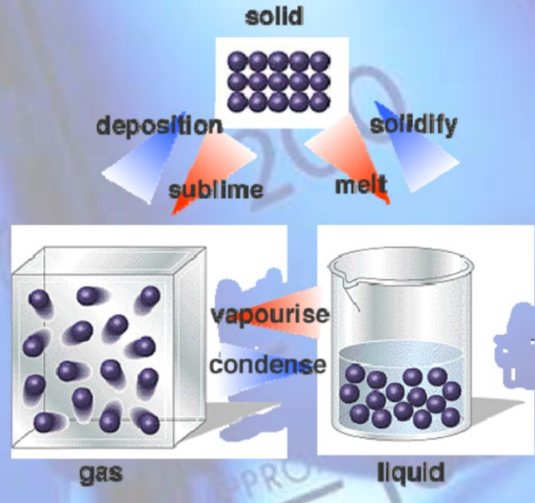
NGSS Regents Chemistry

PRACTICE PACKET

Unit 6: Physical Behavior of Matter (PBOM)



Regents Chemistry **Heat & Temperature**

1. As the temperature of a substance decreases, the average kinetic energy of its particles

A) decreases B) increases
C) remains the same

2. The particles in which sample of LiCl(s) have the same average kinetic energy as the particles in a 2.0-mole sample of $H_2O(\ell)$ at 25°C?

A) 1.0 mol at 75°C B) 2.0 mol at 50.°C
C) 3.0 mol at 25°C D) 4.0 mol at 0°C

3. Energy is being added to a given sample. Compared to the Celsius temperature of the sample, the Kelvin temperature

K = C + 273

A) will have the same reading at 0°
B) will have the same reading at 273°
C) will always be 273° lower
D) will always be 273° greater

4. An iron bar at 325 K is placed in a sample of water. The iron bar gains energy from the water if the temperature of the water is

A) 65 K B) 45 K C) 65°C D) 45°C

5. A sample of helium gas is in a sealed, rigid container. What occurs as the temperature of the sample is increased?

A) The number of moles of gas increases.
B) The volume of each atom decreases.
C) The mass of the sample decreases.
D) The frequency of collisions between atoms increases.

6. Which sample of ethanol has particles with the highest average kinetic energy?

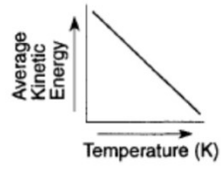
A) 10.0 mL of ethanol at 25°C
B) 10.0 mL of ethanol at 55°C
C) 100.0 mL of ethanol at 35°C
D) 100.0 mL of ethanol at 45°C

7. Solid *A* at 80°C is immersed in liquid *B* at 60°C. Which statement correctly describes the energy changes between *A* and *B*?

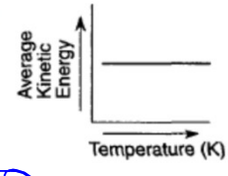
A) *A* releases heat and *B* absorbs heat.
B) *A* absorbs heat and *B* releases heat.
C) Both *A* and *B* absorb heat.
D) Both *A* and *B* release heat.

8. Which graph best shows the relationship between Kelvin temperature and average kinetic energy?

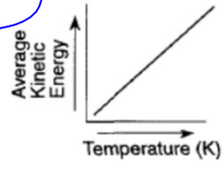
A)



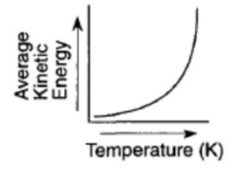
B)



C)



D)



1 kJ = 1000 J

9. Which quantity is equal to 50 kilojoules?

A) 0.05 J B) 5×10^4 J
C) 500 J D) 5×10^3 J

50 kJ = 50000
5.0×10^4 J

10. The temperature of a sample of a substance changes from 10.°C to 20.°C. How many Kelvin does the temperature change?

A) 293 B) 283 C) 20. D) 10.

