Chemistry (Canadian) 4th edition Olmsted Test Bank

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CHAPTER 2

THE BEHAVIOUR OF GASES

CHAPTER STUDY OBJECTIVES

1***. Understand gas pressure and express pressure in various units.***
SKILLS TO MASTER: Converting among pressure units

2. ***Relate pressure, volume, temperature, and amount of gas.***
SKILLS TO MASTER: Using the ideal gas equation; relating final conditions to initial conditions
KEY CONCEPTS: Solving quantitative problems about gases at moderate temperatures and pressures requires only one equation, the ideal gas equation.

3. ***Use the concept of partial pressures in gas mixtures.***
SKILLS TO MASTER: Determining partial pressures
KEY CONCEPTS: In a mixture of gases, each gas contributes to the total pressure the pressure that it would exert if the gas were present in the container by itself.

4. ***Use stoichiometry to solve problems involving gas-phase chemical reactions.***
SKILLS TO MASTER: Using the ideal gas equation in gas stoichiometry problems

5. ***Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.***
KEY CONCEPTS: At a given temperature, all gases have the same molecular kinetic energy distribution. The volume occupied by the molecules of an ideal gas is negligible compared with the volume of its container. The energies generated by forces among ideal gas molecules are negligible compared with molecular kinetic energies.

6. ***Calculate gas densities and molar masses from pressure–volume–temperature data.***
SKILLS TO MASTER: Using gas properties to determine molar mass; using the ideal gas equation to calculate gas densities; using Graham's law for effusion and diffusion problems

7. ***Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.***
SKILLS TO MASTER: Working with the van der Waals Equation

8. ***Do calculations involving water vapour pressure and relative humidity and describe some of the basic chemistry of the troposphere.***

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MULTIPLE CHOICE QUESTIONS

1. If 760 Torr is equivalent to 1 atm and to 1.01325 bar, then a pressure of 1 bar is equivalent to
a) 760 Torr.
b) 770.07 Torr.
c) 750.06 Torr.
d) 129.86 Torr.
e) 133.32 Torr.

Answer: c

Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure
Feedback: a) no conversion applied; b) inverse of conversion factor applied; c) correct answer

2. Which will occupy a larger volume, 10 moles of H_2 (g) or 10 moles of propane, C_3H_8 (g)?
a) H_2 (g)
b) C_3H_8 (g)
c) They will occupy the same volume.

Answer: c

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases
Feedback: a mole is a mole is a mole

3. A glass bulb with a volume of 250.0 mL contains a small amount of solid potassium chlorate. It is connected to a mercury manometer. Upon heating the bulb, the following (unbalanced) reaction occurs:
$KClO_3 \rightarrow KCl + O_2$
After the apparatus cools back to room temperature, 23°C, the difference in the mercury levels in the manometer is now 14.2 cm. Which of the following statements are true?
1. The mercury on the side of the tube connected to the manometer is higher than before.
2. About 1.9×10^{-3} moles $KClO_3$ decomposed.
3. About 0.16 g $KClO_3$ decomposed.
4. The mercury on the side of the tube connected to the manometer is lower than before.
5. About 1.3×10^{-3} moles O_2 were evolved.
a) 1, 2 and 5 only
b) 5 only
c) 2 and 4 only
d) 3 and 4 only
e) 4 and 5 only

Answer: c

Difficulty: Medium

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Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

4. A reaction is carried out under an atmosphere of oxygen. As the reaction proceeds, oxygen is consumed. The reaction started in a 500 ml flask, under a pressure of 1015 mm Hg, and a temperature of 22˚C. How many moles of oxygen had been consumed if at the end of the reaction the pressure was 790 mm Hg and the temperature did not change?
a) 0.0286 moles
b) 46.6 moles
c) 0.0223 moles
d) 0.0250 moles
e) 0.00610 moles

Answer: e

Difficulty: Medium
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

5. Consider a sample of gas in a tank. Under which of the following conditions would you expect the least ideal behaviour?
a) high temperature and high pressure
b) high temperature and low pressure
c) moderate temperature and pressure
d) low temperature and low pressure
e) low temperature and high pressure

Answer: e

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

6. A tank holds a mixture of argon and helium gases. If the partial pressure of oxygen is 3.3 atm and the total pressure of the mixture is 15 atm; what is the mole fraction of helium gas?
a) 0.78
b) 0.18
c) 0.28
d) 0.64
e) 0.81

Answer: a

Difficulty: Easy
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures
Feedback: Students must use partial pressures to determine the mole fraction of gas in a sample.

