Practice questions on Gases

1. When 0.719 g of a liquid is turned into gas at 111.76°C and 0.179 atm, the gas occupies a volume of 2.182 L. The empirical formula of the compound is C_2H_5. What is its molecular formula?
   A) $C_{10}H_{25}$
   B) C_8H_{20}
   C) C_6H_{15}
   D) C_2H_5
   E) C_4H_{10}

2. As you probably know, both the temperature and pressure of air goes down as altitude (height from Earth's surface). A helium balloon with a volume of 3.05 L escapes from little Freddie's hands on a nice Los Angeles day with a temperature of 23.6 °C, where the pressure is 1.04 atm. What will be the volume of the balloon when it rises to an altitude where the air pressure is 0.312 atm and temperature is –46.1 °C?
   A) 0.700 L
   B) 7.78 L
   C) 1.20 L
   D) 13.3 L
   E) 2.15 L

3. Under which of the following conditions would the behavior of carbon monoxide gas deviate the most from that of an ideal gas?
   A) P=0.01 atm, T=476 K
   B) P=1.00 atm, T=476 K
   C) P=1.00 atm, T=273 K
   D) P=10.0 atm, T=273 K
   E) P=10.0 atm, T=155 K

4. CO_2 and SO_2 gases are released at the same spot at the same time. How many seconds does SO_2 take to diffuse to the same distance that CO_2 diffused to in 5.0 seconds? (*Reminder: the question is asking about time, not rate*)
   A) 3.4 s
   B) 7.3 s
   C) 6.0 s
   D) 4.1 s
   E) 2.9 s

5. Density of a gas is
   A) higher when T is low, P is high
   B) higher when both T and P are low
   C) higher when T is high, P is low
   D) higher when both T and P are high
   E) determined only by the molar mass of the gas

6. Four sealed containers, each at 14°C store the gases He, Ne, Ar, and Kr. The pressures in the containers are 1.0, 2.0, 3,.0 and 4.0 atm respectively. For which gas do the gas particles have the smallest average kinetic energy?
   A) He
   B) Ne
   C) Kr
   D) unknown because the thermodynamic states of the gases are not fully defined
   E) same for all the gases

7. A gas is found to diffuse at half the rate of methane (CH_4). Which of the following could be this gas?

   A) O_2
   B) N_2
   C) CO_2
   D) SO_2
   E) C_2H_6

8. Calculate the ratio of the rate of effusion of CO_2 to He.
   A) 0.090/1
   B) 0.30/1
   C) 3.3/1
   D) 11/1
   E) 12/1

9. Consider the reaction between ethane (C_2H_6) and oxygen gas (O_2) to produce carbon dioxide and water:
   $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$
   What volume of carbon dioxide will be produced at STP from the reaction of 4.00 L of ethane with 7.00 L of oxygen?
   A) 6.00 L CO_2
   B) 3.00 L CO_2
   C) 4.00 L CO_2
   D) 2.00 L CO_2
   E) 8.00 L CO_2

10. Consider the reaction between Mg(s) and HCl(aq) to produce aqueous magnesium chloride and hydrogen gas. How many liters of hydrogen gas at STP will be produced when 12.15 g of magnesium reacts with an excess of hydrochloric acid?
   A) 1.00 L
   B) 2.00 L
   C) 5.60 L
   D) 11.2 L
   E) 22.4 L

11. What is the density of oxygen gas, in g per liter, at 25 °C and 0.850 atm?
   A) 1.11
   B) 0.901
   C) 0.556
   D) 1.33
   E) 0.750

12. A sample of nitrous oxide, N_2O, occupies 16,500 mL at STP. What is the mass of the sample?
   A) 18.9
   B) 22.1
   C) 22.8
   D) 32.4
   E) 46.0

13. What will be the pressure of a sample of 48.0 grams of oxygen gas in a glass container of volume 5.2 L at 25 °C?
   A) 0.591 atm
   B) 1.18 atm
   C) 7.05 atm
   D) 14.1 atm
   E) 226 atm

14. A chemical reaction produced 10.1 cm^3 of nitrogen gas at 23 °C and 746 mmHg. What is the volume of this gas if the temperature and pressure are changed to 0 °C and 760 mmHg?
   A) 9.14 cm^3
   B) 9.49 cm^3
   C) 10.8 cm^3
   D) 11.2 cm^3
   E) 10.1 cm^3

15. Real gases are those that
   A) only behave ideally at high pressures or low temperatures
   B) deviate from ideal behavior
   C) are only available naturally in the earth's atmosphere
   D) are called real gases because their behavior can easily be modeled
   E) have an even number of protons

