Kinetic Molecular Theory

1. According to the kinetic-molecular theory, particles of matter are in constant motion
   (A) have different shapes
   (B) have different colors
   (C) are always fluid

2. The kinetic-molecular theory explains the behavior of
   (A) gases only
   (B) solids and liquids
   (C) liquids and gases
   (D) solids, liquids and gases

3. According to the kinetic-molecular theory, which substances are made of particles?
   (A) Ideal gases only
   (B) All gases
   (C) All matter
   (D) All matter except solids

4. According to the kinetic-molecular theory, particles of a gas
   (A) attract each other but do not collide
   (B) repel each other and collide
   (C) neither attract nor repel each other but collide
   (D) neither attract nor repel each other and do not collide

5. At high temperatures the particles of a gas
   (A) move slower and hit the walls of their container less often.
   (B) move faster and hit the walls of their container more frequently
   (C) move faster and hit the walls of their container less frequently
   (D) don’t move at all and don’t hit the walls of their container.

6. The greater the mass or velocity of a particle, the ______ the kinetic energy.
   (A) greater
   (B) lesser
   (C) same as
   (D) Impossible to determine

7. When gas molecules collide, kinetic molecular theory predicts
   (A) the collisions are inelastic and there is less kinetic energy after the collision
   (B) the collisions are perfectly elastic and there is more kinetic energy after the collision.
   (C) the collisions are so hard the gas molecules break apart.
   (D) the collisions are perfectly elastic and there is no net loss of kinetic energy.

8. A temperature of 0°C is equivalent to?
   A) -100 K
   B) 0 K
9. A temperature of -273°C is equivalent to?
   A) -100 K
   B) 0 K
   C) 100 K
   D) 273 K
   E) 373 K

10. A temperature of 373 K is equivalent to?
    A) -100°C
    B) 0°C
    C) 100°C
    D) 273°C
    E) 373°C

**Properties of Gases**

11. What happens to the volume of a gas during compression?
    (A) The volume increases
    (B) The volume decreases
    (C) The volume remains constant
    (D) It is impossible to tell because all gases are different

12. Gases tend to have very low densities because
    (A) a small number of gas particles occupy a large volume
    (B) a large number of gas particles occupy a small volume
    (C) a small number of gas particles occupy a small volume
    (D) they are lighter than liquids and solids

13. Gases are characterized by
    (A) strong intermolecular interactions.
    (B) Intermolecular interactions that are stronger than those found in solids.
    (C) no intermolecular interactions present particles.
    (D) weak intermolecular interactions.

14. One significant difference between gases and liquids is that ________.
    A) a gas is made up of molecules
    B) a gas assumes the volume of its container
    C) a gas may consist of both elements and compounds
    D) gases are always mixtures
    E) All of the above answers are correct.
Measuring Pressure: Barometers, Manometers

15. A gas at a pressure of 10.0 Pa exerts a force of _______ N on an area of 5.5 m$^2$
   A) 55
   B) 0.55
   C) 5.5
   D) 1.8
   E) 18

16. A pressure of 1.00 atm is the same as a pressure of _______ mm Hg.
   A) 193
   B) 101
   C) 760
   D) 29.9
   E) 33.0

17. In a Torricelli barometer, a pressure of one atmosphere supports a 760 mm column of mercury. If the original tube containing the mercury is replaced with a tube having twice the diameter of the original, the height of the mercury column at one atmosphere pressure is _______ mm.*
   A) 380
   B) 760
   C) 1.52x10$^3$
   D) 4.78 x 10$^3$
   E) 121

18. The pressure exerted by a column of liquid is equal to the product of the height of the column times the gravitational constant times the density of the liquid, $P = gh\text{d}$. How high a column of water, $(d=1.0\text{g/ml})$ would be supported by a pressure that supports a 713 mm column of mercury, $(d=13.6 \text{ g/ml})$? **
   A) 14 mm
   B) 52 mm
   C) 713 mm
   D) 1.2 x 10$^4$ mm
   E) 9.7x10$^3$ mm

19. Which statement about atmospheric pressure is false? *
   A) As air becomes thinner, its density decreases.
   B) Air actually has weight.
   C) With an increase in altitude, atmospheric pressure increases as well.
   D) The colder the air, the lower the atmospheric pressure.
   E) Atmospheric pressure prevents water in lakes, rivers, and oceans from boiling away.