11. Which temperature is equal to +20 K?

A) 253°C B) −293°C
C) −253°C D) 293°C

C = K − 273
= 20 − 273 = −253

Heat & Temperature

12. Solid *X* is placed in contact with solid *Y*. Heat will flow spontaneously from *X* to *Y* when

A) *X* is 25°C and *Y* is 30°C
B) *X* is –25°C and *Y* is –10°C
C) *X* is 20°C and *Y* is 20°C
D) *X* is 10°C and *Y* is 5°C

13. A flask containing molecules of gas *A* and a separate flask containing molecules of gas *B* are both at the same temperature. Gases *A* and *B* must have equal

A) average kinetic energies
B) volumes
C) masses
D) pressures

14. At standard pressure, the difference between the freezing point and the boiling point of water, in Kelvin, is

A) 100 B) 180 C) 273 D) 373

15. The average kinetic energy of water molecules increases when

A) $H_2O(\ell)$ at 10°C changes to $H_2O(\ell)$ at 20°C
B) $H_2O(s)$ changes to $H_2O(\ell)$ at 0°C
C) $H_2O(\ell)$ changes to $H_2O(s)$ at 0°C
D) $H_2O(\ell)$ at 20°C changes to $H_2O(\ell)$ at 10°C

16. Which sample of water contains particles having the highest average kinetic energy?

A) 25 mL of water at 95°C
B) 45 mL of water at 75°C
C) 75 mL of water at 75°C
D) 95 mL of water at 25°C

17. Which Kelvin temperature is equal to –73°C?

A) 346 K B) 173 K
C) 200 K D) 100 K

18. Which change in the temperature of a 1-gram sample of water would cause the greatest increase in the average kinetic energy of its molecules?

A) 50°C to 60°C B) 10°C to 1°C
C) 1°C to 10°C D) 60°C to 50°C

19. A sealed flask containing 1.0 mole of $H_2(g)$ and a sealed flask containing 2.0 moles of He(g) are at the same temperature. The two gases must have equal

A) volumes
B) average kinetic energies
C) masses
D) numbers of molecules

20. Which temperature is equal to 120. K?

A) +393°C B) –120.°C
C) –153°C D) +293°C

21. Which sample of Fe contains particles having the highest average kinetic energy?

A) 5 g at 10°C B) 5 g at 400 K
C) 10 g at 25°C D) 10 g at 300 K

22. Two samples of gold that have different temperatures are placed in contact with one another. Heat will flow spontaneously from a sample of gold at 60°C to a sample of gold that has a temperature of

A) 50°C B) 60°C
C) 80°C D) 70°C

23. The average kinetic energies of the molecules in two gas samples could best be compared by measuring their

A) temperatures B) pressures
C) densities D) volumes

24. A liquid's freezing point is –38°C and its boiling point is 357°C. What is the number of Kelvin between the boiling point and the freezing point of the liquid?

A) 395 B) 668 C) 319 D) 592

25. Which temperature represents absolute zero?

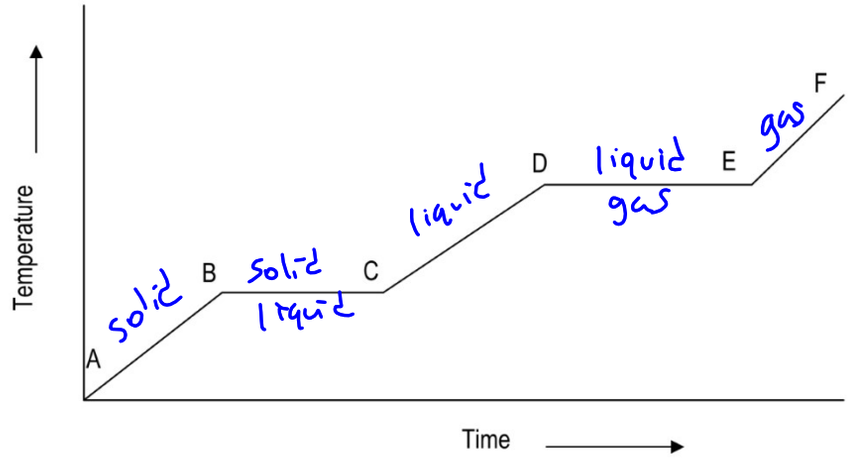
A) 273 K B) 0°C
C) 273°C D) 0 K

26. At which conditions of temperature and pressure would the molecules of a gas have the greatest average kinetic energy?

A) 100°C and 1 atm B) 50°C and 4 atm
C) 10°C and 2 atm D) 0°C and 3 atm

Phase Diagrams and Heat Equations

Directions: Use the phase change diagram below to answer the questions that follow.



