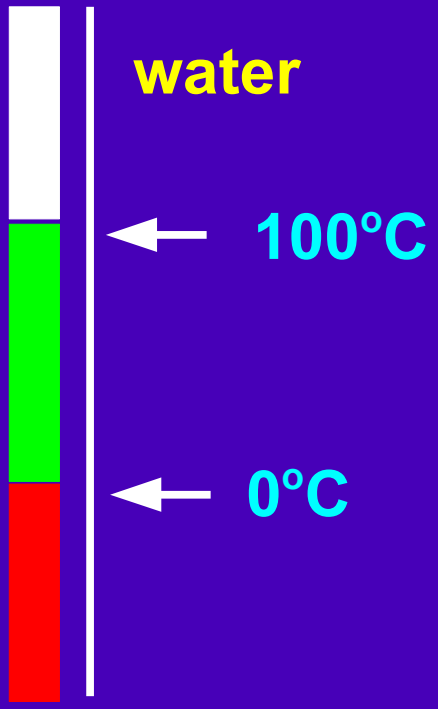
it can at increased pressure!

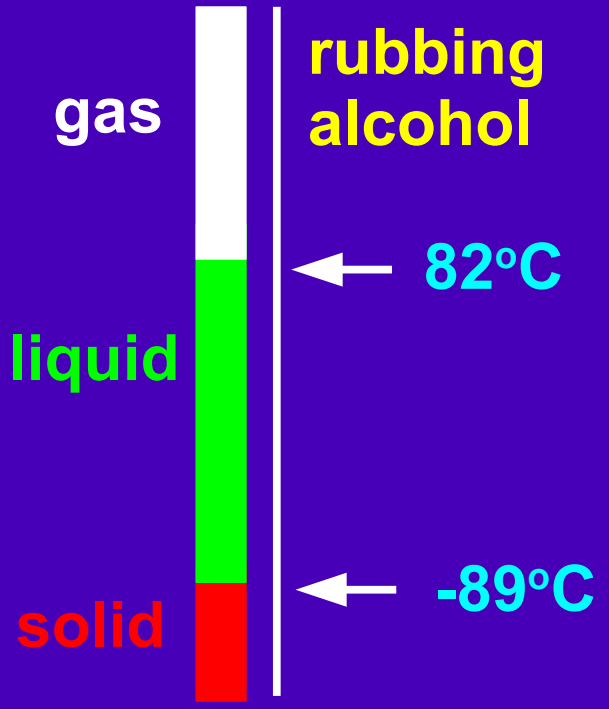
What are some other examples?

rubbing alcohol

melting point: -89°C

boiling point: 82°C





the freezer -17°C liquid

the refrigerator 2°C liquid

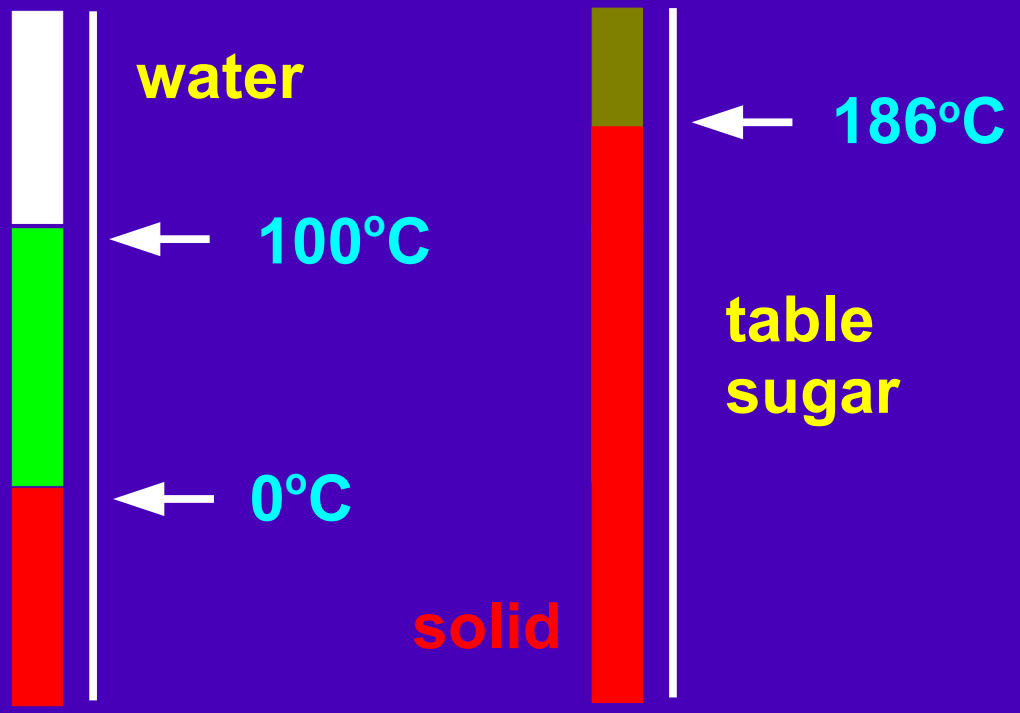
room temperature 25°C liquid

outside on a hot day 43°C liquid

in the oven 180°C gas

in a fire 900°C gas

table sugar



melting point: 186°C (decomposes)