20. Which of the following equations shows an incorrect relationship between pressures given in terms of different units?
   A) 1.20 atm = 122 kPa
   B) 152 mm Hg = 2.03x10$^4$ Pa

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C) 0.760 atm = 578 mm Hg  
D) 1.0 torr = 2.00 mm Hg  
E) 1.00 atm = 760 torr

21. Which of these changes would NOT cause an increase in the pressure of a gaseous system?  
(A) The container is made larger.  
(B) Additional amounts of the same gas are added to the container.  
(C) The temperature is increased.  
(D) Another gas is added to the container.

Gas Laws: Boyle’s, Charles’s, Avogadro’s and Gay-Lussac’s.

22. A sample of gas (24.2 g) initially at 4.00 atm was compressed from 8.00 L to 2.00 L at constant temperature. After the compression, the gas pressure was _______ atm.  
A) 4.00  
B) 2.00  
C) 1.00  
D) 8.00  
E) 16.0

23. A sample of a gas (5.0 mol) at 1.0 atm is expanded at constant temperature from 10 L to 15 L. The final pressure is _______ atm.  
A) 1.5  
B) 7.5  
C) 0.67  
D) 3.3  
E) 15

24. Consider a 1.5-L sample of gas. What was its initial pressure when its volume is compressed to 0.95L at a new pressure of 2.5 atm?  
(A) 0.63  
(B) 3.9  
(C) 3.6  
(D) 1.6  
(E) 1.3

25. A sample of gas in a 10.0-L container exerts a pressure of 565 mm Hg. The pressure exerted by the gas if the volume is changed to 15.0 L at constant pressure is ______ atm.  
(A) 1.11  
(B) 848  
(C) 2.02  
(D) 0.496  
(E) 377

26. A gas originally at 27°C and 1.00 atm pressure in a 3.9 L flask is cooled at constant pressure until the temperature is 11°C. The new volume of the gas is ______ L.  
A) 0.27  
B) 3.7
27. If the temperature is lowered from 60°C to 30°C, the volume of a fixed amount of gas will be one half the original volume assuming the pressure is kept constant.
   A) True
   B) False

28. A balloon originally had a volume of 4.39 L at 44°C and a pressure of 729 torr. The balloon must be cooled to _______°C to reduce its volume to 3.78 L (at constant pressure). *
   A) 0
   B) 38
   C) 72.9
   D) 273
   E) 546

29. Of the following, only _______ is impossible for a gas.
   A) \( \frac{V_1}{T_1} = \frac{V_2}{T_2} \)
   B) \( V_1T_1 = V_2T_2 \)
   C) \( \frac{V_1}{V_2} = \frac{T_1}{T_2} \)
   D) \( V_2 = (\frac{T_2}{T_1})V_1 \)
   E) \( \frac{V_1}{V_2} = \frac{T_1}{T_2} = 0 \)

30. If 3.21 mol of a gas occupies 56.2 L at 44°C and 793 torr, 5.29 mol of this gas occupies _______ L under these conditions. *
   A) 14.7
   B) 61.7
   C) 30.9
   D) 92.6
   E) 478

31. A 2.25 sample of gas occupies 57.9 L. How many moles of gas are present when the gas occupies 30.0 L?
   A) 1.22
   B) 0.82
   C) 1.35
   D) 1.41
   E) 57.9

32. A 4.50 mol sample of a gas occupies a volume of 34.6 L at a particular temperature and pressure. What volume in L does 2.50 mol of the gas occupy at these same conditions of pressure and temperature?
   (A) 19.2
   (B) 62.3
   (C) 0.016
   (D) 22.4
   (E) 0.325
33. A sample of an ideal gas (3.00 L) in a fixed container at 25.0°C and 76.0 torr is heated to 300°C. The pressure of the gas at this new temperature is ______ torr.
   (A) 912
   (B) 146
   (C) 76.5
   (D) 39.5
   (E) $2.53 \times 10^{-2}$

