Gas Laws Chemistry Regents Review

Reference Tables

Table H – Vapor Pressure Curves
Table T – Formulas and Equations (For Combined Gas Law)

Key Vocabulary

Using your textbook or other resources, define each of the following terms as related to this chemistry unit.

- **Avogadro's Hypothesis**
- **Boyle's Law**
- **Charles Law**
- **Combined Gas Law**
- **Dalton's Law of Partial Pressure**
- **Ideal Gases**
- **Kinetic Molecular Theory**
- **Pressure**
- **Real Gases**
- **Standard Temperature and Pressure**

CONTINUED ON BACK →

Key Ideas

Using your knowledge of chemistry and the NYS Chemistry Reference Tables, answer each of the following questions related to the key ideas of this unit.

1) Explain what the Kinetic Molecular Theory states and attempts to explain.

2) How are real gases different from ideal gases?

3) Under what conditions will a real gas behave most like an ideal gas?

4) Describe the relationship between pressure and volume.

5) Describe the relationship between temperature and volume.

6) Equal volumes of all gases at the same temperature and pressure must also contain equal numbers of _____. Why?

7) The pressure on a 200-ml sample of $CO_2(g)$ at constant temperature is increased from 60kPa to 120kPA. What is the new volume of the gas in liters?

8) Using Ref. Table H, what temperature will liquid water boil at if the pressure on its surface is 47kPA?

Gas Laws Regents Review

1. A sample of a gas is contained in a closed rigid cylinder. According to kinetic molecular theory, what occurs when the gas inside the cylinder is heated?

   A) The number of gas molecules increases.
   B) The number of collisions between gas molecules per unit time decreases.
   C) The average velocity of the gas molecules increases.
   D) The volume of the gas decreases.

2. The kinetic molecular theory assumes that the particles of an ideal gas

   A) are in random, constant, straight-line motion
   B) are arranged in a regular geometric pattern
   C) have strong attractive forces between them
   D) have collisions that result in the system losing energy

3. The concept of an ideal gas is used to explain

   A) the mass of a gas sample
   B) the behavior of a gas sample
   C) why some gases are monatomic
   D) why some gases are diatomic

4. Under which conditions does a real gas behave most like an ideal gas?

   A) at low temperatures and high pressures
   B) at low temperatures and low pressures
   C) at high temperatures and high pressures
   D) at high temperatures and low pressures

5. Two basic properties of the gas phase are

   A) a definite shape and a definite volume
   B) a definite shape but no definite volume
   C) no definite shape but a definite volume
   D) no definite shape and no definite volume

6. A real gas behaves more like an ideal gas when the gas molecules are

   A) close and have strong attractive forces between them
   B) close and have weak attractive forces between them
   C) far apart and have strong attractive forces between them
   D) far apart and have weak attractive forces between them

7. Under which conditions of temperature and pressure would a sample of $H_2(g)$ behave most like an ideal gas?

   A) 0°C and 100 kPa B) 0°C and 300 kPa
   C) 150°C and 100 kPa D) 150°C and 300 kPa

8. A real gas differs from an ideal gas because the molecules of real gas have

   A) some volume and no attraction for each other
   B) some volume and some attraction for each other
   C) no volume and no attraction for each other
   D) no volume and some attraction for each other

9. The data table below gives the temperature and pressure of four different gas samples, each in a 2-liter container.

Temperature and Pressure of Gas Samples

Gas Sample	Temperature (K)	Pressure (atm)
He	300.	1.20
Ne	300.	1.00
CO_2	200.	1.20
CH_4	300.	1.00

Which two gas samples contain the same total number of particles?

A) CH_4 and CO_2 B) CH_4 and Ne
C) He and CO_2 D) He and Ne

10. 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 more gas molecules than container Z.
B) Container X contains fewer 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.

11. A closed container holds 3.0 moles of CO_2 gas at STP. What is the total number of moles of Ne(g) that can be placed in a container of the same size at STP?

A) 1.0 mole B) 1.5 moles
C) 3.0 moles D) 0.0 moles

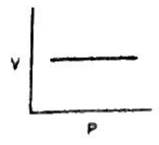
12. A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?

