EPS 200

Name: Answers

Basic Chemistry and the Basis of Cloud Formation

Kinetic Molecular Theory of Gases: the idea that the behavior of gases can be understood by thinking of motions of individual particles (atoms, molecules, ionic compounds, ions…)

Atomic weight or relative atomic mass

hydrogen 1 H 1.0079																		helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 **	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

*Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
**Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]

Element: a substance that cannot be chemically broken down into a simpler substance; a type of atom

Atom: the basic unit of a chemical element; the smallest particle of an element that is still considered to be that element

Periodic Table of The Elements: a table organizing all of the known elements by atomic masses and other characteristics.

Molecule: a group of atoms bonded together by sharing electrons (electron sharing is indicated in Mr. Stapleton's drawings by lines connecting atoms)

"Air molecule:" one of a variety of molecules found in the atmosphere

Composition of the atmosphere (approximate):

- 78% N_2 (nitrogen)
- 20%O_2 (oxygen)
- 0.93%Ar (argon)
- 0.04% CO_2 (carbon dioxide)
- about 1% other stuff

Chemical Compound: more than one type of element chemically combined

Ion: a charged atom or molecule; charge may be + or -

Ionic Compound: multiple types of atoms held together by opposite charges

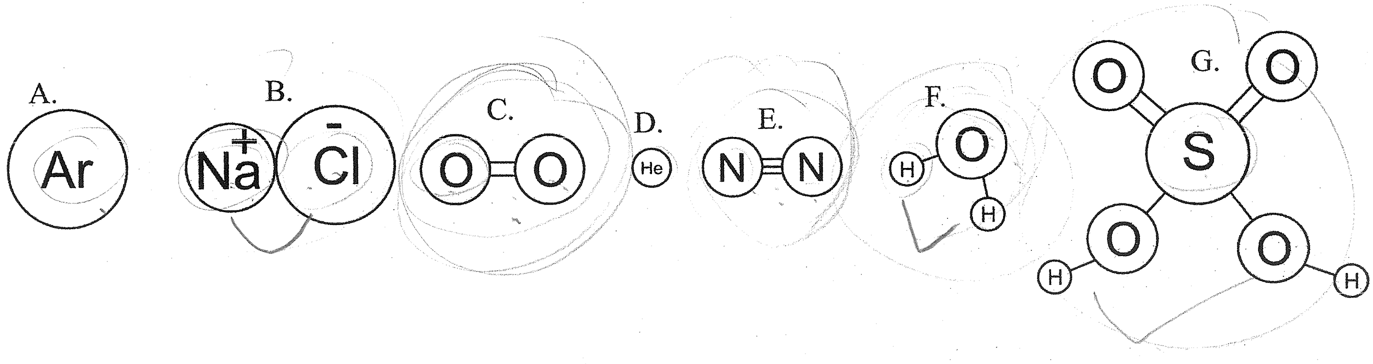
Mole: Avogadro 's number of particles = 6.02×10^{23}

Atomic "weight" of an atom (a.k.a. "relative atomic mass"): the mass, in grams, of one mole of those atoms. Bigger, heavier atoms have greater masses.

Molecular weight: the sum of the atomic weights of the atoms in a molecule

Chemical formula: a shorthand way of listing the numbers of atoms of each element in a compound. The symbol of each element in the substance is followed by the number of atoms of that element.

1. How many atoms are shown in the diagrams below? 18
2. How many elements? 8
3. How many molecules? 4
4. How many compounds? 3
5. How many ions? 2
6. Which lettered items are compounds but not molecules? B
7. Which lettered items are molecules but not compounds? C, E
8. Which items are neither molecules nor compounds? A, D
9. What is the molecular formula for the substance lettered "G?" H_2SO_4 SO_4H_2 H_2O_4S
10. Which substances are common "air molecules?" C, E, A
11. What is the atomic weight of item A?
12. What is the molecular weight of item F?



