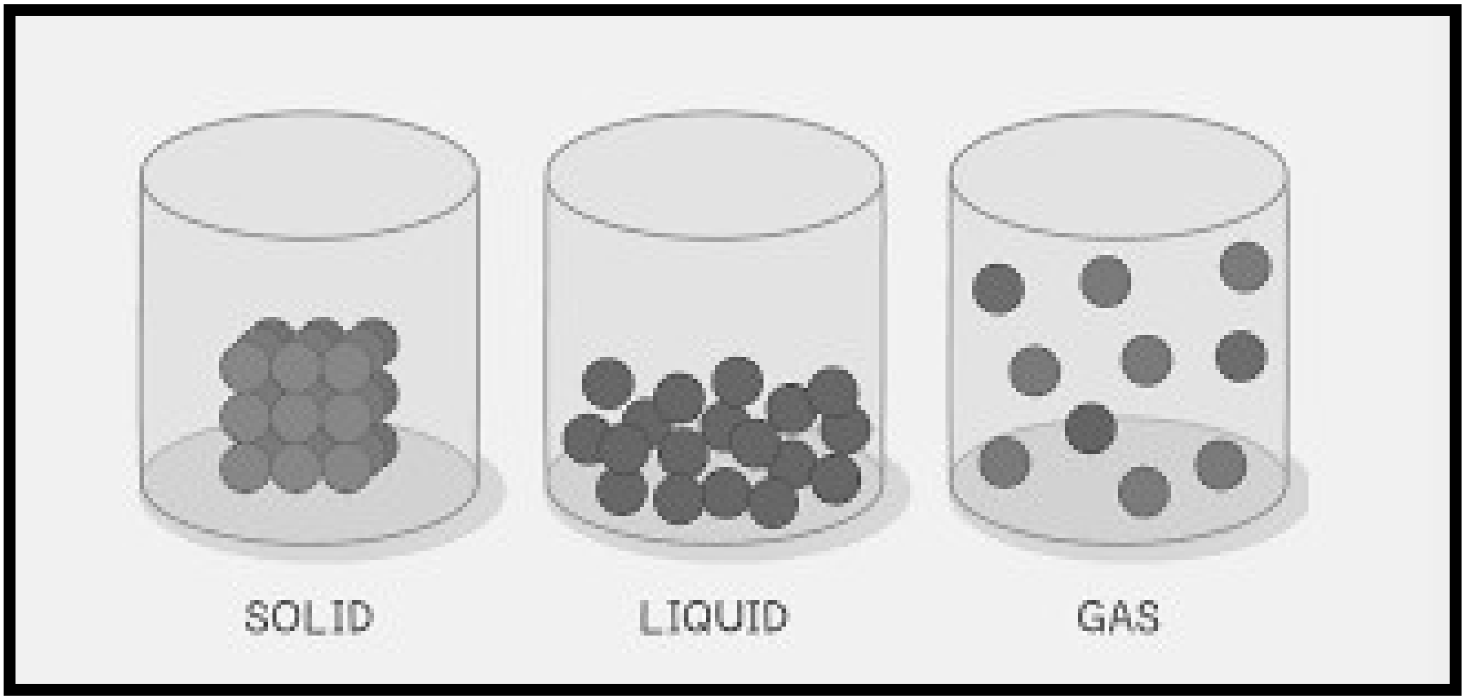
PHASES CHEMISTRY



Read the BASICS.

Make sure you fill in the back cover as soon as you can.

You need to understand the KMT but
you do not have to memorize it.

You should be able to explain each point to your parents.
Make sure you can do that, like for real, okay?

☺

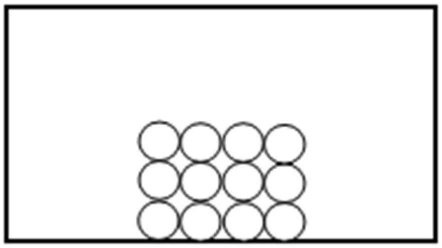
Solids

Particles of solids are strongly attracted to each other by what are called INTERMOLECULAR FORCES of ATTRACTION, or just intermolecular forces (IMF). Other than some vibrations there is almost no movement of solid particles. Solids have an organized, rigid or lattice arrangement. Solids hold their shape and hold their volume. Solids do not take the shape of the containers you put them into. Solids cannot be compressed very much because the particles are already packed very close together. Because of this, most solids have the highest density of all 3 phases. When energy or heat is added, the particles will vibrate more, which often makes solids only slightly expand but remain solid. Particles in the solid phase have the lowest potential energy and usually the lowest kinetic energy as well.

Add sufficient energy and they will vibrate so much that they break apart and turn into liquids. This is a particle diagram of a solid in a rectangle container. The solid particles are the little circles, which are arranged in an orderly, repetitive way. They hold their shape in the container, they do not conform to the bottom of the container, as a liquid would.

This particle diagram shows the particles STUCK TOGETHER by the intermolecular forces.

In solids, these forces are strong enough to hold the particles STUCK because the particles have such low kinetic energy. (kinetic energy is the energy of MOTION).



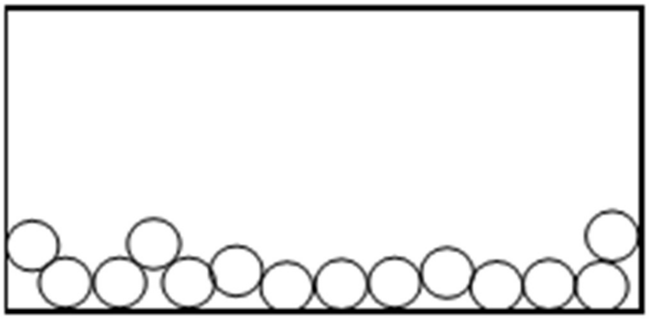
Liquids

Liquid particles are attracted to each other, but because they have MORE KINETIC ENERGY, they can shake free of being stuck but are still STICKY TOGETHER. The intermolecular forces of attraction can't lock these particles tight into a solid, but it can keep them touching as they flow over each other.

Liquid particles flow over themselves. The particles are in constant random motion. Liquids do not have a definite shape which means they take the shape of the bottom of any container you put them in. If you spill liquids, the force of gravity spreads them out. The hotter liquids get when you add energy, the faster the particles move. Liquids expand only slightly when heated. Liquids are rather dense, but usually not as dense as solids. Heat a liquid enough and the particles move so fast that they explode apart turning into gases.

This shows a particle diagram of a liquid in a rectangle container. The particles are little circles. They are arranged in a disorderly pattern. They touch each other, they take the shape of the bottom of the container. (like water in the bottom of a beaker or cup).

The disordered arrangement indicates they are not solid. This shows these particles as "sticky, but not stuck" together by the intermolecular forces. In liquids, these forces are strong enough to keep the particles touching but NOT STUCK. The particles have enough kinetic energy to keep them moving, but not enough to allow for easy vaporization.



Gases

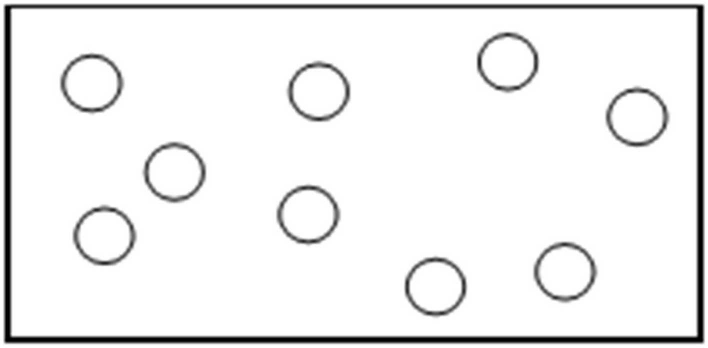
Gas particles are attracted to each other, but their very high kinetic energy is much stronger than the attractions, so the particles are far apart. It appears as if there is no attractive or repulsive forces between the gas particles. The gas particles move in straight lines and very fast. They collide with other particles all the time. These collisions will cause gas (or air) pressure.

Gases spread out and take the shape of any container that you put them in. Any amount of a gas will fill any container that you put the gas in (the gas would change pressure when expanding or squishing). Collisions between gas particles appear to be elastic, meaning there seems to be no loss of kinetic energy due to these collisions, the energy is transferred from particle to particle. Heated gases make the particles move faster and have more collisions, causing the gas to expand.

If the gas is in a hard container and expansion is not possible, then the gas pressure increases due to more and stronger collisions. Gas Particles have the highest kinetic energy. Gases have (by far) the lowest density of the three phases.

This shows a particle diagram of a gas in a rectangle container. The gas particles are little circles, they appear to be “flying” around the container, which is what they do. As a rule, they do not stick together, and we do not draw them hitting each other. Particles that touch are liquids or solids. Gas particles also bounce off the bottom of the container. We don’t draw them touching bottom, we only show the gas particles “up”.

Here the particles have so much kinetic energy that the intermolecular forces of attraction are NOT STRONG ENOUGH to hold the gas particles together.

