Name________________________________ Date_____________________ Period_____

Topic: Physical Behavior of Matter

Matter, Its Properties and Changes Outline

1) **Matter is classified as a pure substance or a mixture of substances. A pure substance (element or compound) has a constant composition and constant properties throughout a given sample, and from sample to sample.**
   - ✓ You can use particle models/diagrams to differentiate among elements, compounds, and mixtures.

2) **The proportions of components in a mixture can be varied. Each component in a mixture retains its original properties. Differences in properties such as density, particle size, molecular polarity, boiling point and freezing point, and solubility permit physical separation of the components of the mixture.**
   - ✓ Methods of separating mixtures include evaporation, filtration, distillation, and chromatography.
   - ✓ Mixtures can be homogeneous or heterogeneous. Solutions are always homogeneous. Heterogeneous mixtures are things like soil, fruit salad, where the composition is NOT uniform throughout the mixture.

3) **The structure and arrangement of particles and their interactions determine the physical state of a substance at a given temperature and pressure.**
   - ✓ Know the states (phases) of the elements at STP; Br and Hg are the only 2 liquids, the noble gases as well as N, O, F, H, and Cl are gases, the rest are solids
   - ✓ Know the 7 elements that are diatomic in their natural states; “7-Up” or “$Br_2I_2N_2Cl_2H_2O_2F_2$”.
   - ✓ Draw particle models of solids, liquids, and gases.

4) **A physical change results in the rearrangement of existing particles in a substance; no new types of particles result from this type of change. A chemical change results in the formation of different particles with changed properties.**
   - ✓ Distinguish between chemical and physical changes based on whether new substances form or not.

5) **Properties can be physical or chemical. Physical properties describe those characteristics that can be observed with the senses or measured. Chemical properties describe how the substance interacts with other substances.**
   - ✓ Distinguish between chemical and physical properties.
   - ✓ One of the more useful properties is density. The density equation is on Table T; D=m/V.
   - ✓ Some common properties of the elements are found on Table S, such as melting and boiling points.

Matter – Questions from previous Regents exams

1. A sample composed only of atoms having the same atomic number is classified as
   (1) a compound (3) an element
   (2) a solution (4) an isomer

2. A dilute, aqueous potassium nitrate solution is best classified as a
   (1) homogeneous compound
   (2) homogeneous mixture
   (3) heterogeneous compound
   (4) heterogeneous mixture

3. At which Celsius temperature does lead change from a solid to a liquid?
   (1) 874°C (3) 328°C
   (2) 601°C (4) 0°C

4. Which statement describes a chemical property of hydrogen gas?
   (1) Hydrogen gas burns in air.
   (2) Hydrogen gas is colorless.
   (3) Hydrogen gas has a density of 0.000 09 g/cm^3 at STP.
   (4) Hydrogen gas has a boiling point of 20. K at standard pressure.

5. Which element has the greatest density at STP?
   (1) calcium (3) chlorine
   (2) carbon (4) copper

6. Which statement describes a chemical property of the element magnesium?
   (1) Magnesium is malleable.
   (2) Magnesium conducts electricity.
   (3) Magnesium reacts with an acid.
   (4) Magnesium has a high boiling point.

7. Matter that is composed of two or more different elements chemically combined in a fixed proportion is classified as
   (1) a compound (3) a mixture
   (2) an isotope (4) a solution

8. Which element is a solid at STP and a good conductor of electricity?
   (1) iodine (3) nickel
   (2) mercury (4) sulfur

9. The table below shows mass and volume data for four samples of substances at 298 K and 1 atmosphere.

Masses and Volumes of Four Samples

Sample	Mass (g)	Volume (mL)
A	30.	60.
B	40.	50.
C	45	90.
D	90.	120.

