Name: Answer key Due Date: ________ Period: ______

Unit 9 Gas Law Study Guide

On the test, you will be given the following information:

1 atm = 760 mmHg = 101.3 kPa $R = \frac{8.31\, kPa \cdot L}{mol \cdot K}$

PV = nRT 0°C = 273 K

Learning Targets Students will be able to:
1. Determine the independent and dependent variables in a relationship and relate them to a graph. The independent variable is manipulated by experimenter and the dependent variable depends on the independent variable. The independent variable goes on the x-axis. The dependent variable goes on the y-axis.
2. Give the mathematical relationship and meaning of direct and inverse relationships. k = constant Directly proportional: $\frac{x}{y} = k$ or $xk = y$ ↑x ↑y inversely proportional: $xy = k$ ↑x ↓y
3. What causes gas pressure? gas molecule collisions w/ walls of their container
4. Explain how air has pressure: air molecules weight exerts a force = air pressure give units and instruments for measurement of air pressure: mmHg or atm or kPa barometer 760 mmHg = 1 atm = 101.35 kPa
5. Give the variables we discussed in classes regarding gases (hint: there are 4) Pressure (P) in kPa or atm or mmHg number of moles (n) temperature (T) K volume (V) L

6. Apply Boyle's Law to gas problems

volume and pressure are inversely proportional when temperature and # moles are held constant.

If a gas at 25.0 °C occupies 3.60 liters at a pressure of 1.00 atm, what will be its volume at a pressure of 2.50 atm?

$V_1 P_1 = V_2 P_2$

$V_1 = 3.60\ L$ $V_2 = ?$

$P_1 = 1.00\ atm$ $P_2 = 2.50\ atm$

$V_2 = \frac{V_1 P_1}{P_2} = \frac{(3.60\ L)(1.00\ atm)}{2.50\ atm} = 1.44\ L$

7. Apply Dalton's Law of Partial Pressures to Mixtures of Gases

http://www.kentchemistry.com/links/GasLaws/dalton.htm

Equation for Dalton's Law: $P_T = P_1 + P_2 + P_3 \ldots$ sum of partial pressure exerted by each gas = total pressure

Nitrogen (80 kPa), oxygen (21.0 kPa), carbon dioxide (0.03 kPa), and water vapor (2.0 kPa) are the usual atmospheric components. What is the total atmospheric pressure in kPa? $P_{N_2} = 80\ kPa$ $P_{O_2} = 21.0\ kPa$ $P_{CO_2} = 0.03\ kPa$ $P_{H_2O} = 2.0\ kPa$

$P_T = P_{N_2} + P_{O_2} + P_{CO_2} + P_{H_2O} = 80\ kPa + 21.0\ kPa + .03\ kPa + 2.0\ kPa = 103.03\ kPa = 100\ kPa$

A mixture of oxygen, hydrogen and nitrogen gases exerts a total pressure of 278 kPa. If the partial pressures of the oxygen and the hydrogen are 112 kPa and 101 kPa respectively, what would be the partial pressure exerted by the nitrogen.

$P_T = 278\ kPa$ $P_T = P_{O_2} + P_{H_2} + P_{N_2}$

$P_{O_2} = 112\ kPa$

$P_{H_2} = 101\ kPa$ $P_{N_2} = P_T - P_{O_2} - P_{H_2} = 278\ kPa - 112\ kPa - 101\ kPa = 65\ kPa$

8. Use a thermometer to measure temperature (performed in lab)

9. Relate and convert between the Celsius and Kelvin temperature scales.

To convert from C $°C + 273 = \_\_ K$

To convert from K $K - 273 = \_\_ °C$

20 degrees C = ?K $20°C + 273 = 293\ K$

Why can't we use Celsius temperatures in gas law calculations? (hint: word of the day comes into play here…) Celsius temperature scale is not directly proportional. It's a relative scale based on water. Since our gas laws are based on proportional relationships, we must use a proportionate temperature scale… enter Kelvin.

10. Use Charles's Law to relate the volume of a gas to its temperature and apply to gas problems.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Volume and Temperature are directly proportional.

A 7.0 liter balloon at room temperature (22°C) contains hydrogen gas. If the balloon is carried outside to where the temperature is –3.0°C, what volume will the balloon occupy?