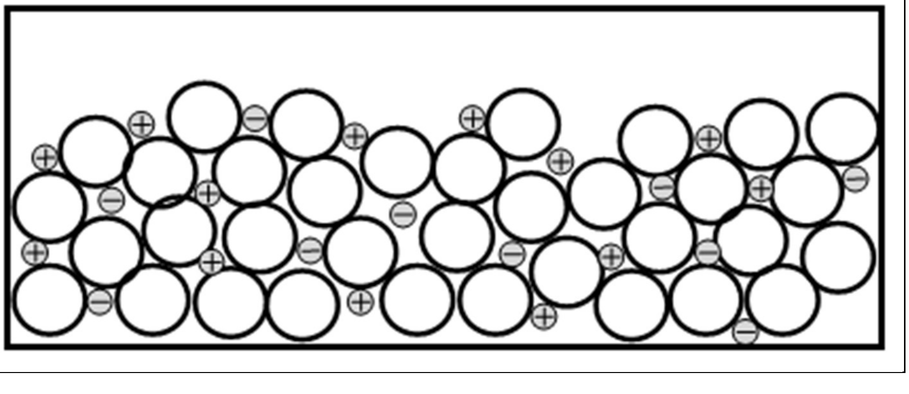


Aqueous

Aqueous is not a “real phase” (like solid, liquid or gas) but so many substances can dissolve into water. Any substance dissolved into water is said to be aqueous. Solid NaCl salt dissolved into water is not a solid anymore. Carbon dioxide gas that dissolves into water to form seltzer or soda is not a gas anymore. Anything that is dissolved into water is called an aqueous solution.

The trickiest phase change is solid → aqueous because it seems like something special is happening even though not much really occurs.

Here: water molecules are the larger white circles, the ions are the grey dots and they are positive and negative, spread out in the water.



There are 6 Phase Changes

Phases change when energy is added or removed from a substance. A phase change is a physical change, not a chemical change. Ice $\rightleftharpoons$ water $\rightleftharpoons$ steam, but it remains H_2O, with the same chemical properties.

Melting

Solids have many intermolecular bonds. The added energy makes the rigid network of particles shake so much that the vibrations reach the point that they exceed the attractive forces that keep them stuck as a solid. The solid then breaks up and turns into a liquid. Ex: ice melts $H_2O_{(S)} \rightarrow H_2O_{(L)}$ or iron melts $Fe_{(S)} \rightarrow Fe_{(L)}$

Freezing

The opposite of melting. When a liquid loses enough energy so that the attractive forces between particles is greater than the kinetic energy (motion) of the particles, then they lock into a lattice or network, a solid results. Ex: water freezes $H_2O_{(L)} \rightarrow H_2O_{(S)}$ or liquid iron cools into a solid $Fe_{(L)} \rightarrow Fe_{(S)}$

Vaporization includes Evaporation

Liquids have enough attraction to hold themselves together, but not enough to be stuck solid. These liquid particles are all moving and have kinetic energy. Not all the particles have the same exact kinetic energy, and when the water molecules with higher kinetic energy, some of them can make the leap into the gas phase. This is evaporation, and it happens from the surface of a liquid, and at all temperatures. Warmer water evaporates faster than cold. All liquids lose particles into the gas phase, all evaporate.
Ex: steam forms: $H_2O_{(L)} \rightarrow H_2O_{(G)}$ or ammonia vaporizes $NH_{3(L)} \rightarrow NH_{3(G)}$

Vaporization includes Boiling

When liquid water gains enough kinetic energy to have ALL the particles have enough energy to jump to the gas phase, this is boiling. The boiling point is when the amount of kinetic energy is sufficient to overcome the attractiveness of the molecules and the air pressure on the surface of the liquid holding it down as a liquid. Boiling occurs throughout the liquid not just at the surface. The bubbles in boiling water are $H_2O_{(G)}$ expanding away from each other. In this gas phase they are LESS DENSE than the liquid water, so the bubbles flow upwards and break into the air, releasing water molecules as gas.

Condensation

The opposite of boiling, gases can condense, or collapse back into a liquid. The gas phase has by far the highest kinetic energy, and when a gas condenses a lot of energy is released. Steam condensing on your hand (for example) is a much more energetic process than spilling hot water on your hand. Steam burns are much worse than hot water burns.
Ex: steam condenses $H_2O_{(G)} \rightarrow H_2O_{(L)}$ or ammonia gas condenses $NH_{3(G)} \rightarrow NH_{3(L)}$

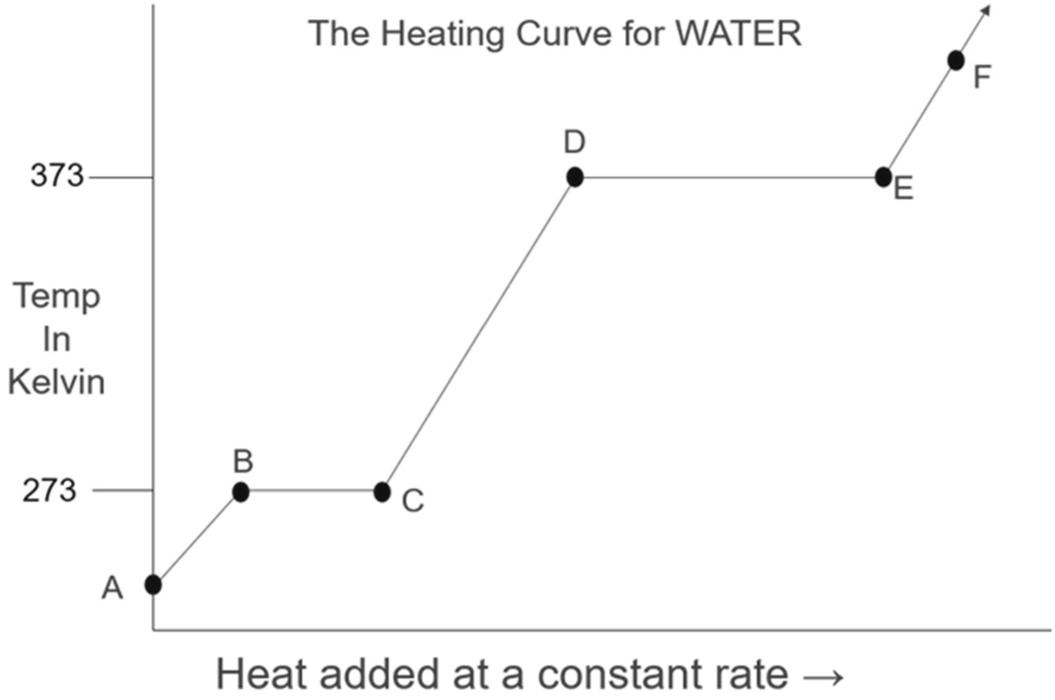
Sublimation

In this process a solid can jump directly to the gas phase. Not all substances normally do this. Iodine solid can be heated directly to an iodine gas. $CO_{2(S)}$ (dry ice) will go directly to the gas phase $CO_{2(G)}$ as well.
Example: iodine sublimes $I_{2(S)} \rightarrow I_{2(G)}$

Deposition

This is the opposite of sublimation. Gases become solids without becoming liquids first. Iodine will do this.
Example: iodine gas undergoes deposition when it changes directly into a solid $I_{2(G)} \rightarrow I_{2(S)}$

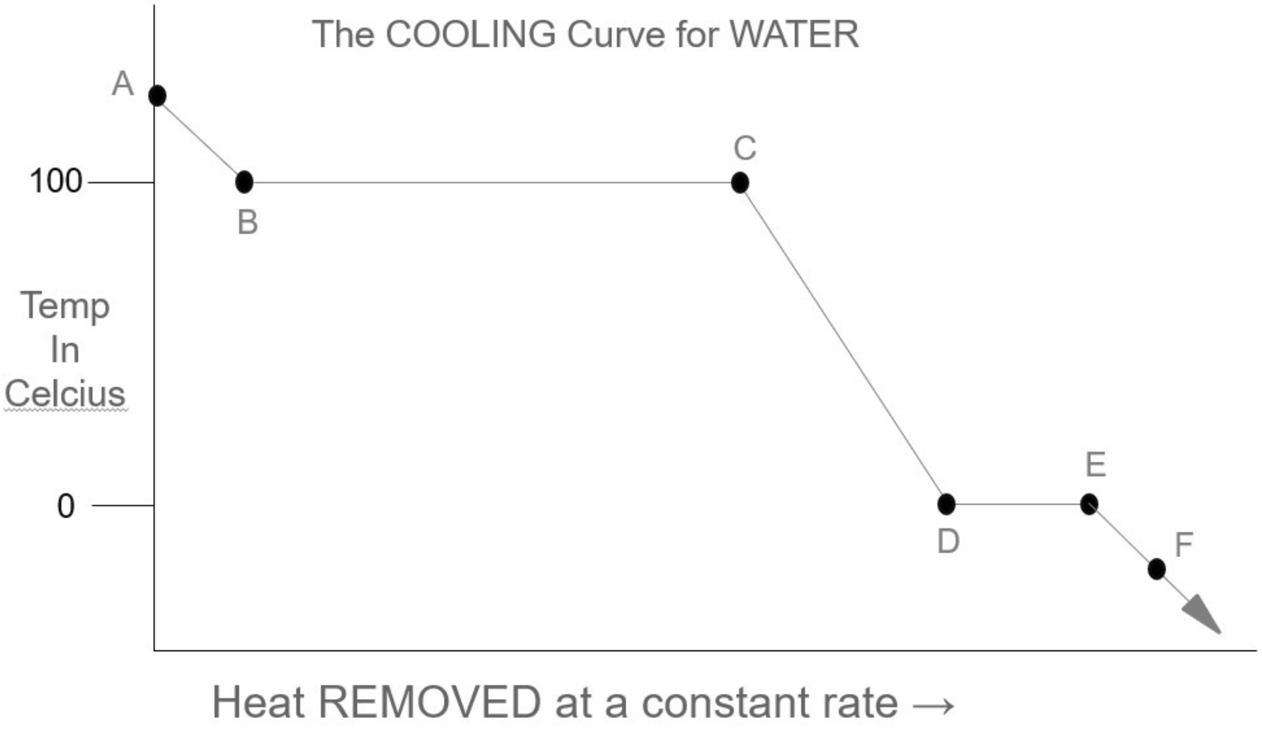
The HEATING CURVE for water shows how water is heated from below the freezing point, through two phase changes until it becomes steam, and then the steam gets hotter as well.



