1. 380. mmHg is equivalent to 380.

   A) K B) °C C) mL **D) Torr** E) atm

2. What is the final volume when both the pressure and the Kelvin temperature of 4.0 liters of an ideal gas are doubled?

   A) 1.0 L B) 2.0 L C) 8.0 L **D) 4.0 L** E) 16.0 L

3. If the pressure on 300 mL of a gas at 293 K is doubled while the temperature remains constant at 293 K, the new volume will be

   A) 150 mL
   B) $300 \times \frac{273}{293}$ mL
   C) $300 \times \frac{293}{273}$ mL
   D) 600 mL
   E) 1200 mL

4. A sample of O_2 occupies a volume of 600 mL. If the pressure exerted on the O_2 is tripled with the temperature remaining constant, the new volume of the oxygen is

   A) 200 mL B) 300 mL
   C) 600 mL D) 1.80×10^3 mL
   E) 5.40×10^3 mL

5. If the temperature remains constant while the volume of a given amount of gas is tripled, the pressure will be

   A) 9 times the original pressure
   B) 3 times the original pressure
   C) $^2/_3$ of the original pressure
   D) $^1/_3$ of the original pressure
   E) the same as the original pressure

6. A container contains air at a pressure of 600 mmHg and 25°C. The container and the air heats up and the pressure increases to 750 mmHg. The container volume is unchanged and the air behaves as an ideal gas. The temperature of the air in Kelvin is expressed by

   A) $\frac{298 \times 750 \text{ K}}{600}$
   B) $\frac{298 \times 750 \text{ K}}{100}$
   C) $\frac{750 \text{ K}}{298 \times 600}$
   D) $\frac{25 \times 100 \text{ K}}{600}$
   E) $(298 - 273) \times \frac{750 \text{ K}}{600}$

7. As the temperature of a sample of gas is raised while the pressure remains constant, the density of the gas

   A) increases
   B) decreases
   C) stays the same
   D) stays the same until the gas condenses
   E) may increase of decrease depending on the initial temperature

8. At constant volume the pressure of a gas in a closed container increases when temperature is increased

   A) mass of the gas increases.
   B) mass of the gas decreases.
   C) volume of molecules increases.
   D) molecules of the gas move faster.
   E) molecules of the gas move slower.

9. As the temperature increases, with the pressure exerted by a certain number of confined gas molecules remaining constant, the volume occupied by the gas

   A) remains constant
   B) steadily increases
   C) steadily decreases
   D) increases at first then sharply drops as the gas changes to a liquid
   E) decreases sharply and then increases steadily

10. A gas occupies 100 mL at 290 K. What will be its volume at 500 K if the pressure remains constant?

A) $100 \times \frac{290}{500}$ mL

B) $100 \times \frac{500}{290}$ mL

C) $100 \times 500 \times 290$ mL

D) $100 \times \frac{1}{290 \times 500}$ mL

E) $\frac{500}{100 \times 290}$ mL

11. The density of a gas

A) decreases as the mass of the gas increases

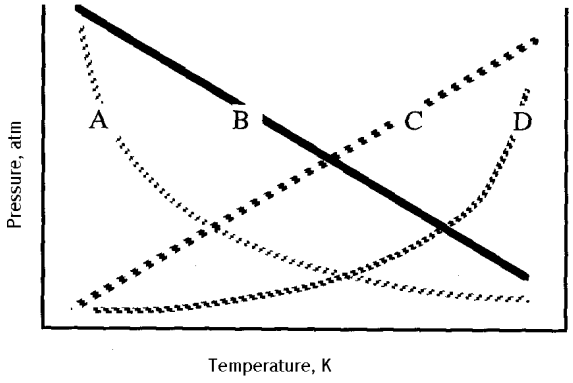
B) varies inversely with pressure at constant temperature

C) varies directly with the absolute temperature at constant pressure

D) varies inversely with the absolute temperature at constant pressure

E) varies directly with absolute temperature at a constant volume

12. Which curve shows the relationship between the presure of an ideal gas and the temperature in Kelvins at consant pressure?