$V_1 = 7.0\ L$

$T_1 = 22°C + 273 = 293\ K$

$V_2 = ?$

$T_2 = -3.0°C + 273 = 270\ K$

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

$$V_2 = T_2 \cdot \frac{V_1}{T_1} = \frac{270\ K \cdot 7.0\ L}{293\ K} = 6.45\ L = 6.5\ L$$

11. Use Gay-Lussac's Law to relate the pressure of a gas to its temperature and apply to gas problems.

pressure and temperature are directly proportional when volume and n are held constant

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

A 20 L cylinder containing 6 atm of gas at 27 °C. What would the pressure of the gas be if the gas was heated to 77 °C?

$P_1 = 6\ atm$

$T_1 = 27°C + 273 = 300\ K$

$P_2 = ?$

$T_2 = 77°C + 273 = 350\ K$

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

$$P_2 = T_2 \cdot \frac{P_1}{T_1} = \frac{350\ K \cdot 6\ atm}{300\ K} = 7\ atm$$

12. Use Avogadro's Hypothesis to relate the volume and amount of a gas.

n is directly proportional to V when T and P are held constant

Equation: $\frac{n_1}{V_1} = \frac{n_2}{V_2}$

312 L of chlorine gas at STP. What mass of fluorine gas would be present at the same volume, temperature and pressure?

① How many mol F_2? How many g F_2?

$V_1 = 312\ L\ Cl_2$

$P_1 = 1\ atm$

$$312\ L\ F_2 \times \frac{1\ mol\ F_2}{22.4\ L\ F_2} \times \frac{2(18.9)\ g\ F_2}{1\ mol\ F_2} = 526.5\ g\ F_2 = 527\ g\ F_2$$

13. Combine gas relationships to construct and use the Combined Gas Law and Ideal Gas Law

Combined gas law: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

A gas has a volume of 800.0 mL at minus 23.00 °C and 300.0 torr. What would the volume of the gas be at 227.0 °C and 600.0 torr of pressure?

$V_1 = 800.0 L$ $V_2 = ?$

$T_1 = -23.00°C + 273 = 250 K$ $T_2 = 227°C + 273 = 500 K$

$P_1 = 300. torr$ $P_2 = 600. torr$

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

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

$V_2 = \frac{500 K}{600 torr} \cdot \frac{800 L \cdot 300 torr}{250 K}$

$V_2 = 800. L$

Ideal gas Law: $PV = nRT$ $R = 8.31 \frac{kPa L}{K mol}$

http://go.hrw.com/resources/go_sc/mc/HUGPS138.PDF

An engineer pumps 5.00 mol of carbon monoxide gas into a cylinder that has a capacity of 20.0 L. What is the pressure in kPa of CO inside the cylinder at 25°C?

$n = 5.00 mol$

$V = 20.0 L$

$P = ?$

$T = 25°C + 273 = 298 K$

$R = 8.31 \frac{L \cdot kPa}{mol \cdot K}$

$\frac{PV}{V} = \frac{nRT}{V}$

$P = \frac{nRT}{V} = \frac{(5.00 mol)(8.31 \frac{L \cdot kPa}{mol \cdot K}) \cdot 298 K}{20.0 L} = 16.9 kPa$

14. Distinguish between real and ideal gases.

ideal		real
no attractive forces between particles	vs	very small attractive + repulsive forces between particles
particles have no V.	vs	particles have very small Volume
collisions = elastic (no loss in total kinetic energy)	vs	collisions = inelastic (when gas particles collide, they lose a small amount of energy)

15. Solve stoichiometric problems involving ideal gases (see 6, 10, 11, 13)

16. Explain the motion of gases using kinetic molecular theory.

4 assumptions of KMT: (1 and 2) gases composed of large # of particles in a state of constant, random motion.

(2) the amount of motion of particles is proportional to the temperature (increased temp = increased motion)

(3) solids/liquids/gases differ in the freedom of motion of their particles and the extent to which the particles interact.

17. Use kinetic molecular theory to explain the diffusion of gases

because gas molecules are small, in constant/rapid motion (according to KMT) they diffuse quickly.

diffusion: movement of gas particles from one place to another