

1. An unknown substance dissolves readily in water but not in benzene (a nonpolar solvent). Molecules of what type are present in the substance?
 - A) neither polar nor nonpolar
 - B) polar
 - C) either polar or nonpolar
 - D) nonpolar
 - E) none of these
2. Of the following elements, which is most likely to form a negative ion with charge 1^- ?
 - A) Ba
 - B) Ca
 - C) Si
 - D) P
 - E) Cl
3. Of the following elements, which has the lowest first ionization energy?
 - A) Ba
 - B) Ca
 - C) Si
 - D) P
 - E) Cl
4. A 24.1-g sample of HF is dissolved in water to give 2.0×10^2 mL of solution. The concentration of the solution is:
 - A) 1.20 M
 - B) 0.24 M
 - C) 0.12 M
 - D) 6.0 M
 - E) 12.1 M
5. Which of the following is the correct order of boiling points for KNO_3 , CH_3OH , C_2H_6 , Ne?
 - A) $\text{Ne} < \text{CH}_3\text{OH} < \text{C}_2\text{H}_6 < \text{KNO}_3$
 - B) $\text{KNO}_3 < \text{CH}_3\text{OH} < \text{C}_2\text{H}_6 < \text{Ne}$
 - C) $\text{Ne} < \text{C}_2\text{H}_6 < \text{KNO}_3 < \text{CH}_3\text{OH}$
 - D) $\text{Ne} < \text{C}_2\text{H}_6 < \text{CH}_3\text{OH} < \text{KNO}_3$
 - E) $\text{C}_2\text{H}_6 < \text{Ne} < \text{CH}_3\text{OH} < \text{KNO}_3$

6. When sodium chloride and lead(II) nitrate react in an aqueous solution, which of the following terms will be present in the balanced molecular equation?
- A) $\text{PbCl}(s)$
 - B) $\text{Pb}_2\text{Cl}(s)$
 - C) $\text{NaNO}_3(aq)$
 - D) $2\text{NaNO}_3(aq)$
 - E) $2\text{PbCl}_2(s)$
7. When solutions of phosphoric acid and iron(III) nitrate react, which of the following terms will be present in the balanced molecular equation?
- A) $\text{HNO}_3(aq)$
 - B) $3\text{HNO}_3(aq)$
 - C) $2\text{FePO}_4(s)$
 - D) $3\text{FePO}_4(s)$
 - E) $2\text{HNO}_3(aq)$
8. When a hydrogen electron makes a transition from $n = 3$ to $n = 1$, which of the following statements is *true*?
- I. Energy is emitted.
 - II. Energy is absorbed.
 - III. The electron loses energy.
 - IV. The electron gains energy.
 - V. The electron cannot make this transition.
- A) I, IV
 - B) I, III
 - C) II, III
 - D) II, IV
 - E) V
9. All of the following are weak acids *except*
- A) HCNO
 - B) HBr
 - C) HF
 - D) HNO_2
 - E) HCN

10. A glass column is filled with mercury and inverted in a pool of mercury. The mercury column stabilizes at a height of 734 mm above the pool of mercury. What is the pressure of the atmosphere?
- A) 1.04 atm
 - B) 0.734 atm
 - C) 0.966 atm
 - D) 461 atm
 - E) 0.644 atm
11. What is responsible for capillary action, a property of liquids?
- A) surface tension
 - B) cohesive forces
 - C) adhesive forces
 - D) viscosity
 - E) two of these
12. Which of the following should have the lowest boiling point?
- A) Na_2S
 - B) HF
 - C) NH_3
 - D) N_2
 - E) H_2O
13. Which of the following has the smallest radius?
- A) K^+
 - B) Cl^-
 - C) Rb^+
 - D) S^{2-}
 - E) Ar

Use the following to answer questions 14-16.

Consider three 1-L flasks at STP. Flask A contains NH_3 gas, flask B contains NO_2 gas, and flask C contains N_2 gas.