1. On the diagram above, label the phases present during each line segment.

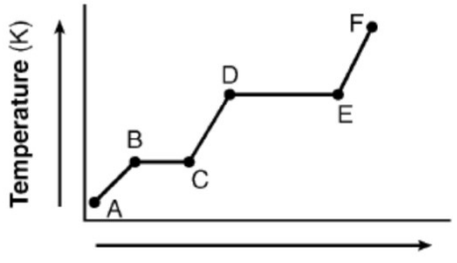
2. Determine the line segment(s) that represents the information below.

   a. Gas, only EF
   b. Liquid, only CD
   c. Solid, only AB
   d. Solid and Liquid, only BC
   e. Liquid and Gas, only DE
   f. Melting Point BC
   g. Boiling Point DE
   h. Kinetic energy is increasing AB, CD, EF
   i. Potential energy is increasing BC, DE

Practice Packet
pg 5 1+2
pg 6 17+18

Regents Chemistry **Phase Diagrams**

Base your answers to questions **1** and **2** on the heating curve below, which represents a substance starting as a solid below its melting point and being heated at a constant rate over a period of time.



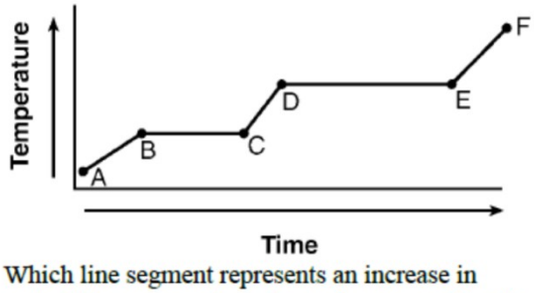
1. What is happening to the average kinetic energy of the particles during segment $\overline{BC}$?

stays the same

2. How does this heating curve illustrate that the heat of vaporization is greater than the heat of fusion?

more energy is being added

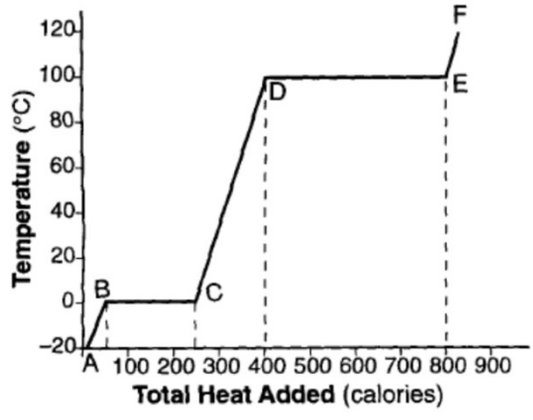
3. The graph below represents the uniform heating of a substance, starting with the substance as a solid below its melting point.



Which line segment represents an increase in potential energy and no change in average kinetic energy?

A) $\overline{CD}$ B) $\overline{AB}$ C) $\overline{BC}$ D) $\overline{EF}$

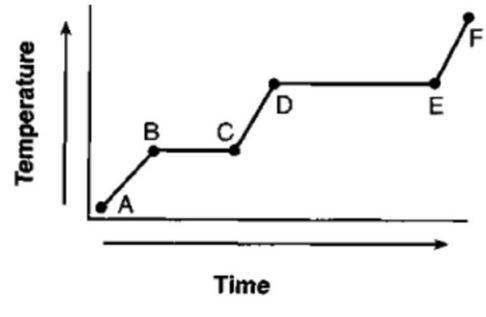
4. The graph below shows the heating curve of 1.0 gram of a solid as it is heated at a constant rate, starting at a temperature below its melting point.



Based on this graph, what is the heat of vaporization?

A) 250 calories, as measured along line *BC*
B) 400 calories, as measured along line *DE*
C) 800 calories, as measured along line *DE*
D) 200 calories, as measured along line *BC*

5. The graph below represents the uniform heating of a substance, starting below its melting point, when the substance is solid.



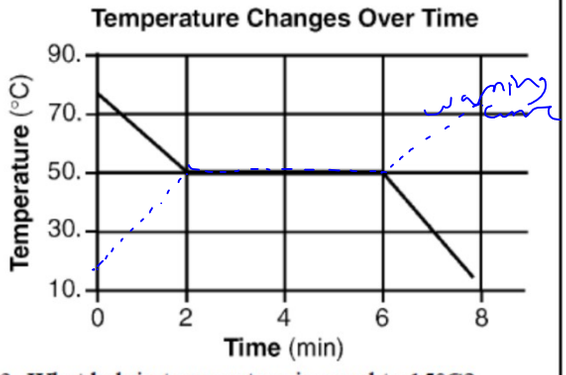
Which line segments represent an increase in average kinetic energy?