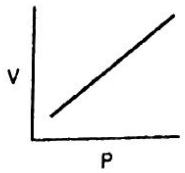
A) 0.177 atm B) 4.43 atm
C) 5.64 atm D) 14.1 atm

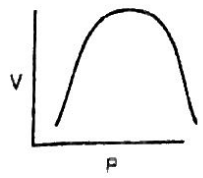
13. A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final kelvin temperature when the volume of the gas is changed to 1880 mL and the pressure is changed to 38.7 kPa?

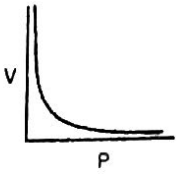
A) 31.5 K B) 292 K
C) 566 K D) 2360 K

14. Which graph best represents the pressure-volume relationship for an ideal gas at constant temperature?

A) 

B) 

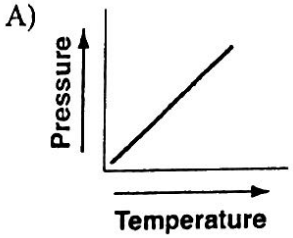
C) 

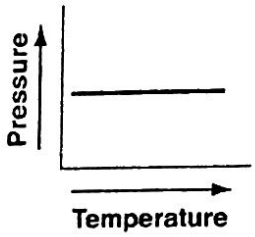
D) 

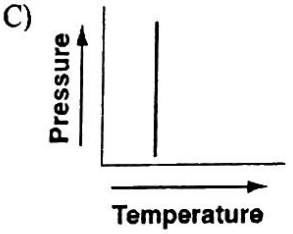
15. A gas occupies a volume of 40.0 milliliters at 20°C. If the volume is increased to 80.0 milliliters at constant pressure, the resulting temperature will be equal to

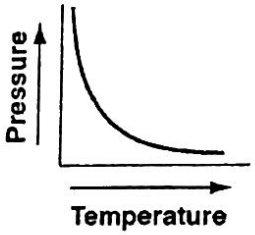
A) $20°C \times \frac{80.0mL}{40.0mL}$ B) $20°C \times \frac{40.0mL}{80.0mL}$
C) $293K \times \frac{80.0mL}{40.0mL}$ D) $293K \times \frac{40.0mL}{80.0mL}$

16. Which graph shows the pressure-temperature relationship expected for an ideal gas?

A) 

B) 

C) 

D) 

17. Which temperature change would cause the volume of a sample of an ideal gas to double when the pressure of the sample remains the same?

A) from 200°C to 400°C
B) from 400°C to 200°C
C) from 200 K to 400 K
D) from 400 K to 200 K

18. As the temperature of a gas increases at constant pressure, the volume of the gas

A) decreases B) increases
C) remains the same

19. A 3.00-liter sample of gas is at 288 K and 1.00 atm. If the pressure of the gas is increased to 2.00 atm and its volume is decreased to 1.50 liters, the Kelvin temperature of the sample will be

A) 144 K B) 288 K C) 432 K D) 576 K

20. If 4.00 moles of oxygen gas, 3.00 moles of hydrogen gas, and 1.00 mole of nitrogen gas are combined in a closed container at standard pressure, what is the partial pressure exerted by the hydrogen gas?

A) 1.00 atm B) 0.125 atm
C) 3.00 atm D) 0.375 atm

21. According to Reference Table *H*, what is the boiling point of ethanoic acid at 80 kPa?

A) 28°C B) 100°C
C) 111°C D) 125°C

22. What is the boiling point of water when the atmospheric pressure exerted on the water is 81 kPa?

A) 50°C B) 90°C C) 100°C D) 110°C

23. The table below lists four gases and their molecular mass.

Gas	Molecular Mass (g/mol)
A	2
B	4
C	17
D	20

Which gas diffuses at the slowest rate at STP?

