

Chemistry Diagnostic Assessment

This diagnostic assessment is solely to help guide your decisions about which courses you should study to increase the likelihood of a successful outcome on your credentialing exam. The results on this assessment will not be used for any other purpose.

These questions represent our best judgement as to what is assessed on this exam and the last course in the sequence of NJCTL courses in which that topic is taught. Hence, if you do well on the questions from an early course, you can better focus your efforts on later courses.

To make this effective it is important that you **do not guess** on questions since if you get them correct by chance you may mislead yourself. Similarly, if you find you struggle or take an excessive amount of time to do a problem, you may be better served by leaving it blank since it would probably be worth learning that topic more thoroughly.

Since this assessment cannot thoroughly probe each aspect of a topic given its limited length, taking the above instructions to heart would give you a more informative result than by trying your best to maximize your score.

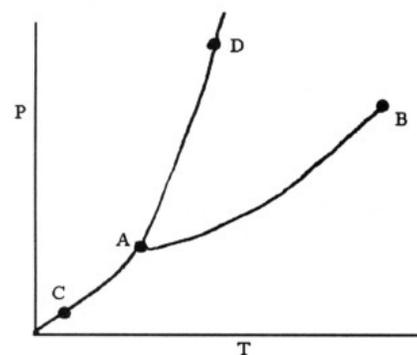
- What did Rutherford conclude about the structure of the atom?
 - Negatively charged particles make up the center of the atom.
 - Atoms are indivisible
 - Atoms contain positively charged particles
 - An atom contains a small, dense, positive center
- A nuclear particle that has about the same mass as a proton, but with no electrical charge is called a(n)
 - Nuclide
 - Neutron
 - Electron
 - Isotope
- Balance the following equation: ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + \underline{\hspace{2cm}}$.
 - ${}_{2}^{4}\text{He}$
 - ${}_{1}^{1}\text{H}$
 - ${}_{0}^{1}\text{n}$
 - ${}_{-1}^{0}\text{e}$
- What is the half-life of an isotope if 125 g of a 500 g sample of the isotope remains after 3.0 years?
 - 1.5 years
 - 2.5 years
 - 3.5 years
 - 4.5 years
- Which of the following lists ranks nuclear radiation from most massive to least massive?
 - alpha, beta, gamma
 - gamma, alpha, beta
 - beta, gamma, alpha
 - gamma, beta, alpha
- Which statement about nuclear reactions is NOT true?
 - Nuclear power plants use fission of uranium.
 - In fission, the total mass of the reactants equals the total mass of the products.
 - In fission, nuclei are split, and in fusion, nuclei are combined.
 - Energy as heat and light in the sun are generated by hydrogen fusion reactions.
- Determine the number of protons, neutrons and electrons in an atom of ${}_{28}^{60}\text{Ni}$.
 - 60 protons, 60 electrons, 32 neutrons
 - 28 protons, 28 neutrons, 32 electrons
 - 28 protons, 28 electrons, 32 neutrons

- D. 28 protons, 32 electrons, 60 neutrons
8. Select the correct ground state electron configuration for Ca^{2+}
- $1s^2 2s^2 2p^2 3s^2 3p^6 4s^2$
 - $1s^2 2s^2 2p^6 3s^2 3p^6$
 - $1s^2 2s^6 2p^6$
 - $1s^2 2s^2 2p^6 3s^2 3p^2$
9. Which pair of elements would you expect to exhibit the greatest similarity in their physical and chemical properties?
- K and Ca
 - S and O
 - Cu and Pb
 - H and He
10. When the light from excited atoms of an element is passed through a prism, the distinct colored lines produced are called
- Ground states
 - Excited states
 - Line-emission spectra
 - Electromagnetic spectra
11. Elements in a group or column in the periodic table can be expected to have similar
- Atomic masses
 - Atomic numbers
 - Numbers of neutrons
 - Properties
12. Arrange the following cations (positive ions) in order of increasing ionic radius: Be^{2+} , K^+ , Mg^{2+} , Rb^+ .
- Be^{2+} , Mg^{2+} , K^+ , Rb^+
 - K^+ , Rb^+ , Be^{2+} , Mg^{2+}
 - Rb^+ , K^+ , Mg^{2+} , Be^{2+}
 - Be^{2+} , K^+ , Mg^{2+} , Rb^+
13. Which statements are correct when calcium and oxygen react to form an ionic compound?
- Each calcium atom loses 2 electrons and forms a cation.
 - Oxygen atoms form oxide anions (O^{2-}).
 - The ions are present in a one-to-one-ratio in the compound.
- I only
 - I and II only
 - II and III only
 - I, II, and III