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7. A tank holds a mixture of oxygen and nitrogen gases. If the partial pressure of oxygen is 3.3 atm and the mole fraction of N_2 gas $X(N_2) = 0.78$, what are the total pressure in the tank and the partial pressure of N_2?
a) 15 atm, 11.7 atm
b) 5.9 atm, 2.6 atm
c) 7.5 atm, 4.2 atm
d) 1 atm, 0.78 atm
e) 4.1 atm, 0.78 atm

Answer: a

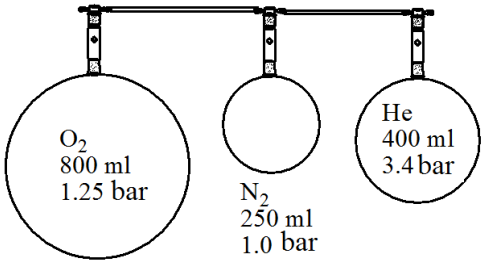
Difficulty: Medium
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures
Feedback: Students must use Dalton's law to determine both the total pressure in the tank and then this result to determine the partial pressure of nitrogen.

8. An ozone measurement in a ultraviolet paint curing facility is 12.2 PPM. The air pressure is 752.1 mm Hg. What is the partial pressure of ozone in the facility?
a) 12.2×10^{-2} mm Hg
b) 12.2×10^{-6} atm
c) 9.2×10^{-3} mm Hg
d) 9.2×10^{-6} atm
e) 92 mm Hg

Answer: c

Difficulty: Medium
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

9. The following set up is arranged in a laboratory. Assuming the volume of the connecting tubing is negligible and there is no temperature change, determine the final total pressure if all three flasks were allowed to mix.



a) 1.0 bar
b) 1.8 bar

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c) 0.69 bar
d) 1.9 bar
e) 5.7 bar

Answer: b

Difficulty: Hard
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

10. A researcher is studying the rate of consumption of CO_2 of some plants. She placed the plants into a sealed container so that they would be the primary user of CO_2 and the primary source of other gasses. Considering the following photosynthesis reaction, what should the researcher be concerned about as the reaction proceeds?

$6\ CO_{2(g)} + 6\ H_2O_{(l)} \rightarrow C_6H_{12}O_{6(s)} + 6\ O_{2(g)}$
a) the build up of total pressure
b) the loss of the partial pressure of reactants
c) the loss of total pressure
d) the loss of partial pressure of products
e) keeping the plant in a dark room

Answer: b

Difficulty: Easy
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

11. Professional cyclists can metabolize more than 80 mL of oxygen per kg of body weight per minute (sometimes called the V-O_2 max). Calculate the mass of glucose (in grams) that could theoretically be consumed by the following reaction by a 70 kg cyclist in an hour (assume 25°C and 1 atm pressure).
$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$
a) 2.28
b) 41
c) 410
d) 4100
e) 6.8

Answer: c

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

12. An SUV gets requires 19.6 L of gasoline per 100 km. If the chemical composition can be

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approximated by C_7H_{16}, with a density of 0.80 g/mL, how many L of CO_2 at 1 bar pressure and 25°C are emitted per km?
a) 2.7 L
b) 23 L
c) 39 L
d) 0.3 L
e) 2.7 x 10^2 L

Answer: e

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

13. If a 0.18 g sample of aluminum metal is dropped into 400 mL of 6 M HCl, hydrogen gas is evolved. The hydrogen evolved is collected over water, so the gas collected is a mixture of water vapour (vapour pressure = 23.8 mm Hg) and hydrogen gas. If the external pressure is 1.02 atm and temperature is 25˚C, what will be the total volume of gas collected in L?
a) 6.7 x 10^{-3} L
b) 0.010 L
c) 0.22 L
d) 0.25 L
e) 0.99 L

Answer: d

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

14. The noxious gas H_2S can be used to remove the acid rain component SO_2 from factory emissions by the Claus Process. What volume of H_2S in litres at STP will be needed to remove 2.00 kg of SO_2?
$2\ H_2S_{(g)} + SO_{2(g)} \rightarrow 3\ S_{(s)} + 2\ H_2O_{(l)}$
a) 1400 litres
b) 7 litres
c) 700 litres
d) 350 litres
e) 50 litres