Graph Segment	Phase or phases present	Temperature	Kinetic Energy is the Energy of MOTION	Potential Energy is the Energy of PHASE
AB	solid (ice only)	Temp Increases	Kinetic Energy Increases	Steady (solid only)
BC	solid melts (ice → water)	Temp Steady	Kinetic Energy Steady	Increases (solid becomes liquid)
CD	liquid (water only)	Temp Increases	Kinetic Energy Increases	Steady (liquid only)
DE	liquid vaporizes (water → steam)	Temp Steady	Kinetic Energy Steady	Increases (liquid becomes gas)
EF	gas (only steam)	Temp Increases	Kinetic Energy Increases	Steady (gas only)

Temp and KE always follow each other. If one increases, so does the other. In a cooling curve (heat removed at a constant rate) when the temp decreases and so does KE. Only one energy (KE or PE) changes at a time.

Things to remember: Kinetic Energy (KE) and Temperature act in unison. If temperature rises, so does KE. When temperature decreases, KE decreases too. When temperature is CONSTANT, KE remains constant.



A → B: steam gas cools as heat is removed. Only steam exists as the temperature is still above 100°C. Kinetic energy decreases along with temperature. Potential energy is steady, with no phase change.

B → C: the HOT phase change. Steam gas condenses into liquid water. Both phases can exist at 100°C. The removal of energy does not lower the temperature, because during the hot phase change all energy that is removed allows the gas to condense. Since the phase “moves lower” down from liquid to solid, the POTENTIAL ENERGY decreases. Steady temp = steady KE.

C → D: liquid only phase, temperature decreases, KE also decreases. There is no phase change as the water stays liquid, which means the PE is steady (no change in phase = no change in PE).

D → E: the cold phase change. Note that the temperature stays constant as all the energy removed allows the liquid water to bond into solid ice. Temperature is steady, so KE is steady too. Since the phase “moves lower” down from liquid to solid, the POTENTIAL ENERGY decreases.

E → F: solid only phase. Although liquid water can NEVER get colder than 0°C (at normal pressure) a solid can get as cold as you can make them (but not to zero Kelvin). As the temperature decreases so does the Kinetic Energy. The phase is constant (solid only) so the PE is steady or constant.

With a cooling curve, the substance starts hot. As it cools, we can graph the temperature change over time. Cooling curves run opposite the heating curve. As temperatures drop, so does the kinetic energy. Kinetic energy and temperature always change together, or remain steady, together (during phase changes).

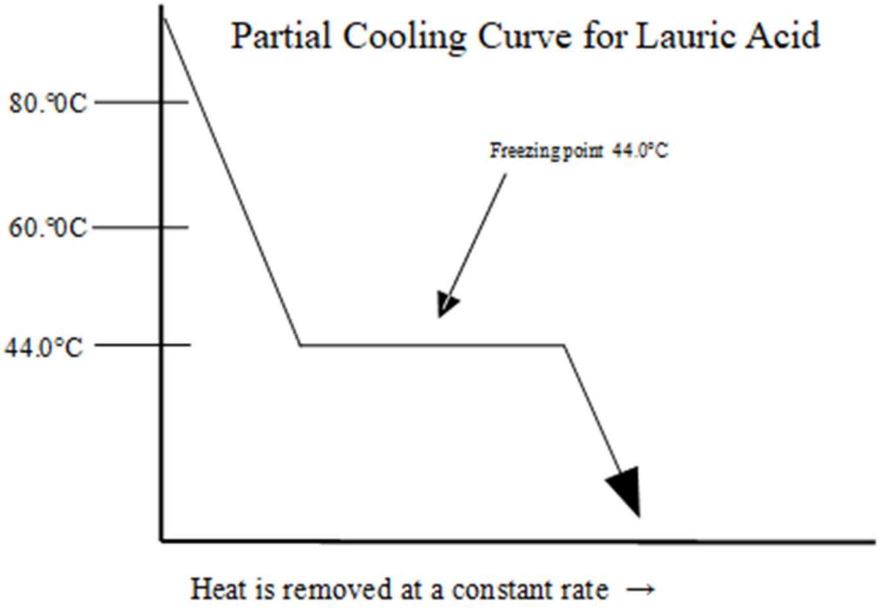
On a graph, the phase changes are always parallel with the horizontal axis, because they only occur at one temperature. Water freezes **at** the freezing point of 273 K or 0°C. That is one exact temperature. A parallel line represents ONE temperature.

Lauric acid is an organic acid with formula of $C_{17}H_{35}COOH$.

It starts as a liquid,
and freezes at 44.0°C.

Above 44.0°C it is liquid,
below 44.0°C it is solid.

At 44.0°C it's changing
from liquid to solid,
it freezes.



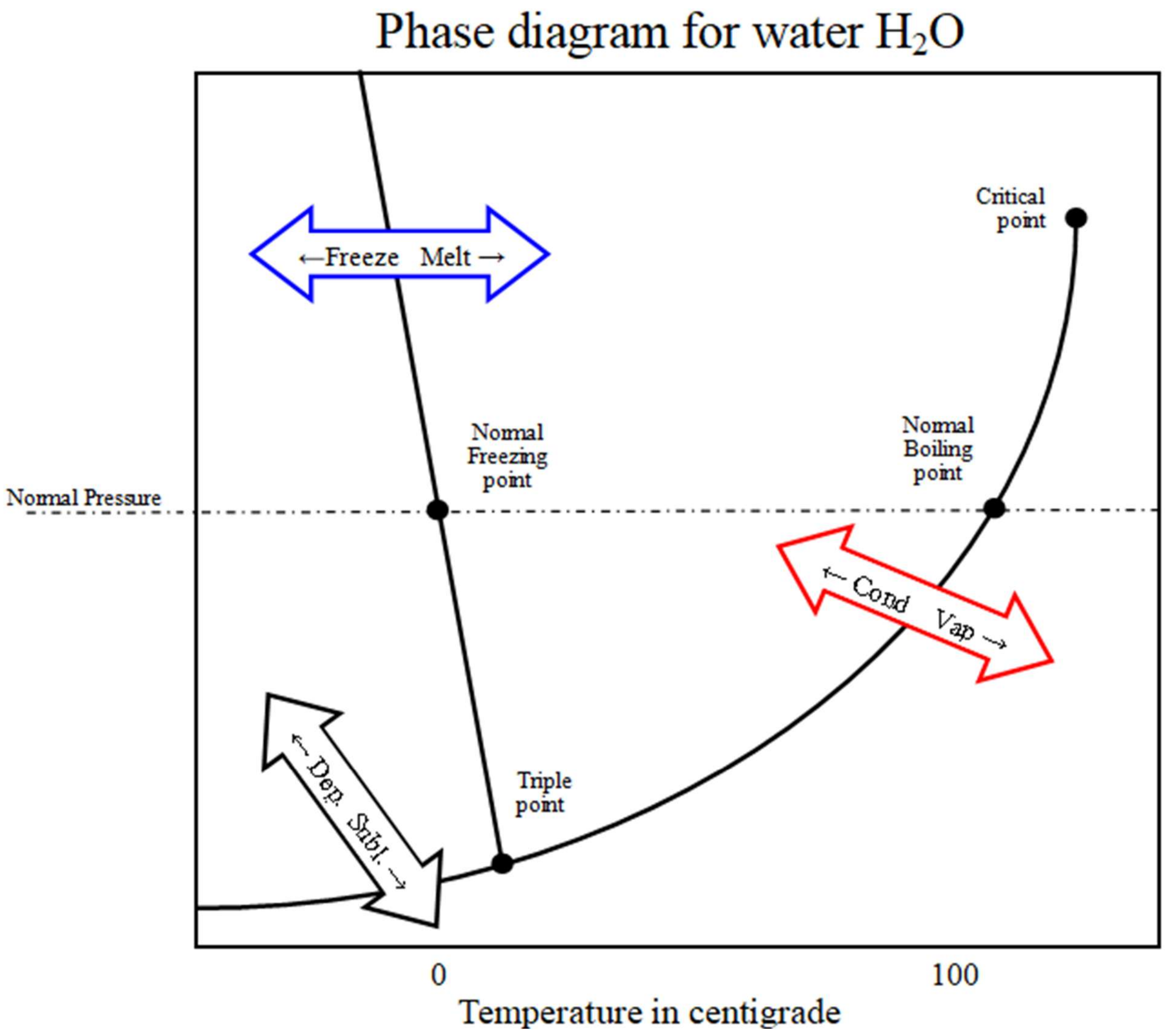
PHASE DIAGRAMS

If we look at a single substance (water for example), at any temperature and pressure it will exist as a solid or liquid or gas. A phase diagram puts that data into graph form. You should memorize the phase diagram for water and be able to draw it without notes. All substances have a phase diagram, and you should be able to interpret them if provided.