14. Of the following compounds, which is the most ionic?
- A. SiCl_4
 - B. BrCl
 - C. PCl_3
 - D. CaCl_2
15. Which of the following is the correct IUPAC name for PCl_3 ?
- A. Potassium chloride
 - B. Potassium trichloride
 - C. Phosphorus chloride
 - D. Phosphorus trichloride
16. Which of the following molecules has the shortest bond length?
- A. N_2
 - B. O_2
 - C. Cl_2
 - D. Br_2
17. Which one of the following types of elements is most likely to be a good oxidizing agent?
- A. transition elements
 - B. alkaline earth elements
 - C. halogens
 - D. alkali metals
18. Which of the following would classify a chemical in the laboratory as "dangerous"?
- A. High pH
 - B. All chemicals in the laboratory should be considered to be dangerous.
 - C. Low pH
 - D. Water-soluble
19. What is the main difference between a scientific theory and a scientific law?
- A. A scientific law is supported with more research; a theory requires more analysis to be done before it is generally accepted.
 - B. Only a scientific law can be tested with experiment.
 - C. A scientific law describes a physical phenomenon but does not explain why it occurs. A scientific theory does both.
 - D. Both a theory and a law can never be changed.
20. Which of the following represents the molecular formula of lead (II) phosphate?
- A. PbPO_4
 - B. $\text{Pb}(\text{PO}_4)_2$
 - C. $\text{Pb}_3(\text{PO}_4)_2$
 - D. Pb_2PO_4

21. The molecular geometry of XeF_4 , as predicted by VSEPR, is best described as:
- A. Pyramidal
 - B. Tetrahedral
 - C. Square Planar
 - D. Octahedral
22. The state of matter in which a material has no definite shape but does not have definite volume is the _____ state.
- A. gaseous
 - B. liquid
 - C. elemental
 - D. solid
23. A chemical change occurs when
- A. Dissolved table sugar solidifies to form sugar crystals
 - B. Tap water is purified through distillation
 - C. Dough turning into bread
 - D. Ice melting into liquid water
24. Which of the following is an extensive property of matter?
- A. Boiling point
 - B. Density
 - C. Volume
 - D. Melting point
25. Which of the following is an exothermic process?
- A. Freezing
 - B. vaporization
 - C. sublimation
 - D. Melting

26. On the phase diagram shown to the right, segment _____ corresponds to the conditions of temperature and pressure under which the solid and the liquid of the substance are in equilibrium.
- A. AB
 - B. AC
 - C. AD
 - D. CD



27. The boiling point of CH_4 is much lower than that of HF . This is because
- A. of hydrogen bonding in HF .

- B. of ion-dipole interactions in CH₄.
- C. CH₄ is polar.
- D. of the dipole-dipole interactions in CH₄.

28. Based on the following information:

CF₄, Molecular Weight 87.99, Normal Boiling Point -182°C

CCl₄, Molecular Weight 153.8, Normal Boiling Point -123°C

Which of the above substances would have the higher equilibrium vapor pressure assuming that both substances are in the liquid state at the same temperature?

- A. CF₄
- B. CCl₄
- C. CF₄ and CCl₄ would have the same vapor pressure
- D. Not enough information

29. What is the molar mass of barium perchlorate, Ba(ClO₄)₂?

- A. 189.90 g/mol
- B. 240.24 g/mol
- C. 336.20 g/mol
- D. 304.24 g/mol

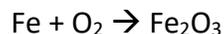
30. Which of these compounds has the largest percent by mass of oxygen?

- A. N₂O
- B. NO
- C. NO₂
- D. N₂O₃

31. The law of conservation of mass states that matter cannot be created or

- A. destroyed.
- B. transferred.
- C. rearranged.
- D. changed.

Questions 32 and 33 refer to the following unbalanced high-temperature reaction:



32. When the coefficient for each of the substances is reduced to its lowest whole number, the coefficient in front of Fe is

- A. 2.
- B. 3.
- C. 4.
- D. 6.

