NAME:______________________________________ DATE:________________________ PERIOD:

AP CHEMISTRY REVIEW WORKSHEET

(Unit 5 – The Gas Laws)

1. Nitrogen gas has a pressure of 452 mmHg. What is this pressure in atmospheres? In kilopascals?

$$\frac{452\,\text{mmHg}}{}\left|\frac{1\ \text{atm}}{760\ \text{mmHg}}\right. = \boxed{0.595\,\text{atm}}$$

$$\frac{452\ \text{mmHg}}{}\left|\frac{101.3\ \text{kPa}}{760\ \text{mmHg}}\right. = \boxed{60.2\ \text{kPa}}$$

2. A sample of a certain gas has a volume of 452 mL at 711 mmHg and 26°C. What would be the volume of this same sample of gas if it were measured at STP?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad \frac{(711\text{mmHg})(452\text{mL})}{299\text{K}} = \frac{(760\text{mmHg})(x)}{273\text{K}}$$

$$\boxed{x = 386\ \text{mL}}$$

3. What is the pressure exerted by 0.981 grams of sulfur dioxide gas placed in a 250. mL container at a temperature of 25°C?

$$\frac{0.981\text{g } SO_2}{}\left|\frac{1\ \text{mol}}{64.07\text{g } SO_2}\right. = 0.0153\text{mol } SO_2$$

$$PV = nRT$$

$$P = \frac{(0.0153)(.08206)(298)}{.250L} = \boxed{1.50\ \text{atm}}$$

4. What is the molar mass of an unknown gas if the density of that gas is 0.762 g/L at a pressure of 0.634 atm and a temperature of 25°C?

$$D = \frac{mP}{RT} \qquad M = \frac{(.762\text{g/L})(.08206)(298\text{K})}{.634\ \text{atm}}$$

$$\frac{DRT}{P} = M \qquad = \boxed{29.4\ \text{g/mol}}$$

5. For a given sample of gas molecules, the average kinetic energy depends only on the value of the

a. pressure b. volume c. moles [✓ d.] temperature

Dalton's Law of Partial Pressures

1. A eudiometer tube holds hydrogen gas with a pressure of 735.5 mm Hg and water vapor with a pressure of 10.0 mm Hg. What is the total pressure in the tube? 745.5 mm Hg

2. The gas in a eudiometer has a total pressure of 750.0 mm Hg. If 740.0 mm Hg is due to pressure of hydrogen gas, what pressure is due to water vapor? 10.0 mm Hg

3. You have 2.5 moles hydrogen gas, 3.5 moles oxygen gas, and 4.0 moles nitrogen gas. What is the mole fraction of each gas?

H_2 $\frac{2.5}{10}$ = .25

O_2 $\frac{3.5}{10}$ = .35

N_2 $\frac{4.0}{10}$ = .40

4. You have 3.0 grams of hydrogen gas, 10.0 grams of oxygen gas, and 50.0 grams of nitrogen gas. What is the mole fraction of each gas?

~~H_2 3.0 / 63.0 = 0.048~~

~~O_2 10.0 / 63.0 = 0.159~~

~~N_2 50.0 / 63.0 = 0.794~~

$\frac{3.0\text{g}}{} \Big| \frac{1}{2.016}$ = 1.5 mol H_2 → .42

$\frac{10.0\text{g}}{} \Big| \frac{1}{32.00}$ = 0.313 mol O_2 → 0.092

$\frac{50.0\text{g}}{} \Big| \frac{1}{28.02}$ = 1.78 mol N_2 → 0.495

3.593 total moles

5. A container holds 5.0 g of helium and 10.0 g of oxygen. What is the mole fraction of each gas?

He $\frac{5\text{g}}{} \Big| \frac{}{4.00}$ = 1.25 mol → .800

O_2 $\frac{10.0\text{g}}{} \Big| \frac{1}{32.00}$ = 0.3125 mol → 0.200

1.5625

pg 3

6 H_2 = .25 P_i = (.25)(800.0 mmHg) = 200 mmHg
O_2 = .35 P_i = (.35)(800.0 mmHg) = 280 mmHg
N_2 = .40 P_i = (.40)(800.0 mmHg) = 320 mmHg

refers to question #3

7. H_2 - .42 P_i = (.42)(650.0) = 273 mmHg
O_2 = .092 P_i = (.092)(650.0) = 59.8 mmHg
N_2 = .495 P_i = (.495)(650.0) = 322 mmHg

refers to question #4

8. He = .800 P_i = (.800)(760.0mmHg) = 608 mmHg
O_2 = .200 P_i = (.200)(760.0 mmHg) = 152 mmHg

refers to question #5

AP Chemistry - Graham's Law of Effusion & RMS Worksheet

1. Under the same temperature conditions what will be the ratio of the rates of effusion of nitrogen to carbon dioxide?

$$\frac{\text{Rate A}}{\text{Rate B}} = \frac{\sqrt{MM_{CO_2}}}{\sqrt{MM_{N_2}}} = \frac{\sqrt{44.01}}{\sqrt{28.02}} = 1.253$$

N_2 effuses 1.253 times faster than CO_2

2. A store receives a shipment of defective balloons. Each has a tiny pinhole of the same size. If one balloon is filled with helium and another is filled with air to the same volume and pressure, which balloon will deflate faster and how much faster? $\rightarrow N_2$ air is mostly N_2

$He = 4.00$

$N_2 = 28.02$

$$\frac{\text{Rate A}}{\text{Rate B}} = \frac{\sqrt{28.02}}{\sqrt{4.00}} = 2.647$$

He will deflate faster by 2.647 times

3. Under the same conditions of temperature and pressure, does hydrogen iodide or ammonia effuse faster? Calculate the relative rates at which they effuse.

$HI = 127.918 \text{ g/mol}$

$\boxed{NH_3 = 17.034}$

moves faster

$$\frac{\text{Rate } NH_3}{\text{Rate } HI} = \frac{\sqrt{127.918}}{\sqrt{17.034}} \quad \boxed{2.74}$$

4. Solar energy may someday be used to split water into hydrogen and oxygen and the hydrogen then used as a fuel. The different rates of effusions of hydrogen and oxygen from a mixture of the two and through a very tiny hole might be the basis of separating them. Which gas effuses more rapidly, and by what relative amount?

$\boxed{H_2 = 2.016}$

$O_2 = 32.00$

$$\frac{\text{Rate } H_2}{\text{Rate } O_2} = \frac{\sqrt{32.00}}{\sqrt{2.016}} = \boxed{3.98}$$

H_2 diffuses 3.98 times more rapidly.

5. What is the formula weight of a gaseous element if at room temperature it effuses though a pinhole 2.16 times as rapidly as xenon? Which element is it?

$$2.16 = \frac{\sqrt{131.29}}{\sqrt{x}} = 28.14 \text{ g/mol}$$

Silicon

6. Compute the relative velocities of H_2 and CO_2 through a fine pin-hole in a barrier.

H_2 : 2.016

CO_2 : 44.01

$$= \frac{\sqrt{44.01}}{\sqrt{2.016}} = \boxed{4.672}$$

7. A small bicycle pump is filled with helium (He) gas. With constant pressure, the gas is forced out through a small aperture in two seconds. The same pump is filled with hydrogen bromide (HBr) gas. Using the same pressure, how long will it take to force out this gas?

He = 4.00

HBr = 80.908

$$\frac{\text{Rate He}}{\text{Rate HBr}} = \frac{\sqrt{80.908}}{\sqrt{4.00}} = 4.497 \text{ times faster}$$

4.497 x 2seconds = $\boxed{8.99 \text{ seconds}}$

8. Calculate the relative rates of diffusion of $H_2(g)$ and $Br_2(g)$ at the same temperatures.

H_2 = 2.016

Br_2 = 159.8

$$\frac{\sqrt{159.8}}{\sqrt{2.016}} = \boxed{8.903}$$

9. A bicycle pump is filled with helium (He) gas. With constant pressure, the gas is forced out through a small aperture in five seconds. How long will it take to expel sulfur dioxide, SO_2, from this same pump under the same constant pressure?

He = 4.00

SO_2 = 64.07

$$\frac{\text{Rate He}}{\text{Rate } SO_2} = \frac{\sqrt{64.07}}{\sqrt{4.00}} = 4.00$$

5seconds x 4.00 = $\boxed{20 \text{ seconds}}$

10. An unknown gas effuses through a capillary in 60 seconds. The same volume of hydrogen escapes in 10 seconds. Calculate the molecular mass of the unknown gas.

hydrogen travels 6 times faster

$$6 = \frac{\sqrt{x}}{\sqrt{2.016}}$$

$$\boxed{x = 72.58 \text{ g/mol}}$$

11. Rate perfume = $\frac{4m}{12s}$ = .33 m/s

$$\frac{x}{.33} = \frac{\sqrt{400}}{\sqrt{255}}$$

x = .417 m/s

Rate knockout gas = $\frac{.417 m/s}{1s}$ = $\frac{5m}{x + \cancel{1.5}}$

~~.417(x+1.5) = 5~~

~~.417x + .6255 = 5~~

~~.417x = 4.3745~~

~~x = 10.49 seconds~~

~~will not get caught~~

$.417 = \frac{5 min}{x}$

x = 12 seconds + 1.5

13.5 seconds

→ will not get caught b/c by the time they smell the perfume the gas has already reached him

12. $U_{rms} = \sqrt{\frac{3 \cdot 8.314 \cdot 431}{.097994}}$ = $\boxed{331 m/s}$

H_3PO_4 → 97.994 g/mol

.097994 kg/mol

* 13. $U_{rms} = \sqrt{\frac{3 \cdot 8.314 \cdot 452}{.222}}$ = $\boxed{225 m/s}$

14. $U_{rms} = \sqrt{\frac{3 \cdot 8.314 \cdot 647}{.35203}}$ = $\boxed{214 m/s}$ UF_6 = 35203

15. $U_{rms} = \sqrt{\frac{3 \cdot 8.314 \cdot 511}{.101006}}$ = $\boxed{355 m/s}$ H_2Cl_2Si = 101.006