A) A

B) B

C) C

D) D

E) None of these graphs show this relationship

13. At constant pressure, the volume of a given mass of an ideal gas

A) varies directly with the Kelvin temperature

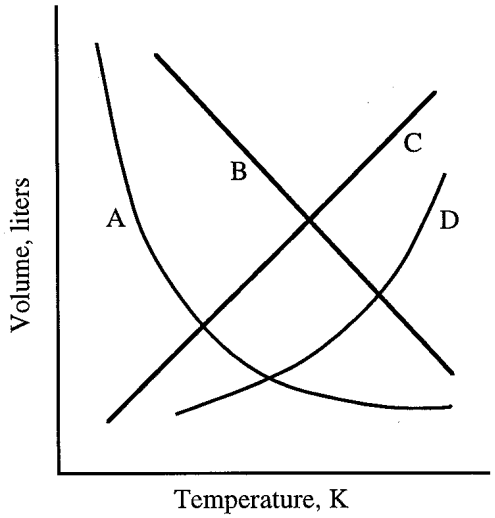
B) varies directly with the Celsius temperature

C) varies inversely with the Celsius temperature

D) varies inversely with the Kelvin temperature

E) is not affected by temperature

14. Which curve shows the relationship between the volume of an ideal gas at constant pressure and its temperature in Kelvin?



A) A

B) B

C) C

D) D

E) None of these lines correctly show the relationship.

15. A vessel contains 2.50 mol of $O_2(g)$, 0.50 mol of $N_2(g)$, and 1.00 mol of an unknown third gas. The total pressure is 800 mmHg. The partial pressure exerted by the O_2 in the mixture is

A) 500 mmHg B) 600 mmHg

C) 800 mmHg D) 1,000 mmHg

E) 1,200 mmHg

16. Nitrogen and neon are mixed in a ratio of 2.0 moles of N_2 to 3.0 moles of Ne, and the total pressure of the system is 600 mmHg. Calculate the partial pressures of the gases.

	Nitrogen, N_2	Neon, Ne
(A)	200 mmHg	400 mmHg
(B)	240 mmHg	360 mmHg
(C)	300 mmHg	300 mmHg
(D)	500 mmHg	100 mmHg

A) A **B) B**

C) C D) D

E) None of the above.

17. There are 2.0 moles of hydrogen, 3.0 moles of nitrogen and 5.0 moles of fluorine in a sealed container. The total pressure is 20.0 atmospheres. What is the partial pressure of the F_2, in atmospheres?

A) 6.0 atm **B) 10.0 atm**
C) 4.0 atm D) 20.0 atm
E) 14.0 atm

18. Calculate the partial pressures of gases A and B. The gases helium and neon are mixed in a ratio of 2.0 moles of helium and 3.0 moles of neon, and the total pressure of the system is 600 mmHg. The partial pressures of the gases are:

	Helium	**Neon**
(A)	71 mmHg	529 mmHg
(B)	120 mmHg	480 mmHg
(C)	240 mmHg	360 mmHg
(D)	300 mmHg	300 mmHg

A) A B) B
C) C D) D
E) None of the above.

19. What is the final volume when both the pressure and the Kelvin temperature of 8.0 Liters of an ideal gas are doubled?

A) 4.0 L **B) 8.0 L** C) 16 L D) 24 L E) 32 L

20. A gas has a volume of 24.0 L at a pressure of 15.0 atm. and 447°C. What would be its volume at 9.0 atm and 177°C?

A) 5.70 L B) 9.00 L
C) 24.0 L **D) 25.0 L**
E) 36.4 L

21. Gas 1 and gas 2 are in containers of equal volume ($V_1=V_2$). If $T_1 = T_2$, $m_1 < m_2$, and $n_1 = n_2$, then what is true about the pressure, P, in the two containers?
Note: T is the temperature in Kelvins, m is the molecular mass of the gas, n is the quantity of matter in moles.

A) $P_1 < P_2$
B) $P_1 > P_2$
C) $P_1 = P_2$, always
D) $P_1 = P_2$, at low temperatures only
E) Not enough data to tell.

22. Gas 1 and gas 2 are in containers of equal volume ($V_1=V_2$). If $P_1 < P_2$, and $T_1 > T_2$, then what is true about the moles of gas, n, in the two containers?
Note: P is the pressure of the gas, T is the temperature in Kelvins.

A) $n_1 < n_2$
B) $n_1 > n_2$
C) $n_1 = n_2$, always
D) $n_1 = n_2$, at low temperatures only
E) Not enough data to tell.

23. Gas 1 and gas 2 are in containers of equal volume ($V_1=V_2$). If $T_1 < T_2$, and $P_1 = P_2$, then what is true about the moles of gas, n, in the two containers?
Note: T is the temperature in Kelvins, P is the pressure of the gas.