The graph LINE shows ALL melting/freezing points at various pressures.
The main part of the graph CURVE shows ALL the boiling/condensing points at various pressures.
In the bottom corner the CURVE shows ALL the sublimation/deposition points at different pressures.

Plotting a point on the graph allows us to know the phase exists at a particular temperature and pressure.
Normal Freezing point (0°C) and Normal Boiling point (100°C) are at NORMAL PRESSURE.
Triple point (0.16°C and 0.600 atm) is where all phase changes occur simultaneously, and all 3 phases coexist.
Critical point (374°C & 281 atm!) liquid and gas H_2O cannot be distinguished, they become the same thing.

On the next page is the PHASE DIAGRAM for water. It will take a few minutes to really look at it. No rushing, think, try hard now.



The Kinetic Molecular Theory and Phases

Explains how gases work, and how scientists explain them. Solids, liquids and gases are made up of the exact same particles, the difference is how close they are, how sticky or stuck they are. For gases, it's how they stay apart from each other.

Kinetic molecular theory (KMT) for an ideal gas, states
1 All gas particles are in random, constant, straight-line motion.
2 All gas particles are separated by great distances relative to their size.
3 The volume of the gas particles is considered negligible compared to gas volume.
4 Gas particles have no attractive forces between them.
5 Gas particles have collisions that may result in a transfer of energy between gas particles, but the total energy of the system remains constant.

Table H and Vapor Pressures (and intermolecular forces of attraction)

Table H can show 3 different things, all on the same graphs.

1. Vapor pressure is the extra pressure caused by the vaporization of a liquid into a gas, inside of a sealed system, like a can of pork and beans or a sealed bottle.

Table H shows the vapor pressures of 4 liquids at different temperatures. To determine vapor pressure, find the temperature, and slide your finger UP to the proper curve, then slide to the left to read the added vapor pressure caused on this liquid by this temperature.

2. Boiling point of these 4 liquids, at any pressure.

Boiling point can change when pressure on the surface changes. We're used to water boiling at 100C, the "boiling point", but that is only the BP at NORMAL PRESSURE. To find the boiling point, put your finger on a pressure value, then slide it to the right until you touch the proper curve, then slide down to read the boiling point temperature at that pressure.

3. Determining phase (liquid or gas) these substances are at any pressure & temperature.

If the point is "behind" the curve it is still a liquid. In front of the curve, it's a gas. If your point is ON THE CURVE, then you have both phases (L and G) at the same time!

In your pre-chemistry minds water always boiled at 100°C, and that was that. Now you need to realize that water boils at 100°C only if the air pressure is at STANDARD, or normal. If the pressure were to change, so would the boiling point.

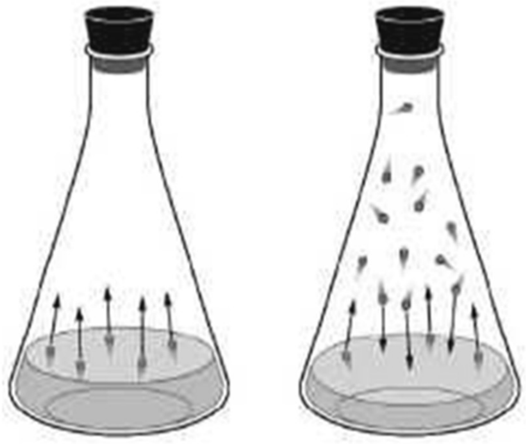
Higher pressure causes a higher boiling point. Low pressure allows for a lower boiling point.

4. Intermolecular forces of attraction. Think through this: find 45°C on Table H. At 45°C, propanone has the HIGHEST VAPOR PRESSURE. Propanone evaporates faster, which causes more pressure inside of a closed system. This happens because the propanone molecules do not stick together as well. Of these 4 liquids, propanone has the weakest IMF (intermolecular forces of attraction).

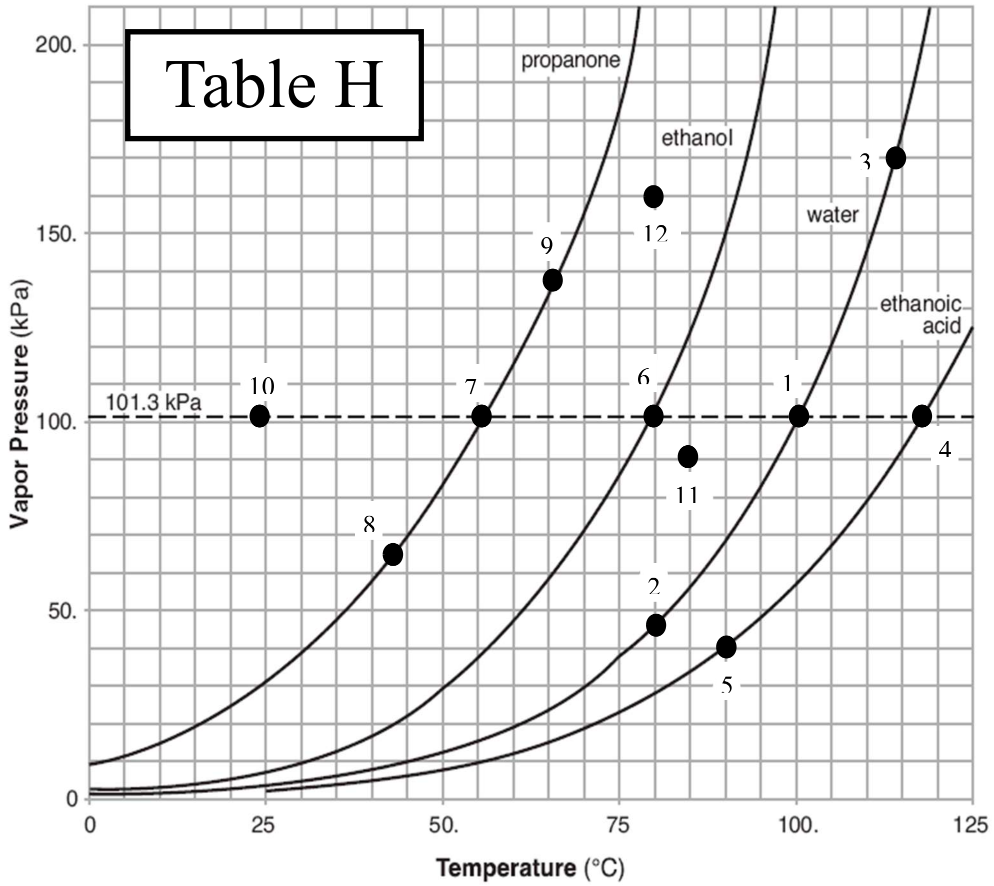
Ethanoic acid has the lowest vapor pressure (at all temps) because it evaporates least well because it has the strongest intermolecular forces of attraction (IMF). Vapor pressure is determined by temperature and the strength of the IMF between the particles of the liquid.

In a closed system, like a corked bottle, there is air pressure above the liquid. As the liquid evaporates it adds more gas molecules to that space above the liquid, which increases the pressure. This extra pressure, over the air pressure that is already there, is called the vapor pressure. Hotter makes more evaporation, and a higher vapor pressure.

How easily a liquid evaporates, depending upon it’s intermolecular attractions, also affects the vapor pressure.



At first, air pressure exists inside the bottle	Soon, air pressure PLUS vapor pressure exists inside the bottle



	Pressure and Temp	What does table H show us at each of these points?
1	101.3 kPa — 100°C	The normal boiling/condensing point of water, gas + liquid coexist.
2	~47 kPa — 80°C	A lower boiling/condensing point of water at lower pressure, gas + liquid coexist.
3	170 kPa — 115°C	A higher boiling/condensing point of water at higher pressure, gas + liquid coexist.
4	101.3 kPa — 117°C	Normal boiling/condensing point of ethanoic acid, gas + liquid coexist.
5	40 kPa — 90°C	A lower BP/CP of ethanoic acid at lower pressure, gas + liquid coexist.
6	101.3 kPa — 80°C	Normal boiling/condensing point of ethanol, gas + liquid coexist.
7	101.3 kPa — 56°C	Normal boiling/condensing point of propanone, gas + liquid coexist.
8	~63 kPa — ~47 °C	A lower BP/CP of propanone at lower pressure, gas + liquid coexist.
9	~137 kPa — ~66°C	A higher BP/CP of propanone at higher pressure, gas + liquid coexist.
10	101.3 kPa — 25°C	All four substances are liquid at this point on the graph.
11	90 kPa — 85°C	Propanone & ethanol are gases here (in front of their curves) Water & Ethanoic acid are liquids (didn't reach their BP at this pressure yet).
12	160 kPa — 80°C	Propanone is a gas. The other substances are all still liquids.

Gas Pressure Conversion Problems

Table A shows us standard temperature and standard pressure. Air or gas pressure is measured with several different units for various reasons. We need to be able to convert from one unit to another.

Standard pressure means normal pressure. The pressure of the air at sea level on Earth was measured all around the world, until it was standardized. In the USA we use pounds per square inch, just because. That's equal to the other, more scientific units.

