Gas Law Problems

I. Correct the volumes of the dry gases as directed in each of the following problems:

1. Change 125 mL of a gas at 25° C to standard temperature.
2. Change 300.0 mL of a gas at 0.0° C to 30.0° C.
3. Change 220.0 mL of a gas at 10.0° C to 100.0° C.
4. Change 1.00 L of a gas at 32° C to 27° C.
5. Change 100.0 mL of a gas at 740.0 torr pressure to standard pressure.
6. Change 250.0 mL of a gas at standard pressure to 780.0 torr.
7. Change 30.0 mL of a gas at standard pressure to 600.0 torr.
8. Change 750.0 mL of a gas at 700.0 torr to 800.0 torr.
9. Change 500.0 mL of a gas at 60.0° C and 800.0 torr to standard conditions.
10. Change 800.0 mL at 40.0° C and 700.0 mm to standard conditions.
11. Change 60.0 mL at standard conditions to 55° C and 745 torr.
12. Change 35 mL at standard conditions to 25° C and 725 torr.
13. Change 50.0 mL at standard conditions to 43° C and 750 mm.
14. Change 75.0 mL at 100.0° C and 450 torr to standard conditions.
15. Change 10.0 mL at 27° C and 1.25 atm to standard conditions.
16. Change 250 mL at 32° C and 750 torr to 47° C and 780 torr.
17. Change 200.0 mL at 17° C and 800.0 mm to 37° C and 700.0 mm.
18. Change 45 mL at 15° C and 790 torr to 23° C and 810 torr.
19. Change 135 mL at 34° C and 800.0 torr to 20.° C and 760 torr.
20. Change 310 mL at 58° C and 730 torr to 15° C and 750 torr.
21. Change 2.0 L at 43° C and 720 torr to 28° C and 800.0 torr.
22. Change 550 mL at 25° C and 790 mm to 55° C and 700.00 mm.

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23. Change 20.0 mL at 33° C and 700.0 torr to 57° C and 1.08 atm.
24. Change 150 mL at 0.0° C and 740 torr to 41° C and 750 torr.
25. Change 375 mL at 13° C and 780 torr to 33° C and 760 torr.
26. Change 80.0 mL at 27° C and 150 mm to standard conditions.
27. Change 37.5 mL at -5° C and 600.0 mm to standard conditions.
28. Change 175 mL at 3.0° C and 720 torr to standard conditions.
29. Change 350 mL at -30.° C and 100.0 mm to standard conditions.
30. Change 2.0 L at -45° C and 25 mm to standard conditions.
31. Change 18 mL at standard conditions to 23° C and 740 torr.
32. Change 120. mL at standard conditions to 60.0° C and 85 cm.
33. Change 36 mL at standard conditions to -13° C and 32 cm.
34. Change 3.2 L at standard conditions to 110° C and 720 mm.
35. Change 42 mL at standard conditions to 27° C and 794 torr.
36. Change 272 mL at standard conditions to 31° C and 3.2 atm.
37. Change 4.0 L at standard conditions to -43° C and 420 mm.
38. Change 75 mL at standard conditions to 17° C and 735 torr.
39. Change 360 mL at standard conditions to -19° C and 360 torr.
40. Change 6.5 L at standard conditions to -23° C and 150 mm.

II. What pressure is needed to make the following changes?

1. 130 mL of a dry gas at 740 torr to 150 mL.
2. 25 mL of a dry gas at 65 cm to 30.0 mL.
3. 1.0 L of a dry gas at 70.0 cm to 1.2 L.
4. 75 mL of a dry gas at 4.1 atm and 27° C to 70.0 mL at 25° C.
5. 60.0 mL of a dry gas at 760 torr and 0.0° C to 10.0 mL at 25° C.
6. 400.0 mL of a dry gas at 760 mm and 15° C to 300.0 mL at -30.0° C.

III. What temperature is needed to make the following changes?

1. 30.0 mL of a dry gas at 14° C to 22 mL.
2. 16.4 mL of a dry gas at 28° C to 20.0 mL.
3. 39 mL of a dry gas at 0.0° C to 35 mL.
4. 50.0 mL of a dry gas at 5° C and 760 mm to 55 mL and 780 mm.
5. 1.0 L of a dry gas at 10.0° C and 800.0 torr to 0.50 L and 760 torr.
6. 10.0 mL of a dry gas at 20.0° C and 760 torr to 1.0 mL and 800.0 torr.

