EPS (Stapleton)
Temperature, Pressure, and Composition of The Universe

Name: A 5/6

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

Periodic Table of the Elements

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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]	darmstadtium 110 Ds [271]	roentgenium 111 Rg [272]	ununbium 112 Uub [277]	ununtrium 113 Uut [284]	ununquadium 114 Uuq [289]	ununpentium 115 Uup [288]	ununhexium 116 Uuh [292]	ununseptium 117 Uus [291]	ununoctium 118 Uuo [294]

■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]

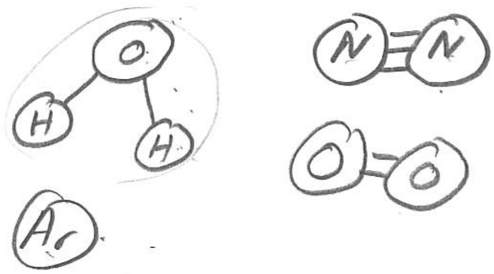
Element: a substance that cannot be chemically broken down into a simpler substance; a type of atom

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

Gas Particle: A single atom or a group of connected atoms that move together in a gas. [Gas particles can be atoms, molecules, and/or compounds.]

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)



"Particle of Matter:" one of a variety of molecules and atoms (or ionic compounds); To simplify understanding the effects of temperature and pressure change, you can think of any particle as a tiny sphere.

Composition of the particles in the Universe (by mass)

Hydrogen: 74% of elements in universe, by mass.

(H)-(H) ← H_2 (H)$^+$ ← H^+

Helium: ≈ 24%   (He) ← He

Other Stuff: ≈ 2%

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

Kinetic Energy: Energy of motion; things have more kinetic energy when they have more mass and velocity

Kinetic Energy Formula: $KE = \frac{1}{2} mv^2$ v = velocity   m = mass

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

Solid phase: Particles are locked in place, touching one another, vibrating. Hotter solids vibrate more violently.

Liquid phase: Particles are touching one another, but sliding and bumping around and changing positions; flowing. Hotter liquid particles slide and bump around faster.

Gas phase: Particles are flying free, but occasionally bumping into one another. Hotter gas particles fly faster.

Evaporation: turning from liquid to a gas; requires added energy.

Condensation: turn from a gas to a liquid; requires removal of energy.

Melt: turn from a solid to a liquid; requires added energy.

Freeze: turn from a liquid to a solid; requires removal of energy.

Temperature Changes Can Cause Pressure Changes

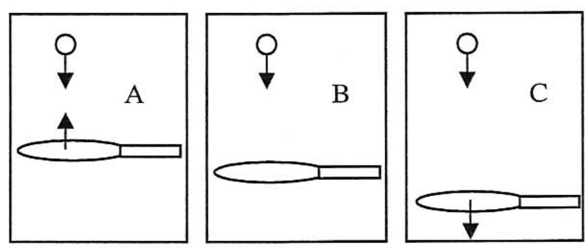
1. When nuclear fusion begins in a star, the process of nuclear fusion increases the star's temperature. What immediate effect does this temperature increase have on the pressure inside the star? Pressure increases

2. Explain why.
As temperature rises, particles move faster, pushing away from each other with more force.

3. What effect does this change in pressure have on the star's volume? Why?
Volume increases. Particles push harder against one another, so they spread out.

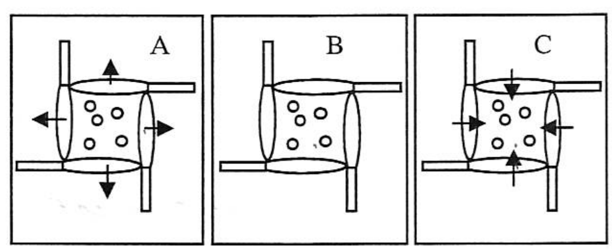
Pressure Changes Can Cause Temperature Changes

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



4. In which situation will the ball speed up the most (and bounce highest) after being hit by the paddle? A
5. In which situation will the ball slow down the most (and bounce the least) after being hit by the paddle? C
6. In which situation will the ball's speed remain approximately the same after hitting the paddle? B

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.



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

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

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

10. What happens to the temperature of a dying star as it collapses and gravity squeezes it together? Why? Temp. rises, because compression speeds up the particles, making them hotter.

11. If the Universe is expanding, what is happening to its overall average temperature? Why?
Temp is decreasing, because expansion slows down the particles, making them cooler.

12. a. Give an example of heating causing something to expand.

Nuclear fusion heats a star, causing it to expand.

b. Give an example of compression causing something to heat up.

Gravity compressed the Earth, heating up the core.

c. Give an example of cooling causing something to shrink.

When nuclear fusion stops, the sun will cool and shrink.

d. Give an example of expansion causing something to cool down.

The Universe is getting colder because it is expanding.

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.

☆ Cloud ⇒ Tiny liquid H_2O droplets (visible)
☆ Clear ⇒ H_2O is a gas (invisible)

13. When you squeeze…

a. What happens to the pressure in the bottle?

Pressure increases

b. Are you pushing the gas particles in the bottle, or are they pushing you?

I'm pushing them

c. Are the gas particles gaining or losing energy?

They are gaining energy (and I'm losing it)

d. Is the gas temperature increasing or decreasing?

Temp is increasing (more energy)

e. Do you see a cloud appear or disappear? Why?

Disappear. Adding energy causes H_2O to turn to a gas and become invisible

14. When you release, do you see a cloud appear or disappear? Why?

Cloud appears, because releasing allows the air to expand. This cools it down and causes H_2O to condense into a liquid, which is visible as a cloud of tiny drops