Answer: a

Difficulty: Medium
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

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15. Consider the conversion of methane to acetylene and hydrogen gas shown in the unbalanced reaction below:
$CH_4 \rightarrow C_2H_2 + H_2$
What is the final pressure in a 100 L reaction vessel following the conversion of 323 g of methane to acetylene and hydrogen gases at 1725˚C?
a) 33.5 bar
b) 67.0 bar
c) 134.0 bar
d) 6.7 bar
e) 0.66 bar

Answer: b

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry
Feedback: a) unbalanced chemical equation; b) correct answer; c) incorrect mole ratios d) error in converting kPa to bar; e) wrong “R” used

16. The concentration of an old solution of hydrogen peroxide is being tested because hydrogen peroxide decomposes over time. The following reaction is catalyzed by potassium iodide and used to determine the concentration. If 3.0 ml of the peroxide solution is tested and produces 55 ml of $O_{2(g)}$ at 750 mm Hg and 23˚C, how many grams of hydrogen peroxide were in the solution?
$2\ H_2O_{2(aq)} \rightarrow 2\ H_2O_{(l)} + O_{2(g)}$
a) 0.0245 g
b) 0.12 g
c) 0.60 g
d) 12.4 g
e) 0.15 g

Answer: e

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

17. Consider a sample of gas in a tank. Under which of the following conditions would you expect the most ideal behaviour?
a) high temperature and high pressure
b) high temperature and low pressure
c) moderate temperature and pressure
d) low temperature and low pressure
e) low temperature and high pressure

Answer: b

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Difficulty: Easy
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.
Section Reference: 2.5 Molecular View of Gases

18. Which of the following molecules/atoms will exert a greater force when it strikes the wall of the container under ideal conditions?
a) Cs atoms at 298 K
b) Naphthalene molecules ($C_{10}H_8$) at 298 K
c) Radon atoms at 298 K
d) He atoms at 298 K
e) They will all hit with the same force.

Answer: e

Difficulty: Easy
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.
Section Reference: 2.5 Molecular View of Gases

19. Which of the following molecules/atoms will exert a greater force when it strikes the wall of the container under ideal conditions?
a) Cs atoms at 1000 K
b) Naphthalene molecules ($C_{10}H_8$) at 1400 K
c) Radon atoms at 880 K
d) He atoms at 1500 K
e) He atoms at 1000 K

Answer: d

Difficulty: Easy
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.
Section Reference: 2.5 Molecular View of Gases

20. Which of the following molecules/atoms will exert a greater force when it strikes the wall of the container under ideal conditions?
a) Cs atoms at 240 m/s
b) Naphthalene molecules ($C_{10}H_8$) at 250 m/s
c) Radon atoms at 200 m/s
d) He atoms at 800 m/s
e) Ar atoms at 300 m/s

Answer: d

Difficulty: Easy
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.

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Section Reference: 2.5 Molecular View of Gases

21. Increasing the number of molecules in a container increases the pressure because
a) there are more atoms in the container.
b) there are more collisions with the wall of the container.
c) the distance to the walls is closer for more molecules.
d) the temperature increases in the container.
e) there are more collisions molecules move faster.

Answer: b

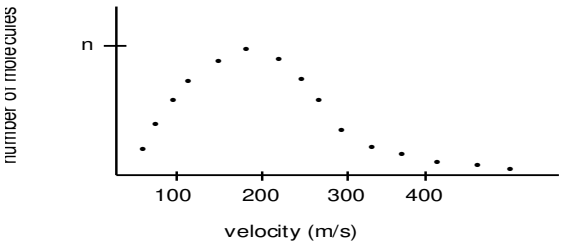
Difficulty: Easy
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.
Section Reference: 2.5 Molecular View of Gases

22. Cooling the gas in a container lowers the pressure because
a) there are less atoms in the container.
b) the potential energy increases in the container.
c) there are less collisions with the wall of the container.
d) the molecules' impact with the wall are less energetic.
e) the molecules slow down so both force and number of collisions with the walls is reduced.

