**Unit 08 Review: The KMT and Gas Laws**

It may be helpful to view the animation showing heating curve and changes of state:
**http://cwx.prenhall.com/petrucci/medialib/media_portfolio/text_images/031_ChangesState.MOV**

**Practice Multiple Choice Questions**

1. Mercury freezes at a temperature of -39 $^{o}$C. The freezing point of mercury on the Kelvin scale is:
a) 234 K
b) 312 K
c) 39 K
d) 273 K

2. The change of state from a gas to a solid is called:
a) condensation
b) boiling
c) sublimation
d) this change of state is impossible

3. The type(s) of molecular motion displayed by particles in the solid state include:
a) vibration only
b) vibration and rotation only
c) vibration, rotation and translation
d) translation only

4. Which of the following are characteristics of oxygen molecules in the gas state?
I. they display rotational motion
II. they have very low potential energy
III. they are fluids
IV. they have very weak intra-molecular forces of attraction

a) I and III only
b) I and IV only
c) II and III only
d) I, III and IV only

5. Which of the following substances has the highest potential energy?
a) pure aluminum at 800 K
b) pure bromine at 800 K
c) pure selenium at 800 K
d) these substances all have the same potential energy

6. Which of the following substances has a fixed volume but no fixed shape?
a) pure carbon dioxide gas
b) pure liquid ethanol
c) pure solid paraffin wax
d) pure water vapour

7. Referring to Periodic Table, which of the following statements is/are true about iodine?
a) the boiling point of iodine is 457.51 K
b) the melting point of iodine is 386.85 K
c) the freezing point of iodine is 386.85 K
d) all of the above

8. Which of the following is the metric (SI) unit for pressure?
a) atm
b) kPa
c) PSI
d) Torr

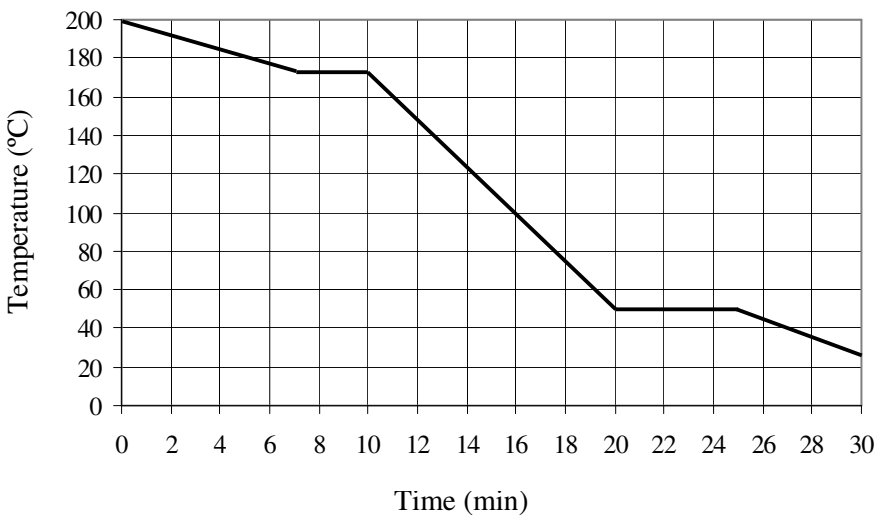
9. Water cools from 12°C to 2°C. During this time:
a) both the kinetic and potential energies of the molecules decrease
b) the kinetic energy of the molecules decreases and potential energy is constant
c) the kinetic energy is constant and the potential energy of the molecules decreases
d) the kinetic energy is increases and the potential energy of the molecules decreases

10. Which of the following is **NOT** part of the Kinetic Molecular Theory?
a) collisions between gas molecules are perfectly elastic
b) attractive forces between gas molecules are negligible
c) the kinetic energy of the gas molecules is directly proportional to their temperature in Celsius
d) the volume of the gas molecules in a container is negligible compared to the volume of the container

11. Which of the following is an assumption made about ideal gases? Ideal gases have:
a) no inter-molecular forces of attraction
b) no potential energy
c) no kinetic energy
d) all of the above