   Which two samples could consist of the same substance?
   (1) *A* and *B* (3) *B* and *C*
   (2) *A* and *C* (4) *C* and *D*

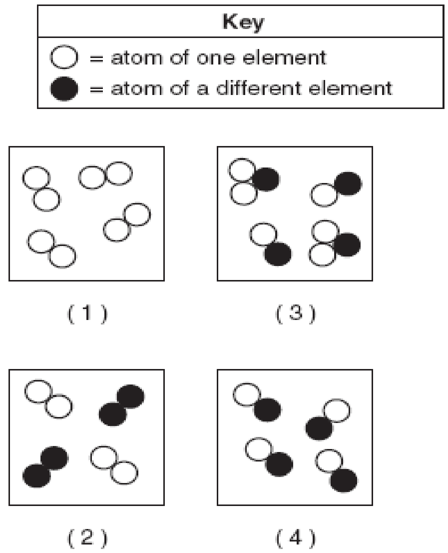
10. Bronze contains 90 to 95 percent copper and 5 to 10 percent tin. Because these percentages can vary, bronze is classified as
   (1) a compound (3) a mixture
   (2) an element (4) a substance

11. At STP, which list of elements contains a solid, a liquid, and a gas?
   (1) Hf, Hg, He (3) Ba, Br_2, B
   (2) Cr, Cl_2, C (4) Se, Sn, Sr

12. A 10.0-gram sample of which element has the *smallest* volume at STP?
   (1) aluminum (3) titanium
   (2) magnesium (4) zinc

13. At room temperature, a mixture of sand and water can be separated by
   (1) ionization (3) filtration
   (2) combustion (4) sublimation

14. Which particle diagram represents a sample of one compound, only?



15. A 1.00-mole sample of neon gas occupies a volume of 24.4 liters at 298 K and 101.3 kilopascals. Calculate the density of this sample. Your response must include *both* a correct numerical setup and the calculated result.

Base your answers to questions 16 through 18 on the information below.

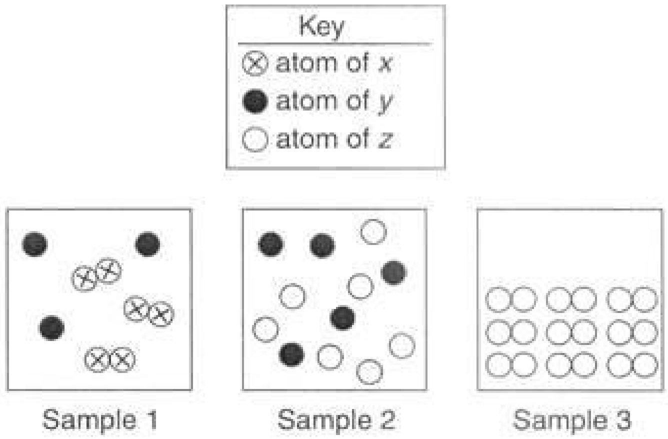
In an investigation, a dripless wax candle is massed and then lighted. As the candle burns, a small amount of liquid wax forms near the flame. After 10 minutes, the candle's flame is extinguished and the candle is allowed to cool. The cooled candle is massed.

16. Identify *one* physical change that takes place in this investigation.

17. State *one* observation that indicates a chemical change has occurred in this investigation.

18. Draw a particle diagram showing the change from solid wax to liquid wax. Use "●" for particles of wax. Draw separate diagrams for the liquid and the solid states.

Base your answers to questions 19 through 21 on the particle diagrams below, which show atoms and/ or molecules in three different samples of matter at STP.



19. Which sample represents a pure substance?

20. When two atoms of y react with one atom of z, a compound forms. Using the number of atoms shown in sample 2, what is the maximum number of molecules of this compound that can be formed?

21. Explain why xx does not represent a compound.

Topic: Physical Behavior of Matter

Heat & Temperature

1. **Energy can exist in different forms – chemical, electrical, electromagnetic, thermal, mechanical, nuclear.**
   - ✓ Stored energy is referred to as potential energy.
   - ✓ Energy of motion is kinetic energy.

2. **The Law of Conservation of Energy states that energy can not be lost or destroyed, only changed from one form to another.**

3. **Heat is a transfer of energy (often but not always thermal energy) from a body of higher temperature to a body of lower temperature.**

4. **Temperature is a measure of the average kinetic energy of the particles in a sample. Temperature is NOT a form of energy and should not be confused with heat.**

5. **The concepts of kinetic and potential energy can be used to explain physical processes such as fusion (melting), solidification (freezing), vaporization (boiling, evaporation), condensation, sublimation, and deposition.**

6. **Processes that are exothermic give off heat energy. This typically causes the surrounding environment to become warmer.**

7. **Processes that are endothermic absorb energy. This typically causes the surrounding environment to become colder.**

Heat & Temperature Outline

1) **Temperature is a "measure of the average kinetic energy of the particles in a sample of matter."**
   - ✓ Kinetic energy is energy due to motion. So as temperature increases, the particles move faster, on average.
   - ✓ Temperature does NOT depend on the mass of the sample.