16. Which of the following situations will always make $PV/nRT > 1$ for a real gas?
   A) When the effect of the volume of the gas molecules on the gas volume is larger than the effect of the attraction between gas particles on the gas pressure
   B) When about half of the particles have speeds greater than the average speed.
   C) If the gas molecules have a very high molar mass.
   D) When temperature and pressure is very high
   E) The condition cannot be satisfied; PV/nRT is always less than 1 for a real gas

17. Complete the following: Because real gas particles have attraction for one another:
   A) Real gases act most ideally at STP.
   B) We assume gas particles have negligible (zero) volume.
   C) One mole of an ideal gas at STP has a volume of 22.4 L.
   D) Real gases act more ideally at higher temperatures and lower pressures.
   E) At least two of the above statements (A-D) correctly complete the statement.

18. Order the following in increasing rate of effusion:

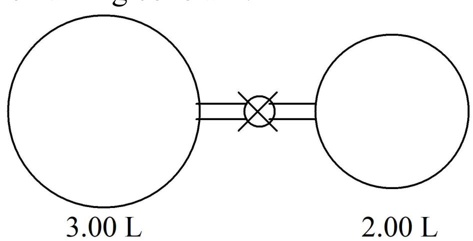
   F_2, Cl_2, NO, NO_2, CH_4

   A) $Cl_2 < NO_2 < F_2 < NO < CH_4$
   B) $Cl_2 < F_2 < NO_2 < CH_4 < NO$
   C) $CH_4 < NO_2 < NO < F_2 < Cl_2$
   D) $CH_4 < NO < F_2 < NO_2 < Cl_2$
   E) $F_2 < NO < Cl_2 < NO_2 < CH_4$

19. A sample of N_2 gas is contaminated with a gas (A) of unknown molar mass. The partial pressure of each gas is known to be 200. torr at 25°C. The gases are allowed to effuse through a pinhole, and it is found that gas A escapes at 2 times the rate of N_2. The molar mass of gas A is:
   A) 7.01 g/mol
   B) 112 g/mol
   C) 56 g/mol
   D) 14.01 g/mol
   E) none of these

20. At 200 K, the molecules or atoms of an unknown gas, X, have an average velocity equal to that of Ar atoms at 400 K. What is X? (Assume ideal behavior.)
A) He
B) CO
C) HF
D) HBr
E) F_2

21. The valve between the 2.00-L bulb, in which the gas pressure is 2 atm, and the 3.00-L bulb, in which the gas pressure is 2.8 atm, is opened. What is the final pressure in the two bulbs, with the temperature remaining constant?



A) 0.800 atm
B) 2.32 atm
C) 2.48 atm
D) 1.68 atm
E) 2.40 atm

22. A gaseous mixture containing 1.5 mol Ar and 3.5 mol CO_2 has a total pressure of 8.4 atm. What is the partial pressure of CO_2?
A) 2.5 atm
B) 1.6 atm
C) 25 atm
D) 5.9 atm
E) 8.4 atm

23. A balloon contains an anesthetic mixture of cyclopropane (cp) and oxygen (O_2) at 171 torr and 570. torr, respectively. What is the ratio of the number of moles of cyclopropane to moles of oxygen?

$$\frac{n_{cp}}{n_{O_2}} = ?$$

A) 3.33
B) 0.230
C) 0.300
D) 0.390
E) 0.460

24. You have a 400-mL container containing 55.0% He and 45.0% Ar by mass at 25°C and 1.5 atm total pressure. You heat the container to 100°C. Calculate the total pressure.
A) 1.20 atm
B) 1.50 atm
C) 1.88 atm
D) 2.01 atm
E) none of these

25. You have a 400-mL container containing 55.0% He and 45.0% Ar by mass at 25°C and 1.5 atm total pressure. You heat the container to 100°C. Calculate the ratio of $P_{\mathrm{He}} : P_{\mathrm{Ar}}$.
A) 1/1.22
B) 1.22/1
C) 1/12.2
D) 12.2/1
E) none of these

26. Oxygen gas, generated by the reaction $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ is collected over water at 27°C in a 1.55-L vessel at a total pressure of 1.00 atm. (The vapor pressure of H_2O at 27°C is 26.0 torr.) How many moles of $KClO_3$ were consumed in the reaction?
   A) 0.0608 moles
   B) 0.0912 moles
   C) 0.0405 moles
   D) 0.0434 moles
   E) 1.50 moles