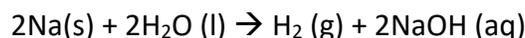
33. Classify the reaction as one of the following:

- A. Oxidation-reduction
- B. Decomposition
- C. Combustion
- D. Single replacement

34. Aqueous solutions of sodium sulfate and calcium chloride are combined. What would you expect to be produced?

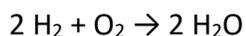
- A. NaCl (s)
- B. CaSO₄ (s)
- C. NaCl (s) and CaSO₄ (s)
- D. No reaction occurs

35. Sodium metal and water react to form sodium hydroxide and hydrogen gas. What mass of Na will react with excess water to produce 15 g NaOH?



- A. 4.3 g
- B. 5.4 g
- C. 8.6 g
- D. 11 g

36. In the reaction below, 8.0 g of H₂ react with 9.0 g of O₂. Which of the following is true?



- A. The equation is not balanced
- B. The H₂ is the limiting reactant
- C. The O₂ is the limiting reactant
- D. 2.0 moles of H₂O would be produced

37. In a particular reaction between copper metal and silver nitrate, 12.7 g Cu produced 38.1 g Ag. What is the percent yield of silver in this reaction?



- A. 56.7%
- B. 77.3%
- C. 88.2%
- D. 176%

38. $\text{MnO}_4^- + \text{HSO}_3^- \rightarrow \text{MnO}_4^{2-} + \text{SO}_4^{2-}$

For the above reaction, the oxidizing agent is _____ and the reducing agent is _____.

- A. MnO₄⁻, HSO₃⁻
- B. MnO₄⁻, OH⁻

C. HSO_3^- , MnO_4^-

D. OH^- , HSO_3^-

39. Which of the following sources of error is not a source of error that can be claimed in an experiment?

A. Systematic error

B. Random error

C. The experimenter did not follow the proper procedure.

D. None of the above; they are all valid.

40. Which of the following numbers have 5 significant figures?

A. 0.03141

B. 0.31410

C. 31,410

D. 31,410.2

41. Which of the following can be used to measure the volume of a liquid to a precise measurement?

A. Test Tube

B. Volumetric Flask

C. Erlenmeyer Flask

D. Striker

42. Which of the following is a balanced half-reaction in basic solution?

A. $\text{Cl}_2 + 3\text{H}_2\text{O} \rightarrow \text{ClO}_3^- + 6\text{H}^+ + 5\text{e}^-$

B. $\text{Cl}_2 + 6\text{OH}^- \rightarrow \text{ClO}_3^- + 5\text{e}^- + 3\text{H}_2\text{O}$

C. $\text{Cl}_2 + 6\text{H}_2\text{O} \rightarrow 2\text{ClO}_3^- + 12\text{H}^+ + 10\text{e}^-$

D. $\text{Cl}_2 + 12\text{OH}^- \rightarrow 2\text{ClO}_3^- + 6\text{H}_2\text{O} + 10\text{e}^-$

43. 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.

44. A sample of a gas occupies a volume of 752 mL at 25°C. What volume will the gas occupy if the temperature increases to 50°C, if the pressure remains constant?