14. In which flask do the molecules have the highest average velocity?
- A) flask A
 - B) flask B
 - C) flask C
 - D) all are the same
 - E) none

15. Which contains the largest number of molecules?
- A) flask A
 - B) flask B
 - C) flask C
 - D) all are the same
 - E) none
16. In which flask are the molecules least polar and therefore most ideal in behavior?
- A) flask A
 - B) flask B
 - C) flask C
 - D) all are the same
 - E) none
17. Which of the following reactions does *not* involve oxidation-reduction?
- A) $\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{CO}_2$
 - B) $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
 - C) $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
 - D) $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{Cl}_2 + 2\text{H}_2\text{O} + \text{MnCl}_2$
 - E) All are oxidation-reduction reactions.
18. In the following reaction, which species is oxidized?
- $$8\text{NaI} + 5\text{H}_2\text{SO}_4 \rightarrow 4\text{I}_2 + \text{H}_2\text{S} + 4\text{Na}_2\text{SO}_4 + 4\text{H}_2\text{O}$$
- A) sodium
 - B) iodine
 - C) sulfur
 - D) hydrogen
 - E) oxygen
19. Which of the following statements is(are) *true*? Oxidation and reduction
- A) cannot occur independently of each other.
 - B) accompany all chemical changes.
 - C) describe the loss and gain of electron(s), respectively.
 - D) result in a change in the oxidation states of the species involved.
 - E) a, c, and d are true
20. According to the law of multiple proportions:
- A) if the same two elements form two different compounds, they do so in the same ratio.
 - B) it is not possible for the same two elements to form more than one compound.
 - C) the ratio of the masses of the elements in a compound is always the same.
 - D) the total mass after a chemical change is the same as before the change.
 - E) none of these

21. Which of the following pairs of compounds can be used to illustrate the law of multiple proportions?
- A) NH_4 and NH_4Cl
 - B) ZnO_2 and ZnCl_2
 - C) H_2O and HCl
 - D) NO and NO_2
 - E) CH_4 and CO_2
22. Many classic experiments have given us indirect evidence of the nature of the atom. Which of the experiments listed below did not give the results described?
- A) The Rutherford experiment proved the Thomson "plum-pudding" model of the atom to be essentially correct.
 - B) The Rutherford experiment was useful in determining the nuclear charge on the atom.
 - C) Millikan's oil-drop experiment showed that the charge on any particle was a simple multiple of the charge on the electron.
 - D) The electric discharge tube proved that electrons have a negative charge.
23. Which of the following statements from Dalton's atomic theory is no longer true, according to modern atomic theory?
- A) Elements are made up of tiny particles called atoms.
 - B) Atoms are not created or destroyed in chemical reactions.
 - C) All atoms of a given element are identical.
 - D) Atoms are indivisible in chemical reactions.
 - E) All of these statements are true according to modern atomic theory.
24. The first people to attempt to explain why chemical changes occur were
- A) alchemists.
 - B) metallurgists.
 - C) physicians.
 - D) physicists.
 - E) the Greeks.
25. The Greeks proposed that matter consisted of four fundamental substances:
- A) fire, earth, water, air
 - B) fire, metal, water, air
 - C) earth, metal, water, air
 - D) atoms, fire, water, air
 - E) atoms, metal, fire, air

26. The first chemist to perform truly quantitative experiments was
- A) Paracelsus.
 - B) Boyle.
 - C) Priestly.
 - D) Bauer.
 - E) Lavoisier.
27. The scientist who discovered the law of conservation of mass and is also called the father of modern chemistry is
- A) Proust.
 - B) Boyle.
 - C) Priestly.
 - D) Bauer.
 - E) Lavoisier.
28. Which of the following pairs can be used to illustrate the law of multiple proportions?
- A) SO and SO₂
 - B) CO and CaCO₃
 - C) H₂O and C₁₂H₂₂O₁₁
 - D) H₂SO₄ and H₂S
 - E) KCl and KClO₂
29. The chemist credited for inventing a set of symbols for writing elements and a system for writing the formulas of compounds (and for discovering selenium, silicon, and thorium) is
- A) Boyle.
 - B) Lavoisier.
 - C) Priestly.
 - D) Berzelius.
 - E) Dalton.
30. What element (in trace amounts) has been shown to help in protecting against heart disease and cancer?
- A) silicon
 - B) oxygen
 - C) selenium
 - D) copper
 - E) potassium

