



Problem Set #5 Unit 8 Gases (GRADED HOMEWORK)

Chemistry 3A Fall 2025 (Secs 43957 & 43958)

SHOW YOUR WORK, YOUR CALCULATIONS, not just the result. This is PART of the grading. Be careful of precision (significant digits, decimal places). All the information to is in the Chap 8 Content lecture slides. Point value is given in question.

How to do this homework? Easiest is to print out and do by hand (neatly please: work it out on scratch paper first). If you can do this online in PDF or DOCX as I did, that's fine too.

1. A gas at 1.00 atm in a volume of 100.0 L is compressed to 5.000 L volume. What is the pressure in the smaller volume?

The problem uses **gas**, **Pressure** and **Volume**, which should identify it as an application of **Boyle's Law** ($PV = k$)

$$P_1V_1 = P_2V_2$$

$$P_2 = \frac{P_1V_1}{V_2}$$

$$P_2 = \frac{1.00 \text{ atm} \times 100.0 \text{ L}}{5.000 \text{ L}} = 20.0 \text{ atm}$$

2. 10.0 mol argon (Ar) at 400 K in a volume of 5.00 L will have a pressure of how many atmospheres (atm)?

The problem mentions **argon**, a gas, an amount in **moles**, a **Volume (V)** in **liters (L)**, a **Temperature (T)** in **Kelvin (K)** and it requests the calculation for a **Pressure (P)**. It provides values for **V**, **T**, and **n**. This is recognized as an application of the **Ideal Gas Law** and the equation is known.

It also requires selection of the **gas constant R** with the correct units to be able to calculate. The value **n** should be **moles**, and the value given is in moles. If the amount (as a mass) was given in **grams**, a conversion to moles using the **molar mass** of the gas substance would be necessary. The value for **temperature** must be given in **K (Kelvin)**, which is given. If it were in another scale like Celsius ($^{\circ}\text{C}$), a conversion $K = ^{\circ}\text{C} + 273$ would be necessary. Finally a volume **V** is given and should be in liters (L) for use of the constant R. A conversion would be required if not in liters. So $R = 0.08205 \text{ L atm/mol K}$ will be used which should cancel the units L, mol, K and leave units of atm

3. Helium (He) in a balloon of 2.00 L volume on a cold (10°C) day is brought into a room at room temperature (25°C) and the balloon expands. What is the new volume?

The keywords of this question are **helium**, **volume (V)**, and **temperature (T)**. Because helium is a gas, the properties indicated lead one to understand that Charles' Law applies, where volume is directly proportional to temperature ($V = kT$). Using algebra, this states that $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, and the constant indicates that $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ to relate two conditions, an initial V_1, T_1 and a V_2, T_2 final condition. There is one constraint to using the Charles' Law equation: temperatures must be on the absolute (Kelvin) scale, so Celsius temperatures must be converted in the process of the calculation. It only remains to substitute the values and do the math.

$$PV = nRT$$

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

$$P = \left(\frac{(10.0 \text{ mol})(400 \text{ K})}{5.00 \text{ L}} \right) \left(\frac{0.08205 \text{ L atm}}{\text{mol K}} \right) =$$

$$\left(\frac{(10.0 \text{ mol})(400 \text{ K})}{5.00 \text{ L}} \right) \left(\frac{0.08205 \text{ atm/L}}{\text{mol K}} \right) = 65.6 \text{ L}$$

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

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

$$V_2 = \frac{(2.00 \text{ L})((10 + 273) \text{ K})}{(25 + 273) \text{ K}} = \frac{(2.00 \text{ L})(283 \text{ K})}{298 \text{ K}} = 1.90 \text{ L}$$