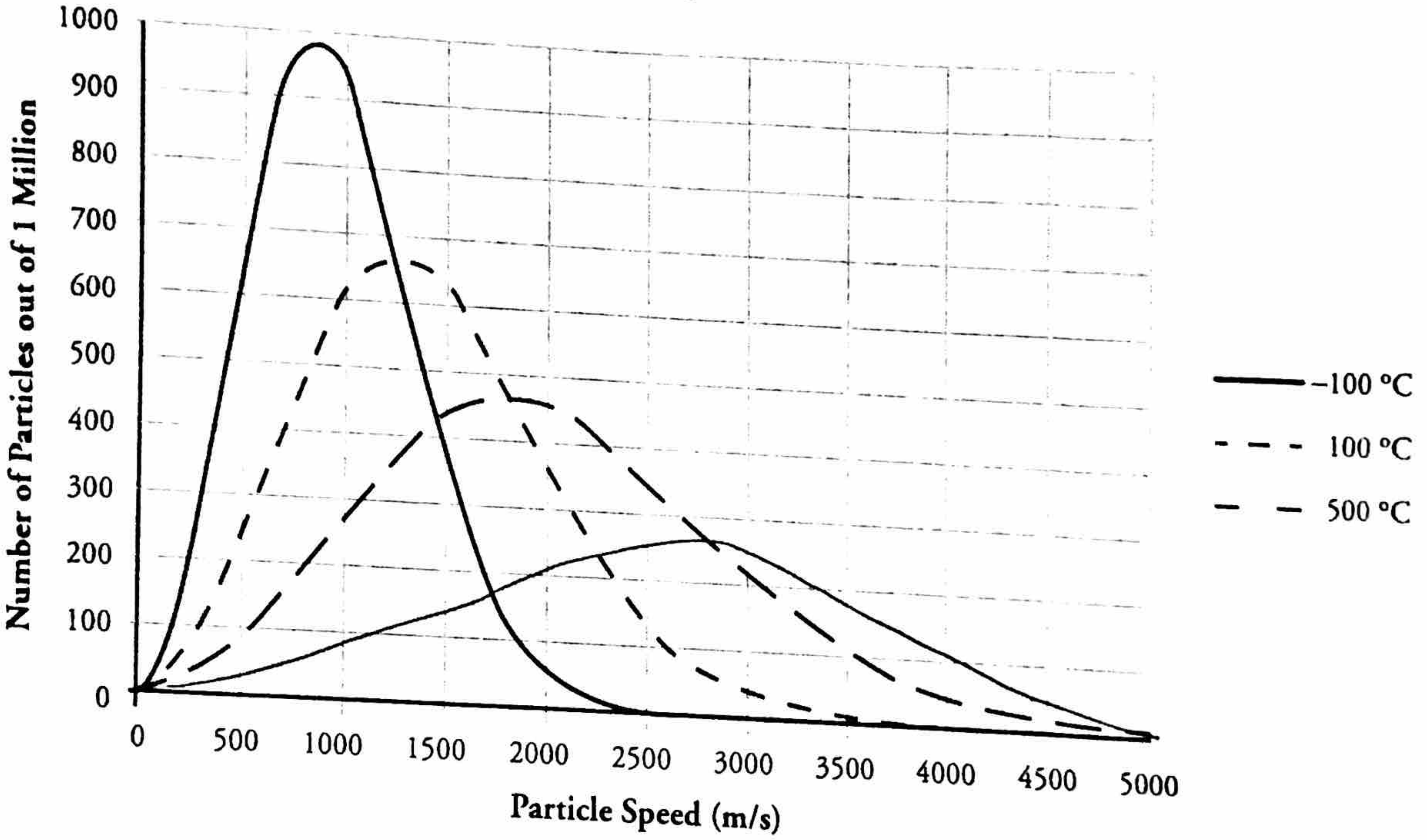
Maxwell-Boltzmann Distributions

How does temperature change the speed of gas particles?

Why?

When a sample of matter is heated, the particles speed up. But what does that mean? Are all the particles in a sample moving at the same speed? Do they all speed up equally? Does mass affect particle speed? Two scientists, James Maxwell and Ludwig Boltzmann, proposed an equation that could be used to predict the speeds of ideal gas particles (atoms or molecules) at any temperature. Their equation is based on statistics and thermodynamic relationships. It is used by chemists and physicists to predict properties of gases such as pressure and diffusion rates, and it can be used to predict rates of reactions involving gases.

Model 1 – Helium at Different Temperatures



1. Consider the graph in Model 1.
   a. What is the variable and unit of the *x*-axis?

   m/s

   b. Particles of what substance are represented in the graph?

   Helium

   c. How many particles are represented in the graph?

   3 million

   d. What temperatures are represented in the graph?

   -100°C, 100 °C, 500°C

7

2. According to Model 1, do all of the gas particles in a sample move at the same speed for a given temperature? Justify your answer with evidence from Model 1.

No, there is a range of speeds that particles move. This is based on the curves shown in the graph

3. According to Model 1, approximately how many gas particles in the sample are traveling 1000 meters per second?

a. at −100 °C? 950

b. at 100 °C? 620

c. at 500 °C? 270

4. According to Model 1, approximately how many gas particles in the sample are traveling 2500 meters per second?

a. at −100 °C? 0

b. at 100 °C? 130

c. at 500 °C? 350

5. Explain why the 500 °C curve is flatter in Model 1 than the −100 °C curve.

there is a wider range of possible speeds for the particles to move

6. At what temperature are the helium particles in the sample moving the slowest on average?

-100°C

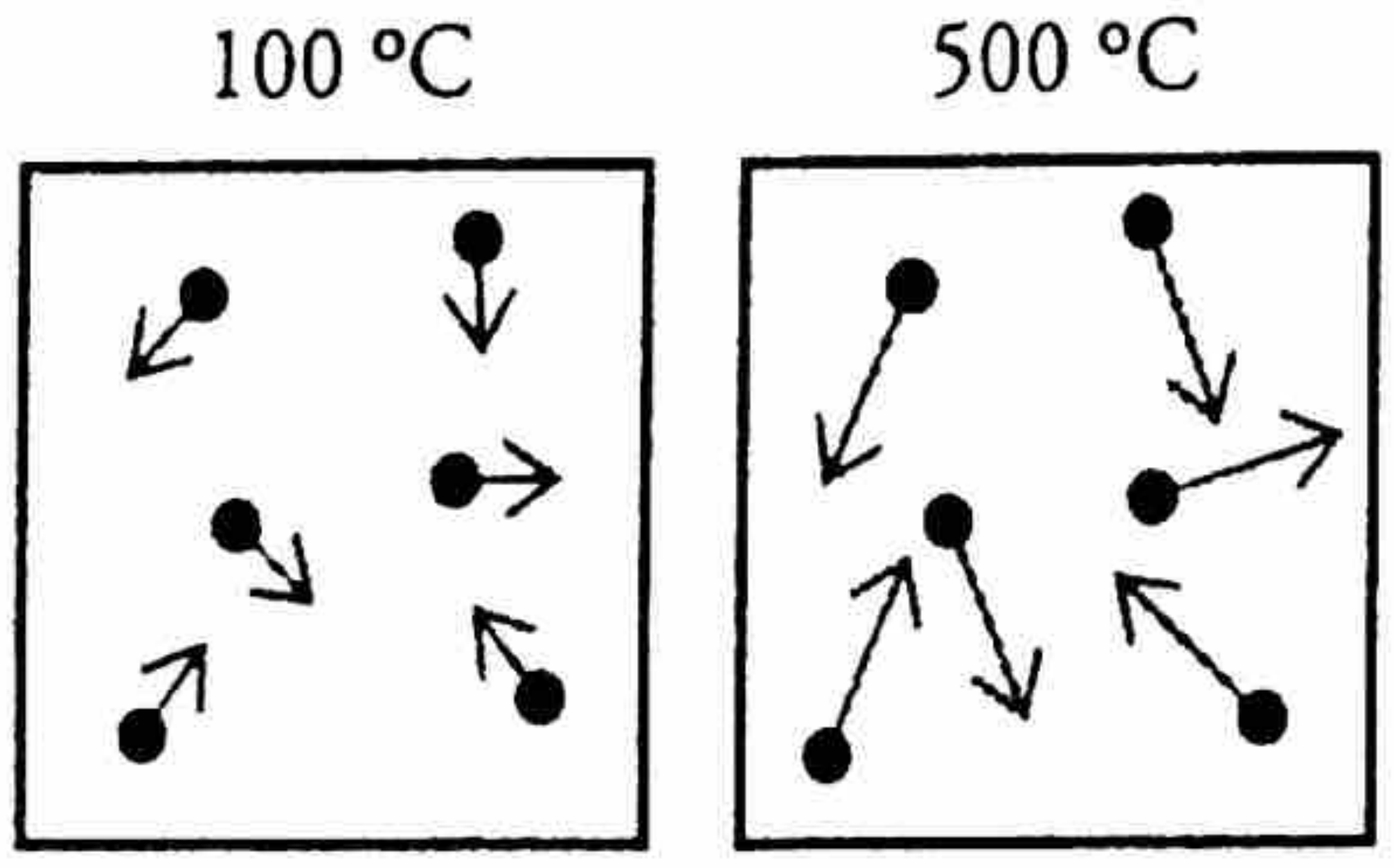
7. At what temperature are the helium particles in the sample moving the fastest on average?

