Charles' Law Worksheet

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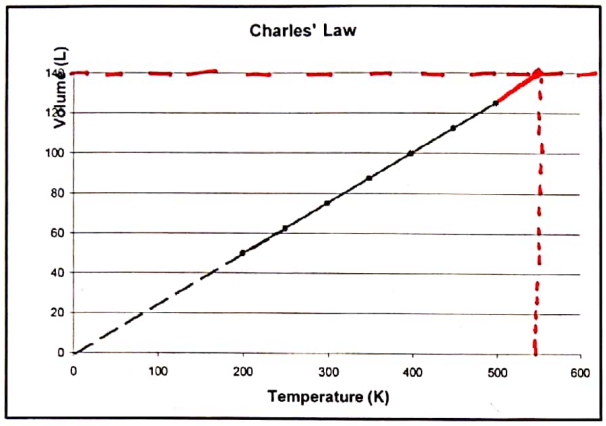
Jacques Charles made the observation the volume of a gas is directly proportional to the Kelvin temperature of the gas. If the Kelvin temperature is doubled, the volume also doubles. The equation for this relationship is $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, where V represents volume and T represents temperature.

The volume of a gas can be measured in liters, milliliters, cubic meters, or a variety of other units, but the temperature must be converted to kelvins. This relationship is only observed when the pressure remains constant.



USEFUL EQUATIONS

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad T_K = T_C + 273$

$1\ mL = 1\ cm^3$ $\quad T_C = (T_f - 32) \div 1.8$

$1\ L = 1000\ mL$

example

A gas sample with a volume of 35 mL is heated from 25°C to 425°C. What is the new volume? Assume a constant pressure.

- list the variables:
  $V_1 = 35\ mL$
  $T_1 = 25\ °C + 273.15 = 298.15\ K$
  $V_2 = ?$
  $T_2 = 425°C + 273.15 = 698.15\ K$
- substitute into the equation and solve using cross multiplication

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad \frac{35}{298.15} = \frac{V_2}{698.15}$

$V_2 (298.15) = 35 (698.15)$ *(cross multiply)*

$V_2 (298.15) = 24{,}435.25$

$V_2 = 81.96\ mL$

Solve the following problems. Assume that the pressure does not change.

1. According to the graph, when the Kelvin temperature of a gas is doubled, what happens to the volume?

   Volume also doubles

2. Using the graph, estimate the Kelvin temperature that the gas sample would reach a volume of 140 L.

   ~550 K (see graph above)

3. The Kelvin temperature of sample of 650 cm^3 sample of ammonia gas is doubled. What is the new volume of the gas? Assume that the pressure stays constant.

   Volume would also double, so $650\ cm^3 \times 2 = 1300\ cm^3$

4. A 240 mL sample of argon gas at 270 K is cooled until the volume is 180 mL. What is the new temperature?

$V_1 = 240$ mL
$T_1 = 270$ K
$V_2 = 180$ mL
$T_2 = ?$ (should ↓)

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

$\frac{240}{270} = \frac{180}{T_2}$

cross multiply:
$240(T_2) = 180(270)$
$240(T_2) = 48600$
$T_2 = 202.5$ K

5. A container of oxygen with a volume of 60 L is heated from 300 K to 400 K. What is the new volume?

$V_1 = 60$ L
$T_1 = 300$K
$V_2 = ?$ (should ↑)
$T_2 = 400$K

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

$\frac{60}{300} = \frac{V_2}{400}$

cross multiply:
$60(400) = V_2(300)$
$24000 = V_2(300)$
$V_2 = 80$ L

6. When a piston with a volume of 35 mL is heated from 25°C to 323°C it expands. Assuming the pressure on the piston remains the same, determine the new volume of the cylinder.

$V_1 = 35$ mL
$T_1 = 25°C + 273.15 = 298.15$ K
$V_2 = ?$ (should ↑)
$T_2 = 323°C + 273.15 = 596.15$ K

must be in Kelvin!

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

$\frac{35}{298.15} = \frac{V_2}{596.15}$

cross multiply:
$35(596.15) = V_2(298.15)$
$20865.25 = V_2(298.15)$
$V_2 = 69.98$ mL

7. A balloon with a volume of 5.3 L is taken from an indoor temperature of 24°C to the outdoors. The volume of the balloon outside is 4.9 L. Determine the Celsius temperature outside.

$V_1 = 5.3$L
$T_1 = 24°C + 273.15 = 297.15$K
$V_2 = 4.9$ L
$T_2 = ?$ (should ↓)

must be in Kelvin

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

$\frac{5.3}{297.15} = \frac{4.9}{T_2}$

cross multiply:
$5.3(T_2) = 4.9(297.15)$
$5.3(T_2) = 1456.035$
$T_2 = 274.72$ K $- 273.15 = 1.57°C$

8. A movable piston contains a sample of 0.680 L of neon gas with a temperature of -5°C. When the piston is heated the sample expands to a volume of 1.32 L. What is the new temperature of the neon gas?

$V_1 = 0.680$ L
$T_1 = -5°C + 273.15 = 268.15$K
$V_2 = 1.32$ L
$T_2 = ?$ (should ↑)

must be in Kelvin

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

$\frac{0.680}{268.15} = \frac{1.32}{T_2}$

cross multiply:
$0.680(T_2) = 1.32(268.15)$
$0.680(T_2) = 353.958$
$T_2 = 520.53$ K

9. A helium balloon has a volume of 2600 cm^3 when the temperature is 21°C. What is the volume of the balloon when it's placed in a freezer with a temperature of -15°C?

$V_1 = 2600$ cm^3
$T_1 = 21°C + 273.15 = 294.15$K
$V_2 = ?$ (should ↓)
$T_2 = -15°C + 273.15 = 258.15$ K

must be in Kelvin

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

$\frac{2600}{294.15} = \frac{V_2}{258.15}$

cross multiply:
$2600(258.15) = V_2(294.15)$
$671190 = V_2(294.15)$
$V_2 = 2281.795$ cm^3

10. A movable piston is allowed to cool from 200°C to 40°C. If the initial volume is 105 mL, what will be the new volume?

$V_1 = 105$ mL
$T_1 = 200°C + 273.15 = 473.15$K
$V_2 = ?$ (should ↓)
$T_2 = 40°C + 273.15 = 313.15$K

must be in Kelvin

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

$\frac{105}{473.15} = \frac{V_2}{313.15}$

cross multiply:
$105(313.15) = V_2(473.15)$
$32880.75 = V_2(473.15)$
$V_2 = 69.49$ mL