2) **Temperature scales used by chemists are the Celsius and Kelvin scales.**
   - ✓ The freezing point of water is a reference point often used in science, and is referred to as "standard temperature." Its value is 0^oC or 273 K, and is noted on Table A.
   - ✓ The boiling point of water is 100^oC or 373 K.
   - ✓ Converting from C^o to K: $K = C^o + 273$ (on Table T)

3) **Heat is a form of energy and IS NOT the same as temperature.**
   - ✓ Heat is dependent on mass. There is more heat in an iceberg that is at 0^0C than a cup full of boiling water.
   - ✓ Heat can be transferred from one substance to another when their particles are in contact (when the objects touch). Heat will move from the object with more particle KE (higher temp) to the one with less.
   - ✓ The amount of heat needed to cause a temperature change is dependent on the mass of the sample, its "specific heat" and the amount of temperature change: $q = m c \Delta T$ (Table T) When heat is absorbed to cause a temperature change, it is resulting in a change in KE of particles.
   - ✓ The amount of heat needed to cause a phase change can be calculated using the $q = mHf$ (melting), or $q = mHv$ (boiling) (Table T). When heat is added to cause a phase change, it is causing a change in intermolecular forces between particles.
   - ✓ The values for water are on Table B.

4) **<u>Heat of fusion</u> (H_f) is the energy needed to convert one gram of a substance from solid to liquid.**

5) **<u>Heat of vaporization</u> (H_v) is the energy needed to convert one gram of a substance from liquid to gas.**

6) **<u>Specific heat</u> (C) is the energy required to raise one gram of a substance 1 degree (Celcius or Kelvin).**
   - ✓ The specific heat of liquid water is 1 cal/g*J or 4.2 J/g*K.

7) The three phases of matter are solid, liquid and gas. Each has its own properties.
- ✓ Solids have a constant volume and shape. Particles are held in a rigid, crystalline structure.
- ✓ Liquids have a constant volume but a changing shape. Particles are mobile but still held together by strong attraction.
- ✓ Gases have no set volume or shape. They will completely fill any closed contained. Particles have largely broken free of the forces holding them together.
- ✓ The phase a substance is in is dependent on the temperature. Melting points and boiling points are on Table S (in Kelvin degrees).

8) Phase changes are a type of physical change. If they are changes that involve heat being absorbed, they are endothermic changes.
- ✓ Endothermic phase changes are melting, boiling, evaporating and subliming (s→l).
- ✓ Opposite type of phase changes (freezing, condensing, depositing) are exothermic.

9) A heating curve (or cooling curve) traces the changes in temperature of a substance as it changes from solid to liquid to gas (or gas to liquid to solid).
- ✓ When the substance undergoes a phase change, there is no change in temperature. The line "flattens" until the phase change is complete.
- ✓ When a phase change is occurring, the potential energy of the substance changes while kinetic energy remains the same.
- ✓ As temperature increases, kinetic energy increases.

10) The amount of heat involved in some chemical changes is shown on Table I, called "heat of reaction" or ΔH.
- ✓ If the value is negative, the reaction is exothermic.
- ✓ This can be expressed as a potential energy diagram.
- ✓ If the energy is written into the equation, and is on the reactants side, the reaction is endothermic.
- ✓ ΔH is the difference between the energy stored in the products (PE) and the potential energy of the reactants.

11) Breaking bonds is ALWAYS endothermic, and forming bonds is ALWAYS exothermic.
- ✓ $I + I \rightarrow I_2$ Bond is forming, I atoms are become stable by bonding, so they release energy (Exo)
- ✓ $H_2 \rightarrow H + H$ Bond is breaking, requires energy in order to put atoms in unbonded state (endo)

Heat and Temperature — Questions from previous Regents exams

1. Given the balanced equation:
   $I + I \rightarrow I_2$
   Which statement describes the process represented by this equation?
   (1) A bond is formed as energy is absorbed.
   (2) A bond is formed and energy is released.
   (3) A bond is broken as energy is absorbed.
   (4) A bond is broken and energy is released.