A. 376 mL

B. 694 mL

C. 815 mL

D. 1500 mL

45. Unlike in an ideal gas, in a real gas

A. All particles move in the same direction

B. All particles have the same kinetic energy

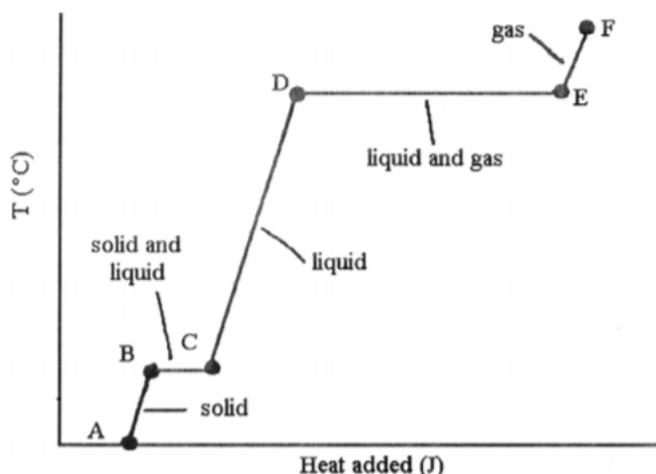
C. All particles cannot diffuse

D. The particles exert attractive forces on each other.

46. The enthalpy change when 1.00 mol of water at 25.0°C is converted to steam at 115.0°C is _____ kJ. The specific heats of ice, water, and steam are 2.09 J/g-K, 4.18 J/g-K, and 2.08 J/g-K, respectively. For H₂O, $\Delta H_{\text{fus}} = 6.01$ kJ/mol, and $\Delta H_{\text{vap}} = 40.67$ kJ/mol

- A. 432.0
- B. 708
- C. 47.36
- D. 46.9

47. The phase changes B → C and D → E, show below, are not associated with temperature increases because the heat energy is used up to _____.



- A. increase the velocity of the molecules.
- B. break bonds between the molecules.
- C. rearrange atoms within the molecules.
- D. break intramolecular bonds.

48. Whose definition of acids and bases emphasizes the role of protons?

- A. Brønsted and Lowry
- B. Lewis
- C. Arrhenius
- D. Faraday

49. A water solution whose pH is 4

- A. Is always neutral
- B. Is always basic
- C. Is always acidic
- D. Might be neutral, basic or acidic

50. The pH of a solution is 10. What is its OH⁻ concentration?

- A. $1.00 \times 10^{-10} \text{ M}$
- B. $1.00 \times 10^{-7} \text{ M}$
- C. $1.00 \times 10^{-4} \text{ M}$
- D. 10 M

51. In the reaction $2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g)$ what is the correct expression of the rate?

- A. $\text{rate} = \frac{-1}{1} \times \frac{\Delta(\text{mol CO})}{\Delta t}$
- B. $\text{rate} = \frac{1}{1} \times \frac{\Delta(\text{mol CO}_2)}{\Delta t}$
- C. $\text{rate} = \frac{-1}{2} \times \frac{\Delta(\text{mol CO})}{\Delta t}$
- D. $\text{rate} = \frac{1}{1} \times \frac{\Delta(\text{mol O}_2)}{\Delta t}$

52. If doubling the concentration of a reactant quadruples the rate of the reaction, the concentration of the reactant appears in the rate law with a(n)

- A. Exponent of 1
- B. Exponent of 2
- C. Exponent of 4
- D. Coefficient of 2

53. Catalysts generally affect chemical reactions by

- A. Increasing the temperature of the system
- B. Increasing the surface area of the reactants
- C. Providing an alternate pathway with a lower activation energy
- D. Providing an alternate pathway with a higher activation energy

54. At equilibrium,

- A. The forward reaction rate is lower than the reverse reaction rate.
- B. The forward reaction rate is higher than the reverse reaction rate.
- C. The forward reaction rate is equal to the reverse reaction rate.
- D. No reaction takes place.

55. A very high value for the equilibrium constant for a reaction indicates that

- A. Equilibrium is reached slowly
- B. Products are favored
- C. Reactants are favored
- D. Equilibrium has been reached

56. If the system $2\text{CO}(g) + \text{O}_2(g) \rightleftharpoons 2\text{CO}_2(g)$ has come to equilibrium and then more $\text{CO}_2(g)$ is added,

- A. $[\text{CO}]$ increases and $[\text{O}_2]$ decreases.

- B. [CO] decreases and [O₂] increases.
- C. both [CO₂] and [O₂] increase.
- D. both [CO] and [O] decrease.

57. What is the value of ΔG at 300 K for a reaction in which $\Delta H = -150 \text{ kJ/mol}$ and $\Delta S = +2.00 \text{ kJ/mol}\times\text{K}$?

- A. -750 kJ/mol
- B. -450 kJ/mol
- C. +750 kJ/mol
- D. +450 kJ/mol

58. Spontaneous reactions are driven by

- A. Decreasing enthalpy and decreasing entropy
- B. Decreasing enthalpy and increasing entropy
- C. Increasing enthalpy and decreasing entropy
- D. Increasing enthalpy and increasing entropy

59. Which of the following is not true of compounds?

- A. They contain two or more elements.
- B. They form after a physical change.
- C. They have their own physical properties.
- D. They do not form randomly.