34. A sample of hydrogen gas in a closed container has a temperature of 37°C and a pressure of 2 atm. What will be the pressure if the sample is heated to 127°C?
   A) 2.58 atm
   B) 3.47 atm
   C) 5.21 atm
   D) 6.77 atm

35. As the temperature of the gas in a balloon decreases ____.
   A) the volume increase.
   B) the average kinetic energy of the gas decreases
   C) the pressure increases
   D) All of the above

36. A sample of a gas originally at 25°C and 1.00 atm pressure in a 2.5 L container is allowed to expand until the pressure is 0.85 atm and the temperature is 15°C. The final volume of the gas is __ L.
   A) 3.0
   B) 0.38
   C) 2.6
   D) 2.1
   E) 2.8

37. A sample of gas at 38°C occupies a volume of 2.97 L and exerts a pressure of 3.14 atm. The gas is heated to 118°C and the volume is decreased to 1.04 L. The new pressure exerted by the gas is ____ atm.
   A) 11.3
   B) 27.8
   C) .036
   D) 7.14
   E) 2.11

38. A sample of gas at 24°C occupies a volume of 3.45 L and exerts a pressure of 2.10 atm. The gas is cooled to -12°C and the pressure is increased to 5.20 atm. The new volume the gas occupies is_____L.
   A) 0.820
   B) 1.22
   C) 0.82

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39. A gas under 25 atm pressure occupies 35.0 L at 127°C. What is the volume of the gas under standard conditions (1 atm, 0°C)?
   A) 0 L
   B) 597.2 L
   C) 1880.9 L
   D) 3000 L

   **Ideal Gas Law**

40. At a temperature of _______ °C, 0.444 mol of CO gas occupies 11.8 L at 889 torr.
   A) 379
   B) 73
   C) 14
   D) 32
   E) 106

41. In ideal gas equation calculations, expressing pressure in Pascals (Pa), necessitates the use of the gas constant, R, equal to _______.
   A) 0.08206 atm L mol⁻¹ K⁻¹
   B) 8.314 J mol⁻¹ K⁻¹
   C) 62.36 L torr mol⁻¹ K⁻¹
   D) 1.98 cal mol⁻¹ K⁻¹
   E) none of the above

42. The volume of an ideal gas is zero at _______.
   A) 0°C
   B) –45°F
   C) -273 K
   D) -363 K
   E) –273°C

43. The molar volume of a gas at STP is _______ L.
   A) 0.08206
   B) 62.36
   C) 1.00
   D) 22.4
   E) 14.7

44. How many moles of gas are there in a 45.0 L container at 25.0°C and 500.0 mm Hg?
   A) 0.630
   B) 6.11
   C) 18.4
   D) 1.21
   E) 207
45. Standard temperature and pressure (STP), in the context of gases, refers to _______.
   A) 298 K and 1 atm
   B) 273 K and 1 atm
   C) 298 K and 1 torr
   D) 273 K and 1 pascal
   E) 273 K and 1 torr

46. How many molecules are there in 4.00 L of oxygen gas at 500°C and 50.0 torr?
   A) 6.02x10^{23}
   B) 2.5x10^{23}
   C) 2.5x10^{21}
   D) 3.5x10^{21}
   E) 3.01x10^{23}

47. A gas is considered "ideal" if one mole of it in a one-liter container exerts a pressure of exactly 1 atm at room temperature.
   A) False
   B) True

48. If 50.75 g of a gas occupies 10.0 L at STP, 129.3 g of the gas will occupy _______ L at STP.
   A) 3.92
   B) 50.8
   C) 12.9
   D) 25.5
   E) 5.08

**Gas Density / Molar mass**

49. A sample of H₂ gas (12.28 g) occupies 100.0 L at 400.0 K and 2.00 atm. A sample weighing 9.49 g occupies _______ L at 353 K and 2.00 atm.
   A) 109
   B) 68.2
   C) 54.7
   D) 147
   E) 77.3