2. Which term is defined as a measure of the average kinetic energy of the particles in a sample?
   (1) temperature (3) thermal energy
   (2) pressure (4) chemical energy

3. Which term refers to the difference between the potential energy of the products and the potential energy of the reactants for any chemical change?
   (1) heat of deposition
   (2) heat of fusion
   (3) heat of reaction
   (4) heat of vaporization

4. Which kelvin temperature is equal to 56°C?
   (1) –329 K (3) 217 K
   (2) –217 K (4) 329 K

5. Which reaction releases the greatest amount of energy per 2 moles of product?
   (1) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
   (2) $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
   (3) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
   (4) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Use the reaction shown below to answer questions 6 and 7.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) + 2219.2 \text{ kJ}$$

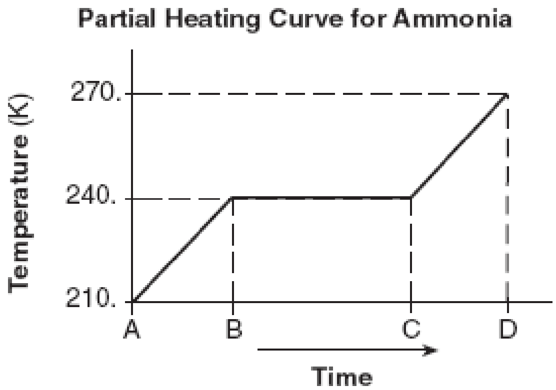
6. Draw a potential energy diagram for this reaction. [1]

7. Determine the total amount of energy released when 2.50 moles of propane is completely reacted with oxygen. [1]

8. Given the balanced equation representing a reaction: $N_2(g) + O_2(g) + 182.6 \text{ kJ} \rightarrow 2NO(g)$
   Draw a potential energy diagram for this reaction. [1]

Base your answers to questions 9 through 11 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.



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

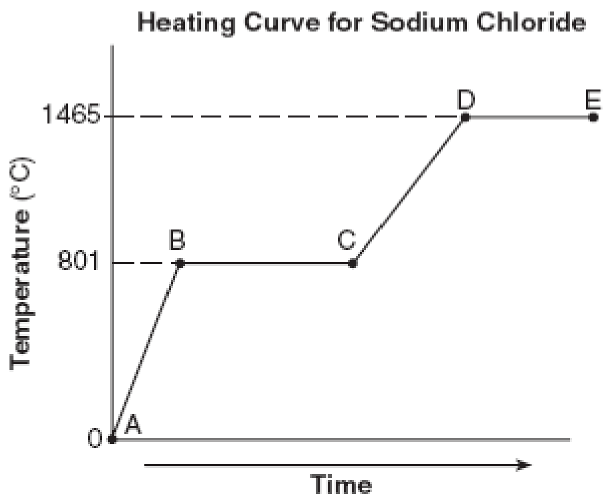
9. Calculate the total heat absorbed by the 5.00-gram sample of ammonia during time interval *AB*. Your response must include *both* a correct numerical setup and the calculated result. [2]

10. 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. [1]

11. Determine the total amount of heat required to vaporize this 5.00-gram sample of ammonia at its boiling point. [1]

Base your answers to questions 12 through 14 on the information below.

A 100.0-gram sample of NaCl(s) has an initial temperature of 0°C. A chemist measures the temperature of the sample as it is heated. Heat is *not* added at a constant rate. The heating curve for the sample is shown below.



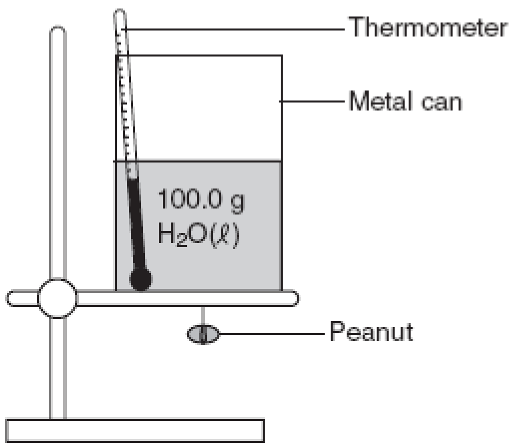
12. Determine the temperature range over which the entire NaCl sample is a liquid. [1]

13. Identify *one* line segment on the curve where the average kinetic energy of the particles of the NaCl sample is changing. [1]

14. Identify *one* line segment on the curve where the NaCl sample is in a single phase and capable of conducting electricity. [1]

Base your answers to questions 15 and 16 on the information below.

