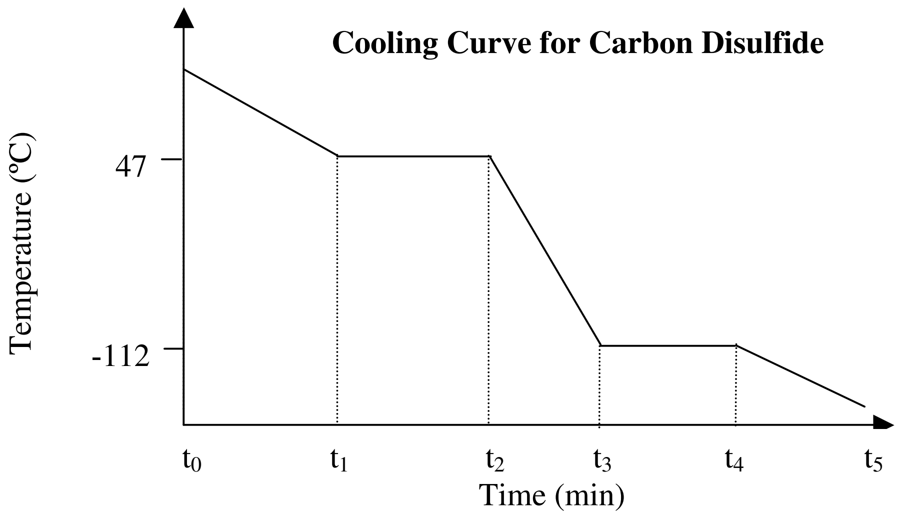
**Unit 8 Review: KMT, States of Matter and Gas Laws, Answers**

Answers to Multiple Choice questions:

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. a | 11. a | 21. b | 31. d | 41. a | 51. b | 61. d |
| 2. c | 12. b | 22. c | 32. c | 42. c | 52. c | 62. c |
| 3. a | 13. b | 23. d | 33. b | 43. b | 53. d | 63. a |
| 4. a | 14. d | 24. b | 34. d | 44. d | 54. a | 64. a |
| 5. b | 15. b | 25. b | 35. b | 45. b | 55. c | 65. d |
| 6. b | 16. d | 26. b | 36. c | 46. d | 56. c | 66. a |
| 7. d | 17. a | 27. c | 37. c | 47. a | 57. b | 67. c |
| 8. b | 18. b | 28. c | 38. b | 48. b | 58. a | 68. d |
| 9. b | 19. d | 29. d | 39. a | 49. d | 59. d | 69. c |
| 10. c | 20. a | 30. a | 40. a | 50. d | 60. b | 70. d |

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. **False**, the temperature is constant so kinetic energy is not changing
b) From $t_1$ to $t_2$, the particles are becoming further apart. **False**, the gas is condensing so the particles are coming closer together
c) From $t_0$ to $t_1$, a change of state is occurring. **False**, the particles are just slowing down
d) From $t_2$ to $t_3$, the particles are becoming closer together. **False**, the particles are in the liquid state, they are just slowing down
e) From $t_1$ to $t_2$, the particles are slowing down. **False**, the temperature is constant so the particles are moving the same speed. Potential energy is decreasing as the particles get closer together
f) From $t_4$ to $t_5$, potential energy is decreasing. **False**, the particles are not changing state. They are just slowing down
g) The melting point of carbon disulfide is -112 °C. **True**
h) The freezing point of carbon disulfide is -112 °C. **True**
i) At 200 K, carbon disulfide is a gas. **False**. 200 K is the same as -73 °C. At this temperature, $CS_2$ is liquid

2. Types of Energy
a) **Kinetic Energy** is the energy of motion. As the speed (motion) of particles increases, their kinetic energy increases. Average kinetic energy is measured by measuring the temperature of the substance.

b) **Temperature** is the measure of the average kinetic energy of the particles in a substance. Temperature measures how fast the particles in a substance are moving. In the study of gases, temperature must be measured in Kelvins, because the Kelvin temperature scale is directly correlated with molecular motion. Absolute zero (0 K) means that the motion of the particles in the substance is also zero, and the Kelvin scale has no negative values.

2b) continued. ** 0°C is the freezing point of water; 0°C does not mean that molecular motion is zero. There is no direct relationship between the temperature in Celsius and the amount of motion of the particles in a substance.

c) **Potential Energy** is the energy that objects have because of their attraction to one another and their position; it is stored energy. As the space between objects increases, their potential energy increases.