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

24. Which gas diffuses most rapidly at STP?

A) Ne B) Ar C) Cl_2 D) F_2

25. Water will boil at 50°C if the pressure on the surface of the water is

A) 101.3 kPa B) 50 kPa
C) 12 kPa D) 3 kPa

26. What is the normal boiling point of ethanoic acid?

A) 52°C B) 55°C
C) 101.3°C D) 117.9°C

27. A sample of a pure liquid is boiling in an open vessel at a temperature of 150°C. The atmospheric pressure is 65 kPa. The vapor pressure of the liquid is

A) 10 kPa B) 15 kPa
C) 65 kPa D) 76 kPa

28. Which substance has the *lowest* vapor pressure at 75°C?

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

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

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

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

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

A) decreases B) increases
C) remains the same

32. Based on Reference Table *H*, which sample has the highest vapor pressure?

A) water at 20°C B) water at 80°C
C) ethanol at 50°C D) ethanol at 65°C

33. Base your answer to the following question on the information below.

Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the unbalanced equation below.

$$NaN_3(s) \rightarrow Na(s) + N_2(g)$$

When the air bag inflates, the nitrogen gas is at a pressure of 1.30 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. Calculate the volume of the nitrogen gas at STP. Your response must include *both* a correct numerical setup and the calculated volume

34. Base your answer to the following question on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

Show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant.

35. A sample of oxygen gas in one container has a volume of 20.0 milliliters at 297 K and 101.3 kPa. The entire sample is transferred to another container where the temperature is 283 K and the pressure is 94.6 kPa. Show a correct numerical setup for calculating the new volume of this sample of oxygen gas.

36. Base your answer to the following question on the properties of propanone.

A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using Reference Table *H*, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

Base your answers to questions **37** through **39** on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

37. What pressure, in atmospheres (atm), is equal to 45.6 kPa?

38. The original pressure at 295 K was 100.8 kPa and the pressure at the higher altitude at 252 K is 45.6 kPa. Assume the balloon does not burst. Show a correct numerical setup for calculating the volume of the balloon at the higher altitude.

39. How does this temperature change affect the gas particle motion?

Base your answers to questions **40** and **41** on the diagram below, which shows a piston confining a gas in a cylinder.

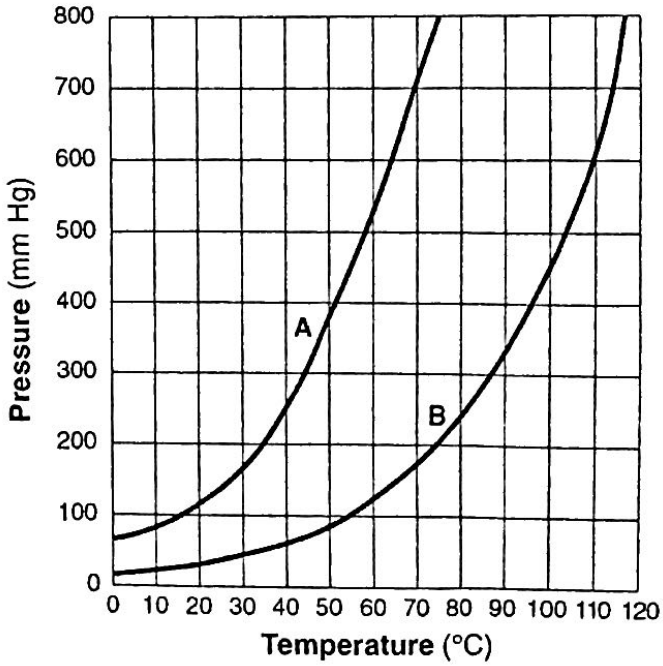
40. Sketch the general relationship between the pressure and the volume of an ideal gas at constant temperature.

41. The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant.

a Calculate the pressure, in atmospheres, after the change in volume. Show all work.

b Record your answer.

Base your answers to questions **42** through **44** on the graph below, which shows the vapor pressure curves for liquids *A* and *B*.



42. Which liquid will evaporate more rapidly? Explain your answer in terms of intermolecular forces.

43. At what temperature does liquid *B* have the same vapor pressure as liquid *A* at 70°C? Your answer must include correct units.

44. What is the vapor pressure of liquid *A* at 70°C? Your answer must include correct units.

Key

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1. A sample of a gas is contained in a closed rigid cylinder. According to kinetic molecular theory, what occurs when the gas inside the cylinder is heated?

   A) The number of gas molecules increases.
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   C) why some gases are monatomic
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   A) at low temperatures and high pressures
   B) at low temperatures and low pressures
   C) at high temperatures and high pressures
   D) at high temperatures and low pressures

5. Two basic properties of the gas phase are

   A) a definite shape and a definite volume
   B) a definite shape but no definite volume
   C) no definite shape but a definite volume
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6. A real gas behaves more like an ideal gas when the gas molecules are

   A) close and have strong attractive forces between them
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7. Under which conditions of temperature and pressure would a sample of $H_2(g)$ behave most like an ideal gas?