Temperature: the average kinetic energy of the molecules or atoms in a substance

Kinetic Energy: Energy of motion; think of it as the energy required to set something in motion at a given speed

Kinetic Energy Formula: $KE = \frac{1}{2} mv^2$

13. How is temperature related to molecule speed?

Faster molecules are hotter

14. At the same temperature (same kinetic energy), which molecules move faster, big ones or little ones? Explain.

Little ones. In order to have as much energy (temperature), they need to move faster to make up for their small mass.

Heat: the transfer of thermal energy

$KE = \frac{1}{2} m v^2$ if mass is small, v must be bigger

Thermal Energy of a substance: the total kinetic energy of the molecules moving *within* the substance

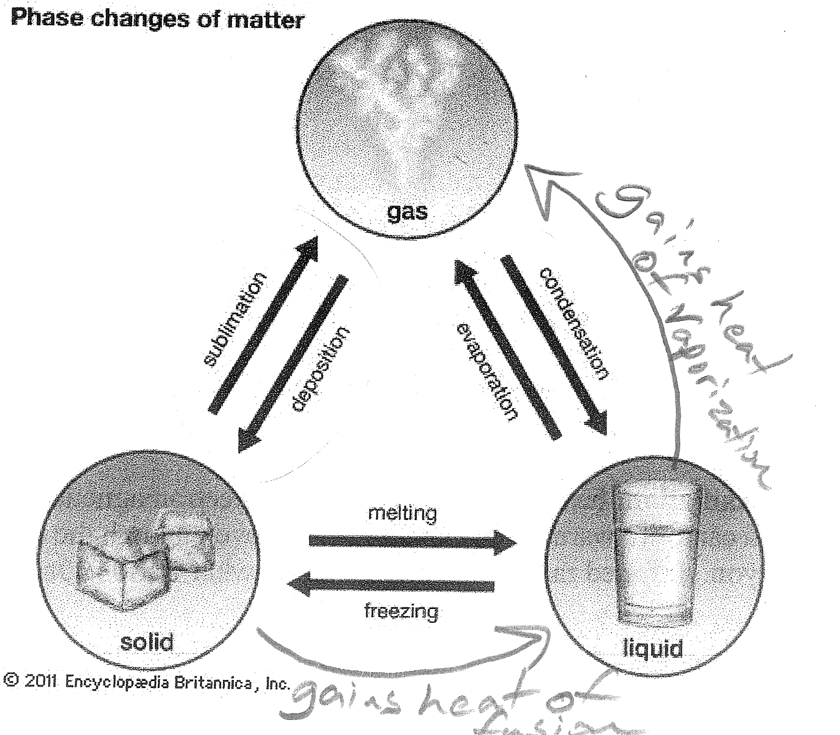
15. Which has more thermal energy, a swimming pool full of 50 degree water or a cup full of 95 degree water?

The pool has more thermal energy. Even though its molecules each have lower energy, its vast number of molecules make the total energy extremely high.

States of Matter (a.k.a. phases of matter)

Solid phase: Molecules (or individual atoms)are locked in place, touching one another, vibrating. Hotter solids vibrate more violently.
Liquid phase: Molecules are touching one another, but sliding and bumping around and changing positions; flowing. Hotter liquid molecules slide and bump around faster.
Gas phase: Molecules flying free, but occasionally bumping into one another. Hotter gas molecules fly faster.