27. A vessel with a volume of 26.9 L contains 2.80 g of nitrogen gas, 0.605 g of hydrogen gas, and 79.9 g of argon gas. At 25°C, what is the pressure in the vessel?
   A) 75.5 atm
   B) 0.183 atm
   C) 2.55 atm
   D) 2.18 atm
   E) 58.7 atm

28. One way to isolate metals from their ores is to react the metal oxide with carbon as shown in the following reaction:

   $2MO(s) + C(s) \rightarrow 2M(s) + CO_2(g)$

   If 34.08 g of a metal oxide reacted with excess carbon and 4.37 L of CO_2 formed at 100°C and 1.50 atm, what is the identity of the metal?
   A) Hg
   B) Mg
   C) Cu
   D) Cd
   E) Zn

29. Given the equation:

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

A 3.00-g sample of $KClO_3$ is decomposed and the oxygen at 24.0°C and 0.717 atm is collected. What volume of oxygen gas will be collected assuming 100% yield?

A) 8.32×10^2 mL
B) 1.01×10^2 mL
C) 1.25×10^3 mL
D) 5.55×10^2 mL
E) none of these

30. An excess of sodium hydroxide is treated with 26.5 L of dry hydrogen chloride gas measured at STP. What is the mass of sodium chloride formed?

A) 1.55 kg
B) 1.69 g
C) 0.138 kg
D) 69.1 g
E) 13.3 g

31. Calcium hydride combines with water according to the equation:

$$CaH_2(s) + 2H_2O(l) \rightarrow 2H_2(g) + Ca(OH)_2(s)$$

Beginning with 84.0 g of CaH_2 and 42.0 g of H_2O, what volume of H_2 will be produced at 273 K and a pressure of 1327 torr?

A) 29.9 L
B) 15.0 L
C) 5.39×10^2 L
D) 25.7 L
E) none of these

32. The purity of a sample containing zinc and weighing 0.312 g is determined by measuring the amount of hydrogen formed when the sample reacts with an excess of hydrochloric acid. The determination shows the sample to be 84.0% zinc. What amount of hydrogen (measured at STP) was obtained?

A) 2.62×10^{-1} L
B) 1.30×10^{-1} g
C) 4.77×10^{-3} mole
D) 2.41×10^{21} molecules
E) 2.41×10^{21} atoms

33. A 3.31-g sample of lead (II) nitrate, $Pb(NO_3)_2$, molar mass = 331 g/mol, is heated in an evacuated cylinder with a volume of 2.37 L. The salt decomposes when heated, according to the equation:

$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$

Assuming complete decomposition, what is the pressure in the cylinder after decomposition and cooling to a temperature of 300. K? Assume the PbO(*s*) takes up negligible volume.

A) 0.260 atm
B) 0.208 atm
C) 0.0519 atm
D) 0.364 atm
E) 34.4 atm

34. Gaseous C_2H_4 reacts with O_2 according to the following equation:

$C_2H_4\,(g) + 3O_2\,(g) \rightarrow 2CO_2 + H_2O\,(g)$

What volume of oxygen gas at STP is needed to react with 5.75 mol of C_2H_4?

A) 17.3 L
B) 42.9 L
C) 3.86×10^{2} L
D) 1.29×10^{2} L
E) Not enough information is given to solve the problem.

35. Argon has a density of 1.78 g/L at STP. How many of the following gases have a density at STP *greater* than that of argon?

Cl_2 He NH_3 NO_2

A) 0
B) 1
C) 2
D) 3
E) 4

36. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure. Which gas has the highest density?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

37. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure. For which gas do the molecules have the highest average velocity?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

38. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure. Which gas sample has the greatest number of molecules?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

39. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure. For which gas do the molecules have the smallest average kinetic energy?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

40. For an ideal gas, which pairs of variables are inversely proportional to each other (if all other factors remain constant)?

1. *V* and *T*
2. *T* and *n*
3. *n* and *V*
4. *P* and *T*

A) 1 and 2 only
B) 3 and 4 only
C) 2 only
D) 1 and 3 only
E) 1, 3, and 4 only

41. A sample of 35.1 g of methane gas has a volume of 3.11 L at a pressure of 2.70 atm. Calculate the temperature.
A) 2.92 K
B) 46.8 K
C) 320 K
D) 32.4 K
E) 35.0 K

42. A 7.94-g piece of solid CO_2 (dry ice) is allowed to sublime in a balloon. The final volume of the balloon is 1.00 L at 301 K. What is the pressure of the gas?
A) 4.46 atm
B) 1.96×10^2 atm
C) 3.11 atm
D) 0.224 atm
E) none of these

43. What volume is occupied by 21.0 g of methane (CH_4) at 27°C and 1.25 atm?
A) 37.2 L
B) 25.8 L
C) 2.32 L
D) 4.14×10^2 L
E) not enough data to calculate

44. You are holding four identical balloons each containing 10.0 g of a different gas. The balloon containing which gas is the largest balloon?
A) H_2
B) He
C) Ne
D) O_2
E) All have the same volume.