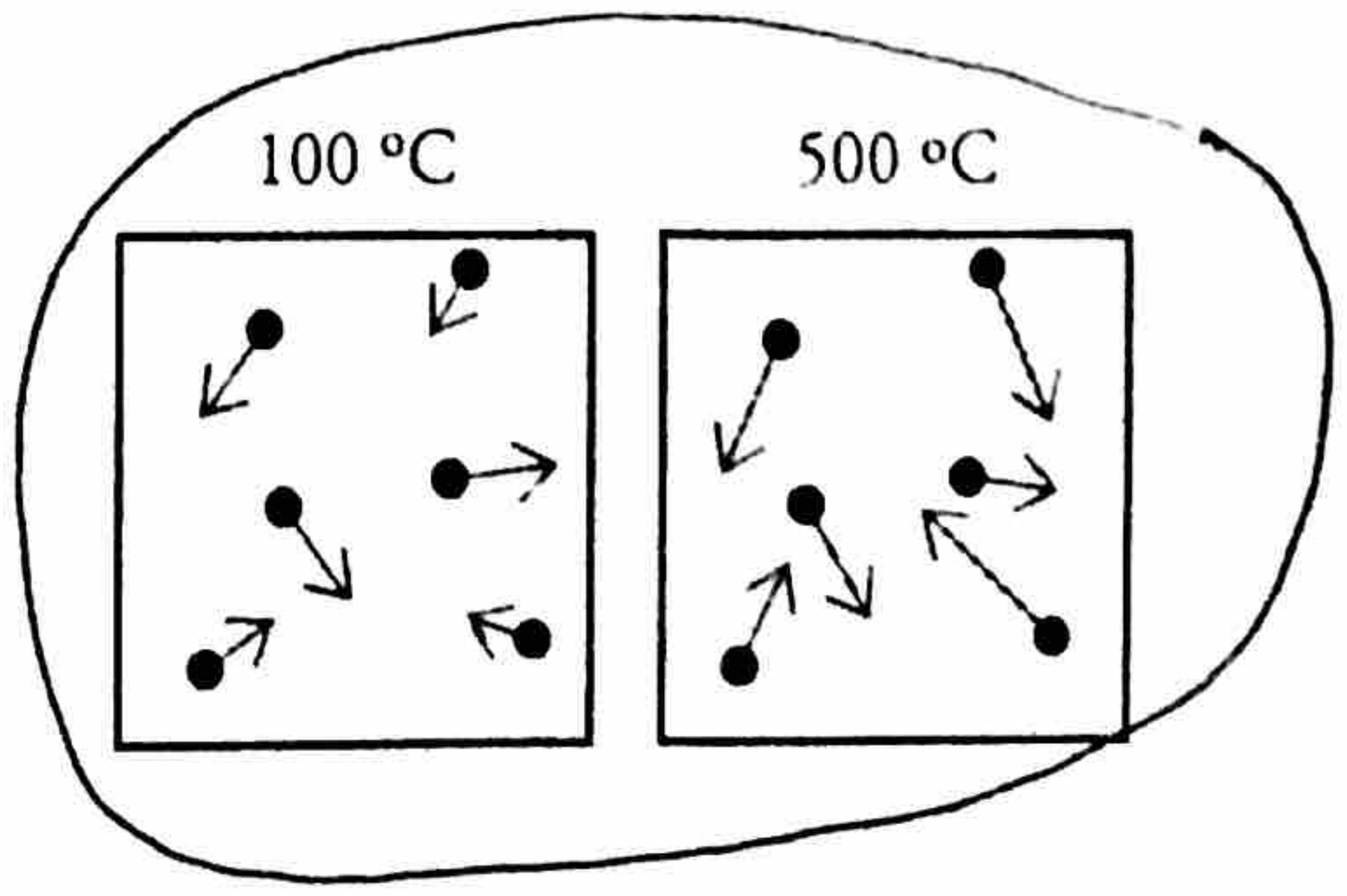
500°C

8. When a sample of gaseous matter is heated, do all of the particles in the sample speed up? Justify your answer with evidence from Model 1.

No they do not, there are some particles, for all three temps, that particles are moving at 0 m/s

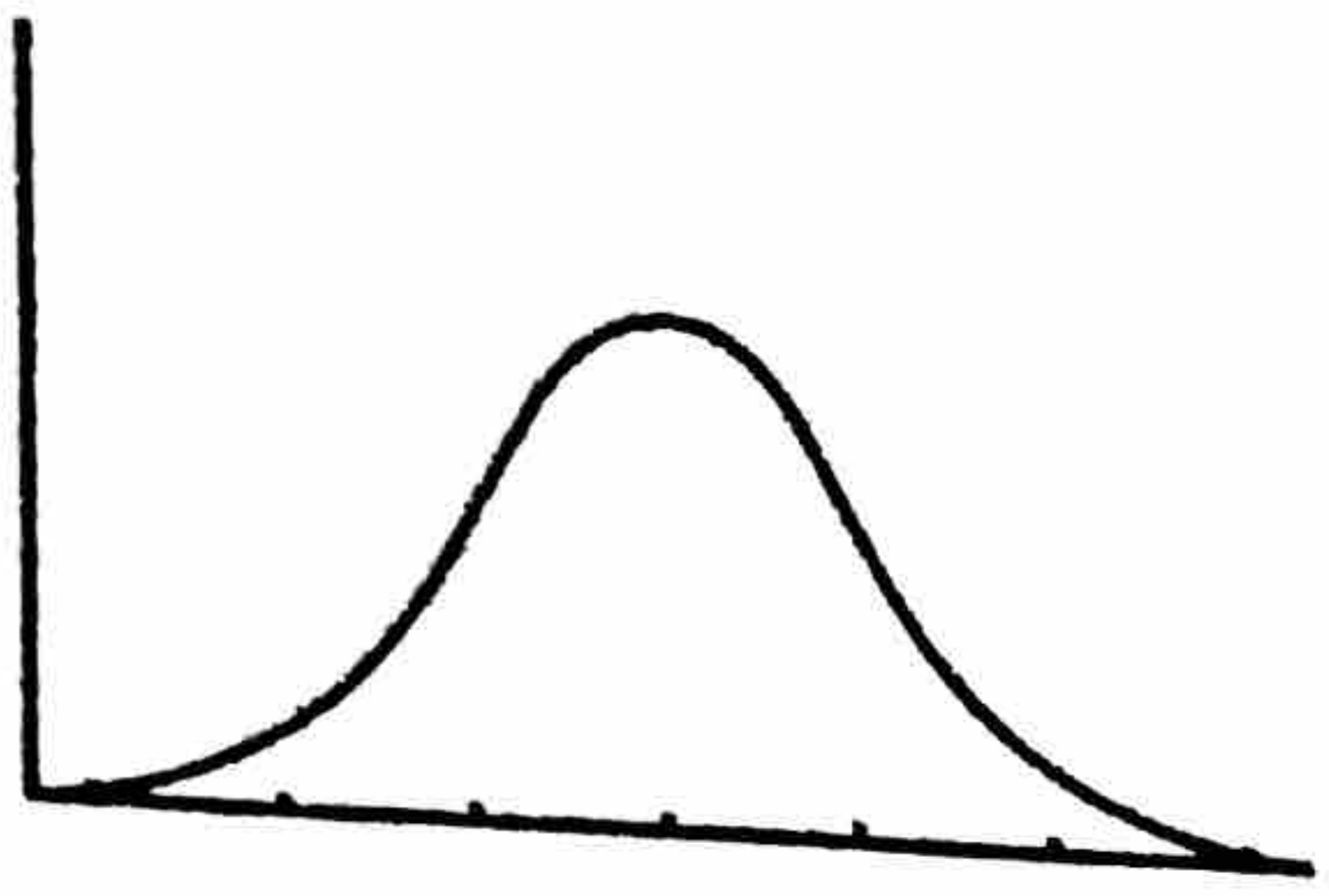
9. Circle the set of drawings below that more accurately illustrates the difference in particle speeds for particles of helium at 100 °C and 500 °C? Justify your reasoning. *Hint:* The longer the arrow, the faster the particle is moving.



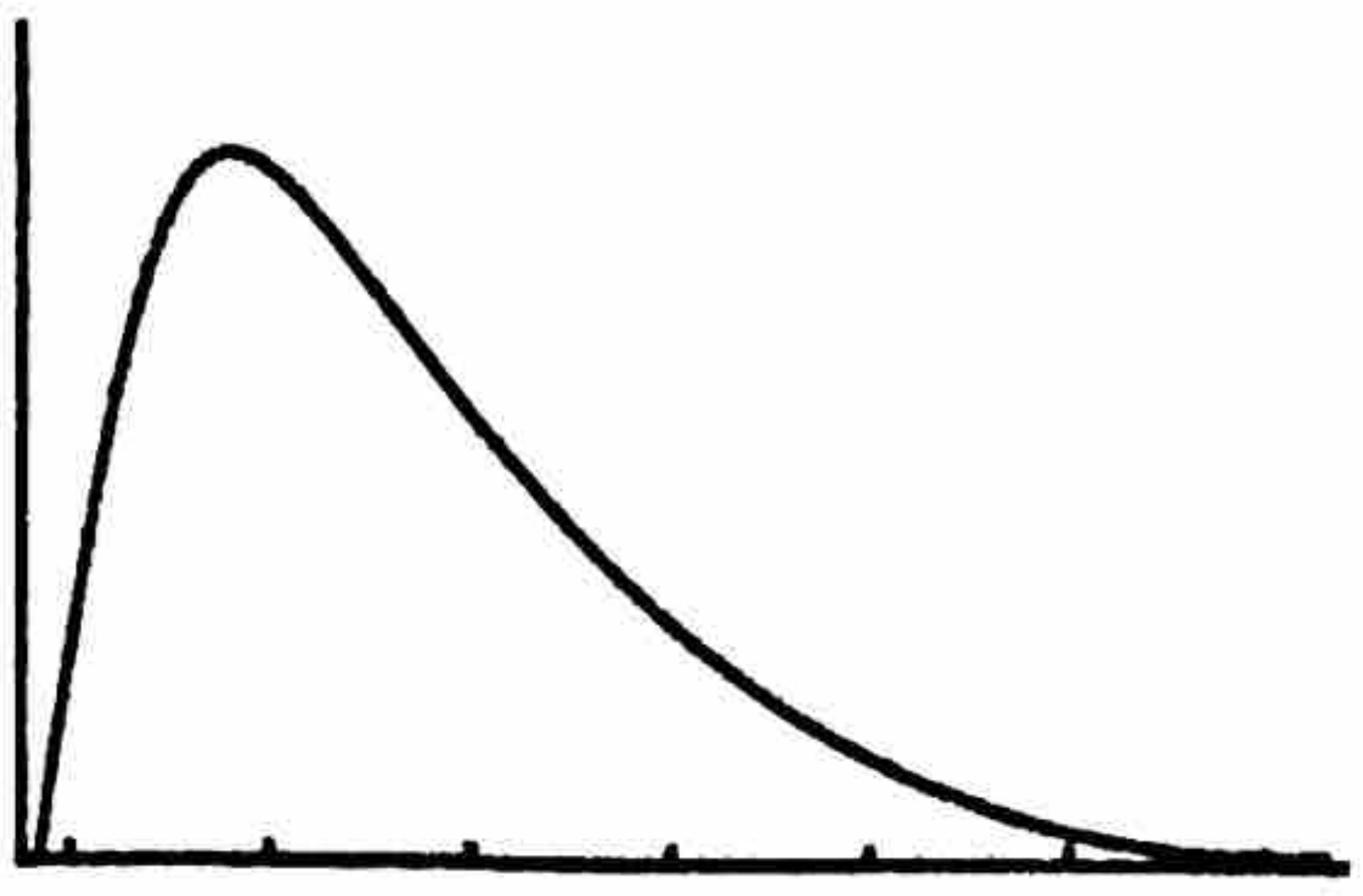


Read This!