31. The first scientist to show that atoms emit any negative particles was
- A) J. J. Thomson.
 - B) Lord Kelvin.
 - C) Ernest Rutherford.
 - D) William Thomson.
 - E) John Dalton.
32. The scientist whose alpha-particle scattering experiment led him to conclude that the nucleus of an atom contains a dense center of positive charge is
- A) J. J. Thomson.
 - B) Lord Kelvin.
 - C) Ernest Rutherford.
 - D) William Thomson.
 - E) John Dalton.
33. Which of the following statements is *true*?
- A) The exact location of an electron can be determined if we know its energy.
 - B) An electron in a 2s orbital can have the same n , l , and m_l quantum numbers as an electron in a 3s orbital.
 - C) Ni has 2 unpaired electrons in its 3d orbitals.
 - D) In the buildup of atoms, electrons occupy the 4f orbitals before the 6s orbitals.
 - E) Only three quantum numbers are needed to uniquely describe an electron.
34. Which of the following is a strong acid?
- A) HF
 - B) KOH
 - C) HClO₄
 - D) HClO
 - E) HBrO
35. When solutions of cobalt(II) chloride and carbonic acid react, which of the following terms will be present in the net ionic equation?
- A) CoCO₃(s)
 - B) H⁺(aq)
 - C) 2CoCO₃(s)
 - D) 2Cl⁻(aq)
 - E) two of these

36. Which of the following statements is true?
- A) The first ionization potential of H is greater than that of He.
 - B) The ionic radius of Fe^+ is larger than that of Fe^{3+} .
 - C) The ionization energy of S^{2-} is greater than that of Cl^- .
 - D) The atomic radius of Li is larger than that of Cs.
 - E) All are false.
37. In the reaction $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$, which, if any, element is oxidized?
- A) zinc
 - B) hydrogen
 - C) sulfur
 - D) oxygen
 - E) none of these
38. Which of the following salts is insoluble in water?
- A) Na_2S
 - B) K_3PO_4
 - C) $\text{Pb}(\text{NO}_3)_2$
 - D) CaCl_2
 - E) All of these are soluble in water.
39. Which of the following statements about quantum theory is *incorrect*?
- A) The energy and position of an electron cannot be determined simultaneously.
 - B) Lower energy orbitals are filled with electrons before higher energy orbitals.
 - C) When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
 - D) No two electrons can have the same four quantum numbers.
 - E) All of these are correct.
40. Which of the following is most likely to be a solid at room temperature?
- A) Na_2S
 - B) HF
 - C) NH_3
 - D) N_2
 - E) H_2O

41. A sample of oxygen gas has a volume of 5.99 L at 27°C and 800.0 torr. How many oxygen molecules does it contain?
- A) 1.54×10^{23}
 - B) 1.17×10^{26}
 - C) 1.71×10^{24}
 - D) 2.35×10^{24}
 - E) none of these
42. The valve between a 5-L tank containing a gas at 9 atm and a 10-L tank containing a gas at 6 atm is opened. Calculate the final pressure in the tanks.
- A) 3 atm
 - B) 4 atm
 - C) 7 atm
 - D) 15 atm
 - E) none of these
43. You fill a balloon with 2.50 moles of gas at 28°C at a pressure of 1.96 atm. What is the volume of the balloon?
- A) 2.93 L
 - B) 19.4 L
 - C) 31.5 L
 - D) 121.0 L
 - E) 22.4 L
44. What volume of $\text{H}_2\text{O}(\text{g})$ measured at STP is produced by the combustion of 7.52 g of natural gas (CH_4) according to the following equation?
- $$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$
- A) 10.50 L
 - B) 21.0 L
 - C) 44.8 L
 - D) 5.25 L
 - E) 22.9 L
45. Which of the species below would you expect to show the least hydrogen bonding?
- A) NH_3
 - B) H_2O
 - C) HF
 - D) CH_4
 - E) all the same