boiling point: none

the freezer -17°C solid

the refrigerator 2°C solid

room temperature 25°C solid

outside on a hot day 43°C solid

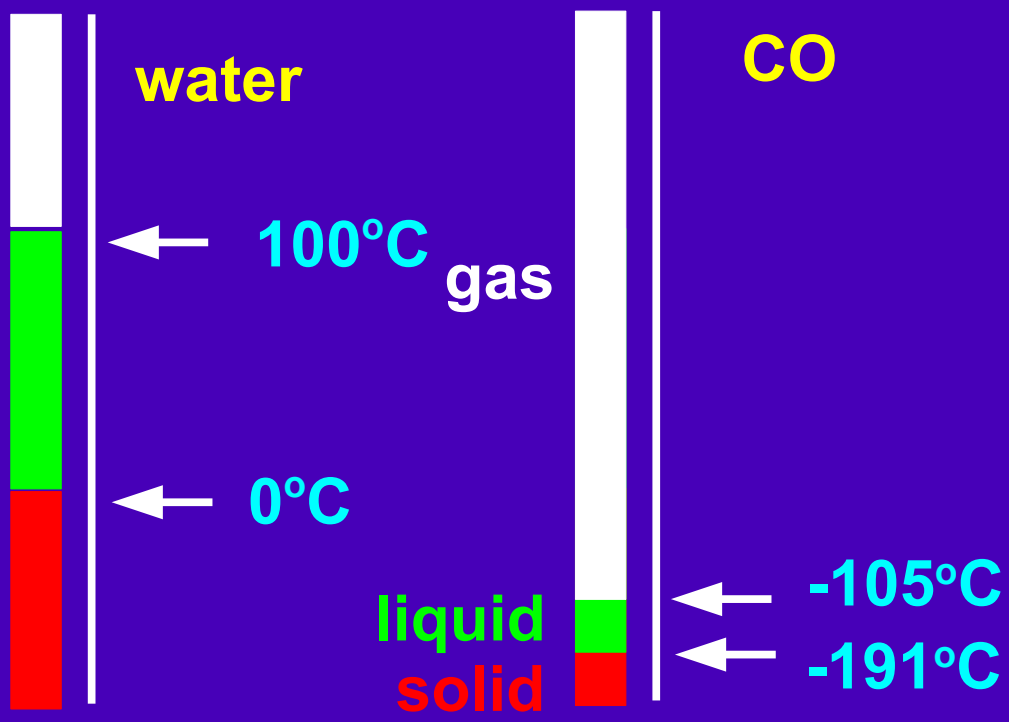
in the oven 180°C decomp (this is how things brown in the oven)