A) $\overline{AB}$ and $\overline{CD}$ B) $\overline{AB}$ and $\overline{BC}$
C) $\overline{DE}$ and $\overline{EF}$ D) $\overline{BC}$ and $\overline{DE}$

Phase Diagrams

Base your answers to questions **13** through **16** on the information below.

The graph below shows a compound being cooled at a constant rate starting in the liquid phase at 75°C and ending at 15°C.



13. What kelvin temperature is equal to 15°C?

288 K

14. State what is happening to the average kinetic energy of the particles of the sample between minute 2 and minute 6.

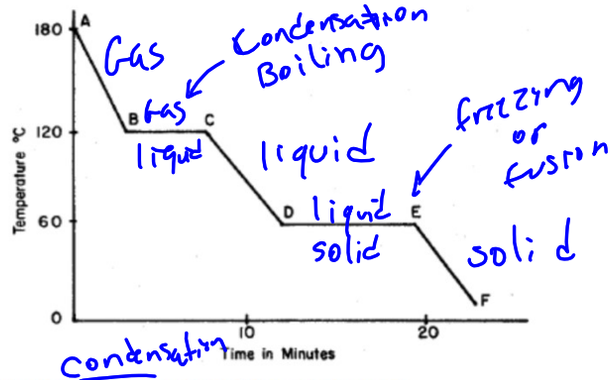
remains the same

15. A different experiment was conducted with another sample of the same compound starting in the solid phase. The sample was heated at a constant rate from 15°C to 75°C. On the graph, draw the resulting heating curve.

16. What is the freezing point of the compound, in degrees Celsius?

50°C

Base your answers to questions **17** and **18** on the graph below, which represents uniform cooling of a sample of a pure substance, starting as a gas.



17. The boiling point of the substance is

A) 10°C B) 120°C
C) 60°C D) 180°C

18. Solid and liquid phases can exist in equilibrium between points

A) *C* and *D* B) *D* and *E*
C) *B* and *C* D) *E* and *F*

Heat Calculation Practice

Use the Heat Equations on Table T and the Physical Constants for Water on Table B in your CRT's to complete the following problems. SHOW ALL WORK.

1) A 5.00 gram sample of water is heated so that its temperature increases from 10.0°C to 15.0°C. What is the total amount of energy absorbed by the water?

$q = ?$
$m = 5.0$
$c = 4.18$
$\Delta T = 15 - 10 = 5$

$q = m c \Delta T$
$= 5 \times 4.18 \times 5$
$= 104.5\ J$

2) When a sample of 25.0 g of water is cooled from 20.0°C to 10.0°C, what is the number of Joules of energy released?

$q = ?$
$m = 25$
$c = 4.18$
$\Delta T = 20 - 10 = 10$

$q = m c \Delta T$
$= 25 \times 4.18 \times 10$
$= 1045\ J$

3) A sample of water is heated from 10.0°C to 15.0°C by adding 125.58 Joules of heat. What is the mass of the water?

$q = 125.58$
$m = ?$
$c = 4.18$
$\Delta T = 15 - 10 = 5$

$m = \frac{q}{c \Delta T} = \frac{125.58}{(4.18 \times 5)}$
$= 58.6\ g$

4) What is the total number of kilojoules of heat needed to change 150. grams of ice to liquid water at 0°C?

$q = m H_f$ $q = 50{,}100\ J$ or $50.1\ KJ$

5) How much energy is required to vaporize 10.00 grams of water at its boiling point?

$q = 22{,}600$ or $22.6\ KJ$

Regents Chemistry **Heat Calculations**

1. In a laboratory where the air temperature is 22°C, a steel cylinder at 100.°C is submerged in a sample of water at 40.°C. In this system, heat flows from

   A) both the air and the water to the cylinder
   B) the air to the water and from the water to the cylinder
   C) the cylinder to the water and from the water to the air
   D) both the cylinder and the air to the water

2. A 50.0-gram block of copper at 10.0°C is carefully lowered into 100.0 grams of water at 90.0°C in an insulated container. Which statement describes the transfer of heat in this system?