Answer questions 12 - 20 about the cooling curve for para-dichloro-benzene at constant volume:

**Cooling Curve for Para-Dichlorobenzene at Constant Volume**




12. From 10 to 20 minutes:
 a) potential energy is decreasing
 b) kinetic energy is decreasing
 c) the particles are getting closer together
 d) all of the above

13. From 25 to 30 min., the particles:
 a) are getting closer together
 b) are slowing down
 c) are getting smaller
 d) all of the above

14. From 20 to 25 minutes:
 a) potential energy is decreasing
 b) kinetic energy is constant
 c) both solid and liquid para-dichlorobenzene are present
 d) all of the above

15. At 30 minutes:
 a) all motion has stopped
 b) the particles have only vibrational motion
 c) the particles have only translational motion
 d) the particles can vibrate, rotate and translate

16. From 0 to 7 minutes:
 a) the particles have very high potential energy
 b) the particles have high kinetic energy
 c) the para-dichlorobenzene is a vapour
 d) all of the above

17. In which regions of the graph is the kinetic energy of the molecules changing?
 I. 0 to 7 minutes
 II. 7 to 10 minutes
 III. 10 to 20 minutes
 IV. 20 to 25 minutes
 V. 25 to 30 minutes
 a) I, III and V only
 b) II and IV only
 c) III only
 d) I, II, III, IV and V

18. Referring to the time periods in question 17, in which regions of the cooling curve is potential energy changing?
 a) I, III and V only
 b) II and IV only
 c) III only
 d) I, II, III, IV and V

19. Which of the following statements is/are true about para-dichlorobenzene?
 a) it is solid at SATP
 b) its melting point is about 50ºC
 c) its freezing point is about 50ºC
 d) all of the above

20. From the shape of the cooling curve, it can be stated that this is a very pure sample of para-dichlorobenzene
 a) true
 b) false
 c) there is no way to determine this

21. If equal volumes of two different gases have the same temperature and pressure, then they must have:
 a) the same total mass
 b) the same average kinetic energy
 c) the same molar mass
 d) all of the above

22. As a gas is cooled in a rigid container:
 a) its volume decreases
 b) the molecules crowd together to stay warm
 c) its pressure decreases
 d) the distance between particles decreases

23. Which of the following is NOT part of the Kinetic Molecular Theory applied to gases?
 a) the kinetic energy of the particles of a gas is in direct proportion to its Kelvin temperature
 b) the particles of a gas are in rapid, random, straight-line motion
 c) the particles of a gas are very small when compared to the distances between them
 d) there is a strong attraction between molecules of a gas

24. Which state of matter has the lowest potential energy?
 a) gas
 b) solid
 c) liquid
 d) vapour

25. Which of the following is NOT true of a sample of gas as it is heated in a rigid, closed container?
 a) the pressure of the molecules increases
 b) the distance between molecules increases
 c) the average speed of the molecules increases
 d) the # of collisions between molecules increases

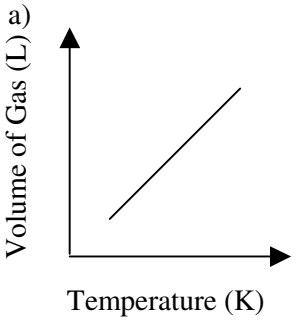
26. If a gas's volume is doubled but the temperature and number of moles remains constant:
 a) the pressure will increase
 b) the pressure will decrease
 c) the molecules move faster
 d) the molecules move slower

27. Small molecules of pure covalent compounds are often what state at SATP?
 a) solid
 b) liquid
 c) gas
 d) vapour

28. A gas is allowed to expand into a larger volume with no change in temperature. Which statement is true?
 a) the average kinetic energy of the particles will increase
 b) the average kinetic energy of the particles will decrease
 c) the potential energy of the particles will increase
 d) the potential energy of the particles will decrease

29. To increase the volume of a fixed amount of gas from 100 mL to 200 mL:
 a) increase the temperature from 25.0 to 50.0 $^{o}$C at constant pressure
 b) increase the pressure from 1.00 to 2.00 atm at constant temperature
 c) reduce the temperature from 400 K to 200 K at constant pressure
 d) reduce the pressure from 608 mm Hg to 0.40 atm at constant temperature