   A) 0°C and 100 kPa B) 0°C and 300 kPa
   C) 150°C and 100 kPa D) 150°C and 300 kPa

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9. The data table below gives the temperature and pressure of four different gas samples, each in a 2-liter container.

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Which two gas samples contain the same total number of particles?

A) CH_4 and CO_2 B) CH_4 and Ne
C) He and CO_2 D) He and Ne

$\frac{40.0\text{ mL}}{293\text{K}} = \frac{80}{X}$ $293 \cdot \frac{80}{40}$

10. 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 more gas molecules than container Z.
B) Container X contains fewer 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.

11. A closed container holds 3.0 moles of CO_2 gas at STP. What is the total number of moles of Ne(g) that can be placed in a container of the same size at STP?

A) 1.0 mole
B) 1.5 moles
C) 3.0 moles
D) 0.0 moles

12. A sample of helium gas has a volume of 900. milliliters and a pressure of 2.50 atm at 298 K. What is the new pressure when the temperature is changed to 336 K and the volume is decreased to 450. milliliters?

A) 0.177 atm
B) 4.43 atm
C) 5.64 atm
D) 14.1 atm

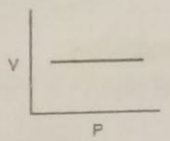
$\frac{(2.5)(900)}{298} = \frac{(x)(450)}{336}$

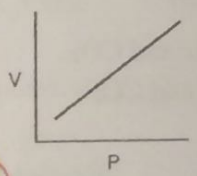
13. A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final kelvin temperature when the volume of the gas is changed to 1880 mL and the pressure is changed to 38.7 kPa?

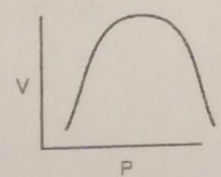
A) 31.5 K
B) 292 K
C) 566 K
D) 2360 K

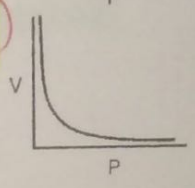
$\frac{(79)(444)}{273} = \frac{(38.7)(1880)}{X}$

14. Which graph best represents the pressure-volume relationship for an ideal gas at constant temperature?

A) 

B) 

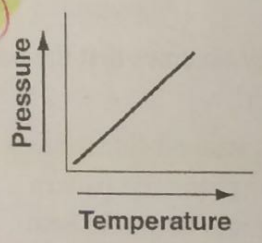
C) 

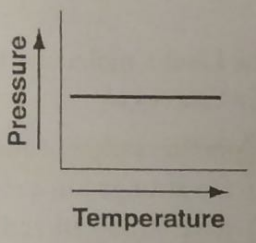
D) 

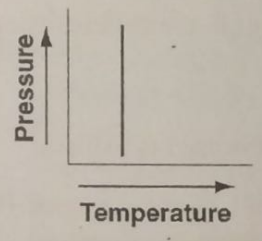
15. A gas occupies a volume of 40.0 milliliters at 20°C. If the volume is increased to 80.0 milliliters at constant pressure, the resulting temperature will be equal to

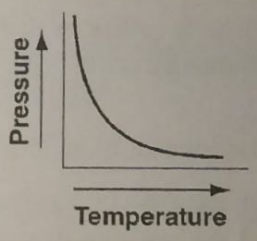
A) $20°\text{C} \times \frac{80.0\text{mL}}{40.0\text{mL}}$
B) $20°\text{C} \times \frac{40.0\text{mL}}{80.0\text{mL}}$
C) $293\text{K} \times \frac{80.0\text{mL}}{40.0\text{mL}}$
D) $293\text{K} \times \frac{40.0\text{mL}}{80.0\text{mL}}$

16. Which graph shows the pressure-temperature relationship expected for an ideal gas?

A) 

B) 

C) 

D) 

17. Which temperature change would cause the volume of a sample of an ideal gas to double when the pressure of the sample remains the same?