   A) The water gains heat and the block loses heat until both are at the same temperature that is between 10.0°C and 90.0°C.
   B) The water loses heat to the block until both are at 10.0°C.
   C) The block gains heat from the water until both are at 90.0°C.
   D) The water loses heat and the block gains heat until both are at the same temperature that is between 10.0°C and 90.0°C.

Base your answers to questions **3** through **5** on the information below.

Heat is added to a 200.-gram sample of $H_2O(s)$ to melt the sample at 0°C. Then the resulting $H_2O(\ell)$ is heated to a final temperature of 65°C.

3. Compare the amount of heat required to vaporize a 200.-gram sample of $H_20(\ell)$ *at its boiling point to the amount of heat required to melt a 200.-gram sample of $H_2O(s)$ at its melting point.*

>The heat necessary to vaporize 200g of water is about seven times larger.

4. In the space below, show a numerical setup for calculating the total amount of heat required to raise the temperature of the $H_2O(\ell)$ from 0°C to its final temperature.

$q = 200\ g \times 4.18 \times 65^{\circ}C$

5. Determine the total amount of heat required to completely melt the sample.

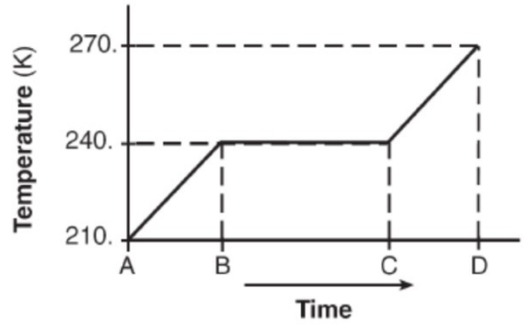
66 800 J or 66.8 KJ

Heat Calculations

Base your answers to questions **6** and **7** on the information below

A 5.00-gram sample of liquid ammonia is originally at 210. K. The diagram of the partial heating curve below represents the vaporization of the sample of ammonia at standard pressure due to the addition of heat. The heat is *not* added at a constant rate.

Partial Heating Curve for Ammonia



Some physical constants for ammonia are shown in the data table below.

Some Physical Constants for Ammonia

specific heat capacity of $NH_3(\ell)$	4.71 J/g•K
heat of fusion	332 J/g
heat of vaporization	1370 J/g

6. Describe what is happening to *both the potential energy and the average kinetic energy of the molecules in the ammonia sample during time interval BC. Your response must include both potential energy and average kinetic energy.*

The potential energy of the ammonia molecules increases and the average kinetic energy of the ammonia molecules remains the same.

7. Calculate the total heat absorbed by the 5.00-gram sample of ammonia during time interval AB. Your response must include *both* a correct numerical setup and the calculated result.

$q = mC\Delta T = 5 \times 4.71 \times 30 = 710\ J$

8. Base your answer to the following question on the following paragraph.

The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is equal to the pressure on the surface of the liquid. The heat of vaporization of ethanol is 838 joules per gram. A sample of ethanol has a mass of 65.0 grams and is boiling at 1.00 atmosphere.

Calculate the minimum amount of heat required to completely vaporize this sample of ethanol. Your response must include *both* a correct numerical setup and the calculated result.

$65 \times 838 = 54{,}500\ J$

VAPOR PRESSURE PROBLEMS

1. Temperature and intermolecular forces are two factors that affect the rate of evaporation. Explain your reasoning behind this for both factors.

As temperature increases, the rate of evaporation increases. As IMF's increase, boiling point increases, so rate of evaporation decreases.

2. Explain how temperature and vapor pressure are related.

As temperature increases, vapor pressure increases, because the rate of evaporation increases.

3. What happens when the pressure above the surface of a liquid is equal to the vapor pressure of the liquid? Explain.

The liquid boils. The pressure pushing up at the surface of the liquid(vapor pressure) is the same as the pressure pushing down(atmospheric pressure).

4. The particles that make up a solid at room temperature are said to be arranged in a regular geometric fashion. Are these particles still moving? Explain.

Yes, they are vibrating in place.

5. If the pressure on the surface of water in the liquid state is 30 kPa, the water will boil at what temperature?

70-71°C

6. What is the vapor pressure of ethanol at its normal boiling point?

101.3 KPa

7. As the pressure on a liquid is changed from 100. kPa to 120.0 kPa, what happens to the boiling point? Explain your answer.