30. Assuming moles of gas and pressure are held constant, which of the following graphs shows how the volume of an ideal gas changes with temperature?

a)
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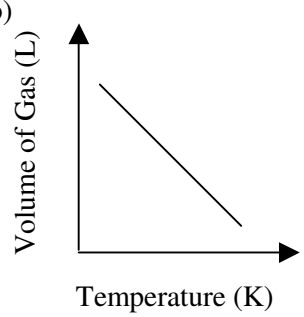


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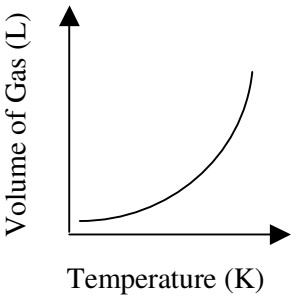
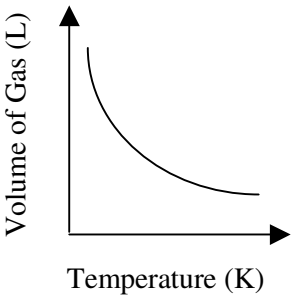


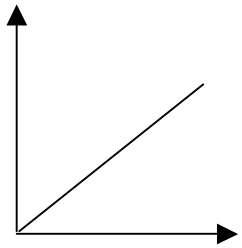

d)


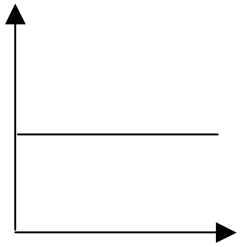

31. Convert 28.0 Torr to kPa:
 a) 210 kPa
 b) 0.553 kPa
 c) 233 kPa
 d) 3.73 kPa

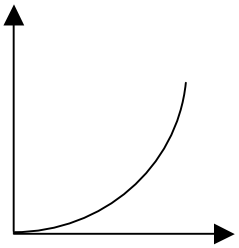
32. The volume of 1.00 mole of He(g) at 0 $^{o}$C and 1000.0 atm is:
 a) 0.0174 L
 b) 0.0460 L
 c) 0.0224 L
 d) 0.0112 L

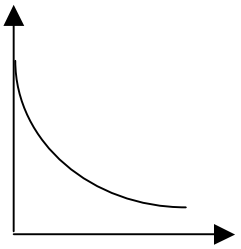
33. What is the volume of one mole of hydrogen gas ($H_2$) at standard temperature and pressure?
 a) 1.0 L
 b) 22.4 L
 c) 2.0 L
 d) 44.8 L

34. Which of the following graphs represents an inverse (indirect) relationship?

a) 

b) 

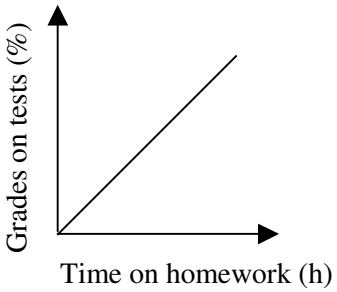
c) 

d) 

35. When 23 mL of $CO_2$ gas is heated at constant pressure from 10°C to 30°C, the volume becomes:
a) 7.7 mL
b) 25 mL
c) 69 mL
d) none of these

36. For a gas, which pair of variables is inversely proportional to each other when all other variables are held constant?
a) P and T
b) V and T
c) P and V
d) n and V

37. If "t" represents time on homework, and "G" represents grades on tests, for the graph shown to the right, which is a correct mathematical relationship?
a) t x G = constant
b) t + G = constant
c) G / t = constant
d) t x G = zero




38. A sample of gas has a volume of 2.5 L at 30 °C and 720 mmHg. What will be the volume of this gas at 22 °C and 750 mmHg?
a) 2.1 x $10^5$ L
b) 2.3 L
c) 0.43 L
d) 1.8 L

39. A sample of gas weighs 0.250 g and has a volume of 112 mL at STP. The molar mass of this gas is:
a) 50.0 g/mol
b) 8.0 g/mol
c) 2.23 g/mol
d) impossible to calculate from the data given