A) $n_1 < n_2$
B) $n_1 > n_2$
C) $n_1 = n_2$, always
D) $n_1 = n_2$, at high temperatures only
E) Not enough data to tell.

24. Gas 1 and gas 2 are in containers of equal volume ($V_1=V_2$). If $T_1 < T_2$, and $n_1 > n_2$, then what is true about the pressure, P, in the two containers?
Note: T is the temperature in Kelvins, n is the quantity of matter in moles.

A) $P_1 < P_2$
B) $P_1 > P_2$
C) $P_1 = P_2$, always
D) $P_1 = P_2$, at high temperatures only
E) Not enough data to tell.

25. When both the pressure and the absolute temperature of a given volume, V_1, of gas are doubled, what will be the new volume?

A) $^1/_2V_1$ **B) V_1** C) $2V_1$ D) $4V_1$ E) $8V_1$

26. According to Graham's law, how many times faster is the rate of effusion of NH_3 than the rate of effusion of CO_2? (Assume both gases are at 273K.)

A) 0.6 B) 0.8 **C) 1.6** D) 1.8 E) 2.6

27. A CH_4 (molar mass 16 grams) effuses at 0.080 mole per minute at 289 K. At that temperature, a gas that effuses at approximately double that rate has what molar mass?

A) 4 grams B) 8 grams
C) 16 grams D) 32 grams
E) 64 grams

28. Equal numbers of moles of $H_2O(g)$, $F_2(g)$, $Cl_2(g)$ are placed into a single container. The container has a pinhole-sized leak (1 mm), and after 10 minutes some gas has escaped from the container. What is best reason for why there is more Cl_2 gas left in the container than any other gas? (NOTE: the molecules do not react with each other)

A) The Cl_2 molecule is too big to escape through the leak-hole
B) The rate of effusion for Cl_2 is less than than that of the other two gases
C) Cl_2 is a nonpolar molecule
D) Cl_2 has the smallest S^o of the three gases
E) H_2O has the greatest rate of diffusion

29. The measured volume of a gas is slightly smaller than the volume calculated from the gas laws at very low temperatures. The best explanation is the gas molecules have

A) lost elasticity
B) a smaller mass than expected
C) a finite volume which is incompressible
D) become smaller at the lower temperatures
E) attractive forces which they exert on each other

30. At the same temperature and pressure, which gas effuses most rapidly?

A) N_2 B) NO C) CO_2 **D) NH_3** E) Ar

31. Molecular motion that occurs when the center of mass of a molecule moves from one place to another is called

A) rotational motion
B) vibrational motion
C) transversal motion
D) translational motion
E) nuclear motion

32. Other factors being constant, the volume of an ideal gas is *not* affected by changes in the

A) pressure
B) temperature
C) size of each molecule
D) number of molecules present
E) molar mass of the gas

33. Which gas has the greatest average molecular velocity at 373 K?

A) H_2 B) O_2 C) He D) CO_2 E) SO_2

34. Which is a basic assumption of the kinetic molecular theory?

A) Particles are in constant motion
B) Particles lose energy as their velocity increases
C) Particles travel faster as the temperature decreases
D) Particles lose energy when the temperature increases
E) Particles lose energy when they collide

35. Which of the following statements about equal volumes of two different gases at the same temperature and pressure is generally true? They have

A) the same mass.
B) the same number of molecules.
C) different numbers of molecules.
D) different values of Pressure × Volume.
E) the same density.

36. A certain volume of H_2 contains 2,000. molecules. The same volume of O_2 at the same temperature and pressure will contain

A) 500.0 molecules.
B) 1,000. molecules.
C) 2,000. molecules.
D) 32,000. molecules.
E) 6.022×10^{23} molecules.

37. When two gases (1 L of H_2 and 1 L of O_2) are measured at STP, 1 L of O_2 contains

A) $^1/_{16}$ as many molecules as 1 L of H_2.
B) 16 times as many molecules as 1 L of H_2.
C) the same number of molecules as 1 L of H_2.
D) the same number of molecules as 16 L of H_2.
E) $^1/_{16}$ as much mass as 1 L of H_2.

38. The average kinetic energy of water molecules is greatest in which of these samples?

A) 10 g of water at 35°C
B) 10 g of water at 55° C
C) 100 g of water at 25°C
D) 100 g of water at 45°C

39. Which change in the temperature of a 1-gram sample of water would cause the greatest increase in the average kinetic energy of its molecules?