The distribution curves in Model 1 are based on the mathematical equation developed by Maxwell and Boltzmann. Their shape is generally a bell curve, but they are skewed to the right.



Normal bell curve



Right-skewed bell curve

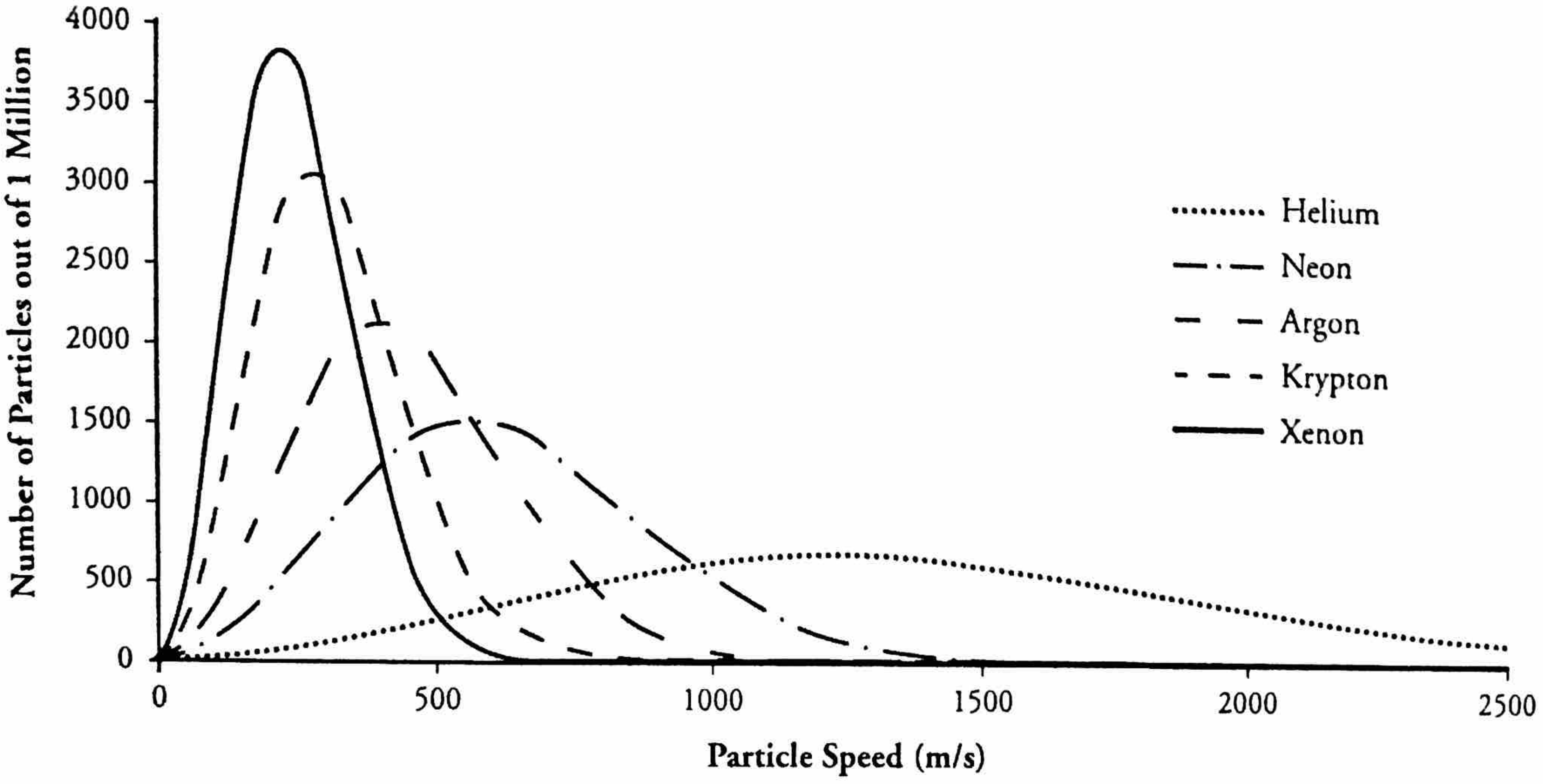
Bell curves are used by mathematicians to model the properties of large groups of things. There will always be some variation to the property, but values in the middle of that range tend to be exhibited more often by members of the group than the extremes. On a normal bell curve, the average value is also the value exhibited by the group most often. The left edge of Maxwell-Boltzmann distributions are limited by a speed of zero—particles cannot have negative speeds. The right edge, however, can extend to very high speeds—theoretically to infinitely high speeds. This causes the distribution to be skewed. The average value is not necessarily the value that is exhibited by the group most often.

10. Describe how the distribution curve for the speeds of particles in a sample changes as the sample is heated.

As the sample is heated the distribution curve shifts more to a bell curve than a right-skewed bell curve

11. Predict the distribution curve for a sample of helium at a temperature of 800 °C. Draw this curve on Model 1.

Model 2 – Noble Gases at 100 °C



12. List the noble gases that are represented in the graph in Model 2 with their average atomic masses.

He - 4.00
Ne - 20.18
Ar - 39.95
Kr - 83.80
Xe - 131.29

13. Which variable explains the difference in distribution curves for the different noble gases in Model 2—temperature or mass? Explain your reasoning.

mass because the temperature was constant for all of them at 100°C

14. Which noble gas has the slowest average particle speed at 100 °C?

Xe

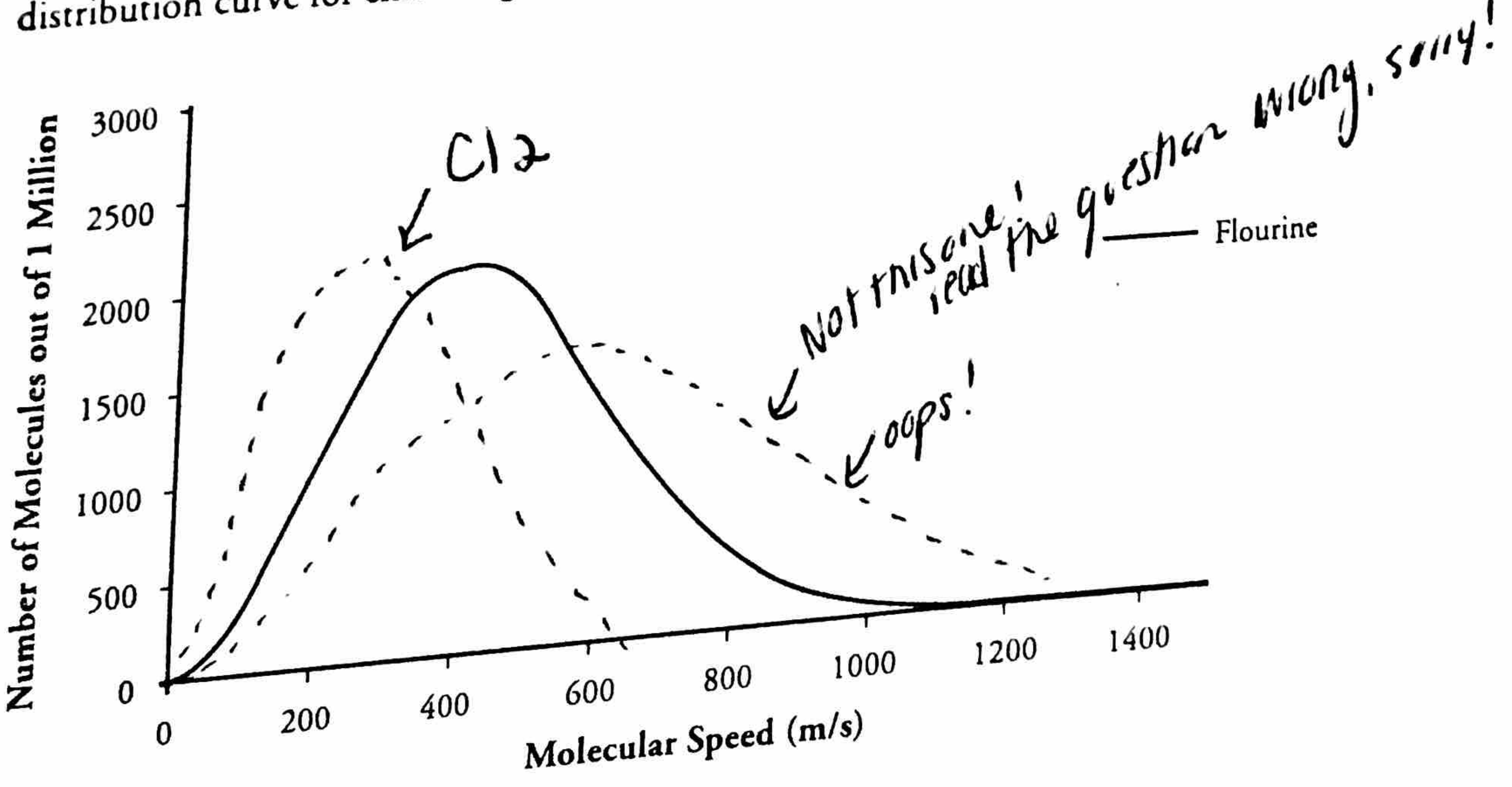
15. Which noble gas has the fastest average particle speed at 100 °C?

He

16. In a complete sentence, describe the relationship between the molar mass of particles in a sample and the average particle speed at a given temperature.