40. A 500.0 mL sample of $O_2$ (g) is at 780 mmHg and 30°C. What will be the new volume if the pressure and amount of gas are held constant, and the temperature is decreased to -15 °C?
a) 426 mL
b) 587 mL
c) 250.0 mL
d) - 250.0 mL

41. Guy-Lussac's Law for gases expresses the relationship between:
a) temperature (in K) and pressure
b) pressure and volume
c) temperature (in K) and volume
d) pressure and number of moles

42. A gaseous hydrocarbon weighing 0.290 g occupies a volume of 125 mL at 25 °C and 760 mmHg. What is the molar mass of this compound?
b) 5.11 g/mol
b) 38.4 g/mol
c) 56.7 g/mol
d) 132 g/mol

43. 16.0 L of a gas has its temperature tripled, pressure halved and half of the gas molecules removed. The final volume of the gas is:
a) 24.0 L
b) 48.0 L
c) 96.0 L
d) 2.67 L

44. The density of a gas is 1.35 g/L at STP. What is the molar mass of the gas?
a) 0.0603 g/mol
b) 22.4 g/mol
c) 6.02 g/mol
d) 30.2 g/mol

45. What volume will 2.90 moles of oxygen gas occupy at 25.0°C and 1.70 atm pressure?
a) 3.5 L
b) 41.7 L
c) 22.4 L
d) 4220 L

46. The inter-molecular attractions between molecules of $H_2$ gas are:
a) hydrogen bonds
b) very strong
c) a crystal lattice
d) negligible

47. Convert 849 mmHg to a pressure in atmospheres:
a) 1.12 atm
b) 8.38 atm
c) 0.895 atm
d) 0.00118 atm

48. Calculate the mass of 2.22 L of pure fluorine gas at 20.0 PSI and 45°C:
a) 0.114 g
b) 4.31 g
c) 2.16 g
d) 0.638 g

49. Which of the following relationships was discovered by Robert Boyle?
a) volume varies directly with pressure
b) pressure varies directly with temperature
c) pressure varies directly with number of moles
d) volume varies inversely with pressure

50. In order to discover the relationship for Guy-Lussac's law, which variables must be held constant?
a) pressure and number of moles of gas
b) temperature and pressure
c) pressure and volume
d) number of moles and volume of gas

51. A 5.0 mol sample of a gas at 1.0 atm is expanded at constant temperature from 10.0 L to 15.0 L. The final pressure is:
a) 7.5 atm
b) 0.67 atm
c) 1.5 atm
d) 3.3 atm

52. Which of the following expresses the relationship for Charles' law?
a) P/T = constant
b) T/P = constant
c) V/T = constant
d) PV = constant

53. A gas originally at 27ºC and 1.00 atm pressure in a 3.9 L balloon is cooled at constant pressure until the temperature is 11ºC. The new volume of the gas is:
a) 0.27 L
b) 3.9 L
c) 0.24 L
d) 3.7 L

54. The amount of gas that occupies 60.82 L at 31ºC and 367 mmHg is:
a) 1.18 mol
b) 0.850 mol
c) 0.120 mol
d) 11.6 mol

55. A 0.325 L flask is filled with gas at 0.914 atm and 19ºC. How many molecules of gas are in the flask?
a) $1.48 \times 10^{-2}$ molecules
b) $1.24 \times 10^{-2}$ molecules
c) $7.47 \times 10^{21}$ molecules
d) $7.37 \times 10^{19}$ molecules

56. A sample of unknown gas at STP has a density of 0.630 g per liter. What is the molar mass of this gas?
a) 2.81 g/mol
b) 22.4 g/mol
c) 14.1 g/mol
d) 63 g/mol

57. The density of an unknown gas is 4.20 g/L at 3.00 atm and 127 °C. What is the molar mass of this gas?
a) 0.0915 g/mol
b) 45.9 g/mol
c) 88.0 g/mol
d) 94.1g/mol

58. The average kinetic energy of the particles in a system is the definition for:
a) temperature
b) pressure
c) potential energy
d) force