**Overall**: The potential energy of a substance depends on its state. And the state of a substance at a given temperature depends on the strength of the inter-molecular attraction between the particles.

d) Liquid water at 40°C has (40°C + 273) = 313 K of kinetic energy.
Liquid water at 60°C has (60°C + 273) = 333 K of kinetic energy.
So, the water at 60°C has slightly more kinetic energy than the water at 40°C
Because both samples of water are in the liquid state, their potential energies are essentially the same.

e) The liquid water at 80°C has the same amount of kinetic energy as the water vapour at 80°C, because their temperatures are the same.
In the liquid water, the particles are very close together, so they have low potential energy.
In the water vapour, the particles are very far apart, so they have very high potential energy.

3. A **gas** refers to a substance which is naturally in the gas state at SATP (room temperature and pressure) because there is very low inter-molecular attraction. A **vapour** refers to a substance which is usually a liquid or solid at SATP, but has been converted to the gas state by the addition of energy.

4. There are three different types of molecular motion:
a) **Vibrational motion**: The particles in a substance vibrate (move back and forth) about a fixed point. For example, the atoms within a compound vibrate back and forth along the bonds.
b) **Rotational motion**: The particles in a substance spin or rotate about a fixed axis, just like the propeller blades on an airplane.
c) **Translational motion**: The particles in a substance can move from place to place.

5. Comparing solids, liquids and gases:

| | **Solids** | **Liquids** | **Gases** |
|---|---|---|---|
| Describe the position of the particles relative to one another | The particles are very close to one another, and they are "locked in place" by very strong inter-molecular attraction | The particles are very close to one another, but they are not "locked in place". Particles can slide around one another. | The particles are very far apart. |
| Describe the strength of the attractions between the particles | Strength of attraction between the particles is very strong | Strength of attraction between the particles is strong | Particles have essentially zero attraction for one another. |
| Describe the type(s) of molecular motion of the particles | **Type of motion**: vibrational motion only | **Type of motion**: vibrational and rotational motion | **Type of motion**: vibrational, rotational and translational motion |

6. The five basic statements of the KMT for gases are:

a) Gases consist of small particles, either atoms or molecules depending on the substance, which are very far apart in comparison to their size.

b) These particles are in rapid and random, straight-line motion. The motion follows the normal laws of physics.

c) Collisions of the particles with the walls of their container or with other particles are PERFECTLY ELASTIC. This means that there is no loss of energy when particles collide.

d) There are essentially no attractive forces between gas particles.

e) The average kinetic energy of the particles is directly proportional to temperature (in K). As the temperature of a gas is increased the particles move faster thereby increasing their kinetic (motion) energy.

7. The statement that the collisions of gas particles are perfectly elastic means that no energy is lost as a result of the collisions. This is important, because if the particles did lose energy as a result of their collisions, then eventually the particles would slow down and stop moving. If this happened, their temperature would decrease and they would become liquids or solids. We know that this doesn't happen because gases will remain gases without the addition of energy to keep them in the gas state.

8. The Gas Laws assume that gas particles behave as "ideal gases". The two assumptions are that the volume of the gas particles themselves is zero and that the gas particles have no attraction for one another.

9. Use the Kinetic Molecular Theory to explain:

a) Liquids and solids are difficult to compress because there is very little space between the particles making up the substance. Gases are easily compressed because there is so much space between the particles. Gas particles can easily be pushed closer together so that they take up less space.

b) Solids have a fixed volume because the particles are very close together. The particles can not be pushed any closer together to take up less space. Solids have a fixed shape because the particles are "locked in place" by strong forces of inter-molecular attraction.

c) Liquids have a fixed volume because the particles are very close together. The particles can not be pushed any closer together to take up less space. Liquids do not have a fixed shape because the particles are not "locked in place". The forces of inter-molecular attraction are strong enough to hold the particles close to one another, but not so strong that the particles are locked in place. This allows the particles to slide around one another (flow), and this allows the shape of the liquid to change and take on the shape of its container.

d) Gases exert pressure on their container when the particles of gas collide with the container's surface. When the particles collide, they "push" on the container. The higher the temperature of the gas, the faster the particles are moving and the stronger the pressure they exert. (Remember Gay-Lussac's Law?)