A student performed an experiment to determine the total amount of energy stored in a peanut. The accepted value for the energy content of a peanut is 30.2 kilojoules per gram. The student measured 100.0 grams of water into a metal can and placed the can on a ring stand, as shown in the diagram below. The peanut was attached to a wire suspended under the can. The initial temperature of the water was recorded as 22.0°C. The peanut was ignited and allowed to burn. When the peanut finished burning, the final water temperature was recorded as 57.0°C. The student's experimental value for the energy content of this peanut was 25.9 kilojoules per gram.

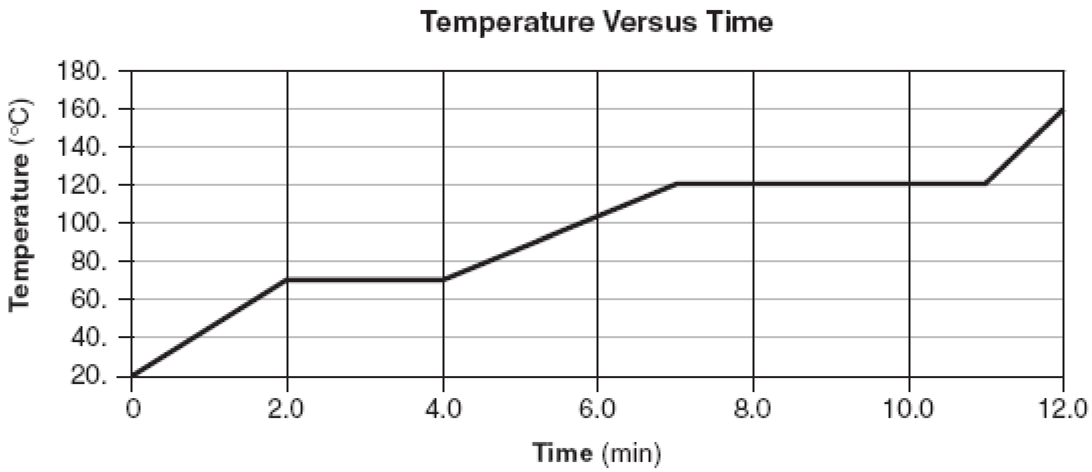


15. Calculate the total amount of heat absorbed by the water. Your response must include *both* a correct numerical setup and the calculated result. [2]

16. Determine the student's percent error for the energy content of this peanut. [1]

Base your answers to questions 17 through 20 on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.



17. What is the boiling point of this sample? [1]

18. Draw *at least nine* particles in the box, showing the correct particle arrangement of this sample during the first minute of heating. [1]

19. What is the total time this sample is in the liquid phase, only? [1]

20. Determine the total amount of heat required to completely melt this sample at its melting point. [1]

Topic: Physical Behavior of Matter

Phases & Gases

1) **The three phases of matter are solid, liquid and gas. Each has its own properties.**
   - ✓ Solids have a constant volume and shape. Particles are held in a rigid, crystalline structure.
   - ✓ Liquids have a constant volume but a changing shape. Particles are mobile but still held together by strong attraction.
   - ✓ Gases have no set volume or shape. They will completely fill any closed contained. Particles have largely broken free of the forces holding them together.

2) **A heating curve (or cooling curve) traces the changes in temperature of a substance as it changes from solid to liquid to gas (or gas to liquid to solid).**
   - ✓ When the substance undergoes a phase change, there is no change in temperature. The line "flattens" until the phase change is complete.
   - ✓ When a phase change is occurring, the potential energy of the substance changes while kinetic energy remains the same.
   - ✓ As temperature increases, kinetic energy increases.

3) **<u>Heat of fusion</u> (H_f) is the energy needed to convert one gram of a substance from solid to liquid.**

4) **<u>Heat of vaporization</u> (H_v) is the energy needed to convert one gram of a substance from liquid to gas.**

5) **<u>Specific heat</u> (C) is the energy required to raise one gram of a substance 1 degree (Celcius or Kelvin).**
   - ✓ The specific heat of liquid water is 1 cal/g*J or 4.2 J/g*K.