A) from 200°C to 400°C
B) from 400°C to 200°C
C) from 200 K to 400 K
D) from 400 K to 200 K

18. As the temperature of a gas increases at constant pressure, the volume of the gas

A) decreases
B) increases
C) remains the same

19. A 3.00-liter sample of gas is at 288 K and 1.00 atm. If the pressure of the gas is increased to 2.00 atm and its volume is decreased to 1.50 liters, the Kelvin temperature of the sample will be

A) 144 K B) 288 K C) 432 K D) 576 K

$\frac{(3.00\text{L})(1\text{ atm})}{288\text{K}} = \frac{(1.50\text{L})(2\text{ atm})}{X}$

20. If 4.00 moles of oxygen gas, 3.00 moles of hydrogen gas, and 1.00 mole of nitrogen gas are combined in a closed container at standard pressure, what is the partial pressure exerted by the hydrogen gas?

A) 1.00 atm
B) 0.125 atm
C) 3.00 atm
D) 0.375 atm

21. According to Reference Table *H*, what is the boiling point of ethanoic acid at 80 kPa?

A) 28°C
B) 100°C
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22. What is the boiling point of water when the atmospheric pressure exerted on the water is 81 kPa?

A) 50°C B) 90°C C) 100°C D) 110°C

95°C
NO CORRECT ANSWER.

23. The table below lists four gases and their molecular mass.

Gas	Molecular Mass (g/mol)
A	2
B	4
C	17
D	20

Which gas diffuses at the slowest rate at STP?

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

24. Which gas diffuses most rapidly at STP?

A) Ne B) Ar C) Cl_2 D) F_2

25. Water will boil at 50°C if the pressure on the surface of the water is

A) 101.3 kPa
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26. What is the normal boiling point of ethanoic acid?

A) 52°C
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27. A sample of a pure liquid is boiling in an open vessel at a temperature of 150°C. The atmospheric pressure is 65 kPa. The vapor pressure of the liquid is

A) 10 kPa
B) 15 kPa
C) 65 kPa
D) 76 kPa

bp
Vp = atmosphere

28. Which substance has the *lowest* vapor pressure at 75°C?

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

29. 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 stronger intermolecular forces than water.
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B) increases
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32. Based on Reference Table *H*, which sample has the highest vapor pressure?

A) water at 20°C 5 kPa
B) water at 80°C 47 kPa
C) ethanol at 50°C 30 kPa
D) ethanol at 65°C 58 kPa

33. Base your answer to the following question on the information below.

Air bags are an important safety feature in modern automobiles. An air bag is inflated in milliseconds by the explosive decomposition of $NaN_3(s)$. The decomposition reaction produces $N_2(g)$, as well as Na(s), according to the unbalanced equation below.

$$NaN_3(s) \rightarrow Na(s) + N_2(g)$$

When the air bag inflates, the nitrogen gas is at a pressure of 1.30 atmospheres, a temperature of 301 K, and has a volume of 40.0 liters. Calculate the volume of the nitrogen gas at STP. Your response must include *both* a correct numerical setup and the calculated volume

$P_1 = 1.30\ atm$ $T_1 = 301\ K$ $V_1 = 40.0\ L$ $P_2 = 1\ atm$ $T_2 = 273\ K$ $V_2 = x$

$$\frac{(1.30\ atm)(40.0\ L)}{301\ K} = \frac{(1\ atm)(x)}{273\ K}$$

$V_2 = 47.11627907$ **47.1 L**

34. Base your answer to the following question on the information below.

A lightbulb contains argon gas at a temperature of 295 K and at a pressure of 75 kilopascals. The lightbulb is switched on, and after 30 minutes its temperature is 418 K.

Show a correct numerical setup for calculating the pressure of the gas inside the lightbulb at 418 K. Assume the volume of the lightbulb remains constant.

$P_1 = 75\ kPa$ $T_1 = 295\ K$ $P_2 = x$ $T_2 = 418\ K$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{75\ kPa}{295\ K} = \frac{x}{418\ K}$$

35. A sample of oxygen gas in one container has a volume of 20.0 milliliters at 297 K and 101.3 kPa. The entire sample is transferred to another container where the temperature is 283 K and the pressure is 94.6 kPa. Show a correct numerical setup for calculating the new volume of this sample of oxygen gas.