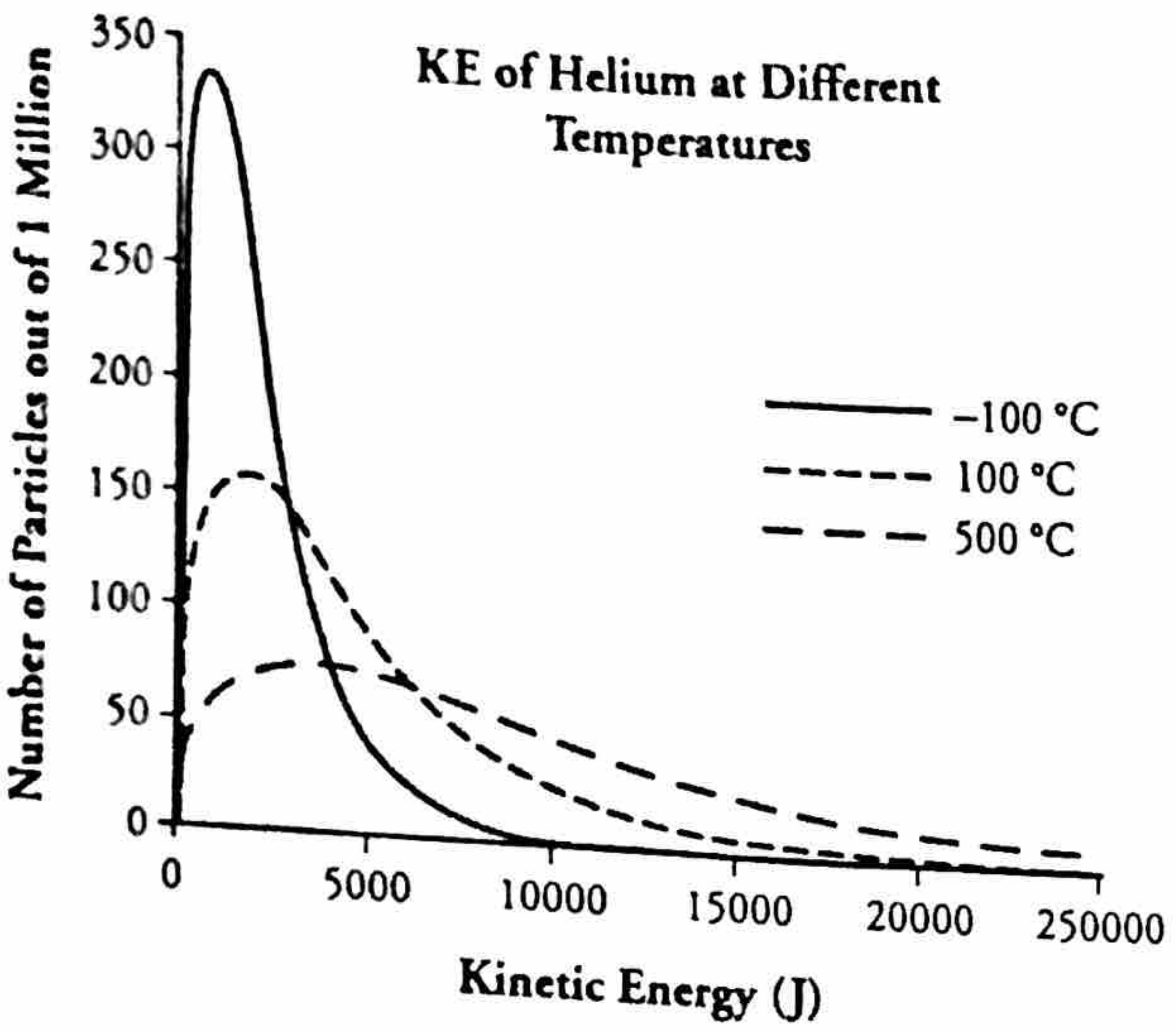
The molar mass and average particle speed in a sample have an inverse relationship, the larger the molar mass the slower the average particle speed.

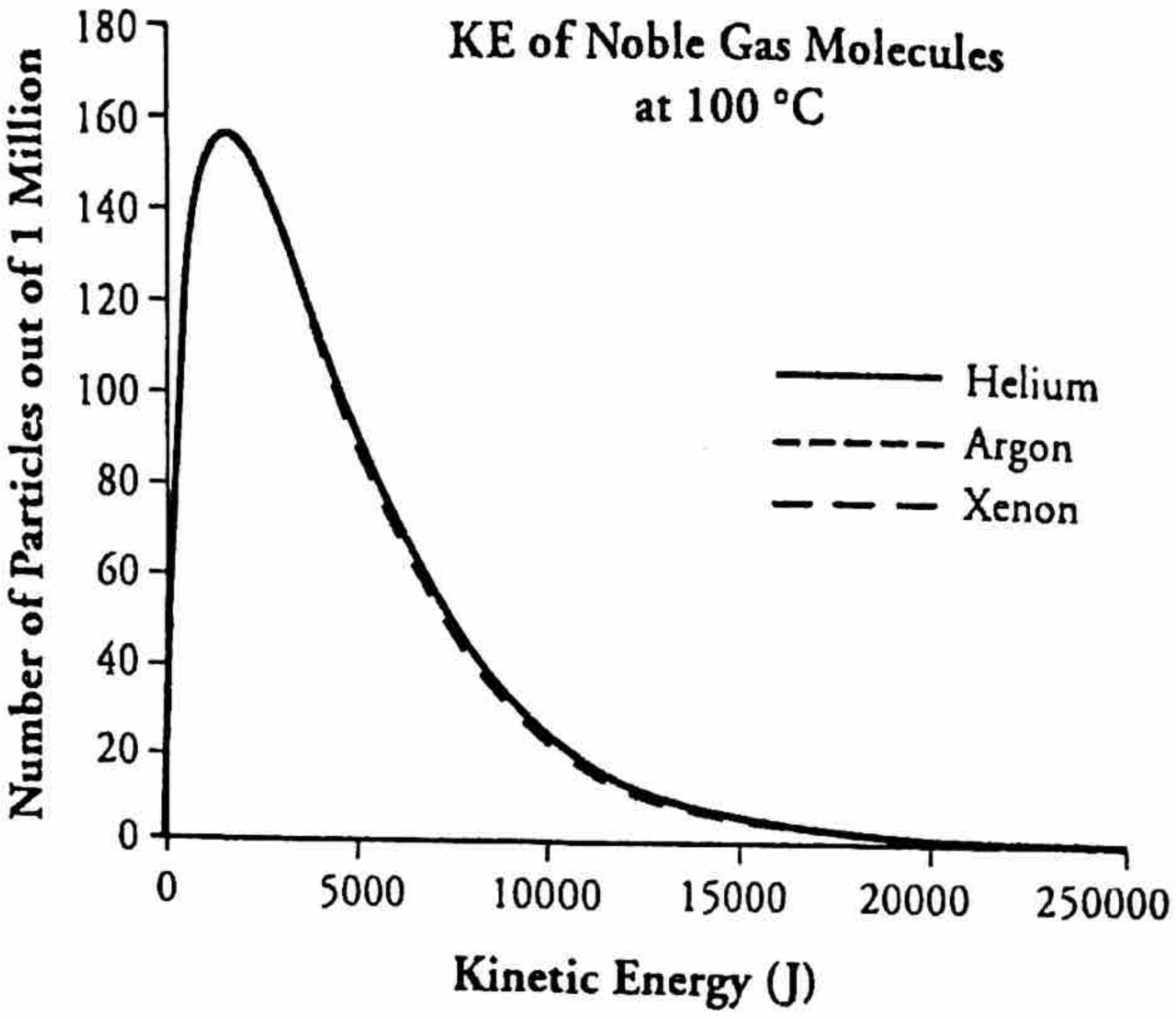
17. Consider the distribution curve below for fluorine gas (F_2) at 100 °C. Sketch an approximate distribution curve for chlorine gas (Cl_2) at 100 °C on the same graph.



STOP

Model 3 – Kinetic Energies





18. What is the variable and unit of the *x*-axis for both of the graphs in Model 3?

kinetic energy (J)

19. What variable, temperature or molar mass, is being varied in the graph on the left?

temp

20. What variable, temperature or molar mass, is being varied in the graph on the right?

molar mass

21. Describe the relationship between the average kinetic energy of the particles in a sample and the temperature when the molar mass is held constant. Use a grammatically correct sentence.

The relationship between the average kinetic energy and temperature is direct, the lower the temperature, the lower the average kinetic energy.

22. Describe the relationship between the average kinetic energy of the particles in a sample and the molar mass when the temperature is held constant. Use a grammatically correct sentence.

There is no relationship between the average kinetic energy and molar mass when temp is held constant.

23. Compare and contrast the graph on the left in Model 3 with the graph in Model 1.

→ still 3 distant lines
→ still right skewed bell curves
→ Model 3 is more distant as right skewed bell curve
→ x-axis changes

24. Compare and contrast the graph on the right in Model 3 with the graph in Model 2.

with kinetic energy as the x-axis insted of particle speed, molar mass does not alter the graph

25. The kinetic energy of a particle in a sample can be calculated by the following equation:

$$KE = \frac{1}{2}mv^2$$

where *m* stands for the mass of the particle and *v* stands for the particle speed.

a. Use the equation above to explain the variation in the distribution curves in the graph on the left in Model 3.

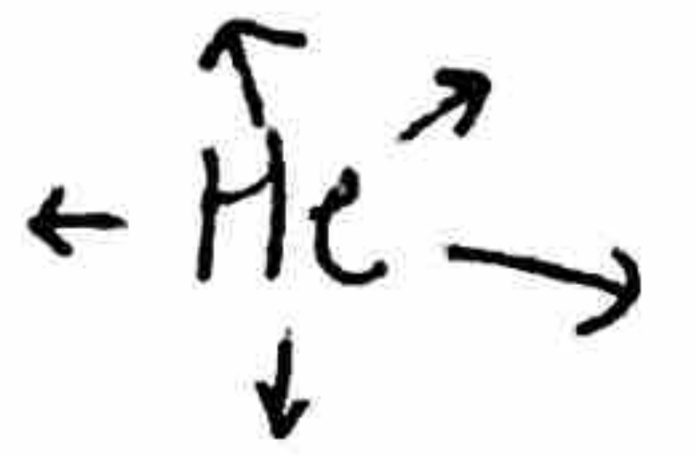
mass is held constant so particle speed is the only variable varying, causing a change in kinetic energy

b. Use the equation above to explain the lack of variation in the distribution curves in the graph on the right in Model 3.