A) 1°C to 10°C B) 10°C to 1°C
C) 50° C to 60° C D) 60°C to 50°C
E) 500°C to 501°C

40. The temperature of a sample of nitrogen gas is a measure of the molecules' average

A) activation energy B) potential energy
C) kinetic energy D) ionization energy
E) electron affinity

41. If two gases of different mass are inside containers and the particles of both gases have the same average molecular speed, the gases must

A) contain different numbers of moles
B) have different densities
C) be at different pressures
D) be at different temperatures
E) none of the above

42. Two containers of equal volume each contain 1 mole of CO_2 gas. If container A is at 273 K and container B is at 298 K, what can definitively be said about the contents of the two container?

A) the gas in container A has a greater density than the gas in container B
B) the gas in container B has a greater density than the gas in container A
C) the average molecular speed of the molecules in container A is higher than that of the molecules in container B
D) the average molecular speed of the molecules in container B is higher than that of the molecules in container A
E) none of the above

43. Gases obey the Ideal Gas Laws most closely at

A) high pressure and low temperature
B) high pressure and high temperature
C) low pressure and high temperature
D) low pressure and low temperature
E) low density and high pressure

44. Real gases behave *most* like ideal gases at

A) high pressure and low temperature
B) low pressure and high temperature
C) low pressure and low temperature
D) high pressure and high temperature
E) high density

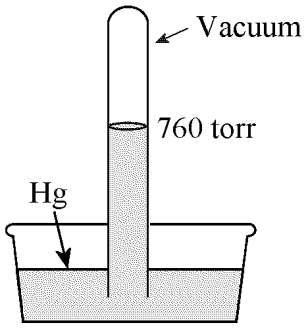
45. Which gas will most closely resemble an ideal gas at STP?

A) Ar B) N_2 C) CO_2 **D) H_2** E) He

46. Real gases do not behave as predicted by ideal gas models. This is because, when compared to ideal gases, real gases

A) collide.
B) have mass.
C) have no volume.
D) have uniform velocities.
E) have molecular attraction.

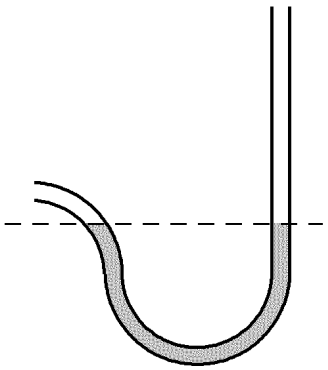
47.



In the image above, if the mercury were replaced by water and the atmospheric pressure remained the same, (assuming the column is tall enough to contain it,) what height would the water reach?

A) 760 torr **B) 760 torr x 13.6**
C) 760 torr x $\frac{1}{13.6}$ D) 13.6 torr
E) $\frac{1}{13.6}$ torr

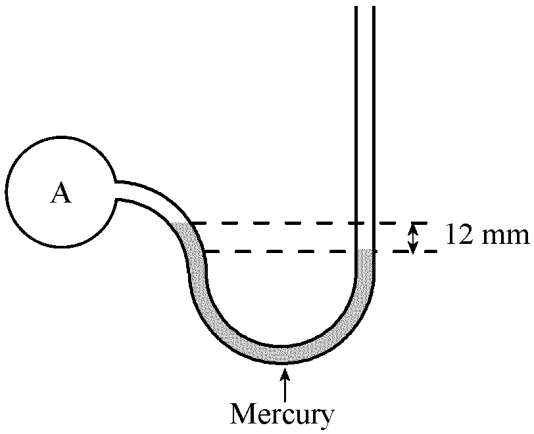
48. Base your answer to the following question on the image below.



Which of these choices could be the atmospheric pressure

A) 760 torr B) 380 torr
C) 77 torr D) 20 torr
E) all of the above

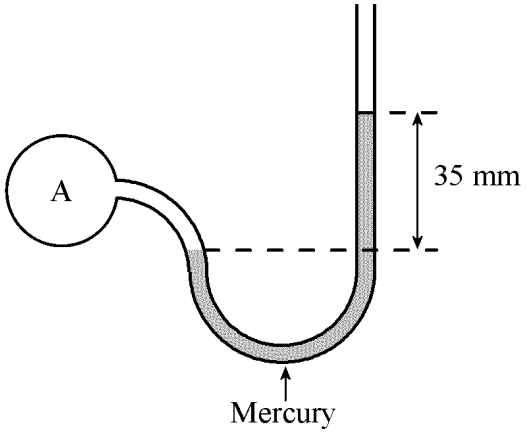
49. Base your answer to the following question on the image below.