59. A sample of oxygen occupies 47.2 litres under a pressure of 1240 torr at 25°C. What volume would it occupy at 25°C if the pressure were decreased to 730.0 torr?
a) 27.8 L
b) 32.3 L
c) 29.3 L
d) 80.2 L

60. The volume of a sample of nitrogen is 6.00 litres at 35°C and 740 torr. What volume will it occupy at STP?
a) 6.59 L
b) 5.18 L
c) 5.46 L
d) 6.95 L

61. A sample of nitrogen occupies 5.50 litres under a pressure of 900 torr at 25°C. At what Celsius temperature will it occupy 10.0 litres at the same pressure?
a) 542°C
b) 154°C
c) -109°C
d) 269°C

62. The density of chlorine gas at STP, in grams per liter, is approximately:
a) 6.2 g/L
b) 3.9 g/L
c) 3.2 g/L
d) 4.5 g/L

63. What pressure (in atm) would be exerted by 76 g of fluorine gas in a 1.50 litre vessel at -37°C?
a) 26 atm
b) 84 atm
c) 4.1 atm
d) 8.2 atm

64. A 20.0 L sealed flask contains $1.55 \times 10^{22}$ atoms of xenon at a temperature of 60.0ºC. What is the pressure (in atm) inside the flask?
a) 0.0352 atm
b) 3.56 atm
c) 5.27 atm
d) 0.0950 atm

65. A container with volume 71.9 mL contains water vapor at a pressure of 10.4 atm and a temperature of 465°C. How many grams of water vapour are in the container?
a) 0.421 g
b) 0.363 g
c) 0.183 g
d) 0.222 g

66. If there are 0.155 moles of $N_2$ (g), 0.110 moles of $O_2$ (g) and 0.120 moles of $CO_2$ (g) in a 2.00 L container at 24ºC, what is the total pressure (in kPa) inside the container?
a) 475 kPa
b) 0.00210 kPa
c) 38.4 kPa
d) 0.0260 kPa

67. Three 1.0 litre flasks are filled with $H_2$ (g), $O_2$ (g) and Ne (g) at STP. Which of the following statements is true?
a) the mass of gas in each flask is the same
b) the density of each gas is the same
c) each flask contain the same number of gas molecules
d) all of the above

68. The Kelvin temperature scale differs from the Celsius temperature scale because:
a) Kelvin temperatures do not have a degree (º) symbol
b) Kelvin temperatures are directly related to the average kinetic energy of the particles in a substance
c) Kelvin "degrees" are much bigger than Celsius degrees
d) both "a" and "b" are true

69. Which of the following statements is/are true at 0ºC?
a) all molecular motion stops
b) the Kelvin temperature becomes negative
c) water freezes
d) all of the above

70. Which of the following would be a vapour in the gas state at SATP?
a) pure bromine
b) pure fluorine
c) pure iodine
d) both "a" and "c"

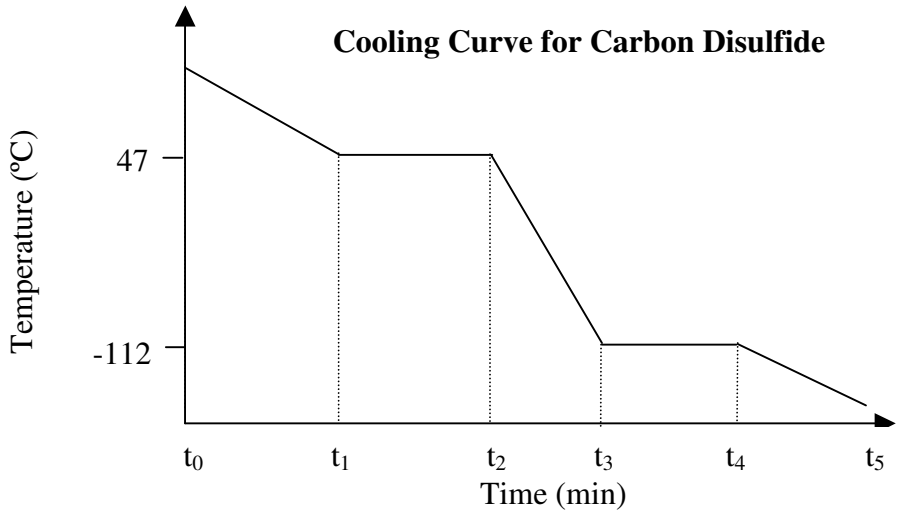
**Unit 8 Review: KMT, States of Matter and Gas Laws**