46. How many atoms of hydrogen are present in 4.0 g of water?

- A) 1.3×10^{23}
- B) 1.2×10^{24}
- C) 4.8×10^{24}
- D) 2.7×10^{23}
- E) 0.44

47. You and a friend have gas samples in open manometers as shown:



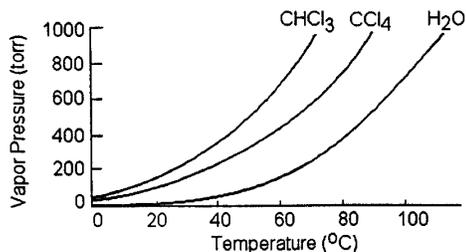
- A) Your sample of gas has the higher pressure.
 - B) Your friend's sample of gas has the higher pressure.
 - C) Both samples of gas have the same pressure.
 - D) There is not enough information to answer the question.
 - E) None of these is correct.
48. You are given the following boiling point data: Which one of the below liquids would you expect to have the highest vapor pressure at room temperature?
- A)
water, H_2O 100°C
 - B)
methanol, CH_3OH 64.96°C
 - C)
ethanol, $\text{CH}_3\text{CH}_2\text{OH}$ 78.5°C
 - D)
diethyl ether, $\text{CH}_3\text{OCH}_2\text{CH}_2\text{CH}_3$ 34.5°C
 - E)
ethylene glycol, $\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$ 198°C

49. How many f orbitals have the value $n = 3$?
- A) 0
 - B) 3
 - C) 5
 - D) 7
 - E) 1
50. Hydrogen bonds account for which of the following observation?
- A) Hydrogen naturally exists as a diatomic molecule.
 - B) Hydrogen is easily combustible with oxygen.
 - C) Water molecules are bent or "V-shaped".
 - D) Air is more dense than hydrogen gas.
 - E) For its molar mass, water has a high boiling point.
51. You have exposed electrodes of a light bulb in a solution of H_2SO_4 such that the light bulb is on. You add a dilute solution and the bulb grows dim. Which of the following could be in the solution?
- A) $\text{Ba}(\text{OH})_2$
 - B) NaNO_3
 - C) K_2SO_4
 - D) $\text{Ca}(\text{NO}_3)_2$
 - E) none of these
52. Which of the following is *not* a strong base?
- A) $\text{Ca}(\text{OH})_2$
 - B) KOH
 - C) NH_3
 - D) LiOH
 - E) $\text{Sr}(\text{OH})_2$
53. Which of the following statements about liquids is true?
- A) Droplet formation occurs because of the higher stability associated with increased surface area.
 - B) Substances that can form hydrogen bonds will display lower melting points than predicted from periodic trends.
 - C) London dispersion forces arise from a distortion of the electron clouds within a molecule or atom.
 - D) Liquid rise within a capillary tube because of the small size lowers the effective atmospheric pressure over the surface of the liquid.
 - E) The boiling point of a solution is dependent solely on the atmospheric pressure over the solution.

54. The triple point of iodine is at 90 torr and 115°C. This means that liquid I₂
- is more dense than I₂(s).
 - cannot exist above 115°C.
 - cannot exist at 1 atmosphere pressure.
 - cannot have a vapor pressure less than 90 torr.
 - can exist at pressure of 10 torr.

55. Order the elements S, Cl, and F in terms of increasing ionization energy.
- S, Cl, F
 - Cl, F, S
 - F, S, Cl
 - F, Cl, S
 - S, F, Cl

56. Given the graph below, what is the boiling point of carbon tetrachloride at standard pressure?



- 60°C
 - 34°C
 - 98°C
 - 77°C
 - graph does not give that information
57. Which of the following are oxidation-reduction reactions?
- $\text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5$
 - $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
 - $\text{CO}_2 + 2\text{LiOH} \rightarrow \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}$
 - $\text{FeCl}_2 + 2\text{NaOH} \rightarrow \text{Fe}(\text{OH})_2 + 2\text{NaCl}$
- III
 - IV
 - I and II
 - I, II, and III
 - I, II, III, and IV

58. The reaction $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$ has the following mechanism:



The catalyst in the reaction is:

