B5 · The combined gas law · Practice key

This is the worked key. Every practice question is worked step by step.

Worked examples

Read these first. There is one for each kind of question in this lesson.

Example 1 · Find the new pressure

Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A gas fills 4.00 L at 98.0 kPa and 18 °C. It changes to 2.50 L and 65 °C. What is the new pressure?

1. Before: P_1 = 98.0 kPa, V_1 = 4.00 L, T_1 = 18 °C. After: V_2 = 2.50 L, T_2 = 65 °C. The unknown is P_2.
2. T_1 = 18 + 273 = 291 K. T_2 = 65 + 273 = 338 K.
3. The units match on both sides, so no unit change is needed.
4. $P_2 = P_1V_1T_2 / (T_1V_2)$ = (98.0 kPa × 4.00 L × 338 K) / (291 K × 2.50 L) = 182 kPa.

Answer: The new pressure is 182 kPa.

Example 2 · Find the volume at SATP

Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. SATP is 25 °C and 100 kPa. A gas fills 2.20 L at 115 kPa and 40 °C. What volume does it fill at SATP?

1. Before: P_1 = 115 kPa, V_1 = 2.20 L, T_1 = 40 °C. After: P_2 = 100 kPa, T_2 = 25 °C. The unknown is V_2.
2. T_1 = 40 + 273 = 313 K. T_2 = 25 + 273 = 298 K.
3. The units match on both sides, so no unit change is needed.
4. $V_2 = P_1V_1T_2 / (T_1P_2)$ = (115 kPa × 2.20 L × 298 K) / (313 K × 100 kPa) = 2.41 L.

Answer: The gas fills 2.41 L at SATP.

Example 3 · Find the new temperature

Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A gas fills 5.00 L at 100 kPa and 27 °C. It changes to 6.00 L at 125 kPa. What is the new temperature?

1. Before: P_1 = 100 kPa, V_1 = 5.00 L, T_1 = 27 °C. After: P_2 = 125 kPa, V_2 = 6.00 L. The unknown is T_2.
2. T_1 = 27 + 273 = 300 K.
3. The units match on both sides, so no unit change is needed.
4. $T_2 = T_1P_2V_2 / (P_1V_1)$ = (300 K × 125 kPa × 6.00 L) / (100 kPa × 5.00 L) = 450 K.
5. 450 − 273 = 177 °C.

Answer: The new temperature is 450 K, which is 177 °C.

Practice

Questions 1 to 4 are easy. Questions 5 to 8 are medium. Questions 9 and 10 are harder.

EASY

1. A gas at 95.0 kPa, 3.00 L and 10 °C is changed to 110 kPa and 50 °C. Sort the five values into "before" and "after", and name the unknown.

1. Before: P_1 = 95.0 kPa, V_1 = 3.00 L, T_1 = 10 °C.
2. After: P_2 = 110 kPa, T_2 = 50 °C. The unknown is V_2.

EASY

2. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. Use the values from question 1. What is the new volume?

1. Before: P_1 = 95.0 kPa, V_1 = 3.00 L, T_1 = 10 °C. After: P_2 = 110 kPa, T_2 = 50 °C. The unknown is V_2.
2. T_1 = 10 + 273 = 283 K. T_2 = 50 + 273 = 323 K.
3. $V_2 = P_1V_1T_2 / (T_1P_2)$ = (95.0 kPa × 3.00 L × 323 K) / (283 K × 110 kPa) = 2.96 L.

EASY

3. The pressure of a gas does not change. Explain which simpler law the combined gas law turns into.

1. Charles's law.
2. P_1 and P_2 are equal, so they cancel, and $V_1/T_1 = V_2/T_2$ is left.

EASY

4. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A gas fills 2.00 L at 100 kPa and 27 °C. It changes to 1.00 L and 327 °C. What is the new pressure?

1. Before: P_1 = 100 kPa, V_1 = 2.00 L, T_1 = 27 °C. After: V_2 = 1.00 L, T_2 = 327 °C. The unknown is P_2.
2. T_1 = 27 + 273 = 300 K. T_2 = 327 + 273 = 600 K.
3. $P_2 = P_1V_1T_2 / (T_1V_2)$ = (100 kPa × 2.00 L × 600 K) / (300 K × 1.00 L) = 400 kPa.