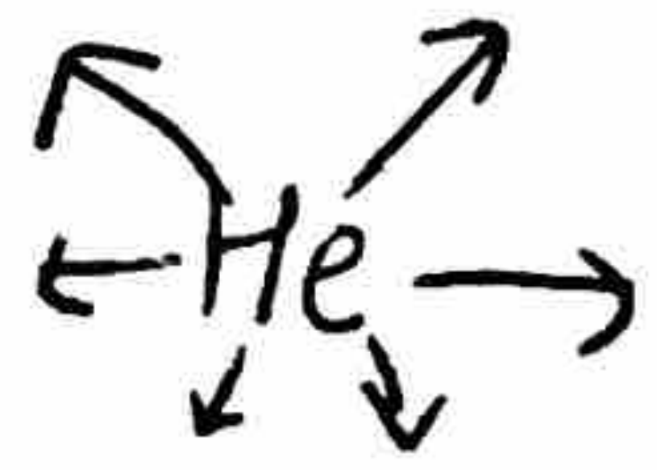
since molar mass and particle speed are both being altered, they off set each other since the higher the molar mass the lower the particle speed.

26. Draw particulate representations of helium atoms at the two different temperatures below. Use arrows to illustrate the distributions in kinetic energies.

He - 0°C



He - 100°C

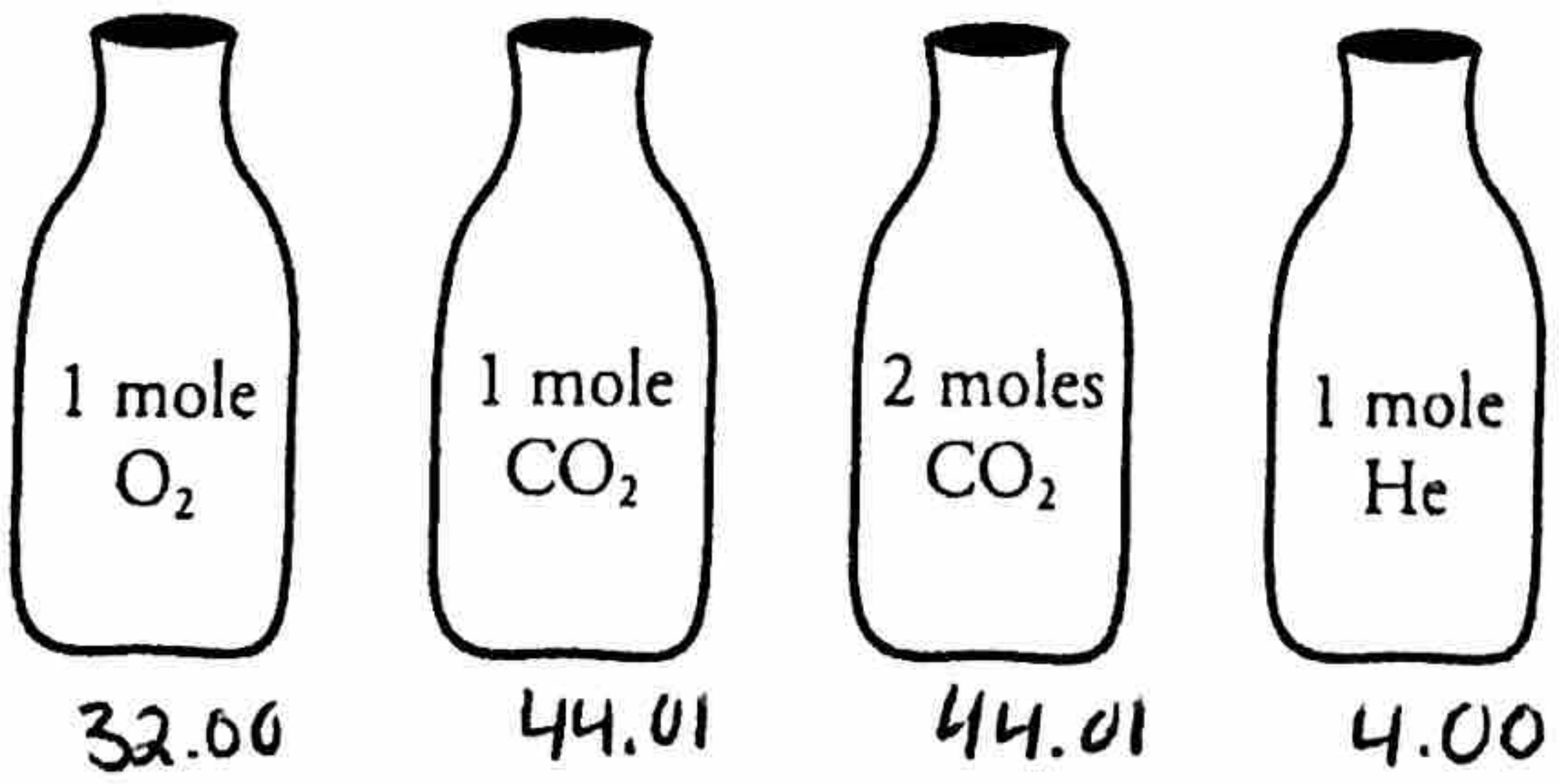


27. Draw particulate representations of two different noble gases at the same temperature below. Use arrows to illustrate the distributions in kinetic energies.

Xe -100°C

Kr - 100°c

28. A student is presented with four bottles containing different gases. All samples are at the same temperature.



a. Which gas sample has the fastest average particle speed?

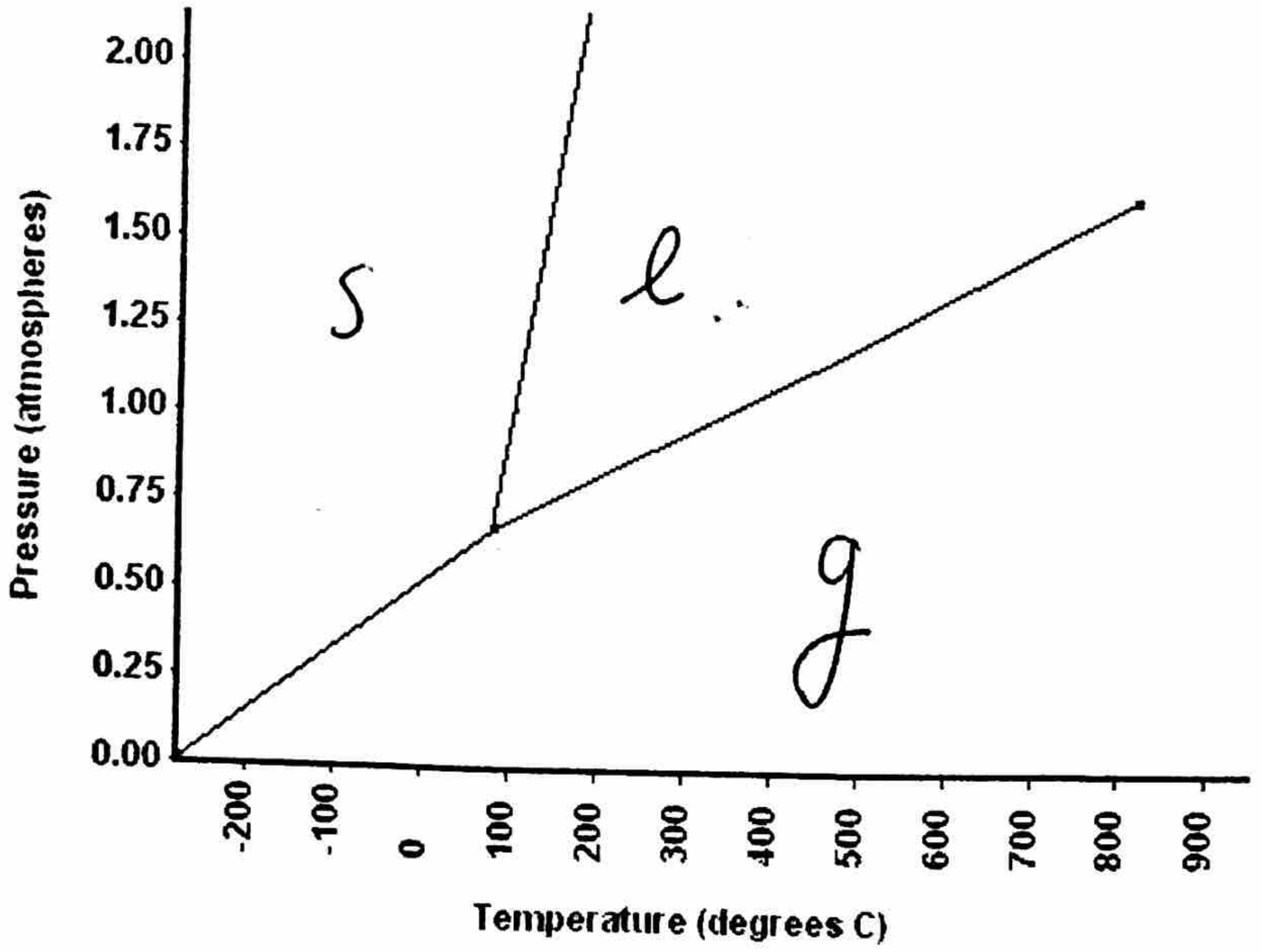
He

b. Which gas sample has the highest average kinetic energy?

all the same

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? 0.65 atm, 90°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? 850°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?

s → l (melting) 100°C

l → g (evaporation) 180°C

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Intermolecular Forces – Multiple Choice