6) **The combined gas law states the relationship between pressure, temperature and volume in a sample of gas.**
   - ✓ Increasing pressure causes a decrease in volume (inverse relationship).
   - ✓ Increasing temperature causes an increase in volume (direct relationship).
   - ✓ Increasing temperature causes an increase in pressure (direct relationship).
   - ✓ $(PV/T)_1 = (PV/T)_2$ reminder!! All temperatures must be in the Kelvin scale when using this equation

7) **An ideal gas model is used to explain the behavior of gases. An "ideal gas" would perfectly obey the combined gas law (PV/T) at all conditions of temperature and pressure.**
   a. A real gas is most like an ideal gas when it is at <u>high temperature and low pressure.</u> In other words, at conditions which would favor the gas staying in the gas phase (and not liquefying).
   b. The real gases that most resemble ideal gases are H_2 and He.

8) **The Kinetic Molecular Theory (KMT) for an ideal gas states that all gas particles:**
   - ✓ are in random motion.
   - ✓ have no forces of attraction between them.
   - ✓ have a negligible volume compared to the distances between them.
   - ✓ have collisions that result in the transfer of energy from one particle to another, with no net loss of energy from the collision.

9) **Equal volumes of gases at the same temp and pressure have an equal number of particles.**

Phases & Gases – Questions from previous Regents exams

1. 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. What is the boiling point of propanone if the pressure on its surface is 48 kilopascals?
   (1) 25°C (3) 35°C
   (2) 30.°C (4) 40.°C

2. At which Celsius temperature does lead change from a solid to a liquid?
   (1) 874°C (3) 328°C
   (2) 601°C (4) 0°C

3. 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 *B* (3) *B* and *C*
   b. *A* and *C* (4) *B* and *D*

4. At which temperature is the vapor pressure of ethanol equal to the vapor pressure of propanone at 35°C?
   (1) 35°C (3) 82°C
   (2) 60.°C (4) 95°C

5. A rigid cylinder with a movable piston contains a 2.0-liter sample of neon gas at STP. What is the volume of this sample when its temperature is increased to 30.°C while its pressure is decreased to 90. kilopascals?
   (1) 2.5 L (3) 1.6 L
   (2) 2.0 L (4) 0.22 L

6. Which kelvin temperature is equal to 56°C?
   (1) –329 K (3) 217 K
   (2) –217 K (4) 329 K

7. A sample of gas is held at constant pressure. Increasing the kelvin temperature of this gas sample causes the average kinetic energy of its molecules to
   (1) decrease and the volume of the gas sample to decrease
   (2) decrease and the volume of the gas sample to increase
   (3) increase and the volume of the gas sample to decrease
   (4) increase and the volume of the gas sample to increase

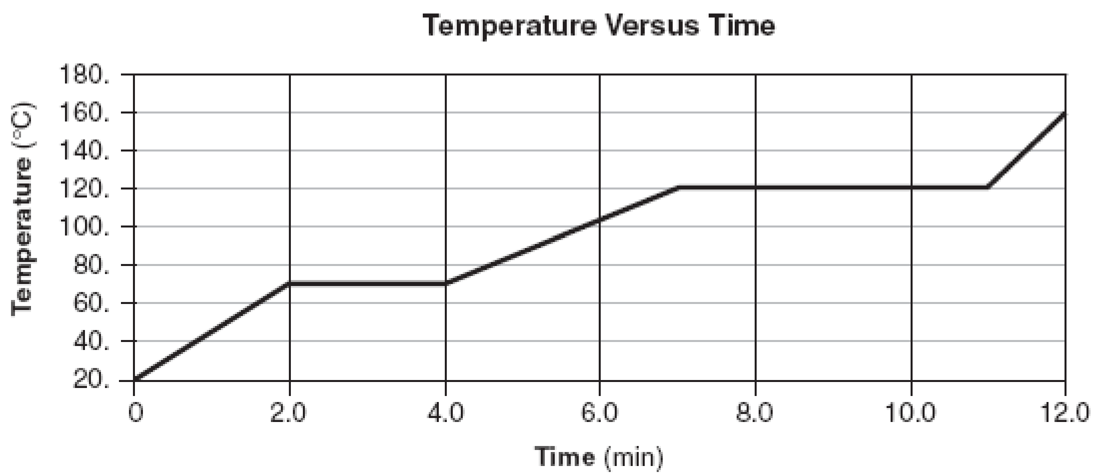
8. At STP, which sample contains the same number of molecules as 11.2 liters of $CO_2(g)$ at STP?
   (1) 5.6 L of $NO_2(g)$ (3) 11.2 L of $N_2(g)$
   (2) 7.5 L of $H_2(g)$ (4) 22.4 L of CO(g)