- A) H_2O
 - B) I^-
 - C) H_2O_2
 - D) IO^-
59. Which of the following is paired incorrectly?
- A) HI – strong acid
 - B) HNO_3 – weak acid
 - C) $\text{Ba}(\text{OH})_2$ – strong base
 - D) HBr – strong acid
 - E) NH_3 – weak acid
60. A certain substance, X, has a triple-point temperature of 20°C at a pressure of 2.0 atm. Which one of the statements a through d cannot possibly be true?
- A) X can exist as a liquid above 20°C .
 - B) X can exist as a solid above 20°C .
 - C) Liquid X can exist as a stable phase at 25°C , 1 atm.
 - D) Both liquid and solid X have the same vapor pressure at 20°C .
 - E) All of the statements a through d could be true.
61. When $\text{NH}_3(\text{aq})$ is added to $\text{Cu}^{2+}(\text{aq})$, a precipitate initially forms. Its formula is:
- A) $\text{Cu}(\text{NH}_3)$
 - B) $\text{Cu}(\text{NO}_3)_2$
 - C) $\text{Cu}(\text{OH})_2$
 - D) $\text{Cu}(\text{NH}_3)_2$
 - E) CuO
62. Which of the following statements is *false*?
- A) An orbital can accommodate at most two electrons.
 - B) The electron density at a point is proportional to ψ^2 at that point.
 - C) The spin quantum number of an electron must be either $+1/2$ or $-1/2$.
 - D) A 2p orbital is more penetrating than a 2s; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1s orbital.
 - E) In the usual order of filling, the 6s orbital is filled before the 4f orbital.

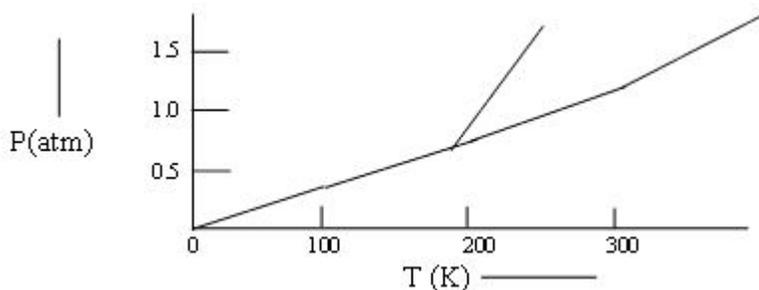
63. For which of the following elements does the electron configuration for the lowest energy state show a partially filled d orbital?
- A) Ti
 - B) Rb
 - C) Cu
 - D) Ga
 - E) Kr
64. Which of the following have 10 electrons in the d orbitals?
- A) Mn
 - B) Fe
 - C) Cu
 - D) Zn
 - E) two of the above
65. Order the elements S, Cl, and F in terms of increasing atomic radii.
- A) S, Cl, F
 - B) Cl, F, S
 - C) F, S, Cl
 - D) F, Cl, S
 - E) S, F, Cl
66. Which of the following atoms has the largest ionization energy?
- A) O
 - B) Li
 - C) N
 - D) Be
 - E) K
67. You mix 260. mL of 1.20 M lead(II) nitrate with 300. mL of 1.90 M potassium iodide. The lead(II) iodide is insoluble. Which of the following is false?
- A) The final concentration of Pb^{2+} ions is 0.0482 M.
 - B) You form 131 g of lead(II) iodide.
 - C) The final concentration of K^+ is 1.02 M.
 - D) The final concentration of NO_3^- is 1.02 M.
 - E) All are true.