PSI Chemistry

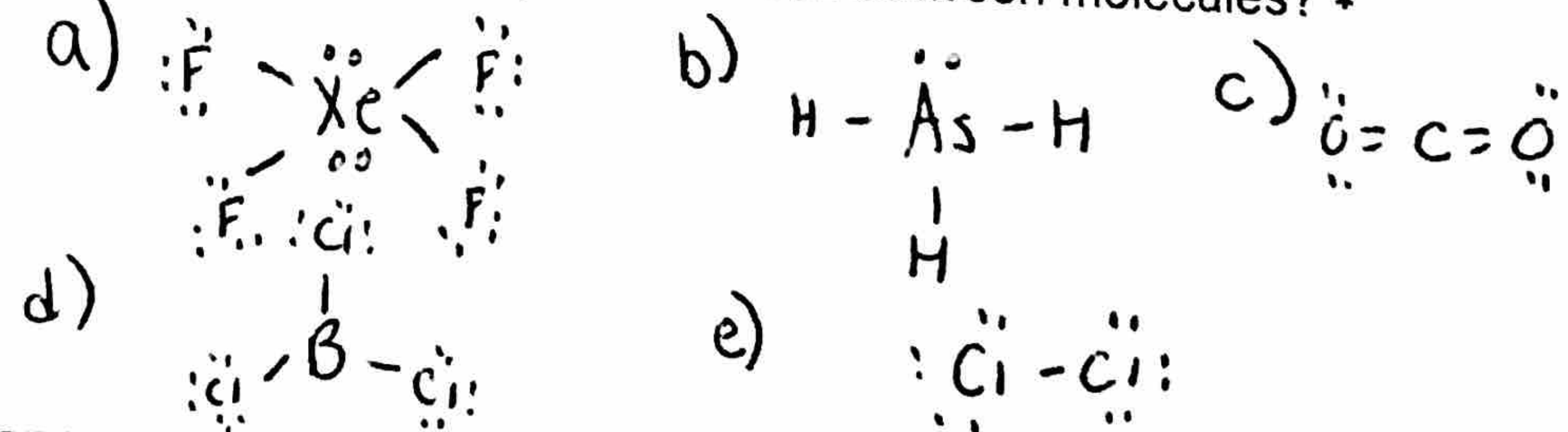
Name______________________________

1. In liquids, the attractive intermolecular forces are __________.
   - a. very weak compared with kinetic energies of the molecules
   - b. strong enough to hold molecules relatively close together
   - c. strong enough to keep the molecules confined to vibrating about their fixed lattice points
   - d. not strong enough to keep molecules from moving past each other
   - [✓ e.] strong enough to hold molecules relatively close together but not strong enough to keep molecules from moving past each other

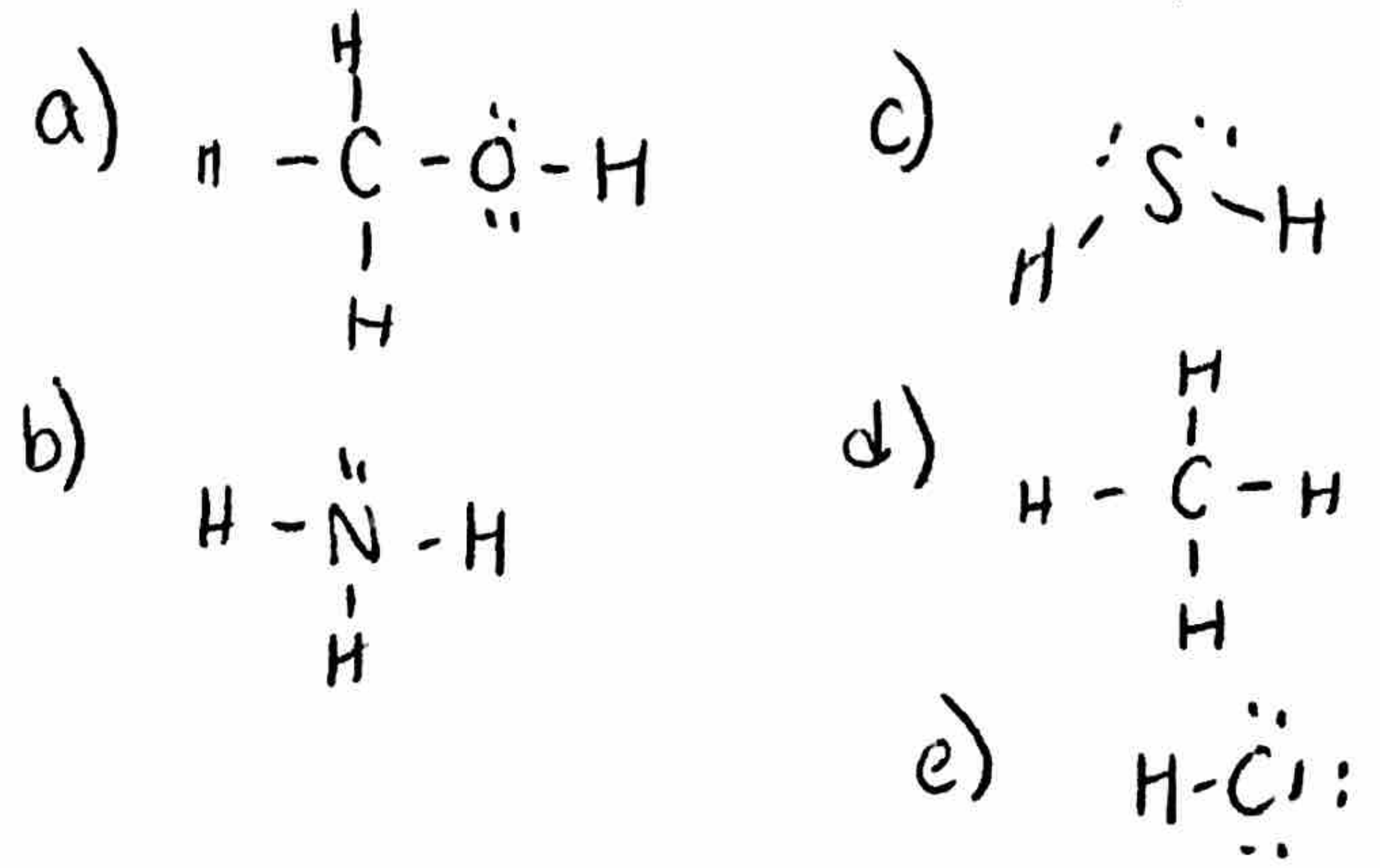
2. As a solid element melts, the atoms become __________ and they have __________ attraction for one another.
   - a. more separated, more
   - [✓ b.] more separated, less
   - ~~c.~~ closer together, more
   - ~~d.~~ closer together, less
   - e. larger, greater

3. The strongest interparticle attractions exist between particles of a __________ and the weakest interparticle attractions exist between particles of a __________.
   - a. solid, liquid
   - [✓ b.] solid, gas
   - ~~c.~~ liquid, gas
   - ~~d.~~ liquid, solid
   - ~~e.~~ gas, solid

4. Which one of the following exhibits dipole-dipole attraction between molecules? *
   - a. XeF_4
   - [✓ b.] AsH_3
   - c. CO_2
   - d. BCl_3
   - e. Cl_2



5. Of the following substances, only __________ has London dispersion forces as its only intermolecular force.
   - a. CH_3OH
   - b. NH_3
   - c. H_2S
   - [✓ d.] CH_4
   - e. HCl



6. Of the following substances, only _________ has London dispersion forces as the only intermolecular force.
   a. CH_3OH
   b. NH_3
   c. H_2S
   [✓ d.] Kr element
   e. HCl

7. Hydrogen bonding is a special case of _________.
   a. London-dispersion forces
   b. ion-dipole attraction
   [✓ c.] dipole-dipole attractions
   d. ion-ion interactions
   e. none of the above

8. Which of the following has hydrogen bonding as its only intermolecular force?
   a. HF
   b. H_2O
   c. $C_6H_{13}NH_2$
   d. $C_5H_{11}OH$
   [✓ e.] None, all exhibit dispersion forces.

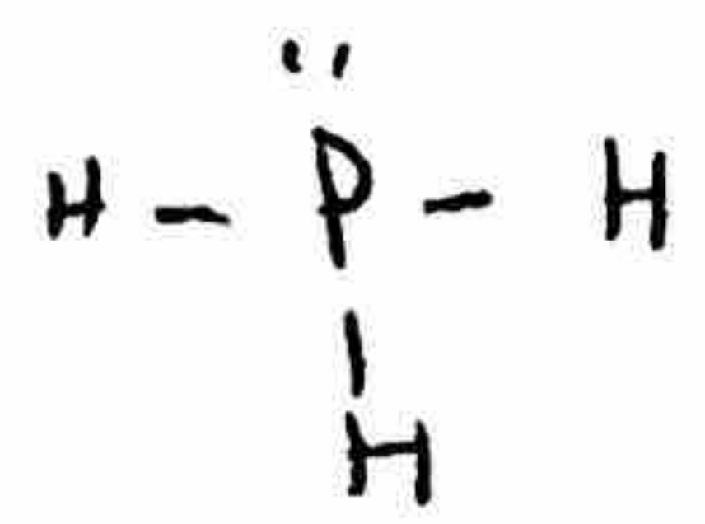
9. When NaCl dissolves in water, aqueous Na^+ and Cl^- ions result. The force of attraction that exists between Na^+ and H_2O is called a(n) _________ interaction.
   a. dipole-dipole
   b. ion-ion
   c. hydrogen bonding
   [✓ d.] ion-dipole
   e. London dispersion force

10. The predominant intermolecular force in CH_3–NH-CH_3 is _________. *
   a. London dispersion forces
   b. ion-dipole forces
   c. ionic bonding
   d. dipole-dipole forces
   [✓ e.] hydrogen bonding

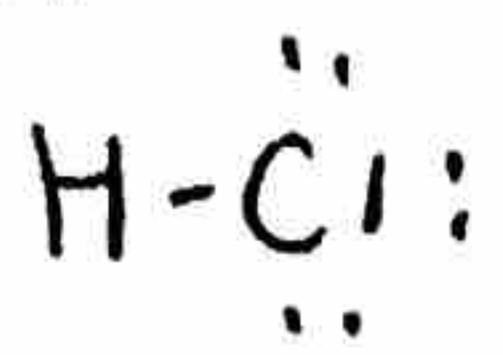
11. $C_{12}H_{26}$ molecules are held together by _________.
   a. ion-ion interactions
   b. hydrogen bonding
   c. ion-dipole interactions
   d. dipole-dipole interactions
   [✓ e.] dispersion forces

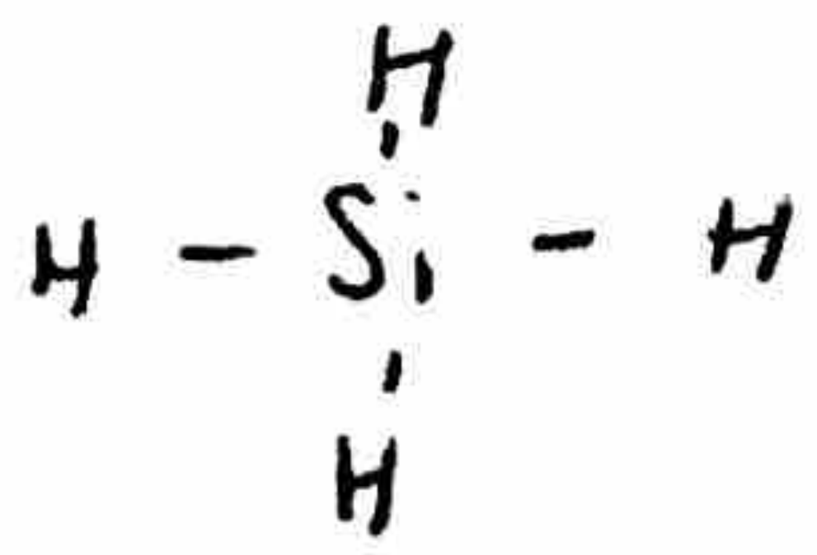
* when just carbon and hydrogen it is always london dispersion forces