in a fire 900°C decomp

carbon monoxide

melting point: -105°C

boiling point: -191°C



the freezer -17°C gas

the refrigerator 2°C gas

room temperature 25°C gas

outside on a hot day 43°C gas

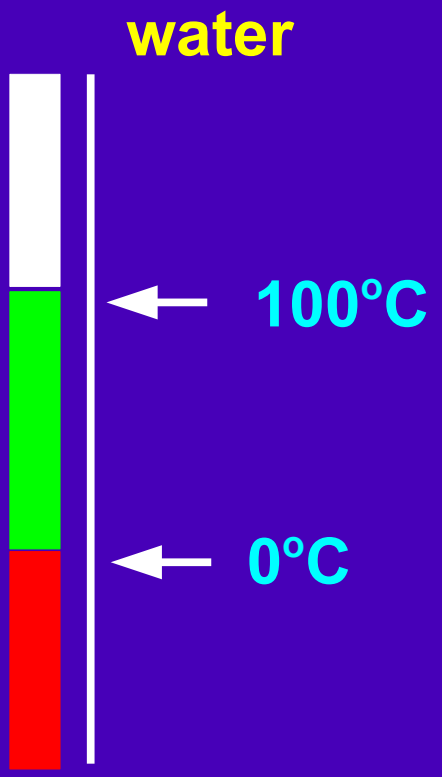
in the oven 180°C gas

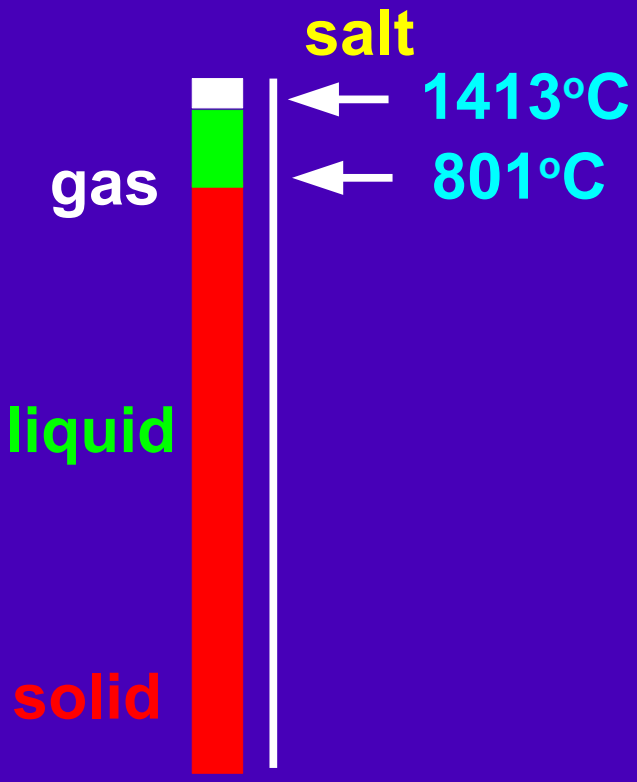
in a fire 900°C gas

table salt

melting point: 801°C

boiling point: 1413°C





the freezer -17°C	solid
the refrigerator 2°C	solid
room temperature 25°C	solid
outside on a hot day 43°C	solid
in the oven 180°C	solid
in a fire 900°C	liquid

Why are the melting and boiling points higher for some substances than for others?

1) size – some atoms and molecules are bigger than others

Will a large molecule have a higher or lower melting point than a small molecule?

less energy to get them moving

more energy to get them moving

lower melting point

higher melting point

Will a large molecule have a higher or lower boiling point than a small molecule?

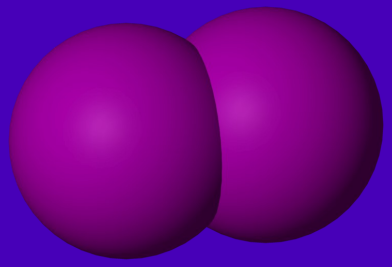
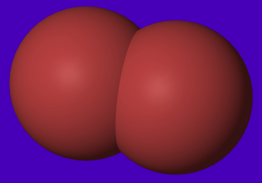
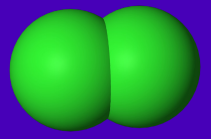
more energy to get it in the air

less energy to get it in the air

higher boiling point

lower boiling point

Use this to explain the states of matter of the following at room temperature:

iodine I_2	bromine Br_2	chlorine I_2
		
solid	**liquid**	**gas**
		

size of molecules: iodine > bromine > chlorine

the larger the molecule, the more energy it takes to melt or boil it

Which will have the higher melting point?

table sugar
$C_6H_{12}O_6$

186°C

largest molecule

rubbing alcohol
C_3H_8O

-89°C

carbon monoxide
CO

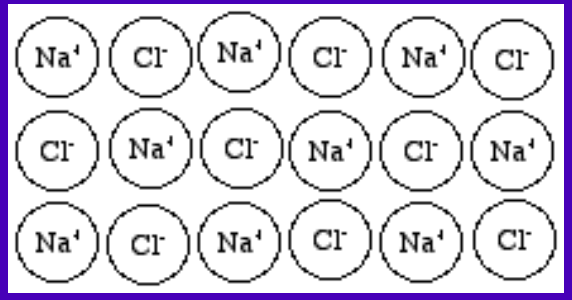
-105°C

smallest molecule

2) attraction between molecules – some particles are attracted to each other more strongly than others

Will a substance with stronger attractive forces have a higher or lower melting point than a substance with weak attractive forces?

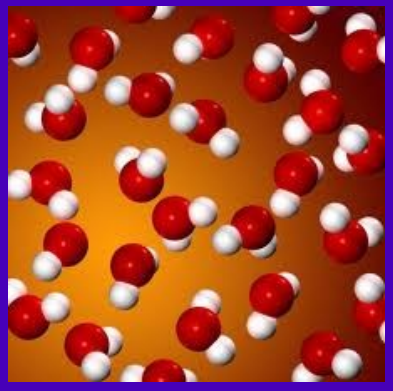
salt



very strong attractive forces

melting point 1413°C

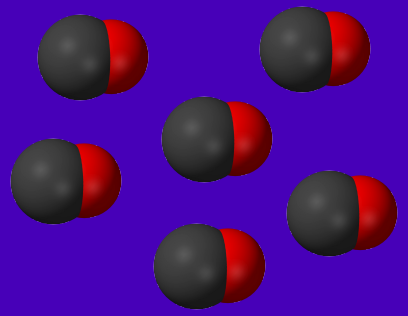
water



medium strength attractive forces

melting point 0°C

carbon monoxide



very weak attractive forces

melting point -105°C