9. At which temperature would atoms of a He(g) sample have the greatest average kinetic energy?
   (1) 25°C (3) 273 K
   (2) 37°C (4) 298

10. A 1.00-mole sample of neon gas occupies a volume of 24.4 liters at 298 K and 101.3 kilopascals. In the space *in your answer booklet*, calculate the density of this sample. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 11 through 14 on the information below.

The temperature of a sample of a substance is increased from 20.°C to 160.°C as the sample absorbs heat at a constant rate of 15 kilojoules per minute at standard pressure. The graph below represents the relationship between temperature and time as the sample is heated.



11. What is the boiling point of this sample? [1] ______________

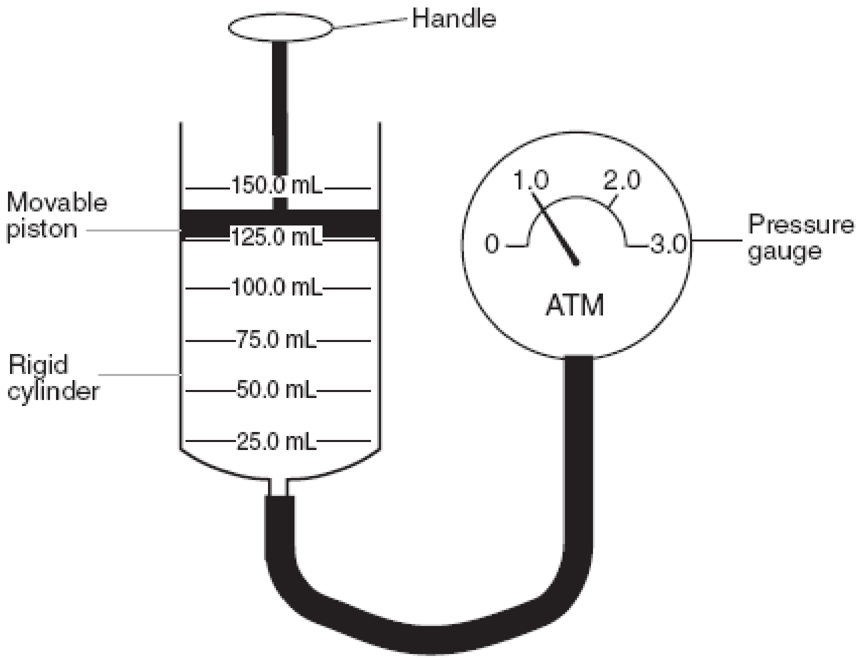
12. Draw *at least nine* particles in the box, showing the correct particle arrangement of this sample during the first minute of heating. [1]

13. What is the total time this sample is in the liquid phase, only? [1] ________________________

14. Determine the total amount of heat required to completely melt this sample at its melting point. [1]

Base your answers to questions 15 through 17 on the information below.

A rigid cylinder is fitted with a movable piston. The cylinder contains a sample of helium gas, He(g), which has an initial volume of 125.0 milliliters and an initial pressure of 1.0 atmosphere, as shown below. The temperature of the helium gas sample is 20.0°C.



15. Express the initial volume of the helium gas sample, in liters. [1]__________________________Liters

16. The piston is pushed further into the cylinder. Show the correct numerical setup for calculating the volume of the helium gas that is anticipated when the reading on the pressure gauge is 1.5 atmospheres. The temperature of the helium gas remains constant. [1]

17. Helium gas is removed from the cylinder and a sample of nitrogen gas, N_2(g), is added to the cylinder. The nitrogen gas has a volume of 125.0 milliliters and a pressure of 1.0 atmosphere at 20.0°C. Compare the number of particles in this nitrogen gas sample to the number of particles in the original helium gas sample. [1]