12. Which one of the following should have the lowest boiling point?
- a. PH_3
- b. H_2S
- c. HCl
- [✓ d. SiH_4]
- e. H_2O

a)


b)


c)


d)


e)


13. Of the following substances, __________ has the highest boiling point.
- [✓ a. H_2O]
- b. CO_2
- c. CH_4
- d. Kr
- e. NH_3

H_2O + NH_3 have hydrogen bonding
18 g/mol 17 g/mol

14. Of the following, __________ has the highest boiling point.
- a. N_2
- [✓ b. Br_2]
- c. H_2
- d. Cl_2
- e. O_2

all london dispersion
→ so highest mass

15. Which one of the following derivatives of ethane has the highest boiling point?
- [✓ a. C_2Br_6]
- b. C_2F_6
- c. C_2I_6
- d. C_2Cl_6
- e. C_2H_6

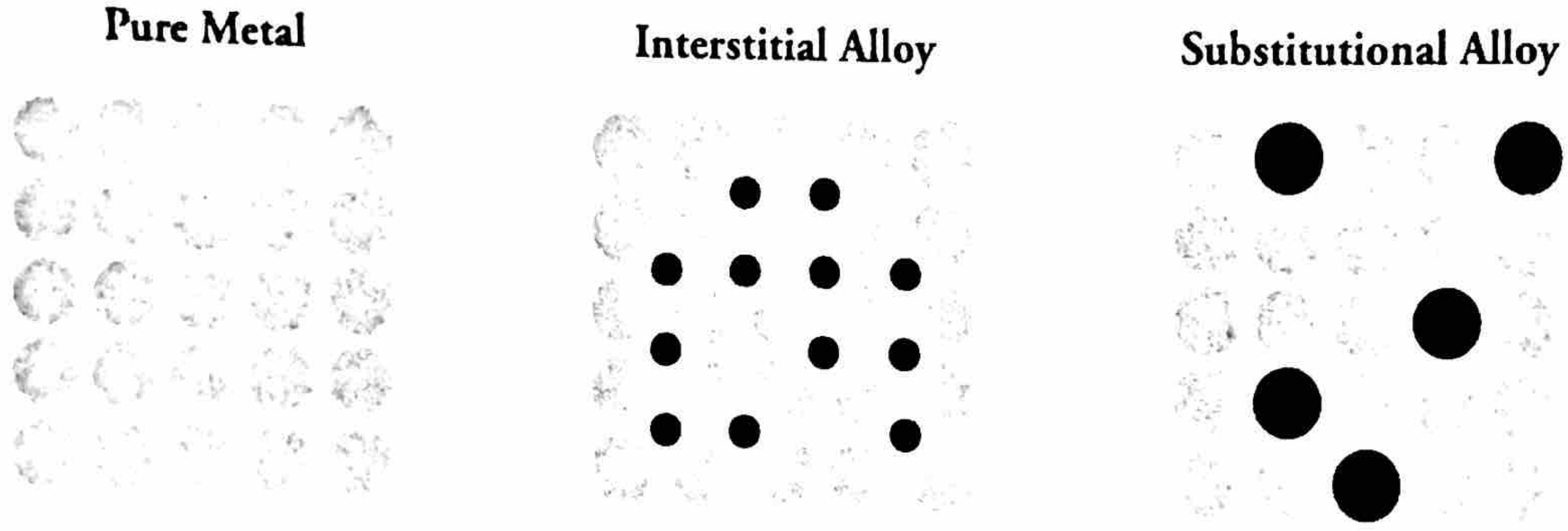
Alloys

How are alloys made and what properties do they have?

Why?

Metals are amazing, and they are all around us. You can probably easily identify them by their shiny surfaces and tinny sound when you tap them. We use metals to run electricity through our house, manufacture our cars, and create circuits for our phones. However, most metals in their pure form are less than perfect for these jobs. Luckily, the properties of metals can be manipulated to make them more useful by adding other elements to form a mixture. These mixtures are called **alloys**. In this activity, you will look at two types of alloys and their properties.

Model 1 – Two Types of Alloys



1. Name the two types of alloys illustrated in Model 1.

interstitial alloy + substitutional alloy

2. According to Model 1, how is an alloy different from a pure metal?

an alloy has a mix of two or more types of metal elements, where a pure metal is just one element.

3. Consider the two types of alloys in Model 1. Based on the diagrams and your understanding of English words, define "substitutional" and "interstitial."

in place of ↲ ↳ between

4. One of the alloys in Model 1 tends to form when elements with similar sized atoms are melted together and allowed to cool. The other type forms when elements with very different sized atoms are combined. Match the descriptions below with each type of alloy.

Component atoms are similar size. Substitutional alloy

Component atoms are different sizes. interstitial alloy

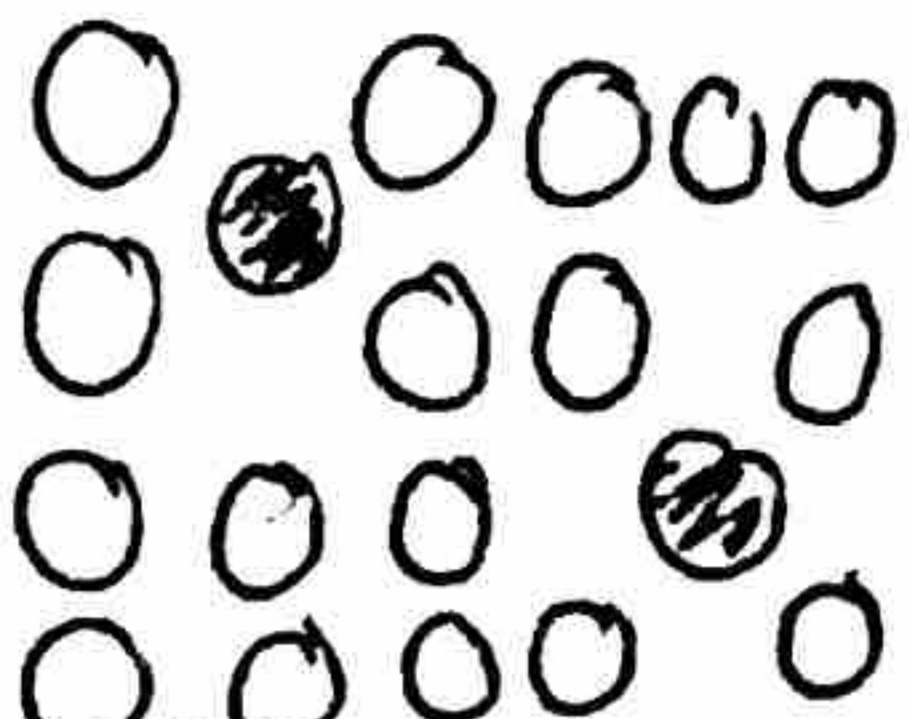
Read This!

It is possible to mix two metal elements together and simply form a mixture of metals that would not be considered an alloy. The distinction is in the properties that result from the mixture. If the addition of an "impurity" to the metal somehow causes a change in a property that is beneficial, then the mixture is considered an alloy. If however the "impurity" results in weakening the metal or causes less desirable properties, then it is considered simply a mixture.

5. Solids are most stable when the arrangement of atoms in the crystal lattice minimizes bond length, maximizes bond strength, and maximizes the number of atoms "touching" one another—in other words, when the atoms fill the space most efficiently.

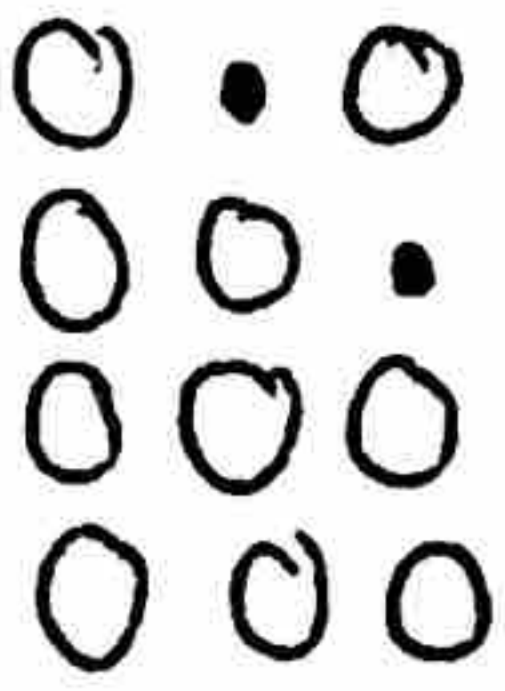
   a. Explain why an interstitial alloy would not form a stable crystal structure if the component atoms were of similar size. Sketch a diagram to illustrate your answer.

   If the atoms were the same size there would be alot of space between the atoms



   b. Explain why a substitutional alloy would not form a stable crystal structure if the component atoms were different sizes. Sketch a diagram to illustrate your answer.

   There would be alot of space between the particles.



6. Consider how the density of an alloy might compare to the density of the original metals.

   a. Would substitutional alloys tend to have a density similar to, significantly greater than or significantly less than the pure metal? Explain your reasoning.

   It would have a similar density b/c they are just replacing an atom in the metal so there would be little change to the mass/volume.

   b. Interstitial alloys oftentimes have a density less than the pure metal. Explain how the addition of a small, low mass atom like carbon could make the density of an interstitial alloy less than the pure metal.

   Because the atoms go between the already present atoms it could spread the lattice out some, causing the volume to be larger.

7. Metals are malleable because of weak bonds between atoms. This allows planes of atoms to slide past one another and into new positions. Some alloys retain their malleability while others become more rigid. Consider the diagrams in Model 1. Predict which type of alloy would result in a more rigid substance. Justify your reasoning.

   The interstitial alloys would be more rigid because with atoms between the lattice the atoms will have less room for movement