50. The pressure of a sample of CH₄ gas (6.022 g) in a 30.0 L vessel at 402 K is _____ atm.
   A) 2.42
   B) 6.62
   C) 0.413
   D) 12.4
   E) 22.4

51. The mass of nitrogen dioxide contained in a 4.32 L vessel at 48°C and 141600 Pa is _____ g. *
   A) 5.35 x 10⁴
   B) 53.5
   C) 10.6
D) 70.5  
E) 9.46 x 10^-2

52. The density of ammonia gas in a 4.32 L container at 837 torr and 45.0°C is ____ g/L. *
   A) 3.86  
   B) 0.719  
   C) 0.432  
   D) 0.194  
   E) 4.22 x 10^-2

53. The density of N₂O at 1.53 atm and 45.2°C is _______ g/L. *
   A) 18.2  
   B) 1.76  
   C) 0.388  
   D) 9.99  
   E) 2.58

54. The molecular weight of a gas is _______ g/mol if 3.5 g of the gas occupies 2.1 L at STP.
   A) 41  
   B) 5.5 x 10^3  
   C) 37  
   D) 4.6 x 10^2  
   E) 2.7 x 10^-2

55. The molecular weight of a gas that has a density of 6.70 g/L at STP is _______ g/mol.
   A) 4.96 x 10^2  
   B) 1.50 x 10^2  
   C) 7.30 x 10^1  
   D) 3.35  
   E) 2.98 x 10^-1

56. The molecular weight of a gas that has a density of 7.10 g/L at 25.0°C and 1.00 atm pressure is _______ g/mol.
   A) 174  
   B) 14.6  
   C) 28.0  
   D) 5.75 x 10^-3  
   E) 6.85x10^-2

57. The molecular weight of a gas that has a density of 5.75 g/L at STP is _______ g/mol.
   A) 3.90  
   B) 129  
   C) 141  
   D) 578  
   E) 1.73x10^-3

58. The density of chlorine Cl₂ gas at 25°C and 60 kPa is _______ g/L.
   A) 20  
   B) 4.9
59. The density of air at STP is 1.285 g/L. Which of the following cannot be used to fill a balloon that will float in air at STP?
   A) CH₄
   B) NO
   C) Ne
   D) NH₃
   E) HF

60. What is the density (in g/L) of oxygen gas at 77.0°C and 700.0 torr?
   A) 1.5 g/L
   B) 1.8 g/L
   C) 1.02 g/L
   D) 1.6 g/L
   E) 3.2 g/L

61. The density of nitric oxide (NO) gas at 1.21 atm and 54.1°C is ________ g/L.
   A) 0.0451
   B) 0.740
   C) 1.35
   D) 0.273
   E) 8.2

**Partial Pressures**

62. A vessel contained N₂, Ar, He, and Ne. The total pressure in the vessel was 987 torr. The partial pressures of nitrogen, argon, and helium were 44.0, 486, and 218 torr, respectively. The partial pressure of neon in the vessel was ________ torr.
   A) 42.4
   B) 521
   C) 19.4
   D) 239
   E) 760

63. The pressure in a 12.2 L vessel that contains 2.34 g of carbon dioxide, 1.73 g of sulfur dioxide, and 3.33 g of argon, all at 42°C is ________ mm Hg.**
   A) 263
   B) 134
   C) 395
   D) 116
   E) 0.347

64. A sample of He gas (3.0 L) at 5.6 atm and 25°C was combined with 4.5 L of Ne gas at 3.6 atm and 25°C at constant temperature in a 9.0 L flask. The total pressure in the flask was ________ atm. Assume the initial pressure in the flask was 0.00 atm and the temperature upon mixing was 25°C. **
65. A sample of H₂ gas (2.0 L) at 3.5 atm was combined with 1.5 L of N₂ gas at 2.6 atm pressure at a constant temperature of 25°C into a 7.0 L flask. The total pressure in the flask is ______ atm. Assume the initial pressure in the flask was 0.00 atm and the temperature upon mixing was 25°C. **
A) 0.56
B) 2.8
C) 1.0
D) 1.6
E) 24