60. How is a compound different from a mixture?

- A. Compounds have two or more components.
- B. Each substance in a compound loses its characteristic properties.
- C. Compounds are commonly found in nature.
- D. Solids, liquids, and gases can form compounds.

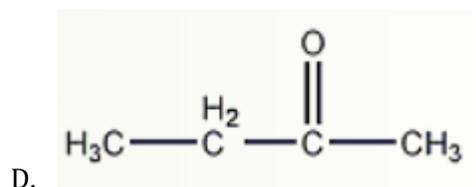
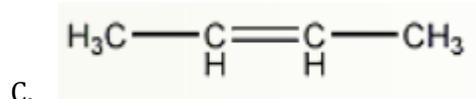
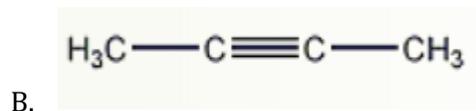
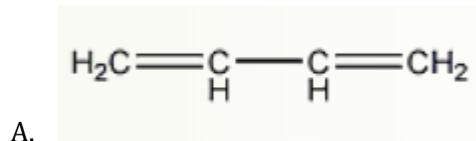
61. The particles in both a solution and a colloid can

- A. scatter light.
- B. settle out.
- C. be soluble.
- D. pass through a fine filter.

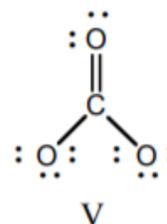
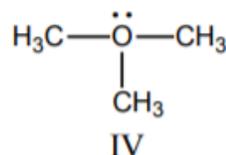
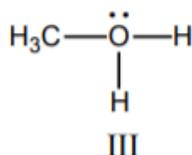
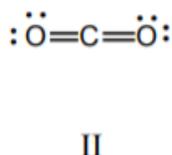
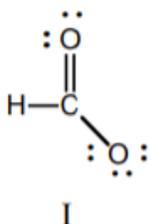
62. Which of the following is an amine?

- A. CH₃CH₂COOH
- B. CH₃OCH₃
- C. H₂CO₃
- D. CH₃NH₂

63. Which one of the following compounds is an alkyne?



64. Which structure(s) contains an oxygen that bears a formal charge of +1?



- A. I and II
- B. III and IV
- C. V
- D. II

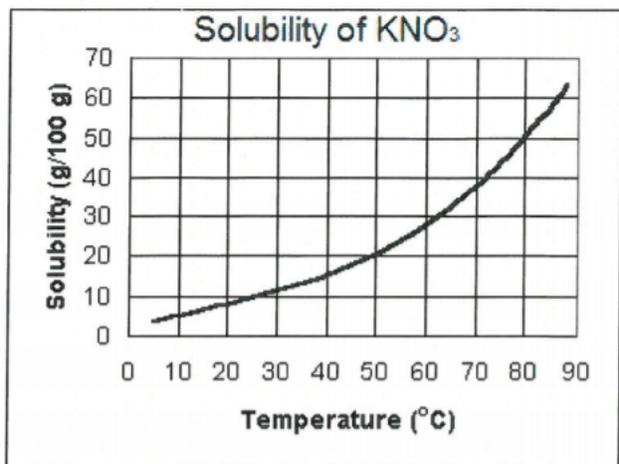
65. The framework of all organic compounds is composed of straight chains, branched chains and rings of