45. A balloon has a volume of 2.32 liters at 24.0°C. The balloon is heated to 48.0°C. Calculate the new volume of the balloon.
A) 2.32 L
B) 2.51 L
C) 2.15 L
D) 4.64 L
E) 1.16 L

46. You have 41.6 g of O_2 gas in a container with twice the volume as one with CO_2 gas. The pressure and temperature of both containers are the same. Calculate the mass of carbon dioxide gas you have in the container.
A) 57.2 g
B) 0.650 g
C) 28.6 g
D) 2.60 g
E) none of these

47. A gas sample is held at constant pressure. The gas occupies 3.62 L of volume when the temperature is 21.6°C. Determine the temperature at which the volume of the gas is 3.42 L.
A) 312 K
B) 278 K
C) 20.4 K
D) 295 K
E) 552 K

48. The air pressure in the inner tube of a tire on a typical racing bike is held at a pressure of about 112 psi. Convert this pressure to atm.
A) 0.147 atm
B) 7.62 atm
C) 0.112 atm
D) 0.131 atm
E) 112 atm

Practice questions on Gases
Answer Section

1. E

   To find the molecular formula from the empirical formula, we need the molar mass.
   Since we are given the mass of the sample, we can find the molar mass from $\text{molar mass} = \frac{\text{mass}}{n}$

   for which we need the number of moles, n.

   From PV=nRT $\Rightarrow$ $n = \frac{PV}{RT} = \frac{(0.179\,\text{atm})(2.182\,\text{L})}{(0.08206\,\frac{\text{L}\times\text{atm}}{\text{mol}\times\text{K}})(111.76+273.15\,\text{K})} = 0.0124\,\text{mol}$

   $\text{molar mass} = \frac{0.719}{0.0124} = 58.12$ g/mol

   molar mass of the empirical formula = (2)(12.01) + (5)(1.008) = 29.06 g/mol

   Molecular formula is larger than the empirical formula by the factor:

   $\frac{\text{molar mass of compound}}{\text{molar mass of empirical formula}} = \frac{58.12}{29.06} = 2$

   Therefore, the molecular formula is: C_4H_{10}

2. B

   Since we are given the initial V, T, P, and then asked about the new V, given the new T and P, this is a "Combined Gas Law" problem.

   $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{(1.04)\ (3.05)}{(23.6+273.15)} = \frac{(0.312)\ V_2}{(-46.1+273.15)} \Rightarrow V_2 = 7.78$ L

3. E
4. C
5. A
6. E
7. D
8. B

9. C

We can treat volumes as if they were moles at a given T and P (remember Avogadro's Law: n is proportional to V) and work in volumes the whole time. However, as it would look too much like magic to too many people, we will do it "properly" here:
We calculate the number of moles of O_2 and C_2H_6 from the volumes given, using the fact that each mol occupies 22.4 L at STP:
n_{C2H6}= (4.00 L) (1 mol / 22.4 L) = 0.17$\underline{8}$6 mol
n_{CO2}= (7.00 L) (1 mol / 22.4 L) = 0.31$\underline{2}$5 mol

Given arbitrary amounts of the reactants, we need to determine which is limiting. We do that by dividing the moles of each reactant by its coefficient in the reaction equation:
C_2H_6: 0.1786 ÷ 2 = 0.0893
O_2: 0.3125 ÷ 7 = 0.0446 ⇐ smaller; therefore O_2 is limiting

We can now calculate the moles of CO_2 produced by 0.3125 mol O_2, and then convert it to volume at STP. We can do that ion one line of dimensional analysis:

$$0.3125 \text{ mol } O_2 \times \frac{4 \text{mol } CO_2}{7 \text{mol } O_2} \times \frac{22.4 \text{ L } CO_2}{1 \text{mol } CO_2} = 4.\ 00 \text{ L } CO_2$$

10. D
11. A
12. D
13. C
14. A
15. B
16. A
17. D
18. A
19. A

M_{N2} = 28.0 g/mol

From Graham's Law we have:

$$\frac{\text{Rate}_{N_2}}{\text{Rate}_A} = \frac{\text{Rate}_{N_2}}{(2)\text{Rate}_{N_2}} = \frac{\sqrt{M_A}}{\sqrt{M_{N_2}}} \quad \Rightarrow \quad \frac{1}{2} = \frac{\sqrt{M_A}}{\sqrt{28.0}} \Rightarrow \left(\frac{1}{2}\right)^2 = \left(\frac{\sqrt{M_A}}{\sqrt{28.0}}\right)^2 \Rightarrow \left(\frac{1}{2}\right)^2 28.0 = M_A$$