68. The molecules in a sample of solid SO_2 are attracted to each other by a combination of
- A) London forces and H-bonding.
 - B) H-bonding and ionic bonding.
 - C) covalent bonding and dipole-dipole interactions.
 - D) London forces and dipole-dipole interactions.
 - E) none of these
69. Which statement regarding water is true?
- A) Energy must be given off in order to break down the crystal lattice of ice to a liquid.
 - B) Hydrogen bonds are stronger than covalent bonds.
 - C) Liquid water is less dense than solid water.
 - D) Only covalent bonds are broken when ice melts.
 - E) All of the statements (a–d) are false.
70. When electrons in a molecule are not found between a pair of atoms but move throughout the molecule, this is called
- A) ionic bonding.
 - B) covalent bonding.
 - C) polar covalent bonding.
 - D) delocalization of the electrons.
 - E) a dipole moment.
71. Choose the element with the highest IE.
- A) Na
 - B) Mg
 - C) Al
 - D) P
 - E) S
72. On a planet where the temperature is so high, the ground state of an electron in the hydrogen atom is $n = 4$. What is the ratio of IE on this planet compared to earth?
- A) 1 : 4
 - B) 4 : 1
 - C) 1 : 16
 - D) 16 : 1
 - E) 1 : 1
73. Which of the following statements is false?
- A) A sodium atom has a smaller radius than a potassium atom.
 - B) A neon atom has a smaller radius than an oxygen atom.
 - C) A fluorine atom has a smaller first ionization energy than an oxygen atom.
 - D) A cesium atom has a smaller first ionization energy than a lithium atom.
 - E) All are true.

74. If the Thomson model of the atom had been correct, Rutherford would have observed
- A) alpha particles going through the foil with little or no deflection.
 - B) alpha particles greatly deflected by the metal foil.
 - C) alpha particles bouncing off the foil.
 - D) positive particles formed in the foil.
 - E) None of the above observations is consistent with the Thomson model of the atom.
75. Rutherford's experiment was important because it showed that:
- A) radioactive elements give off alpha particles.
 - B) gold foil can be made to be only a few atoms thick.
 - C) a zinc sulfide screen scintillates when struck by a charged particle.
 - D) the mass of the atom is uniformly distributed throughout the atom.
 - E) an atom is mostly empty space.
76. Which of the following name(s) is(are) correct?
- 1. sulfide S^{2-}
 - 2. ammonium chloride NH_4Cl
 - 3. acetic acid $HC_2H_3O_2$
 - 4. barium oxide BaO
- A) all
 - B) none
 - C) 1, 2
 - D) 3, 4
 - E) 1, 3, 4
77. At $1000^\circ C$ and 10. torr, the density of a certain element in the gaseous state is $2.9 \times 10^{-3} g/L$. The element is:
- A) Ne
 - B) He
 - C) Na
 - D) Ar
 - E) Hg
78. Which of the following bonds is least polar?
- A) C—O
 - B) H—C
 - C) S—Cl
 - D) Br—Br
 - E) They are all nonpolar.

79. For the elements Rb, F, and O, the order of increasing electronegativity is:
- A) $\text{Rb} < \text{F} < \text{O}$
 - B) $\text{Rb} < \text{O} < \text{F}$
 - C) $\text{O} < \text{F} < \text{Rb}$
 - D) $\text{F} < \text{Rb} < \text{O}$
 - E) None of these
80. In the gaseous phase, which of the following diatomic molecules would be the most polar?
- A) CsF
 - B) CsCl
 - C) NaCl
 - D) NaF
 - E) LiF
81. Calculate the lattice energy for LiF(s) given the following:
- | | |
|----------------------------------|--------------|
| sublimation energy for Li(s) | +166 kJ/mol |
| DH_f for F(g) | +77 kJ/mol |
| first ionization energy of Li(g) | +520. kJ/mol |
| electron affinity of F(g) | -328 kJ/mol |
| enthalpy of formation of LiF(s) | -617 kJ/mol |
- A) 285 kJ/mol
 - B) -650. kJ/mol
 - C) 800. kJ/mol
 - D) -1047 kJ/mol
 - E) None of these
82. The triple point of CO_2 is at 5.2 atm and -57°C . Under atmospheric conditions present in a typical Boulder, Colorado, laboratory ($P = 630$ torr, $T = 23^\circ\text{C}$), solid CO_2 will:
- A) remain solid.
 - B) boil.
 - C) melt.
 - D) sublime.
 - E) none of these