66. A mixture of He and Ne at a total pressure of 0.95 atm is found to contain 0.32 mol of He and 0.56 mol of Ne. The partial pressure of Ne is ______ atm.
A) 1.7
B) 1.5
C) 0.60
D) 0.35
E) 1.0

67. A flask contains a mixture of He and Ne at a total pressure of 2.6 atm. There are 2.0 mol of He and 5.0 mol of Ne in the flask. The partial pressure of He is ______ atm.
A) 9.1
B) 6.5
C) 1.04
D) 0.74
E) 1.86

68. SO₂ (5.00 g) and CO₂ (5.00 g) were placed in a 750.0 mL container at 50.0°C. The total pressure in the container was ______ atm. *
A) 0.192
B) 4.02
C) 2.76
D) 6.78
E) 1.60

69. SO₂ (5.00 g) and CO₂ (5.00 g) are placed in a 750.0 mL container at 50.0°C. The partial pressure of SO₂ in the container was ______ atm.
A) 2.76
B) 4.02
C) 6.78
D) 0.192
E) 1.60
70. What is the partial pressure (in mm Hg) of neon in a 4.00 L vessel that contains 0.838 mol of methane, 0.184 mol of ethane, and 0.755 mol of neon at a total pressure of 928 mm Hg?
A) 234 mm
B) 394 mm
C) 400 mm
D) 294 mm
E) 437 mm

**Molecular Speeds and Effusion**

71. The kinetic-molecular theory predicts that pressure rises as the temperature of a gas increases because _______.
   A) the average kinetic energy of the gas molecules decreases
   B) the gas molecules collide more frequently with the wall
   C) the gas molecules collide less frequently with the wall
   D) the gas molecules collide more energetically with the wall
   E) the gas molecules collide more frequently and more energetically with the wall

72. According to kinetic-molecular theory, if the temperature of a gas is raised from 100°C to 200°C, the average kinetic energy of the gas will _______.
   A) double
   B) increase by a factor of 1.27
   C) increase by a factor of 100
   D) decrease by half
   E) decrease by a factor of 100

73. Which of the following is not part of the kinetic-molecular theory?
   A) Atoms are neither created nor destroyed by ordinary chemical reactions.
   B) Attractive and repulsive forces between gas molecules are negligible.
   C) Gases consist of molecules in continuous, random motion.
   D) Collisions between gas molecules do not result in the loss of energy.
   E) The volume occupied by all of the gas molecules in a container is negligible compared to the volume of the container.

74. Of the following gases, ___ will have the greatest rate of effusion at a given temperature.
   A) NH₃
   B) CH₄
   C) Ar
   D) HBr
   E) HCl

75. At 333 K, which of the pairs of gases below would have the most nearly identical rates of effusion?
   A) N₂O and NO₂
   B) CO and N₂
   C) N₂ and O₂
   D) CO and CO₂
   E) NO₂ and N₂O₄
76. Arrange the following gases in order of increasing average molecular speed at 25°C:
He, O₂, CO₂, N₂
A) He < N₂ < O₂ < CO₂
B) He < O₂ < N₂ < CO₂
C) CO₂ < O₂ < N₂ < He
D) CO₂ < N₂ < O₂ < He
E) CO₂ < He < N₂ < O₂

77. Arrange the following gases in order of increasing average molecular speed at 25°C.
Cl₂, O₂, F₂, N₂
A) Cl₂ < F₂ < O₂ < N₂
B) Cl₂ < O₂ < F₂ < N₂
C) N₂ < F₂ < Cl₂ < O₂
D) Cl₂ < F₂ < N₂ < O₂
E) F₂ < O₂ < N₂ < Cl₂

78. Which of the following gases would have the highest average molecular speed at 25°C?
A) O₂
B) N₂
C) CO₂
D) CH₄
E) SF₆