Phase changes of matter

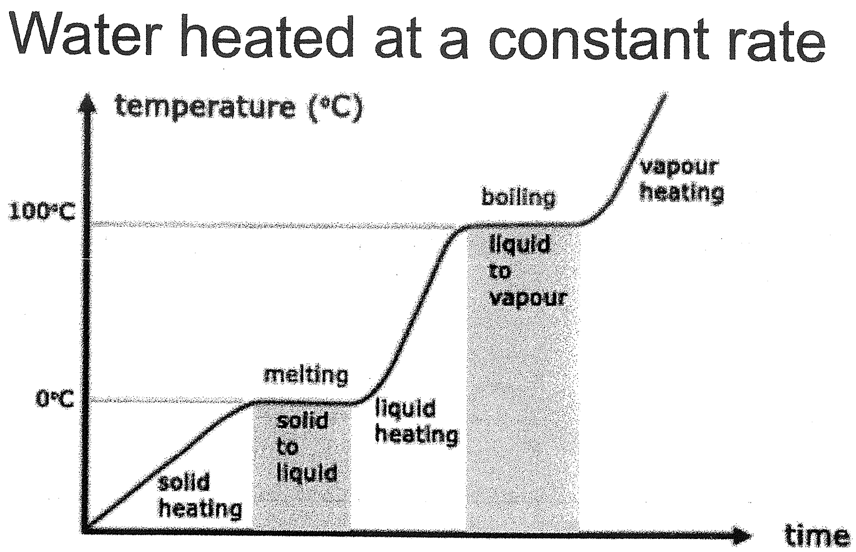


Evaporate: turn from a liquid to a gas
Condense: turn from a gas to a liquid
Melt: turn from a solid to a liquid
Freeze: turn from a liquid to a solid

Latent Heat of Vaporization: the energy that must be added to a substance to allow it to turn from liquid to gas (and which must be removed in order for a gas to turn to a liquid). *Heat of vaporization does not change a substance's temperature; it only changes the substance's phase (see diagram).*

Latent Heat of Fusion: the energy that must be added to a substance to allow it to turn from solid to liquid (and which must be removed in order for a liquid to turn to a solid). *Heat of fusion does not change a substance's temperature; it only changes the substance's phase. (see diagram).*

"Latent" means existing but not yet revealed; hidden. As the diagram below shows, as latent heat is being added, there is no change in the temperature of the water, so the effect of the heat is (in a way) "hidden."



16. Why do humans sweat?

When we sweat, our sweat (hopefully) evaporates. Evaporation requires heat. That heat is taken from us, making us cooler.

17. Why is salt added to ice in the traditional process of making ice cream?

Salt melts ice. Ice needs heat to melt. Ice takes that heat from the cream.

Conduction: heat transfer by touch; when hot object A touches cold object B, the rapidly moving molecules of object A bump into the molecules of object B, causing them to begin moving. The molecules of object A lose some energy in the process, thus cooling down.

Convection: heat transfer by the flow of warm fluid (e.g. blobs rising in a lava lamp carry energy via convection)

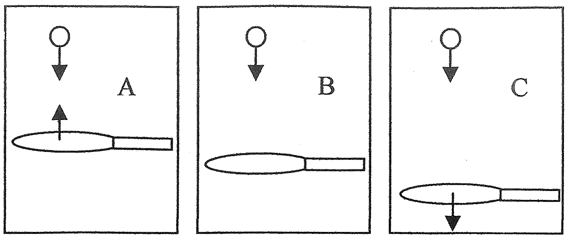
Radiation: heat transfer by photons in electromagnetic waves – no touch and no movement of fluid (e.g. a campfire warms you from a distance even though the air around you flows toward the fire, not toward you. Infrared radiation from the fire is what warms you.)

18. If you inflate a balloon and tie it off, heating will cause the balloon to expand, and cooling will cause it to shrink. Explain why in terms of molecular motion.

Hotter → faster molecules. → molecules push the sides of the balloon out with more force

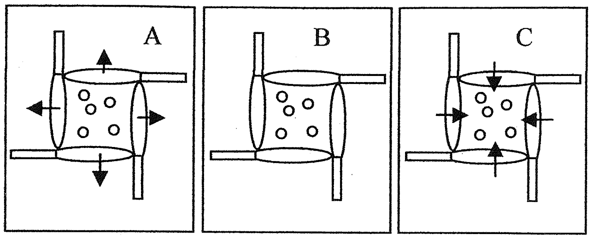
Adiabatic Change

In the three pictures on the right, a "perfectly bouncy" ping pong ball is dropped onto a "perfectly bouncy" ping pong paddle.