**Note**: The melting and boiling points of a substance can be used to indicate the purity of that substance. Pure substances have very "sharp" melting and boiling points. During changes of state, the temperature stays exactly the same until the change of state is complete. On the other hand, impure substances tend to melt and boil over a range of temperatures. The change of state may occur over a range of 5 to 10°C, or more.

You will be given this information on the test:

| | | | |
|---|---|---|---|
| **760 mm Hg**<br>**R = 62.36** | **760 Torr**<br>**R = 62.36** | **1.00 atm**<br>**R = 0.0821** | **15.0 PSI**<br>**R = 1.23** |

1. Refer to the cooling curve for carbon disulfide, below, to answer the following true or false statements:




a) From $t_3$ to $t_4$, kinetic energy is decreasing. _____
b) From $t_1$ to $t_2$, the particles are becoming further apart. _____
c) From $t_0$ to $t_1$, a change of state is occurring. _____
d) From $t_2$ to $t_3$, the particles are becoming closer together. _____
e) From $t_1$ to $t_2$, the particles are slowing down. _____
f) From $t_4$ to $t_5$, potential energy is decreasing. _____
g) The melting point of carbon disulfide is -112 °C. _____
h) The freezing point of carbon disulfide is -112 °C. _____
i) At 200 K, carbon disulfide is a gas. _____

2. Types of energy:
a) Define kinetic energy ($E_k$). How is it measured?
b) Define temperature. What scale is used in the study of gases to measure kinetic energy, and why?
c) What is potential energy ($E_p$)? On what factor does the potential energy of molecules depend?
d) Compare the $E_k$ and $E_p$ of the molecules in liquid water at 40°C and liquid water at 60°C.
e) Compare the $E_k$ and $E_p$ of the molecules in liquid water at 80°C and water vapour at 80°C.

3. Explain the difference between a gas and a vapour.

4. What are the three types of molecular motion? Describe each.

5. Compare gases, liquids and solids in terms of:
a) the position of the particles relative to one another
b) the strength of the attractions between the particles
c) the **type(s)** of molecular motion of the particles

6. What are the five basic statements of the kinetic molecular of matter as it applies to gases?

7. What is meant by the statement "the collisions of gas particles are perfectly elastic"? Why is this important?

8. To use the gas laws, we must assume that they behave as "ideal gases". What two assumptions are made about ideal gases?

9. Use the Kinetic Molecular Theory to explain:
a) why liquids and solids are difficult to compress compared to gases
b) why solids have a fixed volume and shape
c) why liquids have a fixed volume but variable shape
d) how gases exert pressure on their container
e) why gases expand to fill their container

10. A gas is held in a rigid container that cannot expand. If the gas is heated, what will happen to:
a) molecular motion
b) potential energy
c) kinetic energy
d) the gas pressure
e) the volume of the gas

11. A fixed amount of gas expands to fill a larger volume at constant pressure and temperature. Describe what happens to each of the factors in Question 11 for this situation.

12. How does the presence of impurities affect: (see the "note" at the beginning of the written review)
a) the melting point of a solid?
b) the boiling point of a liquid?