79. A sample of oxygen gas O₂ was found to effuse at a rate equal to three times that of an unknown gas. The molecular weight of the unknown gas is _______ g/mol. *
A) 288
B) 96
C) 55
D) 4
E) 10.7

80. A sample of oxygen gas was found to effuse at a rate equal to two times that of an unknown gas. The molecular weight of the unknown gas is _______ g/mol. *
A) 64
B) 128
C) 8
D) 16
E) 8.0

81. A mixture of two gases was allowed to effuse from a container. One of the gases escaped from the container 1.43 times as fast as the other one. The two gases could have been _______. *
A) CO and SF₆
B) O₂ and Cl₂
C) CO and CO₂
D) Cl₂ and SF₆
E) O₂ and SF₆
82. A mixture of carbon dioxide and an unknown gas was allowed to effuse from a container. The carbon dioxide took 1.25 times as long to escape as the unknown gas. Which one could be the unknown gas? *
   A) Cl₂
   B) CO
   C) HCl
   D) H₂
   E) SO₂

83. The effusion rate of a gas is proportional to the square root of its molar mass.
   A) True
   B) False

**Ideal gases vs. Real gases**

84. An ideal gas differs from a real gas in that the molecules of an ideal gas ______. **
   A) have no attraction for one another
   B) have appreciable molecular volumes
   C) have a molecular weight of zero
   D) have no kinetic energy
   E) have an average molecular mass

85. A real gas will behave most like an ideal gas under conditions of _______. *
   A) high temperature and high pressure
   B) high temperature and low pressure
   C) low temperature and high pressure
   D) low temperature and low pressure
   E) STP

86. Which one of the following gases would deviate the least from ideal gas behavior? *
   A) Ne
   B) CH₃Cl
   C) Kr
   D) CO₂
   E) F₂

87. Which noble gas is expected to show the largest deviations from the ideal gas behavior? *
   A) helium
   B) neon
   C) argon
   D) krypton
   E) xenon

88. The Van der Waals equation for real gases recognizes that _______. **
   A) gas particles have non-zero volumes and interact with each other
   B) molar volumes of gases of different types are different
   C) the non-zero volumes of gas particles effectively decrease the amount of "empty space" between them
D) the molecular attractions between particles of gas decreases the pressure exerted by the gas
E) All of the above statements are true.

**General Gas Facts**

89. One significant difference between gases and liquids is that ________ *
   A) a gas is made up of molecules
   B) a gas assumes the volume of its container
   C) a gas may consist of both elements and compounds
   D) gases are always mixtures
   E) All of the above answers are correct.

90. Which of the following statements about gases is false? *
   A) Gases are highly compressible.
   B) Distances between molecules of gas are very large compared to bond distances within molecules.
   C) Non-reacting gas mixtures are homogeneous.
   D) Gases expand spontaneously to fill the container they are placed in.
   E) All gases are colorless and odorless at room temperature.

91. Of the following, ________ has a slight odor of bitter almonds and is toxic.
   A) NH₃
   B) N₂O
   C) CO
   D) CH₄
   E) HCN

92. Of the following, ________ has the odor of rotting eggs.
   A) NH₃
   B) H₂S
   C) CO
   D) NO₂
   E) HCN

93. Molecular compounds of low molecular weight tend to be gases at room temperature. Which of the following is most likely not a gas at room temperature?
   A) Cl₂
   B) HCl
   C) LiCl
   D) H₂
   E) CH₄
94. The main component of air is oxygen.
   A) True
   B) False

**Answers**

1. A  38. B  
3. C  40. E  72. B  
4. C  41. B  73. A  
5. B  42. E  74. B  
6. A  43. D  75. B  
7. D  44. D  76. C  
8. D  45. A  77. A  
10. C  47. A  79. A  
15. B  52. B  84. A  
17. E  54. C  86. A  
20. D  57. B  89. B  
23. C  60. C  92. B  
26. B  63. E  
27. B  64. D  
28. A  65. D  
29. B  66. C  
30. D  67. D  
31. A  68. D  
32. A  69. A  
33. B  70. B  
34. A  
35. B  

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36. E
37. A