The boiling point increases because the pressure pushing down on the surface of the liquid increases.

Regents Chemistry **Vapor Pressure**

1. At which temperature is the vapor pressure of ethanol equal to 80. kPa?

   A) 48°C B) 73°C
   C) 80°C D) 101°C

2. Which compound has the *lowest* vapor pressure at 50°C?

   A) ethanol B) water
   C) ethanoic acid D) propanone

3. At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as

   A) polar molecules
   B) ionic crystals
   C) metallic crystals
   D) nonpolar molecules

4. Which liquid has the highest vapor pressure at 75°C?

   A) propanone B) ethanoic acid
   C) ethanol D) water

5. Based on intermolecular forces, which of these substances would have the highest boiling point?

   A) CH_4 B) He C) O_2 D) NH_3

6. Using your knowledge of chemistry and the information in Reference Table *H*, which statement concerning propanone and water at 50°C is true?

   A) Propanone has a higher vapor pressure and weaker intermolecular forces than water.
   B) Propanone has a lower vapor pressure and weaker intermolecular forces than water.
   C) Propanone has a higher vapor pressure and stronger intermolecular forces than water.
   D) Propanone has a lower vapor pressure and stronger intermolecular forces than water.

7. According to Reference Table *H*, what is the vapor pressure of propanone at 45°C?

   A) 33 kPa B) 70 kPa
   C) 22 kPa D) 98 kPa

8. As the temperature of a liquid increases, its vapor pressure

   A) decreases B) increases
   C) remains the same

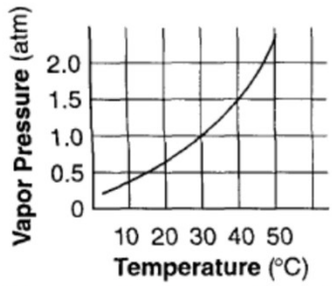
9. Which sample of water has the *lowest* vapor pressure?

   A) 100 mL at 50°C B) 200 mL at 30°C
   C) 300 mL at 40°C D) 400 mL at 20°C

10. Based on Reference Table *H*, which substance has the weakest intermolecular forces?

    A) propanone B) ethanol
    C) water D) ethanoic acid

11. The graph below shows the relationship between vapor pressure and temperature for substance *X*.



What is the normal boiling point for substance *X*?

A) 20°C B) 30°C
C) 50°C D) 40°C

12. When the vapor pressure of water is 30 kPa, the temperature of the water is

    A) 20°C B) 100°C
    C) 70°C D) 40°C

Avogadro's Gas Law I

Questions 1-5 are based on the following information:

Two samples of gas are contained in separate flasks as shown in the drawing. Both flasks have a volume of 1 liter. Choose a phrase from the list A-C below to complete each statement.

Flask 1 (O_2) Flask 2 (N_2)

A - flask number 1 is greater B - flask number 2 is greater C - each flask is the same

1. If each sample is at STP, then the number of molecules in C
2. If each sample is at STP, then the mass of the contents of A
3. If each sample is at STP and they are both heated to the same temperature, then the pressure in C
4. If each sample is at STP and the temperature of both flasks is doubled, then the average kinetic energy of the molecules in C
5. ★ If each sample is at STP, then the average velocity of the molecules in 3 (KE = ½ mv^2)

Question 6-9 are based on the chart below. Please read each question and determine whether Gas A, B, C, or D is the best answer

Sample	Quantity (moles)	Pressure (mmHg)	Temperature (K)
Gas A	2	760	273
Gas B	1	380	273
Gas C	1	760	273
Gas D	2	760	546

6. Which sample contains molecules with the highest average kinetic energy? Gas D
7. Which sample contains the same number of molecules as sample A? Gas D
8. ★ Between Gas B and Gas C, which will have the smallest volume? Gas C

Regents Chemistry **KMT & Avogadro's Law**

1. Which rigid cylinder contains the same number of gas molecules at STP as a 2.0-liter rigid cylinder containing $H_2(g)$ at STP?

   A) 1.0-L cylinder of $O_2(g)$
   B) 2.0-L cylinder of $CH_4(g)$
   C) 1.5-L cylinder of $NH_3(g)$
   D) 4.0-L cylinder of He(g)

2. The table below shows data for the temperature, pressure, and volume of four gas samples.

Data for Four Gas Samples

Gas Sample	Temperature (K)	Pressure (atm)	Volume (mL)
A	100.	2	400.
B	200.	2	200.
C	100.	2	400.
D	200.	4	200.