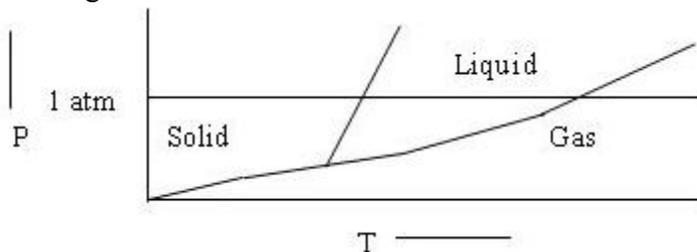
83. A sample of helium gas occupies 19.7 L at 23°C and 0.956 atm. What volume will it occupy at 40°C and 1.20 atm?
- A) 26.1 L
 B) 27.3 L
 C) 14.84 L
 D) 16.6 L
 E) 19.9 L
84. Which one of the following decreases as the strength of the attractive intermolecular forces increases?
- A) The heat of vaporization.
 B) The normal boiling temperature.
 C) The extent of deviations from the ideal gas law.
 D) The sublimation temperature of a solid.
 E) The vapor pressure of a liquid.
85. Above is a phase diagram for compound X. You wish to purify a sample of X which was collected at $P = 1.0$ atm and $T = 100$ by subliming it. In order to sublime the sample, you should:



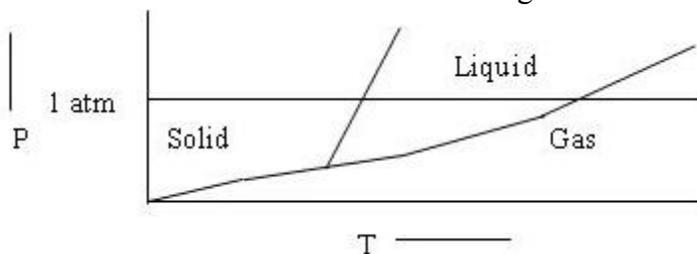
- A) increase P to 1.5 atm and then increase T to 300 K.
 B) increase T to 300 K, keeping $P = 1.0$ atm.
 C) lower P to 0.5 atm and then increase T to 200 K.
 D) increase T to 300 K and then lower P to 0.5 atm.
 E) abandon the attempt to sublime X.
86. Bromine exists naturally as a mixture of bromine-79 and bromine-81 isotopes. An atom of bromine-79 contains
- A) 35 protons, 44 neutrons, 35 electrons.
 B) 34 protons and 35 electrons, only.
 C) 44 protons, 44 electrons, and 35 neutrons.
 D) 35 protons, 79 neutrons, and 35 electrons.
 E) 79 protons, 79 electrons, and 35 neutrons.

87. Which of the following would you expect to have the highest boiling point?
- A) F_2
 - B) Cl_2
 - C) Br_2
 - D) I_2
 - E) All of the above have the same boiling point.
88. How many electrons in an atom can have the quantum numbers $n = 3, l = 2$?
- A) 2
 - B) 5
 - C) 10
 - D) 18
 - E) 6
89. On a relative basis, the weaker the intermolecular forces in a substance,
- A) the greater its heat of vaporization.
 - B) the more it deviates from ideal gas behavior.
 - C) the greater its vapor pressure at a particular temperature.
 - D) the higher its melting point.
 - E) none of these
90. A gas sample is heated from $-20.0^\circ C$ to $57.0^\circ C$ and the volume is increased from 2.00 L to 4.50 L. If the initial pressure is 0.107 atm, what is the final pressure?
- A) 0.0365 atm
 - B) -0.136 atm
 - C) 0.314 atm
 - D) 0.185 atm
 - E) 0.0620 atm
91. Order the intermolecular forces (dipole-dipole, London Dispersion, ionic, and hydrogen-bonding) from weakest to strongest .
- A) dipole-dipole, London Dispersion, ionic, and hydrogen-bonding
 - B) London Dispersion, dipole-dipole, hydrogen-bonding, ionic
 - C) hydrogen-bonding, dipole-dipole, London Dispersion, and ionic
 - D) dipole-dipole, ionic, London Dispersion, and hydrogen-bonding
 - E) London Dispersion, ionic, dipole-dipole, and hydrogen-bonding

92. Shown above is a phase diagram for sulfur (not drawn to scale). Sulfur can exist in solid modifications, rhombic and monoclinic, denoted by S_R and S_M , respectively. Which of the following statements is incorrect?