⇒ M_A= 7.01 g/mol

20. C

For this question, we either need to be given the equation for u_{rms}:

$$u_{rms} = \sqrt{\frac{3RT}{M}}$$

or recall that $u_{rms} \propto \sqrt{T}$ and $u_{rms} \propto \frac{1}{\sqrt{M}}$, which we would have to deduce from the above equation.

Then we have:

$$\frac{(u_{rms})_1}{(u_{rms})_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}} \frac{\sqrt{M_2}}{\sqrt{M_1}}$$ and in this particular case,

$$\frac{(u_{rms})_{Ar}}{(u_{rms})_X} = \frac{\sqrt{T_{Ar}}}{\sqrt{T_X}} \frac{\sqrt{M_X}}{\sqrt{M_{Ar}}}$$, where, if substitute the given fact $(u_{rms})_{Ar} = (u_{rms})_X$, along with the temperatures for each gas, we obtain:

$$1 = \frac{\sqrt{400.}}{\sqrt{200.}} \frac{\sqrt{M_X}}{\sqrt{39.948}} \Rightarrow 1^2 = \frac{400.}{200.} \frac{M_X}{39.948} \Rightarrow M_X = 20.0 \text{ g/mol}$$

$\Rightarrow$ X = HF (it's the choice that matches the deduced molar mass for X)

21. C

We can treat each gas separately, and recognize what's happening to each gas as a "Boyle's Law" problem.

Each gas is expanding from a given P_1 and V_1 (the P they have in their original bulb, with its V) to a new volume, V_2 (the total volume of the two bulbs, since the gas would occupy both, after the valve is opened), and of course a new pressure P_2.

V_2 = Total volume of the two bulbs

V_2 is the same for both gases, since they both end up expanding into the whole volume.

Since the two gases occupy the same final volume after they expand, the new pressures (P_2 values for each gas) are their partial pressures in the mixture.
The final pressure, after both gases fill both bulbs, is the sum of the two partial pressures.

Let's call the two gases A and B.

For Gas A:
P_1=2 atm, V_1=2.00 L
$P_1V_1=P_2V_2 \Rightarrow (2)(2.00)=P_2(2.00+3.00) \Rightarrow P_2=0.800$ atm

For Gas B:
P_1=2.8 atm, V_1=3.00 L
$P_1V_1=P_2V_2 \Rightarrow (2.8)(3.00)=P_2(2.00+3.00) \Rightarrow P_2=1.68$ atm

22. D

Mole fractions are like "pressure fractions".

$$\frac{n_{CO_2}}{n_{CO_2}+n_{Ar}}=\frac{P_{CO_2}}{P_{CO_2}+P_{Ar}}$$

$$P_{total}=P_{CO_2}+P_{Ar}=8.4\text{ atm}$$

$$n_{total}=n_{CO_2}+n_{Ar}=1.5+3.5=5\text{ mol}$$

$$\frac{1.5}{5}=\frac{P_{CO_2}}{8.4} \Rightarrow P_{CO_2}=5.9\text{ atm}$$

23. C
24. C

This is unfortunately a "trick question" testing your ability to zero in on the relevant information by including some unnecessary information. The value of the volume, or the makeup of the gas are irrelevant. Unfortunately the question tempts you to launch into a partial pressure calculation, converting the mass percents to mole fractions, etc., which would lead to no useful information.

The problem gives the original total pressure (P_1), original temperature (T_1), and the volume. There is no mention of the volume changing. It just says we heat the container to another temperature (T_2). Number of moles (which we could calculate if we needed, since we know V, T, P) is also constant, since there is no mention of any gas escaping or being added to the container. So, it's a problem involving constant V and n, where T and P are changing. If we remember Gay-Lussac's Law, or derive it from the ideal gas law, we have:

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

$$\Rightarrow \quad \frac{P_2}{1.5}=\frac{(100.+273.15)}{(25+273.15)} \Rightarrow P_2=1.88\text{ atm}$$

25. D
26. C
27. D
28. C
29. C
30. D
31. A
32. D
33. A
34. C
35. C
36. B
37. A
38. E
39. E
40. C

41. B
42. A
43. B
44. A
45. B
46. C
47. B
48. B