Standard pressure is equal to 1.0 atm (1 atmosphere). It's an old-fashioned unit, but it works. Standard pressure was also measured with the mercury barometers of years gone by. At standard pressure, the column of mercury was pushed up the tube to 760. millimeters in height, so standard pressure also equals 760. mm Hg.

Metric standard pressure is measured in kilo-pascals. 101.3 kPa is standard and metric!
In total, all standard pressures are the same, so:

$$1.0 \text{ atm} = 760. \text{ mm Hg} = 101.3 \text{ kPa} = 14.7 \text{ psi}$$

Because these quantities are all equal, you can make many conversion factors from these, to convert one unit to another. All these conversion factors are equal to 1.

$\frac{1.0 \text{ atm}}{760. \text{ mm Hg}}$	=	$\frac{1.0 \text{ atm}}{101.3 \text{ kPa}}$	=	$\frac{760. \text{ mm Hg}}{101.3 \text{ kPa}}$	=	$\frac{760. \text{ mm Hg}}{1 \text{ atm}}$	=	$\frac{101.3 \text{ kPa}}{1.0 \text{ atm}}$

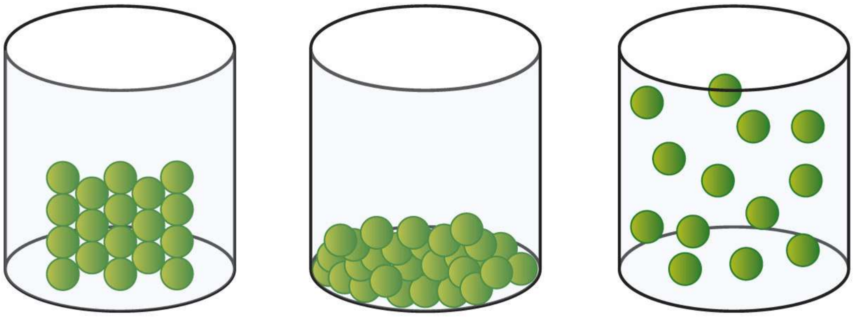
$\frac{101.3 \text{ kPa}}{760. \text{ mm Hg}}$	=	$\frac{1.0 \text{ atm}}{14.7 \text{ psi}}$	=	$\frac{14.7 \text{ psi}}{101.3 \text{ kPa}}$	=	$\frac{14.7 \text{ psi}}{760. \text{ mm Hg}}$	All these conversion factors = 1

Practice problems for pressure conversion (all 3 SF except for the last one!)

Using the equalities you put onto Table A you can make any conversion factors you need.

Convert 744 mm-Hg to atm.	$\frac{744\ \text{mm Hg}}{1}$	x	$\frac{1.0\ \text{atm}}{760.\ \text{mm Hg}}$	= 0.979 atm
Convert 744 mm-Hg to kPa.	$\frac{744\ \text{mm Hg}}{1}$	x	$\frac{101.3\ \text{kPa}}{760.\ \text{mm Hg}}$	= 99.2 kPa
Convert 155 kPa to mm-Hg	$\frac{155\ \text{kPa}}{1}$	x	$\frac{760.\ \text{mm Hg}}{101.3\ \text{kPa}}$	= 1160 mm Hg
Convert 155 kPa to atm	$\frac{155\ \text{kPa}}{1}$	x	$\frac{1.0\ \text{atm}}{101.3\ \text{kPa}}$	= 1.53 atm
Convert 0.724 atm to kPa	$\frac{0.724\ \text{atm}}{1}$	x	$\frac{101.3\ \text{kPa}}{1.0\ \text{atm}}$	= 73.3 kPa
Convert 0.724 atm to mm-Hg	$\frac{0.724\ \text{atm}}{1}$	x	$\frac{760.\ \text{mm Hg}}{1.0\ \text{atm}}$	= 550. mm Hg
Convert 0.724 atm to psi	$\frac{0.724\ \text{atm}}{1}$	x	$\frac{14.7\ \text{psi}}{1.0\ \text{atm}}$	= 10.6 psi
Convert 25.6 psi to mm-Hg	$\frac{25.61\ \text{psi}}{1}$	x	$\frac{760.\ \text{mm Hg}}{14.7\ \text{psi}}$	= 1324 mm Hg

Phases Notes

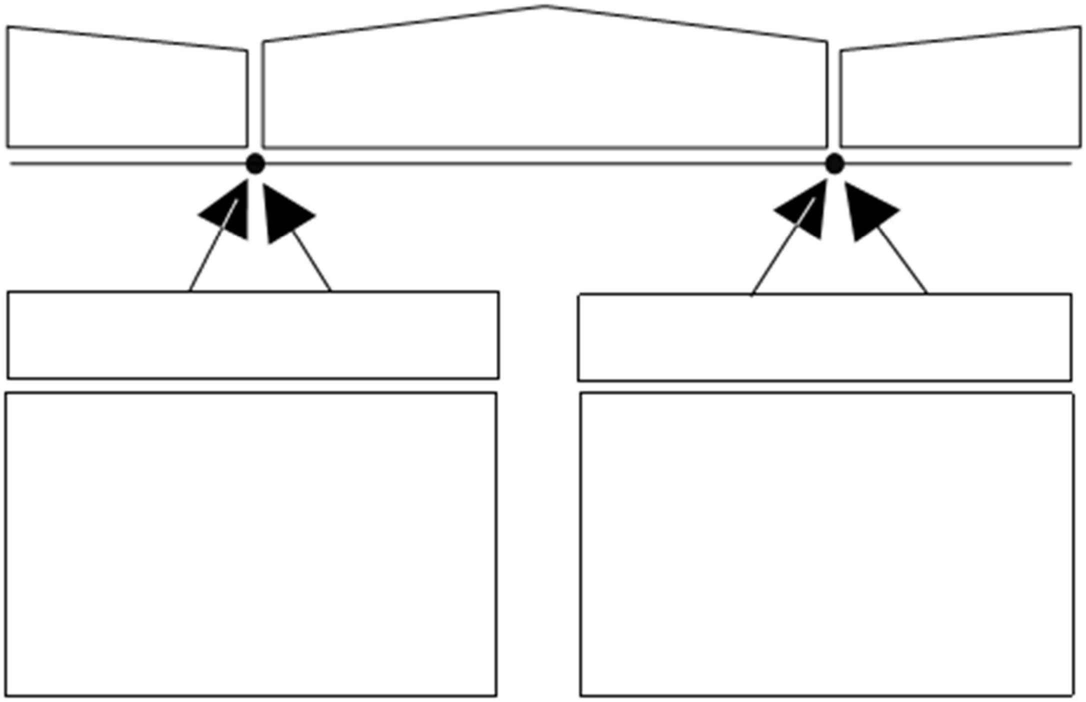


1 There are 3 phases of matter:

2 There are 6 phase changes	which are called
Solid to Liquid	
Liquid to Solid	
Solid to Gas	
Gas to Solid	
Liquid to Gas	
Gas to Liquid	

3	Endothermic (energy is absorbed	Exothermic (energy is emitted)
These six phase changes are	solid → liquid	liquid → solid
	liquid → gas	gas → liquid
	solid → gas	gas → solid

4 Indicate the important phase change temperatures for water.



6. The Melting point = ____

MELTING is ______________________ (emits heat energy)

FREEZING is ______________________ (absorbs heat energy)

7. The Boiling point =____

VAPORIZING is ______________________ (emits heat energy)

CONDENSING is ______________________ (absorbs heat energy)