If the pressure of the gas labeled A is 1 atm, what is the atmospheric pressure?

A) 772 torr
B) 712 torr
C) 748 torr
D) 89.3 torr
E) 115.3 torr

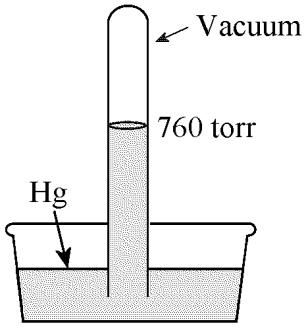
50. Base your answer to the following question on the image below.



If the atmospheric pressure is 730 torr, what is the pressure of the gas labeled A?

A) 35 torr
B) 630 torr
C) 695 torr
D) 765 torr
E) 795 torr

51. In the picture below, how far above the surface of the mercury is the mark that reads 760 torr?



A) 30 mm
B) 385 mm
C) 76 cm
D) 101.3 cm
E) none of the above

52. I. Water boils at a higher temperature at low altitudes than at high altitudes

BECAUSE

II. the atmospheric pressure decreases as the altitude increases.

A) I is *TRUE*, II is *FALSE*
B) I is *FALSE*, II is *TRUE*
C) I and II are *BOTH FALSE*
D) I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
E) I and II are *BOTH TRUE* and II *IS* a correct explanation of I

53. I. When a sample of water boils, the change is exothermic

BECAUSE

II. steam has a higher potential energy than water.

A) I is *TRUE*, II is *FALSE*
B) I is *FALSE*, II is *TRUE*
C) I and II are *BOTH FALSE*
D) I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
E) I and II are *BOTH TRUE* and II *IS* a correct explanation of I

54. A gas has a density of 0.600 g/L at a pressure of 0.1642 atm and a temperature of 127.°C. What is the molar mass of the gas?

A) 60.0 g/mol **B) 120. g/mol**
C) 240. g/mol D) 360. g/mol
E) 480. g/mol

55. The total internal energy change for a gas is +2800. J. If it expanded from 2.000 liters to 4.000 liters against a pressure of 3.000 atm. What was the change in heat for the system?
(1.00 L•atm = 101.0 J)

A) –3406. J B) –2194. J
C) +606. J D) +2194. J
E) +3406. J

56. A gas gives off 1500. J of heat at the same time that it expands from 3.000 liters to 6.000 liters against a pressure of 1.500 atm.
(1 L•atm =101.0 J).
What is the internal energy change of the gas?

A) –1955. J B) –1803. J
C) –1045. J D) +1045. J
E) +1955. J

57. At 25ºC He gas (molar mass 4.00 grams) effuses at a rate of 0.100 mole per minute. What is the rate of effusion of O_2 (molar mass 32.0 grams)?

A) 0.025 mole per minute
B) 0.035 mole per minute
C) 0.10 mole per minute
D) 0.20 mole per minute
E) 0.40 mole per minute

58. The pressure on a sample of gas is increased from 100 kPa to 130 kPa at constant temperature. Which of the following increases?

I. The density of the gas
II. The average distance between molecules
III. The average speed of the molecules.

A) I only B) III only
C) I and III only D) I and II only
E) I, II, and III

59. What is the density of oxygen gas at STP?

A) 0.7 g/L **B) 1.4 g/L**
C) 2.5 g/L D) 16. g/L
E) 32. g/L

60. A student collected a sample of gas using water displacement. Which of the following measurements is necessary to determine the vapor pressure of the water in the sample?

A) The volume of the gas
B) The kinetic energy of the gas
C) The volume of the water
D) The temperature of the water
E) The water solubility of the gas

61. Equal numbers of moles of $CO_2(g)$, $NH_3(g)$, $SO_2(g)$ are placed into 3 separate identical containers. If each container has an identical pinhole leak, which of the following is true about the moles of gas remaining in each container after some time has elapsed?

A) mol CO_2 < mol NH_3 < mol SO_2
B) mol CO_2 < mol SO_2 < mol NH_3
C) mol NH_3 < mol SO_2 < mol CO_2
D) mol NH_3 < mol CO_2 < mol SO_2
E) mol SO_2 < mol CO_2 < mol NH_3

62. A sealed metal tank is filled with neon gas. Which of the following does NOT occur when neon gas is pumped into the tank at a constant temperature?

A) The average speed of the neon atoms remains the same.
B) The density of neon gas inside the tank increases.
C) The average distance between molecules decreases.
D) The volume of the gas decreases.
E) The pressure inside the tank increases.