IV. Solve the following gas law problems:

1. If 120 mL of oxygen are collected over water at 27° C and 740 mm pressure, what will the volume of the dry gas be at STP?

2. If 500.0 mL of hydrogen are collected over water at 20.0° C and 745 torr, what will the volume of the dry gas be at STP?

3. If 250 mL of nitrogen are collected over water at 25° C and 750 torr, what will the volume of the dry gas be at STP?

4. A certain gas is collected over water at 740 mm and 23° C. The collecting tube is left in place, and the volume is not measured until the next day when the pressure is 745 mm and the temperature 20.0° C, at which time the volume is found to be 15.3 mL. What was the original volume?

5. If 153.48 mL of carbon dioxide are collected over mercury at 14° C and 723 torr, what will its volume be at STP?

6. 113 mL of oxygen are collected over water at 22° C and 741 torr and left in position over night. On the next day, the volume has reduced to 109 mL and the temperature reads 21° C. What is the pressure on the second day?

7. If 18 mL of oxygen are collected over water at 27° C and 740 mm of pressure, what volume will the dry gas have at STP?

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8. 36 mL of nitrogen are collected over water at 25° C. The barometer is broken and no pressure can be read. Three days later, when a new barometer arrives, the volume of the damp gas has changed to 32 mL at a temperature of 21° C. The barometric reading is 739 torr. What was the original pressure?

V. Listed below are the densities for a number of gases at standard conditions. Find the new density of the gas in each case at the stated conditions.

1. carbon dioxide: 1.98 grams per liter (at 40.0° C)

2. helium: 0.178 grams per liter (at 23° C)

3. nitric oxide: 1.34 grams per liter (at 750 mm)

4. hydrogen chloride: 1.64 grams per liter (at 780 torr)

5. acetylene: 1.17 grams per liter (at 37° C and 780 torr)

6. oxygen: 1.43 grams per liter (at 17° C and 740 mm)

7. sulfur dioxide: 2.93 grams per liter (at 25° C and 755 torr)

8. ethylene: 1.26 grams per liter (at 15° C and 70.0 cm)

9. chlorine: 3.21 grams per liter (at 8.0° C and 795 mm)

10. nitrogen: 1.25 grams per liter (at −23° C and 400 torr)

11. ammonia: 0.77 grams per liter (at 500.0° C and 25 cm)

12. methane: 0.717 grams per liter (at 250° C and 4520 torr)

13. hydrogen sulfide: 1.54 grams per liter (at −53° C and 2550 mm)

(continued)

14. hydrogen: 0.09 grams per liter (at 2850° C and 0.010 atm)

15. argon: 1.78 grams per liter (at −150° C and 225 atm)

16. 25 mL of fluorine gas weigh 0.0390 g at 25° C. What is the density of fluorine at standard conditions?

17. Find the density of carbon monoxide gas at standard conditions if $30\overline{0}$ mL of the gas weigh 0.395 g at 800.0 mm of pressure.

18. 10.0 mL of neon would weigh 10.8 g at 10,000.0 torr and −270° C. From this information, calculate the density of neon at standard conditions.

19. The weight of 230 mL of hydrogen at 5.0 atm and −53° C is 0.128 g. What is the density of hydrogen at standard conditions?

20. The weight of 15 mL of nitrous oxide at 50.0 mm and 2000.0° C is 2.3×10^{-4} g. What would 1.0 L of this gas weigh at standard conditions?

21. A student collected a liter flask full of oxygen over water when the thermometer read 23° C and the barometer read 750 mm. Two hours later, the volume of the gas in the flask had reduced to 978 mL although the barometer had not changed. What change had occurred in the temperature?

22. A large balloon containing 400.0 L of hydrogen is released from the earth when the temperature is 21° C and the pressure 760 mm. What volume will the gas occupy when it reaches the atmospheric level at which the temperature is −67° C and the pressure 125 torr.

23. Suppose the balloon in problem 22 reached the given level, but the temperature was +67° C instead of −67° C. (All other conditions as stated in 22.) What volume would the hydrogen occupy then?

24. A quantity of nitrogen gas is enclosed in a tightly stoppered 500.0 mL flask at room temperature (20.0° C) and 760 mm pressure. The flask is then heated to 680° C. If the flask can withstand pressures of less than 3 atm, will it explode under this heating?