8. Draw the heating curve for water – all labels required.

SEGMENT	TEMPERATURE CHANGE	KINETIC ENERGY CHANGE	POTENTIAL ENERGY CHANGE	PHASES PRESENT
AB				
BC				
CD				
DE				
EF				

11. Temperature is deemed hotter when the particles are moving ________________________.

12. Colder temperatures indicate that the substance's particles are moving _________________.

13. Skip this one.

14. The "energy of motion" is called __________________________ energy.

15. When temperature increases,

____

16. That means ____________________+ _____________________________ change together

17. If ____
(particles slow).

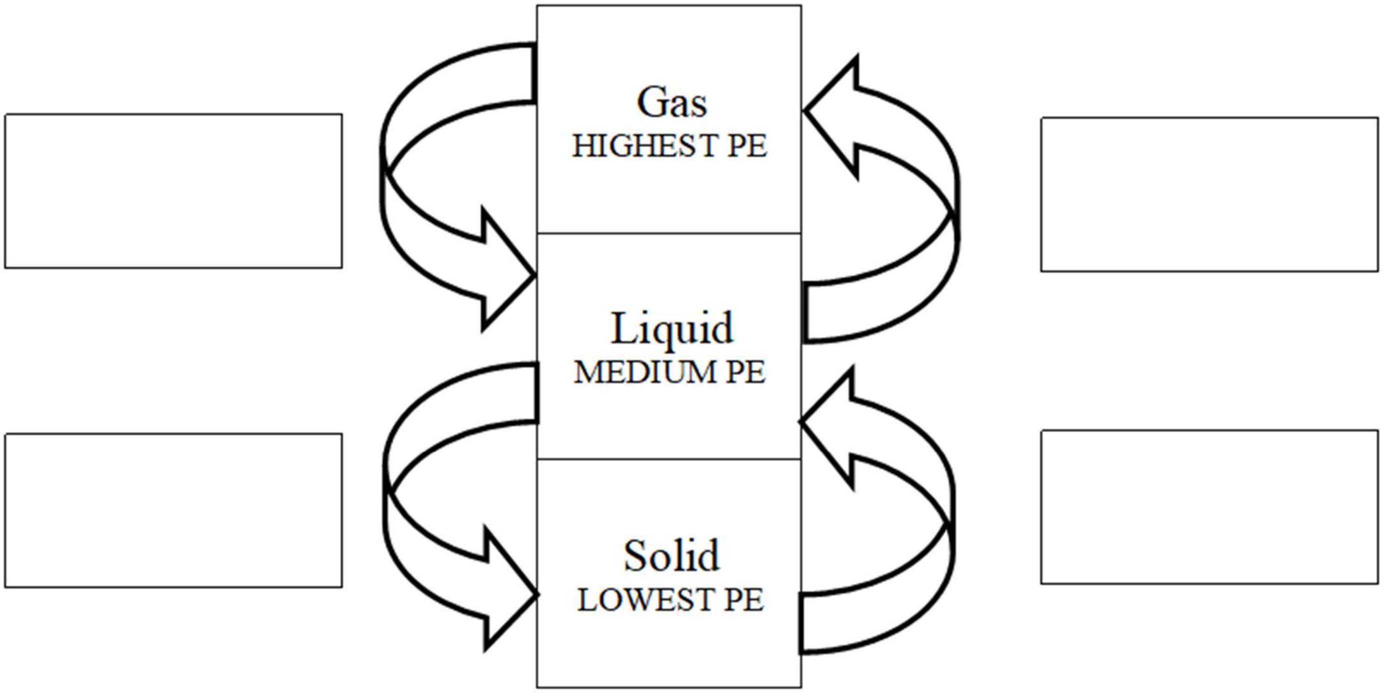
18. If ____
(particles speed up).

19 If ____ too

20 During a phase change on the heating curve, segment BC, heat energy is being added at a constant rate, but the temperature (and the Kinetic Energy) stays steady. How do we explain heat energy being added while the Kinetic Energy remains steady?

The Law of Conservation of Energy (memorize this)

22. Potential Energy of each phase



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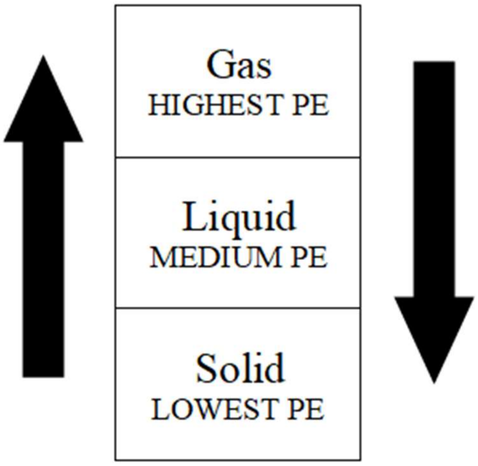


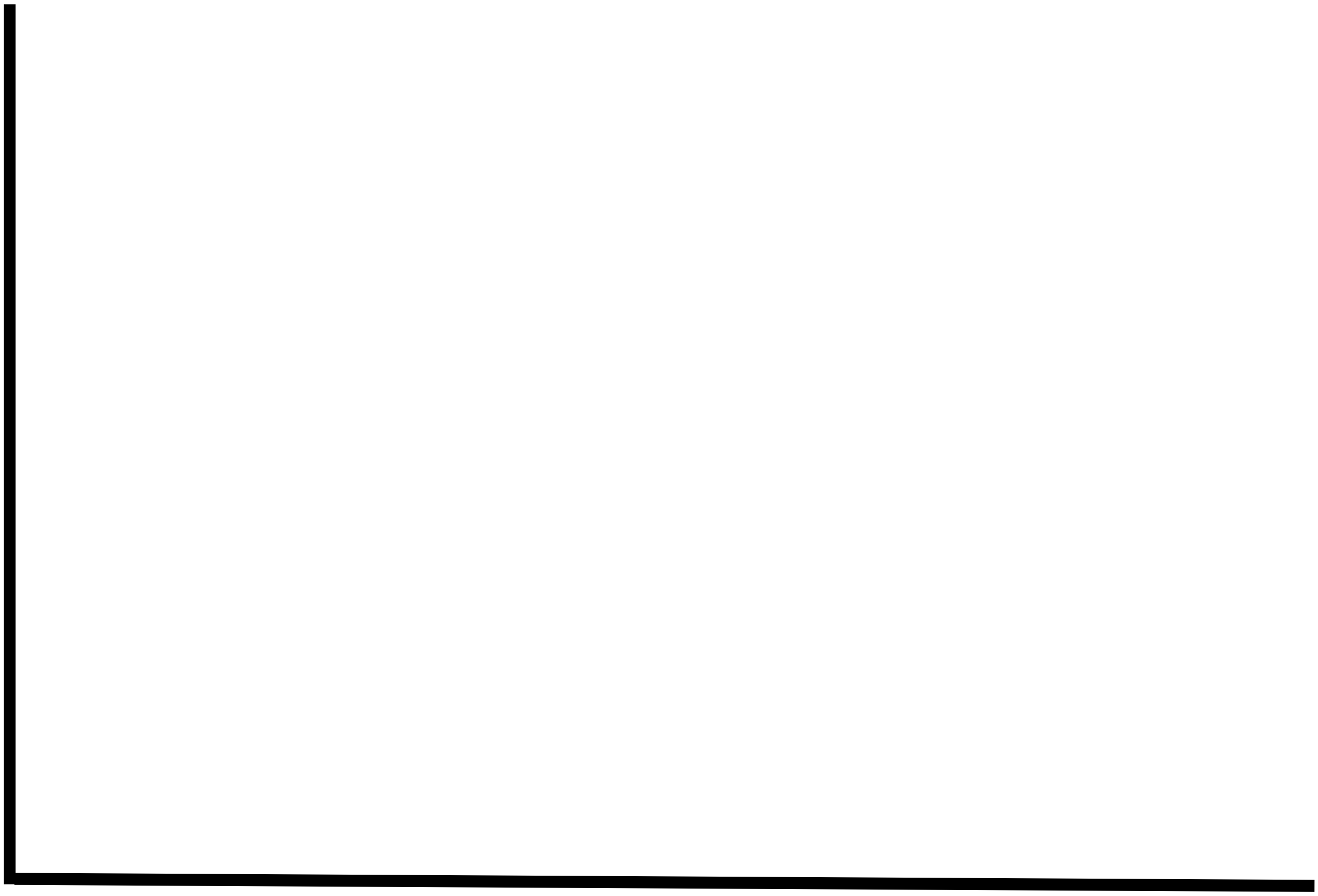
24. Which phase has the highest potential energy? Solid Liquid Gas

25. Which phase has the lowest potential energy? Solid Liquid Gas

26. The cold phase change for $H_2O_{(S)} \rightarrow H_2O_{(L)}$ is endothermic. Energy is added, but the temperature remains steady at 273 K. If the law of conservation of energy holds (it does) what energy increases during this phase change?

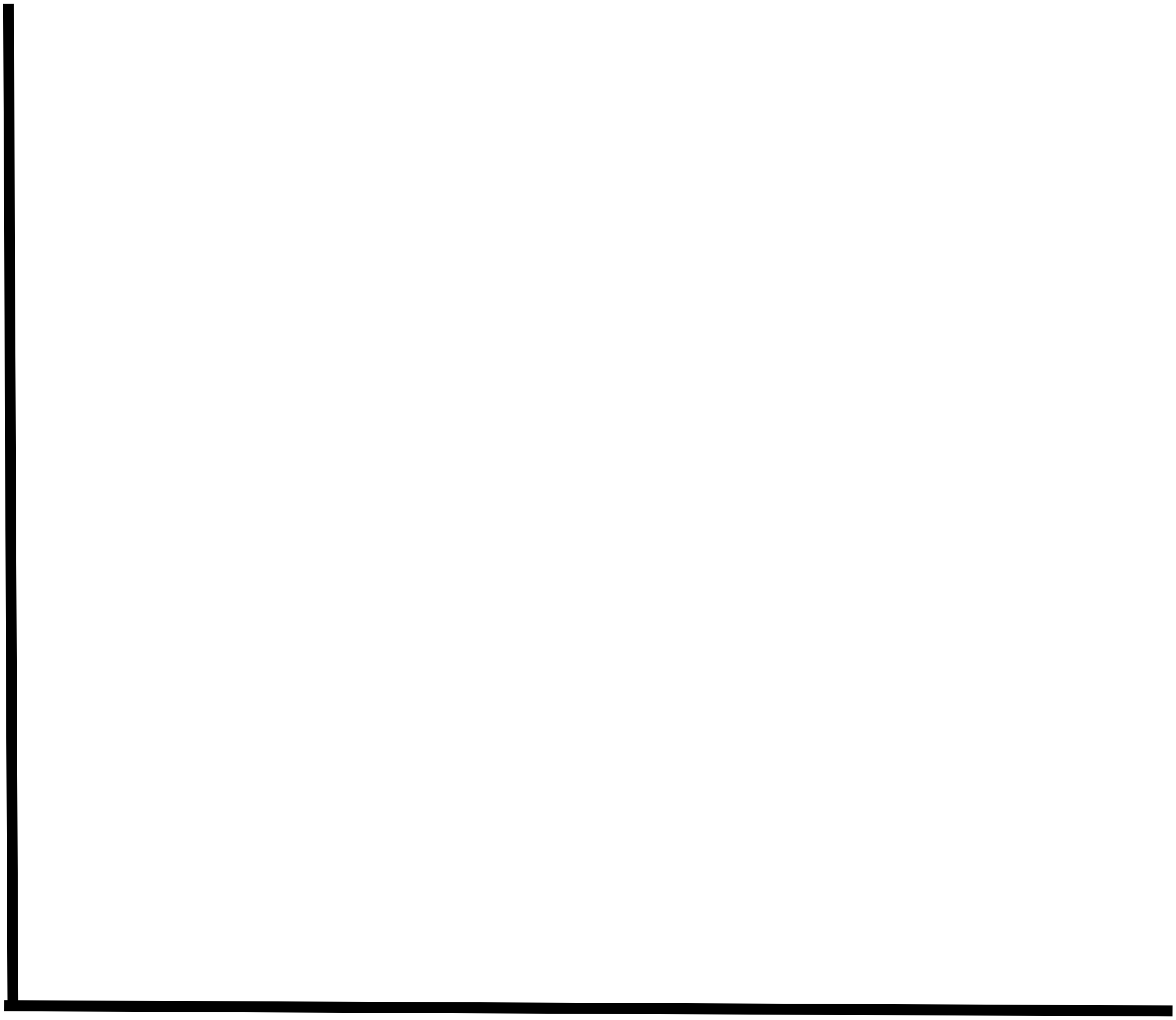
27. Can both the kinetic energy and potential energy change at the same time?