MEDIUM

5. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. STP is 0 °C and 101.325 kPa. A gas fills 650 mL at 92.0 kPa and 35 °C. What volume does it fill at STP?

1. Before: P_1 = 92.0 kPa, V_1 = 650 mL, T_1 = 35 °C. After: P_2 = 101.325 kPa, T_2 = 0 °C. The unknown is V_2.
2. T_1 = 35 + 273 = 308 K. T_2 = 0 + 273 = 273 K.
3. $V_2 = P_1V_1T_2 / (T_1P_2)$ = (92.0 kPa × 650 mL × 273 K) / (308 K × 101.325 kPa) = 523 mL.

MEDIUM

6. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A gas fills 15.0 L at 150 kPa and 22 °C. It changes to 12.0 L and 85 °C. What is the new pressure?

1. Before: P_1 = 150 kPa, V_1 = 15.0 L, T_1 = 22 °C. After: V_2 = 12.0 L, T_2 = 85 °C. The unknown is P_2.
2. T_1 = 22 + 273 = 295 K. T_2 = 85 + 273 = 358 K.
3. $P_2 = P_1V_1T_2 / (T_1V_2)$ = (150 kPa × 15.0 L × 358 K) / (295 K × 12.0 L) = 228 kPa.

MEDIUM

7. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A gas fills 2.00 L at 90.0 kPa and 7 °C. It changes to 3.00 L at 120 kPa. What is the new temperature, in kelvin and in °C?

1. Before: P_1 = 90.0 kPa, V_1 = 2.00 L, T_1 = 7 °C. After: P_2 = 120 kPa, V_2 = 3.00 L. The unknown is T_2.
2. T_1 = 7 + 273 = 280 K.
3. $T_2 = T_1P_2V_2 / (P_1V_1)$ = (280 K × 120 kPa × 3.00 L) / (90.0 kPa × 2.00 L) = 560 K.
4. 560 − 273 = 287 °C.

MEDIUM

8. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. SATP is 25 °C and 100 kPa. A tank holds 8.50 L of gas at 240 kPa and 12 °C. What volume does the gas fill at SATP?

1. Before: P_1 = 240 kPa, V_1 = 8.50 L, T_1 = 12 °C. After: P_2 = 100 kPa, T_2 = 25 °C. The unknown is V_2.
2. T_1 = 12 + 273 = 285 K. T_2 = 25 + 273 = 298 K.
3. $V_2 = P_1V_1T_2 / (T_1P_2)$ = (240 kPa × 8.50 L × 298 K) / (285 K × 100 kPa) = 21.3 L.

HARDER

9. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. Use 1 atm = 101.325 kPa = 760 mm Hg. A gas fills 1.50 L at 1.25 atm and 25 °C. It changes to 150 kPa and 100 °C. First change 1.25 atm to kilopascals. Then find the new volume.

1. The two pressures must be in the same unit.
2. 1.25 atm × 101.325 kPa / 1 atm = 127 kPa.
3. Before: P_1 = 127 kPa, V_1 = 1.50 L, T_1 = 25 °C. After: P_2 = 150 kPa, T_2 = 100 °C. The unknown is V_2.
4. T_1 = 25 + 273 = 298 K. T_2 = 100 + 273 = 373 K.
5. $V_2 = P_1V_1T_2 / (T_1P_2)$ = (127 kPa × 1.50 L × 373 K) / (298 K × 150 kPa) = 1.59 L.

HARDER

10. Use the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, and T (K) = t (°C) + 273. The amount of gas does not change. A spray can holds 0.400 L of gas at 310 kPa and 20 °C. The can cannot change size. It warms to 55 °C in the sun. Find the new pressure. Then explain, using particles, why the pressure rose.

1. Before: P_1 = 310 kPa, V_1 = 0.400 L, T_1 = 20 °C. After: V_2 = 0.400 L, T_2 = 55 °C. The unknown is P_2.
2. T_1 = 20 + 273 = 293 K. T_2 = 55 + 273 = 328 K.
3. $P_2 = P_1V_1T_2 / (T_1V_2)$ = (310 kPa × 0.400 L × 328 K) / (293 K × 0.400 L) = 347 kPa.
4. The hotter particles move faster.
5. They hit the walls harder and more often, so the pressure goes up.