

## Gas Law Questions

Mr Canning's words of wisdom:

**“Always convert temperature units into Kelvin (K).  
Remember 0 °C = 273 K”**

Friday 13<sup>th</sup> December 2013

### **Information (Gas Laws - Boyle's Law)**

Boyle's Law says that for a sample of gas at constant temperature the volume is inversely proportional to the pressure.

1. Which equation links  $P_1$ ,  $V_1$ ,  $P_2$  and  $V_2$ ?
2. A 144 mL sample of gas in a piston chamber has a pressure of 2.25 atm. If the piston is pushed in so that the gas has a volume of 36.0 mL, what is the new pressure? Assume the temperature remains constant.

### **Information (Gas Laws - Charles' Law)**

Charles' Law says at constant pressure the volume occupied by a given amount of gas is directly proportional to its absolute temperature.

3. Which equation links  $T_1$ ,  $V_1$ ,  $T_2$  and  $V_2$ ?
4. A 5.00 L sample of gas in a piston chamber at 25 °C is heated to 100 °C, while the pressure is maintained at 1.00 atm. What is the volume of the gas after heating?

### **Information (Gas Laws - Combined Gas Law)**

Boyle's Law and Charles' Law can be combined into one equation that expresses the volume, temperature, and pressure relationships for a fixed amount of gas.

5. Which equation links  $P_1$ ,  $V_1$ ,  $T_1$ ,  $P_2$ ,  $V_2$  and  $T_2$ ?
6. At 29 °C and 756 torr, a gas occupies 2.50 L. What is the volume if the temperature is changed to 159 °C, and the pressure is changed to 1550 torr?

### **Information (Ideal Gas Law)**

For any sample of gas under ideal conditions, the relationship between the amount of gas in moles ( $n$ ) and its temperature, pressure, and volume is given by the relationship  **$PV = nRT$**  in which  $R$  is the *gas constant*, with a value of 0.082 L atm/K mol. When using this value of  $R$ , volume must be in liters, temperature must be in Kelvin, and amount of gas must be in moles. If other units are given, convert to these units. When other units are used, the value of  $R$  is different. [Later, we will see another use of  $R$ , where its value and units are 8.314 J/K mol, when using the SI units; L, kPa, K, mol]

7. A sample of He(g) occupies 15.0 L with a pressure of 856 torr when the temperature is 52 °C. How many grams of He(g) does the sample contain?  
Data:

- Atomic mass of He = 4.00 g/mol
- 1 atmosphere = 760 torr
- Moles = mass (g) / atomic mass

### Information (Seeing Gas Law Relationships in $PV = nRT$ )

We have seen equations for Boyle's Law, Charles' Law, and the Combined Gas Law. You really do not need to remember these equations if you know  $PV = nRT$ , because these and some other relationships we have not seen yet are contained in the ideal gas law. For example, Boyle's Law is the relationship between volume and pressure when amount and temperature are constant. If we take the variable  $n$  and  $T$  in  $PV = nRT$  as constants, then everything on the right is a constant. The product of any number of constants is a constant, so we could write  $PV = nRT = b$  where  $b = nRT$ . The resulting equation,  $PV = b$ , is our previous equation for Boyle's Law.

8. Derive the equation for Charles' Law by rearranging  $PV = nRT$  to put all the constants on one side of the equation. Then, redefine the product of the constants to be the constant  $c$ .
9. Do the same for Gay Lussac's Law.

### Theoretical Questions

1. Sketch a graph of Boyle's Law?
2. Sketch a graph of Charles' Law?
3. Sketch a graph of Gay Lussac's Law?
4. In many households one might find a device called a pressure cooker. These are especially common in households at high altitudes. A pressure cooker is used to reduce the time it takes cook food. Explain why cooking time would be of concern at higher altitudes, and explain why the operation of a pressure cooker is an application of Gay-Lussac's Law.

### Bonus Questions

1. Every aerosol can you purchase includes a warning that reads something like "DANGER! Contents under pressure. Do not incinerate." To illustrate this danger, assume that an aerosol can starts at standard temperature and pressure (STP - 0°C and 1 atmosphere) before being incinerated. What would be the internal pressure of the can when the temperature reaches 1000° C?
2. A typical propane tank for a home gas grill contains 13.8 L of propane fuel when filled. The pressure inside the tank is 124 psi (1 atm = 14.70 psi). If all of the gas in the tank was vented into the atmosphere, what volume would it occupy?

- The airbag in a typical SUV has a volume of 70 L when inflated. The gas temperature immediately after the air bag deploys is 93 degrees Celsius. If the bag has no leaks and is allowed to cool to standard temperature, what volume will the gas fill?

### Problems

- Calculate the temperature at which we can find 2 g of H<sub>2</sub> that occupies a volume of 10 L at a pressure of 1.5 atm. If pressure is lowered down to 0.5 atm at constant temperature, what will be the new volume?
- We have 2 L of a certain gas at a pressure of 35 atm and 93 °C. How many moles of gas do we have? How many molecules will there be? Bring your answers to one decimal place.
- Calculate the volume that 1 mol of any gas occupies at 0 °C and a pressure of 1 atm (normal conditions).
- Let's have 8 g of oxygen in a 2 L flask, initially at 20 °C. How much will the pressure increase if we transfer the gas to a 3000 mL flask at 585 K?
- Complete the following table, corresponding to the same gas (1atm=760 mmHg =760 Torr):

<b>P</b>	608 mmHg	0.2 atm	300 Torr	<b>c)</b>	312 Torr
<b>V</b>	2 L	500 mL	<b>b)</b>	750 cm <sup>3</sup>	2.5 L
<b>T</b>	117 °C	<b>a)</b>	-73 °C	175 °C	<b>d)</b>

- If the previous gas was ammonia, how many grams of ammonia did we have?
- We have 0.4 g of methane in a 10 L flask at -29 °C. What is the pressure? If we take half of the amount of gas keeping constant the pressure, what will the temperature be?
- Calculate the density of carbon dioxide in normal conditions.
- The density of a given gas is, in STP conditions, 1.26 g/L. Calculate the molecular mass of this gas.