8. Draw the cooling curve for RUBIDIUM – all labels required.



SEGMENT	TEMPERATURE CHANGE	KINETIC ENERGY CHANGE	POTENTIAL ENERGY CHANGE	PHASES PRESENT
AB				
BC				
CD				
DE				
EF				

30 Draw the Cooling curve for BISMUTH, and Heating curve for LEAD (both)			
Get this data before you begin, then put in temperature scale FIRST	Metal	freezing/melting point	boiling/condensation point
	LEAD	K	K
	BISMUTH	K	K



Graphing Note: the “hot” phase change is always LONGER than the “cold” phase change

What are the characteristics of solids, liquids and gases?

31. True or False, nearly every substance can be a solid, liquid or a gas? True False

32. An exception is ________________________________, which is a mixed solid. It combusts before it can melt. All elements & *nearly* all compounds can be any phase with proper temperature + pressure.

33. Where do we find most element melting points and boiling points?

34. Where do we find the freezing points and the condensing points if we need to know them?

35	Particle Attraction	Particle Movement	Particles are...	Relative Density	Compressibility
Solid					
Liquid					
Gas					

36. Draw the particle diagrams of solid, liquid and a gas in the boxes below.

solid	liquid	gas
Particles are rigidly arranged, orderly, repetitively spaced. They have a definite shape. They DO NOT take the shape of container. Definite Shape, Definite Volume.	Particles in constant motion and touch each other. They do not have definite shape. They TAKE the shape of the container. Indefinite Shape, Definite Volume.	Particles are in fast motion, only touching when colliding. They have no shape. TheyFILL any container they're in. Indefinite Shape, Indefinite Volume.

Gas or Air Pressure

37. Gas Pressure is caused by the ______________________________ of particles with each other and the container walls that hold it.

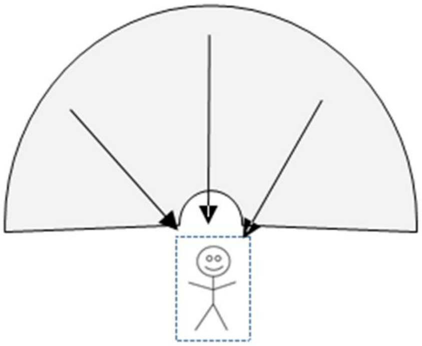
38. More collisions = ________________________ Stronger collisions = higher pressure

39. ____________________________________ = more and stronger collisions

40. ______________________________________ = less and weaker collisions.

Hot ballons = happy kids.   Cold balloons = sad kids.

41. Normal or Standard Pressure is



_____________________________________.

1 atm = ______________ kPa, or kilopascals.

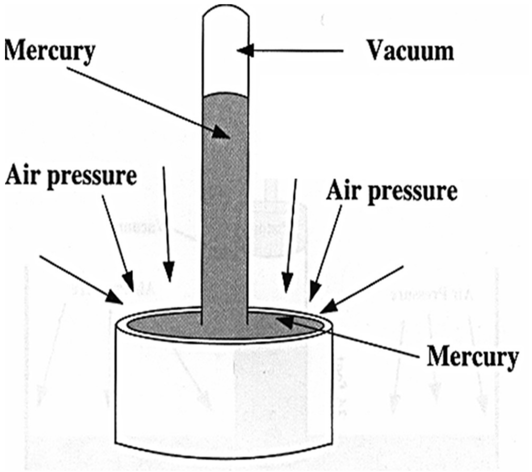
42. In the USA &England we use crazy English units.

For pressure they are ____!

$$1 \text{ atm} = 101.3 \text{ kPa} = 14.7 \text{ psi}$$

43. Measuring pressure was originally figured out by an Italian guy named EVANGLISTA TORRICELLI

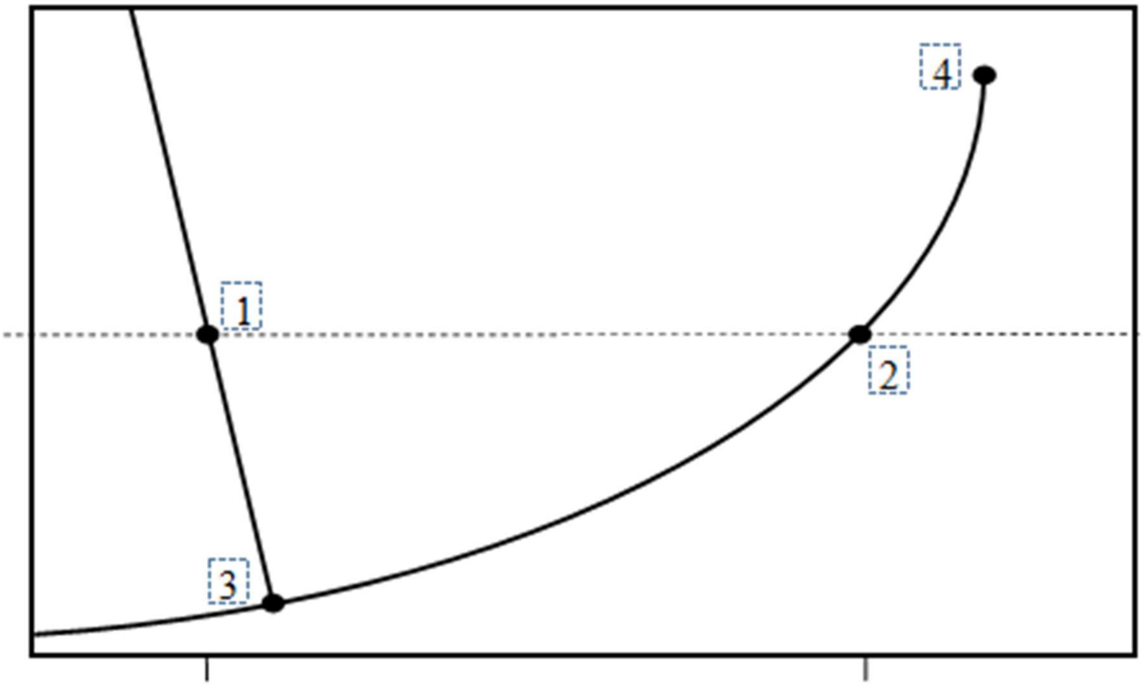
44. He invented a device called the ___________________________________



45

46	Convert 1.08 atm into kilopascals
47	Convert 145 kPa into atmospheres
48	Convert 905 mm Hg into kPa
49	Convert 31.0 kPa (pressure on Mr. Everest) into atmospheres.
50	Convert the high pressure of 2.68 atm into pounds per square inch.
51	Maximum pressure of an NBA basketball is 8.50 psi. Convert 8.50 psi into mm of Hg.
52	A PHASE diagram shows the phases of a substance at a variety of temperatures and pressures. Every substance has one, let's look at the PHASE DIAGRAM OF WATER.

Title:



53	The dotted line is	
54	Point 1 is called	
55	Point 2 is called	
56	Point 3 is called	
57	Point 1 is called	
58	The triple point for water is… The critical point for water is…	
59	The slanted line represents	
60	The curve (from point 3 to 4) represents	

63	These containers are examples of___________________________________ systems. Heating them up could cause an EXPLOSION due to the increasing VAPOR pressure. Vapor pressure is the extra pressure caused by the evaporating liquid inside of a closed system (like a can of Pork and Beans, or bottle, or a corked flask!)	
64	If you warm up a sealed can of beans to 25°C, how much vapor pressure is added to the inside of this can by the water inside it?	
65	If you warm up a sealed can of beans to 80°C, how much vapor pressure is added to the inside of this can by the water inside it?	
66	If you warm up a sealed can of beans to 95°C, how much vapor pressure is added to the inside of this can by the water inside it?	
67	What is the vapor pressure of….	
	Propanone at 45°C	Ethanoic acid at 90°C?
	Water at 105°C?	Ethanol at 90°C?
68 69 70	How much pressure is in the top of the bottle when you start? How much is in it after the water warms up to 25°C? What if the bottle is heated up to 90°C? 	