Answer: e

Difficulty: Medium
Learning Objective: Explain the basic concepts of kinetic molecular theory: molecular speed, energy, and the effects of temperature and volume on gas pressure.
Section Reference: 2.5 Molecular View of Gases

23. Data for a pulsed molecular beam experiment at a temperature of 297 K is shown below:



Which are the following are probably true about the sample?
1. The sample consists of two different molar mass molecules.
2. The sample has a lower molar mass than ammonia (avg is 490 m/s).
3. The sample has a higher molar mass than ammonia (avg is 490 m/s).
4. The sample consists of molecules with the same molar mass.
5. The average velocity is near 200 m/s.
a) 1 and 5 only

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b) 3, 4 and 5 only
c) 2, 4 and 5 only
d) 4 and 5 only
e) 2 and 5 only

Answer: b

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

24. A sample of gas is heated from 200 K to 400 K. Which of the following statements accurately describes the sample at its new conditions?
1. The average velocity is twice as fast.
2. The molecules have four times the kinetic energy.
3. The average velocity is nearly the same.
4. The average kinetic energy is half the original.
5. The kinetic energy is twice the original.
a) 1 and 5 only
b) 3, 4 and 5 only
c) 2 and 5 only
d) 3 and 5only
e) 5 only

Answer: e

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

25. A sample of gas is cooled from 273°C to 0°C. Which of the following statements accurately describes the sample at its new conditions?
1. The kinetic energy is now nearly zero.
2. The average velocity is now twice as fast.
3. The average velocity is half as fast.
4. The average kinetic energy is halved.
5. The average velocity is about two thirds of the original.
a) 1 only
b) 3 only
c) 2 and 4 only
d) 4 and 5 only
e) 2 and 5 only

Answer: d

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–

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temperature data.
Section Reference: 2.6 Additional Gas Properties

26. A sample of gas is cooled to its vapourization temperature. What is true before the sample reaches equilibrium between the liquid and gaseous phases?
a) More molecules are depositing than vapourizing.
b) More molecules are condensing than vapourizing.
c) More molecules are vapourizing than condensing.
d) No liquid is present.
e) The liquid molecules have more kinetic energy than the gas molecules.

Answer: b

Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

27. At 1000°C and 10.0 Torr, the density of a certain element in the gas phase is 2.9×10^{-3} g/L. What is the element?
a) Ar
b) Ne
c) Br
d) Cl
e) Na

Answer: e

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

28. A sample of N_2 gas is contaminated with a gas. It is found that that contaminant effuses at 0.36 times the rate of N_2. What is the contaminating gas?
a) He
b) Cl_2
c) H_2
d) Kr
e) Rn

Answer: e

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

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29. A sample of radon is expected to diffuse _____ than oxygen gas.
a) 2.6 times faster
b) 2.6 times slower
c) 6.9 times faster
d) 6.9 times slower

Answer: b

Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

30. A sample of oxygen is expected to diffuse _____ than chlorine gas.
a) 1.5 times faster
b) 1.5 times slower
c) 0.66 times as fast
d) 1.05 times faster

Answer: a

Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

31. The ideal gas equation is expected to be valid at
a) low temperature.
b) low pressure.
c) high pressure.
d) low temperature and low pressure.
e) low temperature and high pressure.

Answer: b

Difficulty: Easy
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases

32. Consider the van der Waals “a” coefficient for He, O_2 and C_6H_6 increases because
a) the number of different atoms increases.
b) the intermolecular forces acting between molecules increase.
c) the strength of chemical bonds increases.
d) the volume occupied by the molecules becomes more significant as the size of the molecule increases.
e) the mass of the molecules increases.

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Answer: b

Difficulty: Easy
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases

33. Consider the van der Waals "b" coefficient for He, O_2 and CO_2 increases because
a) the number of different atoms increases.
b) the intermolecular forces acting between molecules increases.
c) the strength of chemical bonds increases.
d) the volume occupied by the molecules becomes more significant as the size of the molecule increases.
e) the mass of the molecules increases.

Answer: d

Difficulty: Easy
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases

34. If the compressibility factor, pV/nRT, is greater than 1, then
a) the gas is ideal.
b) the volume the gases occupy is no longer negligible.
c) attractive forces are acting between the molecules.
d) repulsive forces are acting between the molecules.
e) volume occupied by gases is no longer negligible and/or intermolecular repulsive forces dominate.

Answer: e

Difficulty: Medium
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases

35. If the compressibility factor, pV/nRT is 1 at pressure p, then
a) the gas is ideal.
b) the gas may be ideal, but is not necessarily ideal.
c) the gas is not ideal.
d) the gas is under optimum conditions.

Answer: b

Difficulty: Medium
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the

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deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases
Feedback: pV/nRT = 1 does not mean that the gas is behaving ideally; for an ideal gas pV/nRT = 1 for all p.