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25. A 1.0 L rubber bladder is filled with carbon dioxide gas in a warm (25° C) room (pressure = 745 torr). What volume will the gas occupy when it is taken out into the open air where the temperature is −12° C and the pressure, 742 torr?

26. 500.0 mL of air are trapped in a tube over mercury at 25° C. It is found that, after six days, the air has expanded so that 32 mL have escaped from the tube. What total temperature change occurred over this period if the pressure remained constant?

27. A rubber balloon containing 1.0 L of gas is carried from the top of a mountain to the bottom of the mountain, where its volume is measured as 0.85 L at standard pressure. Assuming that there was no temperature change during the trip, what was the pressure at the top of the mountain?

28. A sudden cold snap in June causes Mr. Van Dellen to order a 15 L tank of butane gas for his cottage heater. The temperature on this day was 18° C and the atmospheric pressure, 743 mm. Assuming that some type of piston arrangement was built into the tank so that the gas could expand freely, what volume would the butane gas occupy a week later when the temperature reached 42° C and 721 mm of pressure (assume 3.0 L of gas had been used)?

29. A toy balloon containing 425 mL of air escapes from a little boy watching a parade. The temperature is 32° C at street level and the pressure is 745 torr. When the balloon stops rising, its volume has become 895 mL although the atmospheric pressure has decreased by only 300.0 torr. What is the temperature at this level?

30. To what temperature must 15 L of oxygen gas at 0.0° C be heated at 1.00 atm pressure in order to occupy a volume of 23 L, assuming that the pressure increases by 5.0 mm?

VI. Solve the following problems involving the ideal gas law equation.

1. What pressure is exerted by 1.0 mol of an ideal gas contained in a 1.0 L vessel at 0.0° C?

2. What volume will 5.0 mol of an ideal gas occupy at 25.0° C and 1.5 atm of pressure?

3. Calculate the molecular weight of a gas if 4.5 L of the gas at 785 torr and 23.5° C weigh 13.5 g.

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4. 0.453 mol of a gas confined to a 15.0 L container exerts a pressure of 1.24 atm on the walls of the container. What is the temperature of the gas?

5. 5.4 g of carbon dioxide gas are confined to a 20.0 L container at a temperature of 32.5° C. What pressure does the gas exert?

6. 2.125 g of a gas in a 1.25 L container exert a pressure of 0.838 atm at 40.0° C. What is the molecular weight of the gas?

7. To what temperature must 10.0 g of ammonia gas have to be heated in a 15.0 L container in order for it to exert a pressure of 3.50 atm?

8. 2.0×10^{-5} g of hydrogen gas at 155° C exert a pressure of 322.5 torr on the walls of a small cylindrical tube. What is the volume of the tube?

VII. Listed below are various combinations of (1) molar composition of a gas mixture (m_A, m_B, m_C, etc.), (2) partial pressure of each gas in the mixture (p_A, p_B, p_C, etc.), and (3) the total pressure of the mixture (p_T). From this information, calculate any of the variables which are not given.

1. p_T = 785 mm; m_A = 45%; m_B = 55%

2. p_T = 1.050 atm; m_A = 38%; m_B = 40%; m_C = 22%

3. p_A = 420 torr; p_B = 180 torr; p_C = 200 torr

4. p_T = 1.12 atm; p_A = 0.43 atm (two gases only)

5. m_A = 21%; m_B = 34%; m_C = 45%; p_A = 183 torr

6. 10.0 g of carbon dioxide; 15.0 g of nitrogen; p_T = 1.142 atm

7. 5.0 g of argon; 5.0 g of xenon; 5.0 g of krypton; p_{Ar} = 86.4 torr

8. p_T = 1.28 atm; 3.4×10^{-3} g sulfur dioxide; 1.8×10^{-3} g carbon dioxide; 4.0×10^{-2} g nitrogen

VIII. Find the relative rate of diffusion between each of the following pairs of gases.

1. hydrogen and nitrogen
2. oxygen and carbon dioxide
3. hydrogen and carbon dioxide
4. nitrogen and oxygen
5. hydrogen chloride and chlorine
6. carbon monoxide and carbon dioxide

IX. Listed below are (1) the relative rate of diffusion between two gases and (2) the density of the less dense gas. From this information, calculate the density of the more dense gas.