- A. nitrogen
- B. hydrogen
- C. carbon
- D. oxygen

66. The part of a fat molecule that allows it to interact with polar molecules is the _____ end.

- A. hydrophobic
- B. hydrophilic
- C. amino
- D. None of the above

67. What are the starting materials for plants to produce carbohydrates?
- A. Oxygen and water
 - B. Carbon dioxide and water
 - C. Glucose and oxygen
 - D. Carbon dioxide, water, and nitrogen
68. Which of the following is the functional group for a carboxylic acid?
- A. -COOH
 - B. -OH
 - C. -CO-
 - D. -O-
69. Which of the following would be the most concentrated solution?
- A. 200 g of $C_{12}H_{22}O_{11}$ in 1 kg of water
 - B. 1500 ppm of $C_{12}H_{22}O_{11}$ in water
 - C. 1000 ppm of $C_{12}H_{22}O_{11}$ in water
 - D. 1 mole of $C_{12}H_{22}O_{11}$ in 1 L of solution
70. The solubility of a solution depends on
- A. The nature of the solute and the temperature of the solvent.
 - B. The nature of the solute only.
 - C. The temperature of the solvent only.
 - D. Neither the nature of the solute nor the temperature of the solvent.
71. Compared with a 0.01M sugar solution, a 0.01 M $MgCl_2$ solution has
- A. The same freezing point depression
 - B. About twice the freezing point depression
 - C. About three times the freezing point depression
 - D. About four times the freezing point depression
72. A crystal is placed into a solution and it dissolves. The solution must have been
- A. unsaturated.
 - B. saturated.
 - C. supersaturated.
 - D. dilute.
73. Using the diagram below, how would you describe a solution of KNO_3 at $80^\circ C$ if there are about 45 g of KNO_3 dissolved in 100 g of H_2O .

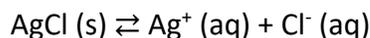


- A. Supersaturated
- B. Dilute
- C. Unsaturated
- D. Saturated

74. The solubility product expression for a saturated solution of $\text{Fe}_2(\text{SO}_4)_3$ is

- A. $K_{sp} = [\text{Fe}^{3+}]^2[\text{SO}_4^{2-}]^3$
- B. $K_{sp} = [2\text{Fe}^{3+}][3\text{SO}_4^{2-}]$
- C. $K_{sp} = [\text{Fe}^{3+}]^2[\text{SO}_4^{2-}]^3 / [\text{Fe}_2(\text{SO}_4)_3]$
- D. $K_{sp} = [\text{Fe}_2(\text{SO}_4)_3] / [\text{Fe}^{3+}]^2[\text{SO}_4^{2-}]^3$

75. Consider the following equilibrium:



When $\text{Cl}^- \text{ (aq)}$ is added to a saturated solution of AgCl

- A. more AgCl dissolves and its solubility product increases.
- B. more AgCl precipitates and its solubility product decreases.
- C. more AgCl dissolves and its solubility product remains constant.
- D. more AgCl precipitates and its solubility product remains constant.

76. An indicator with which titration range would be appropriate to use during a titration of a strong acid with a weak base?

- A. pH 3.1-4.4
- B. pH 5.5-8.0
- C. pH 6.0-7.6
- D. pH 8.0-9.6

77. What is the molarity of an NaOH solution if 3.47 mL is titrated by 11.1 mL of 0.0904 M HNO_3 ?

- A. 0.289 M
- B. 0.355 M
- C. 0.460 M
- D. 0.620 M

78. The pH of a 0.02 M solution of an unknown weak acid is 3.7. what is the pK_a of this acid?
- A. 5.7
 - B. 4.9
 - C. 3.2
 - D. 2.8
79. What is the percent ionization of an 1.2 M HF solution?
- A. 2.4 %
 - B. 4.2 %
 - C. 0.84 %
 - D. 0.082 %
80. Consider a solution which is 0.10 M in CH_3COOH and 0.20 M in $NaCH_3COO$. Which of the following statements is **true**?
- A. If a small amount of NaOH is added, the pH decreases very slightly.
 - B. If NaOH is added, the OH^- ions react with the CH_3COO^- ions.
 - C. If a small amount of HCl is added, the pH decreases very slightly.
 - D. If HCl is added, the H^+ ions react with CH_3COOH ions.

Answer Key:

1. D 2. B 3. A 4. A 5. A 6. B 7. C 8. B 9. B 10. C 11. D 12. A 13. D 14. D 15. D 16. A 17. C 18. B	CHEM6741 _____/18
19. C 20. C 21. C 22. B 23. C 24. C 25. A 26. C 27. A 28. A 29. C 30. C 31. A 32. C 33. A 34. B 35. C 36. C 37. C 38. A 39. C 40. B 41. B 42. D	CHEM6742 _____/24
43. C 44. C 45. D	CHEM6743 _____/16

46. D 47. B 48. A 49. C 50. C 51. C 52. B 53. C 54. C 55. B 56. C 57. A 58. B	
59. B 60. B 61. D 62. D 63. B 64. B 65. C 66. B 67. B 68. A 69. D 70. A 71. C 72. A 73. C 74. A 75. C 76. A 77. A 78. A 79. A 80. C	CHEM6727 _____/22