$V_1 = 20.0\ mL$ $T_1 = 297\ K$ $P_1 = 101.3\ kPa$ $V_2 = x$ $T_2 = 283\ K$ $P_2 = 94.6\ kPa$

$$\frac{(101.3\ kPa)(20.0\ mL)}{297\ K} = \frac{(94.6\ kPa)(x)}{283\ K}$$

36. Base your answer to the following question on the properties of propanone.

A liquid's boiling point is the temperature at which its vapor pressure is equal to the atmospheric pressure. Using Reference Table *H*, what is the boiling point of propanone at an atmospheric pressure of 70 kPa?

145 kPa

Base your answers to questions **37** through **39** on the information below.

A weather balloon has a volume of 52.5 liters at a temperature of 295 K. The balloon is released and rises to an altitude where the temperature is 252 K.

37. What pressure, in atmospheres (atm), is equal to 45.6 kPa?

$$45.6\ kPa \times \frac{1\ atm}{101.3\ kPa} = .450\ atm$$

38. The original pressure at 295 K was 100.8 kPa and the pressure at the higher altitude at 252 K is 45.6 kPa. Assume the balloon does not burst. Show a correct numerical setup for calculating the volume of the balloon at the higher altitude.

$P_1 = 100.8\ kPa$ $P_2 = 45.6\ kPa$
$T_1 = 295\ K$ $T_2 = 252\ K$
$V_1 = 52.5\ L$ $V_2 = x$

$$\frac{(100.8\ kPa)(52.5\ L)}{295\ K} = \frac{(45.6\ kPa)(x)}{252\ K}$$

39. How does this temperature change affect the gas particle motion?

As temp ↓, particle motion slows down

Base your answers to questions **40** and **41** on the diagram below, which shows a piston confining a gas in a cylinder.

40. Sketch the general relationship between the pressure and the volume of an ideal gas at constant temperature.

41. The gas volume in the cylinder is 6.2 milliliters and its pressure is 1.4 atmospheres. The piston is then pushed in until the gas volume is 3.1 milliliters while the temperature remains constant.

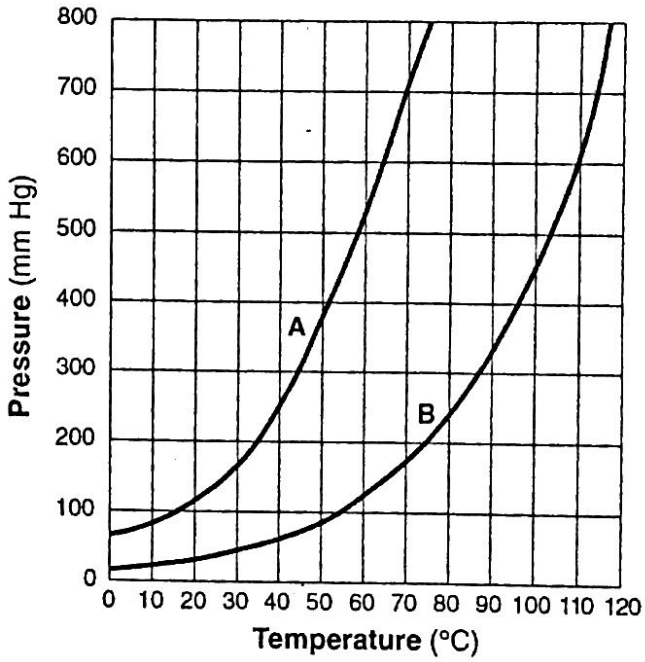
a Calculate the pressure, in atmospheres, after the change in volume. Show all work.

b Record your answer.

$P_1 = 1.4\ atm$ $P_2 = x\ atm$
$V_1 = 6.2\ mL$ $V_2 = 3.1\ mL$

$$P_1V_1 = P_2V_2$$
$$(1.4\ atm)(6.2\ mL) = (x)(3.1\ mL)$$
$$x = 2.8\ atm$$

Base your answers to questions **42** through **44** on the graph below, which shows the vapor pressure curves for liquids *A* and *B*.



42. Which liquid will evaporate more rapidly? Explain your answer in terms of intermolecular forces.

A - higher vapor pressure indicates weaker intermolecular forces.

43. At what temperature does liquid *B* have the same vapor pressure as liquid *A* at 70°C? Your answer must include correct units.

114°C

44. What is the vapor pressure of liquid *A* at 70°C? Your answer must include correct units.

700 mmHg