36. Consider the van der Waals equation:

$$P = \frac{nRT}{V - nb} - a\left(\frac{n^2}{V^2}\right)$$

a) the van der Waals "a" term is proportional to molecular size and "b" is proportional to the magnitude of intermolecular forces.
b) the van der Waals "b" term is proportional to molecular size and "a" is proportional to the magnitude of intermolecular forces.
c) large molecules tend to have smaller values for both a and b.
d) the van der Waals equation describes successfully describes the behaviour of non-ideal gases.

Answer: b

Difficulty: Hard
Learning Objective: Calculate the pressure of a gas under non-ideal conditions, and explain the deviations from ideality.
Section Reference: 2.7 Non-Ideal (Real) Gases

~~37. Athletes are reminded to drink more water when they are exercising in cold weather because it is easy to get dehydrated. The main reason for this is~~
~~a) the increased dew point at lower temperatures.~~
~~b) the higher vapour pressure of water at lower temperatures.~~
~~c) the lower relative humidity of the air at lower temperatures.~~
~~d) higher relative humidity.~~
~~e) lower vapour pressure.~~

~~Answer: c~~

~~Difficulty: Easy~~
~~Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.~~
~~Section Reference: 2.8 Chemistry of the Earth's Atmosphere~~

Commented [MA1]: Moved to Ch 22

~~38. Ground level ozone~~
~~a) forms the ozone layer which protects animal and plant life from harmful solar radiation.~~
~~b) is a contributor to photochemical smog.~~
~~c) is harmful to the respiratory system.~~
~~d) both a and b.~~
~~e) both b and c.~~

~~Answer: c~~

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~~Difficulty: Easy~~
~~Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.~~
~~Section Reference: 2.8 Chemistry of the Earth's Atmosphere~~

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ESSAY QUESTIONS

39. The pressure in an underwater dwelling is 9.52 atm. What is the pressure in Torr and Pascals?

Answer: 7.24×10^3 Torr; 9.65×10^6 Pa

Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure

40. The level of mercury on the sample side of a manometer is 56.0 mm above that of the atmospheric side. If the atmospheric pressure is 1.05 bar, what is the pressure of the gas sample (in Torr)?

Answer: 732 Torr

Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure

41. The level of mercury on the sample side of a manometer is 56 mm below that of the atmospheric side. If the atmospheric pressure is 1.05 bar, what is the pressure of the gas sample (in bar)?

Answer: 1.12 bar

Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure

42. The level of mercury on the sample side of a manometer is 56.0 mm above that of the atmospheric side. If the atmospheric pressure is 103 kPa, what is the pressure of the gas sample (in Torr)?

Answer: 717 Torr

Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure

43. The level of mercury on the sample side of a manometer is 156 mm below that of the atmospheric side. If the atmospheric pressure is 758 Torr, what is the pressure of the gas sample (in bar)?

Answer: 1.22 bar

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Difficulty: Easy
Learning Objective: Understand gas pressure and express pressure in various units.
Section Reference: 2.1 Pressure

44. An automobile tire has a volume of about 42 L. How many moles of air are contained in such a tire at a pressure of 220 kPa at a temperature of 28°C?

Answer: 3.7 moles

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

45. A steel cylinder 1.2 m tall and 20 cm in diameter is filled with nitrogen at a pressure of 152 bar at a temperature of 24°C. How many kg of nitrogen does the cylinder contain?

Answer: 6.5 kg

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

46. In this chapter, some important applications of high vacuum are discussed. Pressures of 1.0 x 10^{-9} atm can be routinely achieved in the laboratory. CO is a common contaminant at these low levels. How many molecules of CO would be present if it was the only contaminant in a 1.0 L container at a pressure of 1.0 x 10^{-9} atm and 298 K?

Answer: 2.5 x 10^{13}

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

47. A mylar novelty balloon is filled with 4.5 L of He at 1 atm pressure and 23°C temperature. It is then dipped into a liquid nitrogen (77K) until the gas and balloon are at 77K. What is the volume of the balloon at 77K?

Answer: 1.2 L

Difficulty: Medium
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

48. A spherical weather balloon is constructed so that the gas inside can expand as the balloon ascends to higher altitudes where the pressure is lower. If the radius of the spherical balloon is

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2.5 m at sea level where the pressure is 753 Torr, what will be the radius at an altitude of about 10 km where the pressure of the gas is 210 Torr if the temperature has not changed?