   Which two gas samples have the same total number of molecules?

   A) *A* and *C* B) *A* and *B*
   C) *B* and *C* D) *B* and D

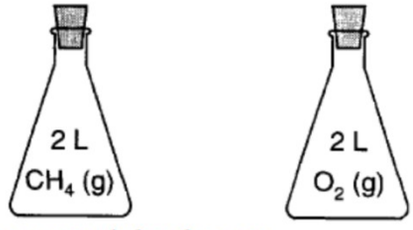
3. A sample of oxygen gas is sealed in container X. A sample of hydrogen gas is sealed in container Z. Both samples have the same volume, temperature, and pressure. Which statement is true?

   A) Container X contains fewer gas molecules than container Z.
   B) Container X contains more gas molecules than container Z.
   C) Containers X and Z both contain the same number of gas molecules.
   D) Containers X and Z both contain the same mass of gas.

4. At the same temperature and pressure, 1.0 liter of $CO(g)$ and 1.0 liter of $CO_2(g)$ have

   A) equal masses and the same number of molecules
   B) equal volumes and the same number of molecules
   C) different volumes and a different number of molecules
   D) different masses and a different number of molecules

5. Each stoppered flask below contains 2 liters of a gas at STP.



   Each gas sample has the same

   A) density
   B) number of atoms
   C) number of molecules
   D) mass

6. Equal volumes of all gases at the same temperature and pressure contain an equal number of

   A) molecules B) atoms
   C) protons D) electrons

7. According to the kinetic molecular theory, the particles of an ideal gas

   A) are arranged in a regular, repeated geometric pattern
   B) have no potential energy
   C) have strong intermolecular forces
   D) are separated by great distances, compared to their size

Combined Gas Law: In practical terms, it is often difficult to hold any of the variables constant. When there is a change in pressure, volume, and temperature, the combined gas law is used.

$$\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$

Using the Combined Gas Law please complete the following chart:

	P_1	V_1	T_1	P_2	V_2	T_2	Work Shown
1	1.5atm	3.0 L	20.°C	2.5atm	1.86 L	30.°C	
2	.95 atm	256mL	25°C	1.05 atm	250mL	50.°C	
3	.8 atm	2.5L	22°C	1atm	1.8L	266K	
4	1.2L	750mL	0.0°C	2.0atm	500.mL	25°C	
5	95kPa	4.0L	295K	101kPa	6.0L	471 K	
6	X	198mL	100. °C	X	225mL	150.°C	
7	1.1atm	1.5L	15°C	.694 atm	2.5L	30. °C	
8	125kPa	125mL	544K	100.kPa	100.mL	75°C	

Dalton's Law of Partial Pressures

1. What is the total pressure exerted by a mixture containing two gases if the partial pressure of one gas is 70. torr and the partial pressure of the other gas is 30. torr?

100 torr

2. A 1-Liter flask contains two gases at a total pressure of 3.0 atmospheres. If the partial pressure of one of the gases is 0.5 atmospheres, then the partial pressure of the other gas must be what?

2.5 atm

3. A mixture of oxygen, nitrogen, and hydrogen gases exerts a total pressure of 740. mmHg at 0°C. The partial pressure of the oxygen is 200. mmHg and the partial pressure of nitrogen is 400. mmHg. What is the partial pressure of the hydrogen gas in this mixture?

140 mm Hg

4. A sealed flask contains 1 mole of hydrogen and 3 moles of helium at 20°C. If the total pressure is 400 torr, the partial pressure of the hydrogen is?

100 torr

5. A 300.-milliliter container that is filled with 100. milliliters of oxygen and 200. milliliters of hydrogen has a total pressure of 750. millimeters of mercury. What is the partial pressure of the oxygen?

250 mm Hg $\frac{100}{300} = \frac{x}{750}$

6. When 7.00 moles of gas A and 3.00 moles of gas B are combined, the total pressure exerted by the gas mixture is 760. mmHg. What is the partial pressure exerted by gas A in this mixture?

532 mm Hg

7. A container hold three gases. The total pressure exerted by all three gases is 45.0 atm. If one gas exerts a pressure of 12.0 atm and a second gas exerts a pressure of 9.00 atm, determine the pressure exerted by the third gas.

24 atm