e) Gases expand to fill their container because gas particles move in straight lines. They keep moving until they collide with something, such as the walls of their container. So, whatever container they are put in, they will move until they hit its walls, and this will fill the 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** will increase because temperature will increase (the particles will move faster)

b) **potential energy** stays the same because the container cannot expand, so the particles can not spread out

c) **kinetic energy** will increase because temperature has increased

d) **gas pressure** will increase because the temperature has increased, so the particles are moving faster and will hit the sides of the container with more force and exert more pressure

e) **volume** of the gas will be constant because the container is rigid and cannot expand

11. If a fixed amount of gas expands to fill a larger volume at constant pressure and temperature, then

a) **molecular motion** will stay the same because the temperature is not changing

b) **potential energy** will increase because the particles will spread out to fill the new container. Because there is more space between the particles, their potential energy has increased

c) **kinetic energy** will still be the same, because temperature has not changed. That is, the particles will be further apart, but they will still be moving the same speed

d) **gas pressure** will be constant, because the speed of the particles is constant

e) **volume** of the gas will increase because gases expand to fill their containers

12. How does the presence of impurities affect:

a) the melting point of a solid? Melting point is not as "sharp". The solid will melt over a range of temperatures. Usually the melting point is lowered (the solid melts at a lower temperature).

b) the boiling point of a liquid? Boiling point is not as "sharp". The solid will boil over a range of temperatures. Usually the boiling point is raised (the liquid boils at a higher temperature).

13. A sample of gold melts at 1024.6 ºC; this is the same as 1297.6 K. The melting point of pure gold is 1337.58 K (from your Periodic Table). Because the sample of gold melts at a lower temperature than pure gold, then the sample of gold can not be pure.

14. Name the following changes of state and state whether energy is absorbed or released:

a) solid to liquid: **melting**. Energy is **absorbed**.

b) solid to gas: **sublimation**. Energy is **absorbed**.

c) gas to liquid: **condensation**. Energy is **released**.

d) liquid to solid: **freezing or solidification**. Energy is **released**.

e) gas to solid: **deposition** or **sublimation**. Energy is **released**.

f) liquid to gas: **boiling or evapourization**. Energy is **absorbed**.

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

| | **Charles' Law** | **Boyle's Law** | **Gay-Lussac's** |
|---|---|---|---|
| Variables that are changed | V and T | V and P | T and P |
| Variables that are constant | n and P | n and T | n and V |
| Direct or indirect relationship? | direct | indirect | direct |
| Proportionality statement | V α T | V α 1/P | P α T |
| Mathematical equation (without *k*) | $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ | $V_1 P_1 = V_2 P_2$ | $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ |
| Explain what is happening at the particle level | as temp. increases, particles speed up and spread out so they take up more space | as pressure increases, it pushes the particles closer together so they take up less space | as temp. increases, particles speed up so they hit their container harder and P increases |

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

a) **Charles’ Law** states that the volume of a gas is directly proportional to its temperature (in Kelvins) when the number of moles of gas and pressure are held constant.

b) **Boyle’s Law** states that the volume of a gas is inversely proportional to its pressure when the number of moles and temperature are held constant.

c) **Gay-Lussac’s Law** states that the pressure of a gas is directly proportional to its temperature (in Kelvins) when the number of moles of gas and volume are held constant.

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 **96.0** L.

b) A gas occupies 5.0 litres at 20 °C. At 40 °C the volume of the gas will be **5.3** litres. (assume constant pressure)

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 **decrease by a factor of five**.

d) 650 K is equal to **377 °C**. 250°C is equal to **523 K**.

e) The variables "W" and "Z" vary inversely. Write this using the “proportionality” (α) sign, then write it as a mathematical equality using a constant.

$W \propto 1/Z$ or $W = k/Z$

f) The variables “Q” and “Y” vary directly. Write this using the “proportionality” (α) sign, then write it as a mathematical equality using a constant.

$Q \propto Y$ or $Q = k\,Y$

g) STP stands for **S**tandard **T**emperature and **P**ressure: this is **0 °C** and **101.3 kPa**.

h) SATP stands for **S**tandard **A**mbient **T**emperature and **P**ressure: **25 °C** and **100 kPa**.

i) Standard pressure is **101.3 kPa**, **1.00 atmospheres**, **760 mm Hg**, **15.0 PSI**.

j) 250 kPa is equal to **2.47 atm**. 800 mm Hg is equal to **15.8 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? All of these substances are **gases**.

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

29. **Dalton’s Law of Partial Pressures** states that the total pressure of a mixture of non-reacting gases is equal to the sum of the partial pressures of the individual gases making up the mixture.