Answer: 3.8 m

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

49. One group of compounds that contain only carbon and hydrogen are called the *cycloalkanes* and have the empirical formula CH_2. The vapour from a sample of one of these compounds occupies a volume of 253.2 mL at a temperature of 99.8°C and a pressure of 754.8 Torr. The vapour has a mass of 0.5921g. What is the molecular formula of the compound?

Answer: MM = 72.1 g/mole; C_5H_{10}

Difficulty: Hard
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

50. Carbon monoxide is used frequently in the production of metals and steel. A cylinder of CO is shipped to a research facility with a pressure of 170. atm and a volume of 90.0 litres. How many kilograms of CO are needed to fill the cylinder at 10.0˚C?

Answer: 8.4 kg

Difficulty: Medium
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

51. A cylinder of carbon dioxide is shipped to a research facility. This cylinder is under a pressure of 145 atm and has a volume of 95 litres. What volume would this same amount of gas fill if the valve was opened to the room, which is under a pressure of 745 mm Hg?

Answer: 14,000 litres

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

52. A hair spray bottle will explode if under 9 atm of internal pressure. If this bottle is originally under 5 atm of pressure at 25˚C and is placed to close to a campfire and raises to 48˚C, what will be the pressure inside the bottle now?

Answer: 5.4 atm

Difficulty: Easy

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Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

53. A diver exhales a bubble with a volume of 250 ml at a pressure of 2.4 atm and 15˚C. What will be the volume of that bubble when it reaches the surface where the pressure if 1 atm and the temperature if 29˚C?

Answer: 630 ml

Difficulty: Easy
Learning Objective: Relate pressure, volume, temperature, and amount of gas.
Section Reference: 2.2 Describing Gases

54. A tank holds a mixture of nitrogen and chlorine gases. If the partial pressure of nitrogen is 3.3 atm and the total pressure of the mixture is 22,000 kPa; what is the mole fraction of chlorine gas?

Answer: 0.98

Difficulty: Easy
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures
Feedback: Dalton's law and unit conversion required.

55. A 400 L steel tank is filled with a mixture of 20 kg of methane (CH_4), 5 kg of ethane (C_2H_6) and 0.050 g of butanethiol ($C_4H_{10}S$). (This last sulphur-containing compound has an intense smell to indicate any leaks of this flammable mixture). What is the total pressure in the tank and the partial pressure of each component if the temperature is 24 °C?

Answer: 86 atm

Difficulty: Medium
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

56. A 400 L steel tank is filled with a mixture of 20 kg of methane (CH_4), 5 kg of ethane (C_2H_6) and 0.050 g of butanethiol ($C_4H_{10}S$). (This last sulphur-containing compound has an intense smell to indicate any leaks of this flammable mixture). Determine the composition of the gas in terms of mole fraction and ppm.

Answer:

$X\text{ (methane)} = \frac{1.25 \times 10^3}{1.41 \times 10^3} = 0.88$	$\text{ppm(methane)} = X(10^6) = 8.8 \times 10^5$
$X\text{(ethane)} = \frac{1.67 \times 10^2}{1.41 \times 10^3} = 0.12$	$\text{ppm(ethane)} = X(10^6) = 1.2 \times 10^5$

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$$X(\text{butanethiol}) = \frac{5.54 \times 10^{-4}}{1.41 \times 10^{3}} = 3.9 \times 10^{-7} \qquad \text{ppm(butanethiol)} = X(10^{6}) = 0.39$$

Difficulty: Hard
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

57. Vinyl chloride is a important industrial chemical used in many different applications. However, it has health impacts even at the PPB level. If an average breath is about 1.5 L, how many vinyl chloride molecules would be contained in one breath, assuming 1 atm pressure and 26°C if the vinyl chloride concentration is 10 PPB?

Answer: 4×10^{14} molecules

Difficulty: Medium
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

58. A gas mixture containing oxygen, nitrogen, and helium exerts a total pressure of 925 Torr. If the partial pressures are oxygen 425 Torr, and helium 75 Torr, what is the partial pressure (in bar) of nitrogen in the mixture?

Answer: 0.567 bar

Difficulty: Easy
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures

59. A gas mixture containing oxygen, nitrogen, and helium; if the partial pressure and mole fraction of oxygen is 425 Torr and 0.46, respectively, and the partial pressure of helium is 74 Torr, what is the partial pressure (in bar) of nitrogen in the mixture?