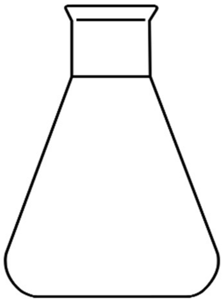
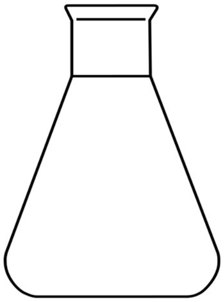
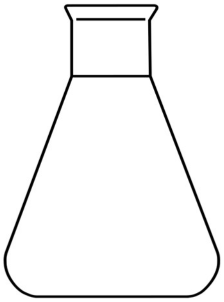
<table>
<tr><td colspan="2">3 corked bottles with equal volumes of different liquids.
What happens as we heat them slowly?</td><td></td><td></td><td></td></tr>
<tr><th>#</th><th>Temp</th><th>Ethanol
Vapor pressure kPa</th><th>Ethanoic Acid
Vapor pressure kPa</th><th>Propanone
Vapor pressure kPa</th></tr>
<tr><td>71</td><td>25°C</td><td></td><td></td><td></td></tr>
<tr><td>72</td><td>45°C</td><td></td><td></td><td></td></tr>
<tr><td>73</td><td>75°C</td><td></td><td></td><td></td></tr>
</table>

Table H tells us 3 different things…

74. It tells us the vapor pressures of 4 liquids, at many temperatures.
Vapor pressure is the extra pressure inside of a closed system, caused by the evaporation of a liquid.

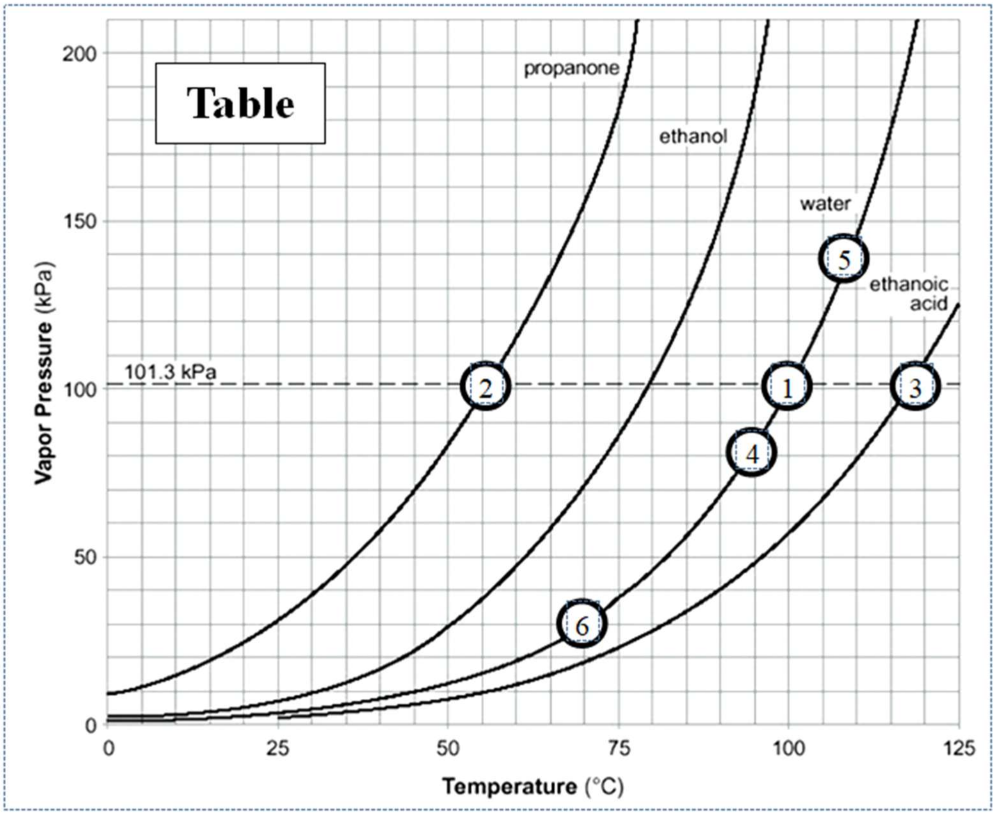
Some liquids evaporate easier (higher VP, weaker IMF)
Some liquids evaporate worse (lower VP, stronger IMF).

75. It tells us the boiling points of 4 liquids, at many pressures.

76. It tells us what phase (liquid or gas) these 4 substances are, at any pressure/temperature point on the graph.

This is SO BIG because it is SO IMPORTANT. I'm YELLING!

77. Point 1 is called



78. Point 2 is called the

79. Point 3 is called the

What is the BOILING POINT OF	
83	ethanol at 60 kPa
84	propanone at 70 kPa
85	ethanol at 150 kPa
86	water at 180 kPa
87	ethanol at 30 kPa

80. Point 4 is called the

81. Point 5 is called the

82. Point 6 is called the

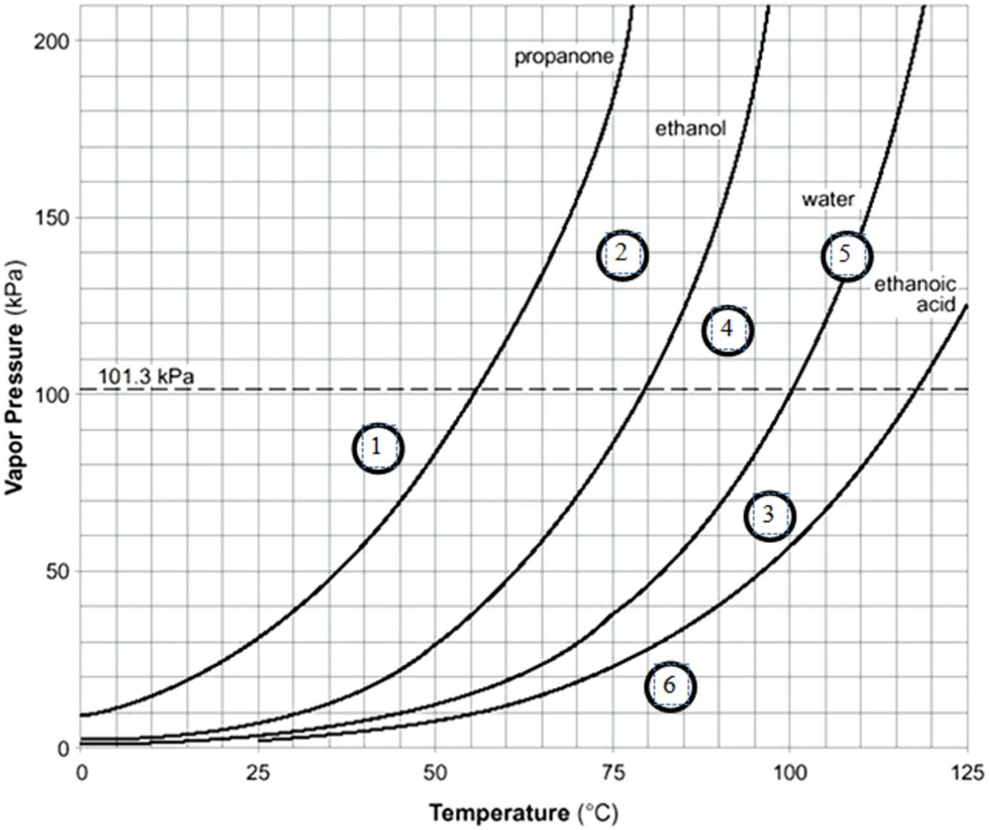
88. Get out your Table H now… fill in this chart.

At this Pressure	and Temperature	this compound	is a…
80 kPa	50°C	Ethanol	Liquid
110 kPa	95°C	Ethanol	
110 kPa	95°C	Water	
110 kPa	95°C	Ethanoic acid	
120 kPa	60°C	Propanone	

89. Get out your Table H now… fill in this chart.

At this Pressure	and Temperature	this compound	is a…
130 kPa	65°C	Propanone	
40 kPa	90°C	Ethanoic acid	
190 kPa	115°C	Water	
101.3 kPa	56°C	Ethanol	
20 kPa	10°C	ALL FOUR	

90.
Table H
Practice



At point	What phase is…	
1	propanone	liquid
2	propanone	
2	ethanol	
3	water	
3	ethanoic acid	
4	ethanoic acid	
4	ethanol	
5	ethanol	
5	water	
6	all 4 compounds	

97. The Kinetic Molecular Theory of Gases (KMT)

This theory explains how gases “work”. How is it that gases stay gases? How do they exist? How do the particles act with other particles of gas (atoms and or molecules)? How do scientists explain them?

A

B

C

D

E

What does this mean?

Gases are real and made up of atoms and molecules.
When these particles collide with each other and the sides of containers, pressure is exerted.
More collisions = higher pressure.
Gases are mostly empty space, and particle size is insignificant.
Collisions of course result in the loss of energy. Not a lot, but this loss should cause gases to turn to liquids over time as they run out of energy. They don’t because (really) the Sun comes out and rewarms the Earth every day. And we turn on the heat in our buildings too.

Gases usually stay gases, but the theory talks about perfection and real gases are not perfect