4. From problem #3, the mass of helium is 10.00 g. What is the pressure of the gas at the initial conditions of 10°C?

This problem refers back to problem #3, to its initial conditions of volume ($V = 2.00 \text{ L}$) and temperature ($T = 10^\circ\text{C}$). It adds the information of the mass of helium ($m = 10.00 \text{ g}$), and then it asks for a pressure P . After brief thought, it is clearly asking to solve this with the ideal gas law equation ($PV = nRT$), because all the values are provided. The constraints on the parameters are that temperature must be on absolute (Kelvin) scale, the amount n should be in moles. This is not seen: the mass of He in grams is given, so the molar mass (= 4.003 g/mol) of the element will be used in conversion. No units are specified for pressure P , which can be converted with no problem. Volume V would be conveniently converted to liters (L) temporarily for calculation, but can be converted to and from the liters dimension easily.

$$PV = nRT$$

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

$$P = \frac{(10.00 \text{ g He}) \left(\frac{1 \text{ mol He}}{4.003 \text{ g He}} \right) \left(\frac{0.08205 \text{ L atm}}{\text{mol K}} \right) ((273 + 10) \text{ K})}{2.00 \text{ L}}$$

$$P = \frac{(10.00 \text{ g He}) \left(\frac{1 \text{ mol He}}{4.003 \text{ g He}} \right) \left(\frac{0.08205 \text{ L atm}}{\text{mol K}} \right) ((273 + 10) \text{ K})}{2.00 \text{ L}} = 29.0 \text{ L}$$

5. A gas at a temperature of 100°C has a pressure of 1.0 atm. The temperature is brought way down to -20°C. What is the pressure now?

The keywords of this question are **volume** (V), and **temperature** (T). This is an application of Gay-Lussac's Law, where pressure is directly proportional to temperature ($P = kT$). Using algebra, this states that $\frac{P_1}{T_1} = \frac{P_2}{T_2}$, and the constant indicates that $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ to relate two conditions, an initial P_1, T_1 and a P_2, T_2 final condition. There is one constraint: temperatures must be on the absolute (Kelvin) scale, so Celsius temperatures must be converted in the process of the calculation.

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

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

$$P_2 = \frac{(1.0 \text{ atm})((100 + 273) \text{ K})}{(-20 + 273) \text{ K}} = \frac{(1.0 \text{ atm})(373 \text{ K})}{253 \text{ K}} = 1.5 \text{ atm}$$

6. 50.0 g of potassium chlorate is heated in a 20.0 L sealed container, and produces diatomic oxygen (O_2) according to the reaction below. If the temperature after reaction is at 25°C, what is the pressure in the flask? Use any units for the pressure you want.



This is one of these questions where the amount of a compound in grams or moles that is a gas is NOT given directly. Instead it is to be calculated as the formation or production of the gaseous substance by a chemical reaction occurring, with the assumption that the reaction goes to 100% completion and the matter is conserved.

The extra step required is to know how to write the chemical reaction equation and to be careful about the stoichiometry. The chemical reaction is given. KClO_3 is the reactant whose mass is given. 2 moles of the chlorate will produce 3 moles of oxygen (O_2) gas, which is the focus. This acts like a conversion factor actually

$$\frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3}$$

This will be applied in setting up the calculation. It will be necessary to convert the grams of KClO_3 to mole (molar mass = 122.55 g/mol). The target quantity is pressure (any units are okay), the rest of the inputs include volume V and temperature T . These are all the values used for an **ideal gas law equation** calculation.

$$PV = nRT$$

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

$$P = \frac{(50.00 \text{ g KClO}_3) \left(\frac{1 \text{ mol KClO}_3}{122.55 \text{ g KClO}_3} \right) \left(\frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3} \right) \left(\frac{0.08205 \text{ L atm}}{1 \text{ mol O}_2 \text{ (K)}} \right) ((273 + 25) \text{ K})}{20.0 \text{ L}}$$

$$P = \frac{(50.00 \text{ g KClO}_3) \left(\frac{1 \text{ mol KClO}_3}{122.55 \text{ g KClO}_3} \right) \left(\frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3} \right) \left(\frac{0.08205 \text{ L atm}}{1 \text{ mol O}_2 \text{ (K)}} \right) (298 \text{ K})}{20.0 \text{ L}}$$

$$= 0.748 \text{ atm}$$