Answer: 425Torr

Difficulty: Medium
Learning Objective: Use the concept of partial pressures in gas mixtures.
Section Reference: 2.3 Gas Mixtures
Feedback: Must use mole fraction to determine total pressure and Dalton's law to determine partial pressure.

60. A tank is pressurized with 5.0 atm of N_2 and 10.0 atm of H_2. Ammonia (NH_3) is formed. When the pressure finally remains constant, indicating that the reaction has proceeded as far as it will go, the partial pressure of ammonia is 3.2 atm. What is the total pressure in the tank assuming that neither the temperature nor the volume of the container have changed?

Answer: 11.8 atm

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Difficulty: Medium
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

61. Methanol, CH_3OH, is produced by the reaction of methane with oxygen under carefully controlled conditions:
$2\ CH_{4\ (g)} + O_{2\ (g)} \rightarrow 2\ CH_3OH_{\ (g)}$
A 200 L reactor is filled with a mixture of methane to a pressure of 10.5 atm and 3.50 atm oxygen at 298 K. The reactor is then heated to 350°C.
(a) What is the mass of methanol formed if the reaction proceeds to 100% yield?
(b) What are the partial pressures of each of the substances and the total pressure in the reactor at the end of the reaction if the temperature is 350°C?

Answer:
(a).83 x 10^3 g

(b) $p_T = p_{CH_4} + p_{O_2} + p_{CH_3OH} = 7.32 + 0 + 14.6$ atm = $\boxed{21.9\ \text{atm}}$

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

62. At an elevation of 10 km above sea level (about 33,000 feet, approximately the cruising altitude of a jet airliner), the atmospheric pressure is 210 Torr and the temperature is 230K. Assuming air is 21% O_2, how many L of air at this altitude would be required to completely burn 1 kg of jet fuel, $C_{12}H_{26}$?

Answer: 3.54 x 10^4 L

Difficulty: Hard
Learning Objective: Use stoichiometry to solve problems involving gas-phase chemical reactions.
Section Reference: 2.4 Gas Stoichiometry

63. Acetic acid, shown below, is the substance responsible for the odour of vinegar.



What is the average velocity and average kinetic energy (kJ/mol) of acetic acid molecules?

Answer: 3.7 x10^3 kJ/mole and 350 m/s

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

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64. Methylamine, whose line structure is shown below, is one of the substances for the "fishy" odour of not-so-fresh fish.



What is the average velocity and average kinetic energy (kJ/mole) of gaseous methylamine molecules at 25°C?

Answer: 3.7 x 10^3 kJ/mole and 490 m/s

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

65. If the density of a sample of nitrogen gas was 8.0 x 10^{-3} g/L, what is the density of He under identical conditions of temperature and pressure?

Answer: 1.1 x10^{-3} g/L

Difficulty: Easy

66. If the density of a sample of nitrogen gas was 1.2 g/L at 298K; what is the density of chlorine gas at 298K if the pressure of the chlorine gas is twice that of the nitrogen?

Answer: 6.1 g/L

Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

67. The density of air at room temperature and pressure (1 atm) is about 1.16 g/L. Other gases have different vapour densities and may be less dense than air (such as helium) or more dense (propane). Gases with vapour densities greater than air mix slowly with air (because on average, the molecules have smaller velocities) and collect in low-lying areas. In Bhopal, India, a large quantity of methyl isocyanate, CH_3OCN, escaped from a storage tank killing thousands of people. Calculate the vapour density of methyl isocyanate at room temperature and pressure.

Answer: 2.33 g/L

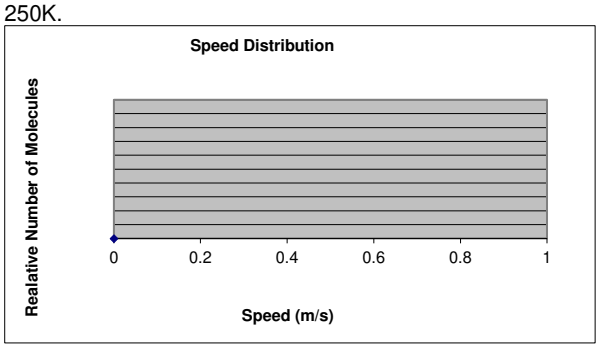
Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