63. Base your answer to the following question on the following types of energy.

(A) Lattice energy
(B) Potential energy
(C) Kinetic energy
(D) Electromagnetic energy
(E) Vaporization energy

Energy that is measured by $\frac{1}{2}mv^2$

A) A B) B **C) C** D) D E) E

64. A rigid container filled with an ideal gas has its temperature raised from 283 K to 293 K. Which of the following increases?

I. Average distance between the molecules
II. Average speed of the molecules
III. Density
IV. Influence of particle-particle interaction

A) I only
B) II only
C) III only
D) I, II, and III only
E) I, II, and IV only

65. As a balloon floats higher, the surrounding air become colder. Soon the balloon stops floating higher and begins sinking. Assuming that there is no air loss, which of the following is the best explanation for this observation?

A) The difference in temperature between the air inside and outside the balloon produces convection currents, which lose strength at high altitude.
B) The rate of diffusion of cooler air is less than that of warmer air.
C) The air density inside the balloon has become greater than the surrounding air density.
D) The cooler air outside the balloon pushes in on the walls of the balloon.
E) The pressure on the walls of the balloon decreases with decreasing temperature.

66. What is the correct formula of Van der Waal's equation (with correction factors)?

A) $(P + an^2/V^2)(V - nb) = nRT$
B) $(P + an_2)(V - nb) = nRT$
C) $(P + an_2/V^2)(V) = nRT$
D) $PV = nRT$
E) $(P + a/V^2)(V - nb) = nRT$

67. Under which conditions does a real gas most closely approximate an ideal gas?

A) Low pressure and low temperature
B) Low pressure and high temperature
C) High pressure and high temperature
D) High pressure and low density
E) Low temperature and high density

68. The pressure of a real gas is sometimes less than that predicted by the ideal gas law because the ideal gas law does not include the factor of

A) mass of molecules
B) shape of molecules
C) intermolecular forces
D) size of molecules
E) energy of molecules

69. An organic compound is found to be 42.9% carbon, 2.4% hydrogen, 16.6% nitrogen, and 38.1% oxygen. An aqueous solution prepared by dissolving 32.8 g of the compound in 50.0 g of benzene has a freezing point of –7.26ºC.

(a) Determine the empirical formula of the unknown substance.

(b) Calculate the molar mass of the compound and determine its molecular formula.

(c) Determine the mole fraction of water in the solution above.

(d) The vapor pressure of water at 30.0ºC is 31.8 mmHg. What is the vapor pressure of this solution?

70. A student collected a sample of helium gas by the displacement of water. The following data were collected.

Volume of CO_2 sample	72.5 mL
Temperature	30°C
Atmospheric pressure	785 mmHg
Equilibrium vapor pressure of water at 30°C	31.8 mm Hg

(a) How many atoms of He (g) are present in the sample collected?

(b) How many moles of $H_2O(g)$ are in the sample?

(c) What is the ratio of average molecular velocity between He(g) and $H_2O(g)$?

(d) Which one of the gases exhibits behavior closer to ideal. Explain.

Answer Key
Gases

1. **D**
2. **D**
3. **A**
4. **A**
5. **D**
6. **A**
7. **B**
8. **D**
9. **B**
10. **B**
11. **D**
12. **C**
13. **A**
14. **C**
15. **A**
16. **B**
17. **B**
18. **C**
19. **B**
20. **D**
21. **A**
22. **A**
23. **B**
24. **E**
25. **B**
26. **C**
27. **A**
28. **B**
29. **E**
30. **D**
31. **D**
32. **E**
33. **A**
34. **A**
35. **B**
36. **C**
37. **C**
38. **B**
39. **C**
40. **C**
41. **D**
42. **D**
43. **C**
44. **B**
45. **D**
46. **E**
47. **B**
48. **E**
49. **C**
50. **D**
51. **C**
52. **E**
53. **B**
54. **B**
55. **A**
56. **A**
57. **B**
58. **A**
59. **B**
60. **D**
61. **D**
62. **A**
63. **C**
64. **B**
65. **C**
66. **A**
67. **B**
68. **C**
69. (a) $C_3H_2NO_2$ (b) 168.1 g/mol, $C_6H_4N_2O_4$ (c) 0.934 (d) 29.7 mm Hg
70. (a) 1.74×10^{21} (b) 1.22×10^{-4} (c) .707 or $1:\sqrt{2}$ (d) Helium, it is smaller and has a dipole moment of 0.