- A) This system has two triple points.
 B) Under ordinary atmospheric conditions (at sea level), sulfur does not sublime.
 C) At pressures close to 1 atm, rhombic sulfur can be in stable equilibrium with liquid sulfur.
 D) At a given pressure, there is (at most) one temperature at which rhombic sulfur can exist in equilibrium with monoclinic sulfur.
 E) None of the above statements is incorrect.
93. Based on electronegativities, which of the following would you expect to be most ionic?
 A) N_2
 B) CaF_2
 C) CO_2
 D) CH_4
 E) CF_4
94. Choose the correct statement about the diagram below.



- A) The diagram is qualitatively correct for water.
 B) The diagram shows that the melting point of the solid increases with increasing pressure.
 C) The diagram shows the triple point above 1 atm pressure.
 D) The diagram could represent the phase diagram of CO_2 .
 E) None of the above statements is correct.

95. When a nonpolar liquid displays a convex meniscus, which of the following explains this behavior?
- A) It has a low surface tension, and therefore clings to the glass.
 - B) The cohesive forces are stronger than the adhesive forces toward the glass.
 - C) The adhesive forces toward the glass are stronger than the cohesive forces.
 - D) The liquid's viscosity is low.
 - E) none of these

96. Given below are the temperatures at which two different liquid compounds with the same empirical formula have a vapor pressure of 400 torr.

Compound	T (°C)
dimethyl ether, CH ₃ -O-CH ₃	-37.8
ethanol, CH ₃ CH ₂ OH	63.5

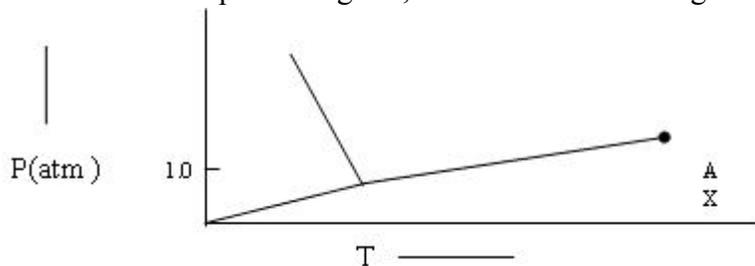
Which of the following statements (a–d) is false?

- A) Increasing the temperature will increase the vapor pressure of both liquids.
 - B) Intermolecular attractive forces are stronger in (liquid) ethanol than in (liquid) dimethyl ether.
 - C) The normal boiling point of dimethyl ether will be higher than the normal boiling point of ethanol.
 - D) The reason that the temperature at which the vapor pressure is 400 torr is higher for ethanol (than for dimethyl ether) is that there is strong hydrogen bonding in ethanol.
 - E) None of these is false.
97. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively?
- A) S, O, F, and F, O, S
 - B) F, S, O, and O, S, F
 - C) S, F, O, and S, F, O
 - D) F, O, S, and S, O, F
 - E) none of these
98. For the elements Cs, F, and Cl, the order of increasing electronegativity is:
- A) F < Cl < Cs
 - B) Cs < Cl < F
 - C) Cl < Cs < F
 - D) F < Cs < Cl
 - E) None of these

99. Which of these is an isoelectronic series?

- A) Na^+ , K^+ , Rb^+ , Cs^+
- B) K^+ , Ca^{2+} , Ar , S^{2-}
- C) Na^+ , Mg^{2+} , S^{2-} , Cl^-
- D) Li , Be , B , C
- E) none of these (a-d)

100. Given the below phase diagram, which of the following statements (a–d) is false?



- A) The solid has a higher density than the liquid.
- B) At some (constant) temperature, the gaseous substance can be compressed into a solid and then into a liquid in this order.
- C) When phase A is compressed at constant temperature at point X, no change is observed.
- D) When heated at 1 atm, this substance will first melt, then boil.
- E) None of the above statements is false.