13. A sample of gold melts at 1024.6 ºC. Is the gold pure?

14. Name the following changes of state and indicate whether energy is absorbed or released during each change:
a) solid to liquid: _____, energy is _____
b) solid to gas: _____, energy is _____
c) gas to liquid: _____, energy is _____
d) liquid to solid: _____, energy is _____
e) gas to solid: _____, energy is _____
f) liquid to gas: _____, energy is _____

15. Copy and complete the following chart in your notes: (memorize the material in this chart!!)

| | **Charles' Law** | **Boyle's Law** | **Guy-Lussac's** |
|---|---|---|---|
| Variables that are changed | | | |
| Variables that are constant | | | |
| Direct or indirect relationship? | | | |
| Proportionality statement | | | |
| Mathematical equation (without *k*) | | | |
| Explain what is happening at the particle level | | | |

16. Write each of the laws in the chart in question 15 "in words". Be complete.

17. Complete the following statements:

a) A gas occupies 12.0 litres at 400 kPa pressure. At 50 kPa the volume of the gas would be _____ L.

b) A gas occupies 5.0 litres at 20 °C. At 40 °C the volume of the gas will be _____ litres.

c) The number of molecules of a gas in a balloon is decreased by a factor of 5. At constant temperature and pressure the volume of the gas will _____.

d) 650 K is equal to _____ °C. 250°C is equal to _____ K.

e) The variables "W" and "Z" vary inversely. Write this using the "proportionality" (%) sign, then write it as a mathematical equation.

f) The variables "Q" and "Y" vary directly. Write this using the "proportionality" (%) sign, then write it as a mathematical equation.

g) STP stands for _____ : _____ °C and _____ kPa

h) SATP stands for _____ : _____ °C and _____ kPa

i) Standard pressure is _____ kPa, _____ atmospheres, _____ mm Hg, _____ PSI.

j) 250 kPa is equal to _____ atm. 800 mm Hg is equal to _____ PSI.

k) The potential energy of the molecules of a substance increases most as it is (warmed, melted, boiled).

l) The kinetic energy of water molecules (increases, decreases, remains the same) as ice is melted.

m) What is the state of each of: $N_2$, $O_2$, $H_2$, $F_2$, $Cl_2$ at SATP?

n) You can recognize an ionic substance from its chemical formula because the first element is always a _____. What is the state of all ionic substances at SATP? _____

18. 0.75 mol of a certain gas exerts a pressure of 156 kPa at 75°C when in a 3.6 L container. What would the pressure be when 0.40 mol of the same gas are put into a 5.2 L container at - 100°C? (29 kPa)

19. A gas is pumped into a 4.00 L container at 20°C and 240 kPa. What volume would this same gas occupy at 150°C and 100 kPa? (13.9 L)

20. A person in a food processing plant is using dry ice (solid $CO_2$). He has 16.5 kg of dry ice. What volume will the $CO_2$ occupy after sublimation, at 3°C and 102 kPa? ($8.43 \times 10^3$ L)

21. Calculate the pressure exerted by 20.0 g of natural gas, $CH_4$, at 35°C and a volume of 21.3 L. (150 kPa)

22. What volume would $7.30 \times 10^{24}$ gas molecules occupy at 77°C and 174 kPa? (203 L)

23. A new pressure unit called the "spark" has been developed. Standard pressure is 48.0 sparks. What value of the ideal gas constant, R, would be used in conjunction with this new unit? (R = 3.94, for "sparks")

24. A sample of gas has the # of moles doubled, volume is halved and the temperature is tripled. If the initial pressure of the gas was 140.0 kPa, what pressure is exerted by the gas under the new conditions? (1680 kPa)

25. 24. A sample of gas occupies a volume of 250 L. What will the volume of the gas be if the pressure is quadrupled (multiplied by 4), the number of moles is tripled and the temperature is halved? (93.8 L)

26. A blimp contains a mixture of gases. The partial pressure of helium is 80 kPa, the partial pressure of nitrogen is 15 kPa and the partial pressure of neon is 2 kPa. What is the total pressure of the gas in the blimp? (97 kPa)

27. A 89.12 g sample of a diatomic (HOBrFINCl) gas has a volume of 30.72L at 27 °C and 102.0 kPa pressure. What is the molar mass, and likely identity of this gas? (MM = 70.90 g/mol; it is probably chlorine, $Cl_2$)

28. A Noble gas is collected from the basement of a home on the Canadian Shield. A 578 mL sample of the purified gas has a mass of 18.0 g and exerts a pressure of 3.63 atm at 42 °C. What is the molar mass and likely identity of the gas? (MM = 222 g/mol; the gas is probably radon)

29. Write Dalton's Law of Partial Pressures.