19. In which situation will the ball speed up the most (and bounce highest) after being hit by the paddle?
20. In which situation will the ball slow down the most (and bounce the least) after being hit by the paddle?
21. In which situation will the ball's speed remain approximately the same after hitting the paddle?

The three pictures on the right show "boxes" which have tennis rackets for walls. Inside the boxes, tennis balls are bouncing around. In one box, the walls are pushing inward against the balls. In another box, the rackets are relaxed, allowing the balls to push them out. In a third box the walls are held stationary.



22. In which "box" will the walls' behavior cause the balls to speed up?

23. In which "box" will the walls behavior cause the balls to slow down?

24. In which "box" will the walls behavior not affect the balls' speeds?

25. Why does rapidly compressing a gas cause the temperature to increase?

Compression pushes the molecules, speeding them up.

26. Why does allowing a gas to rapidly decompress cause its temperature to decrease?

As molecules expand and push outward they ~~use up~~ lose energy in the act of pushing.

Make a cloud in a bottle

Complete these steps and then answer the questions that follow:

Get a clear 2-Liter bottle with a cap.

a. Get the inside of the bottle wet by putting water in it and shaking the water around. Then pour out the water.
b. Light a match and get it burning well. Blow it out as you place it in the bottle. The point is to get some smoke the bottle. Cap the bottle tightly before the smoke escapes.
c. Now squeeze the bottle as hard as you can for one second.
d. Stop squeezing and let the bottle expand for one second.
e. Squeeze again for another second, with all of your might. But don't jump on the bottle. This should be a steady squeeze.
f. Release your squeeze.
g. Squeeze again….
h. Keep repeating this until you see a cloud forming and disappearing. Pay close attention to when the cloud is appearing and when it is disappearing. Holding the bottle in a bright light with a dark background will make the cloud easier to see.

27. Do you see a cloud when you squeeze or when you release?

28. Explain why the cloud appears. Make sure you mention the effect of your action on the pressure and temperature inside the bottle, as well as the phase of the water.

Squeezing increases pressure, and increased pressure raises temperature. Increased temperature causes water in bottle to evaporate.

29. ~~Do you think this~~ would this work without the smoke? Why or why not?

No. Droplets need smoke or dust particles to condense upon.

30. If the weatherman says the air pressure is dropping, should you expect clear or cloudy skies?

Releasing decreases temperature and pressure. Cooling causes water in air to condense into droplets.

Cloud Formation at the Equator:

The equator is one of the rainiest parts of the world. At the equator, the Sun's rays warm the ocean's surface as well as the air near the ocean's surface. Explain how this warming of the ocean and the air above it causes cloud formation at the equator.

The warmth at the ocean's surface transfers heat to the ocean water, causing the speed of water and air molecules to increase (increase or decrease). Eventually, the water molecules have gained enough energy to evaporate (evaporate or condense). Their state of matter turns from liquid to gas, and they leave the ocean to become an invisible part of the warm air near the ocean's surface. The energy the water molecules have gained in order for this change to occur is called latent heat of vaporization.

Another effect of this increasing warmth near the ocean's surface is that the surface air's volume begins to increase. This change in volume causes the air's density to decrease. This density change causes the air to rise (rise or sink). As it moves upward, this rising mass of air carries heat with it, so it is called a convection (conduction, convection, or radiation) current. As the air rises, it encounters lower (higher or lower) air pressure. This change in air pressure causes the volume of the air to increase, and it causes the temperature of the air to decrease. This new change in the temperature of the air causes the speed of the air molecules to slow down. As the air rises, this temperature change causes water molecules to change phase (state) again from gas to liquid. When this happens, tiny droplets of water form around specs of dust, creating clouds. At first the droplets are too small and light to fall to the ground. They fall so slowly that even gentle updrafts keep pushing them back up. Eventually, when enough individual droplets coalesce, they form bigger drops that fall fast enough to make it to the ground.