1. 1.14; 1.93 g/L
2. 2.04; 1.28 g/L
3. 1.42; 1.13 g/L
4. 1.85; 1.62 g/L
5. 1.63; 1.46 g/L
6. 1.55; 1.39 g/L

Gas Law Problems:

Group I.

1. 110 mL
2. 330 mL
3. 290 mL
4. 0.98 L
5. 97.37 mL
6. 243.6 mL
7. 38.0 mL
8. 656.3 mL
9. 431 mL
10. 642 mL
11. 74 mL
12. 40 mL
13. 59 mL
14. 32 mL
15. 11 mL
16. 250 mL (252 mL)
17. 240 mL
18. 45 mL (45.1 mL)
19. 140 mL
20. 260 mL
21. 1.7 L
22. 680 mL
23. 18 mL
24. 170 mL
25. 410 mL
26. 14 mL
27. 30. mL
28. 160 mL
29. 52 mL
30. 0.079 L
31. 20. mL
32. 130 mL
33. 81 mL
34. 4.7 L
35. 44 mL
36. 95 mL
37. 6.1 L
38. 82 mL
39. 710 mL
40. 30. L

Group II.

1. 640 mm
2. 54 cm
3. 58 cm
4. 4.4 atm
5. 5000 mm (4980 mm)
6. 860 mm

Group III.

1. −63° C
2. 95° C
3. −28° C
4. 40° C (41° C)
5. −140° C
6. −240° C

Group IV.

1. 100 mL
2. 446 mL
3. 220 mL
4. 16 mL
5. 140 mL
6. 730 mm
7. 15 mL
8. 650 mm

Group V.

1. 1.73 g/L
2. 0.16 g/L
3. 1.3 g/L
4. 1.7 g/L
5. 1.1 g/L
6. 1.3 g/L
7. 2.6 g/L
8. 1.1 g/L
9. 3.3 g/L
10. 0.72 g/L
11. 0.090 g/L
12. 2.2 g/L
13. 6.4 g/L
14. 8×10^{-5} g/L (7.85×10^{-5} g/L)
15. 890 g/L
16. 1.7 g/L
17. 1 g/L (1.25 g/L)
18. 0.90 g/L
19. 0.090 g/L
20. 2.0 g/L
21. decreased by 7° C
22. 1700 L
23. 2800 L
24. yes pressure reaches about 3.2 atm
25. 0.88 L
26. increased by 19° C
27. 650 mm
28. 14 L
29. 110° C
30. 150° C

Group VI.

1. 22 atm
2. 82 L
3. 71
4. 227° C
5. 0.15 atm
6. 52
7. 814° C
8. 8.3 mL

Group VII.

1. $p_A = 353$ mm; $p_B = 432$ mm
2. $p_A = 0.399$ atm; $p_B = 0.420$ atm; $p_C = 0.231$ atm
3. $p_T = 800$ torr; $m_A = 53\%$; $m_B = 23\%$; $m_C = 25\%$
4. $p_B = 0.69$ atm; $m_A = 38\%$; $m_B = 62\%$
5. $p_B = 296$ torr; $p_C = 392$ torr; $p_T = 871$ torr
6. $m_{CO_2} = 0.227$ mol (29.8%); $m_{N_2} = 0.536$ mol (70.2%); $p_{CO_2} = 0.340$ atm; $p_{N_2} = 0.802$ atm
7. $m_{Ar} = 0.125$ mol (56.1%); $m_{Xe} = 0.038$ mol (17.1%); $m_{Kr} = 0.060$ mol (26.9%); $p_{Xe} = 7.1$ torr; $p_{Kr} = 41.4$ torr
8. $m_{SO_2} = 5.3 \times 10^{-5}$ mol (3.5%); $m_{CO_2} = 4.1 \times 10^{-5}$ mol (2.7%); $m_{N_2} = 1.4 \times 10^{-3}$ mol (93.8%); $P_{SO_2} = 0.045$ atm; $p_{CO_2} = 0.035$ atm; $p_{N_2} = 1.20$ atm

Group VIII.

1. 1 : 3.74
2. 1 : 1.17
3. 1 : 4.69
4. 1 : 1.07
5. 1 : 1.39
6. 1 : 1.25

Group IX.

1. 2.51 g/L
2. 5.33 g/L
3. 2.28 g/L
4. 5.54 g/L
5. 3.88 g/L
6. 3.34 g/L