68. On the graph provided draw the speed distribution of O_2 at 250K, O_2 at 350 K, and H_2 at

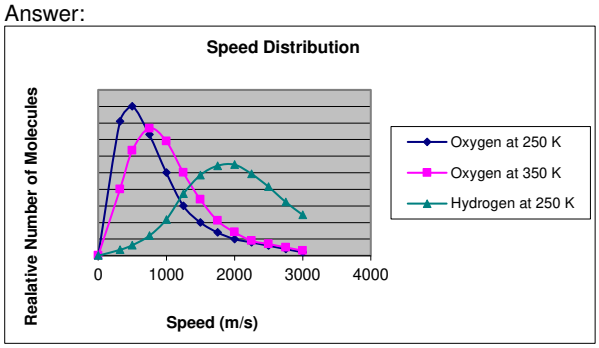
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250K.



Answer:



Difficulty: Medium
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

69. A 1.56 L sample of nitrogen gas (1.21×10^{-2} g) is heated from 24°C to 350°C. Calculate the densities of the nitrogen at the different temperatures.

Answer: 7.74×10^{-3} g/L at 24°C; 3.69×10^{-3} g/L at 350 °C

Difficulty: Hard
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

70. A sample of N_2 gas is contaminated with one of the noble gases. It is found that the contaminant effuses at 1.87 times the rate of N_2. What is the contaminating noble gas?

Answer: He

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Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

71. If the rate of effusion of Kr is 3×10^{-5} moles/s and the rate of effusion of an unknown gas under identical conditions is 4.3×10^{-5} moles/s, what is the identity of the unknown gas?

Answer: argon

Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

72. If the rate of effusion of Kr is 5×10^{-5} moles/s, what is the rate of effusion of chlorine gas under identical conditions in units of molecules/s?

Answer: 3.3×10^{19} molecules/s

Difficulty: Easy
Learning Objective: Calculate gas densities and molar masses from pressure–volume–temperature data.
Section Reference: 2.6 Additional Gas Properties

~~73. Argon is an important gas, used in many applications where an unreactive gas is needed. If the mole fraction of argon in dry air is 9.34×10^{-3}, how many kg argon can be extracted from 1 km^3 dry air at 298K and 1 atm total pressure?~~

~~Answer: 1.5×10^{7} kg~~

~~Difficulty: Medium~~
~~Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.~~
~~Section Reference: 2.8 Chemistry of the Earth's Atmosphere~~

Commented [MA3]: Moved to Ch22

~~74. If the relative humidity at 28°C is 58.3 %, what is the dew point?~~

~~Temp (°C)~~	~~Vapour Pressure~~	~~Temp (°C)~~	~~Vapour Pressure~~	~~Temp (°C)~~	~~Vapour Pressure~~
~~18~~	~~15.5 mm Hg~~	~~26~~	~~25.2 mm Hg~~	~~34~~	~~40.0 mm Hg~~
~~20~~	~~17. 6~~	~~28~~	~~28.4~~	~~36~~	~~44.6~~
~~22~~	~~19.8~~	~~30~~	~~31.9~~	~~38~~	~~49.8~~
~~24~~	~~22.4~~	~~32~~	~~35.7~~	~~40~~	~~55.4~~

~~Answer: 19°C~~

~~Difficulty: Easy~~

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Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.
Section Reference: 2.8 Chemistry of the Earth's Atmosphere

Commented [MA4]: Moved to Ch22

75. If atmospheric pressure atop Mount Everest is about 250 mm Hg, what is the partial pressure of oxygen?

Answer: 50 mm Hg

Difficulty: Easy
Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.
Section Reference: 2.8 Chemistry of the Earth's Atmosphere

Commented [MA5]: Moved to Ch22

76. In the summer there is frequently dew on the grass on humid nights. What will the dew point be if during the afternoon there was a relative humidity of 78% at 32°C (90°F)?

Temp (°C)	Vapour Pressure	Temp (°C)	Vapour Pressure	Temp (°C)	Vapour Pressure
20	17. 6 mm Hg	28	28.4	36	44.6
22	19.8	30	31.9	38	49.8
24	22.4	32	35.7	40	55.4
26	25.2	34	40.0	42	61.6

Answer: below 28°C, or 82°F

Difficulty: Easy
Learning Objective: Relative humidity and describe some of the basic chemistry of the troposphere.
Section Reference: 2.8 Chemistry of the Earth's Atmosphere

Commented [MA6]: Moved to Ch22

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