PSI AP Chemistry Unit 4: Chemical Bonding MC Review Name _____

Part A: Introduction to Ionic and Covalent Bonding

1. Which of the following processes involves breaking intremolecular forces?

 $\begin{array}{l} (A) H_2(g) + Cl_2(g) \to 2 \ \text{HCl}(g) \\ (B) I_2(g) \to 2 \ \text{I}(g) \\ (C) \ \text{Na}(s) \to \text{Na}(g) \\ (D) 2 \ C_2 H_6(g) + 7 \ \text{O}_2(g) \to 4 \ \text{CO}_2(g) + 6 \ \text{H}_2 \text{O}(g) \\ (E) 2 \ \text{KBr}(s) \to 2 \ \text{K}(g) + \text{Br}_2(g) \end{array}$

2. As electronegativity ______ between atoms, the bonds covalent character ______.

(A) Increases, decreases(B) Increases, increases(C) Decreases, increases(D) A and C(E) B and C

- 3. Which bond has the greatest ionic character?
 - (A) H-CL (B) H-F (C) H-O (D) H-N (E) H-S
- 4. Which of the following bonds would be most covalent in character?
 - (A) B-F (B) C-F (C) Be-F (D) O-F (E) N-F
- 5. Which pair of ions should form the ionic lattice with the highest energy?
 - (A) Na+ and Br(B) Li+ and F(C) Cs+ and F(D) Li+ and O²⁻
 (E) K+ and F-

- 6. Which compound has the greatest lattice energy?
 - (A) BaO (B) MgO (C) CaS (D) MgS (E) CaO
- 7. The lattice energy for ionic crystals increases as the charge on the ions ______ and the size of the ions ______.
 - (A) increases, increases
 - (B) increases, decreases
 - (C) decreases, increases
 - (D) decreases, decreases
 - (E) none of the above is generally correct
- 8. In which of these substances are the atoms held together by polar covalent bonding?
 - (A) SrCl₂
 - (B) CsCl
 - (C) CIF
 - (D) TiF_2
 - (E) S_8
- 9. Which bond is the most polar?
 - (A) H—C (B) H—N (C) H—P (D) H—O (E) H—Se

10. Whish molecule has the weakest bond?

(A) CO (B) O₂ (C) NO (D) N₂ (E) Cl₂

11. Which species has the greatest bond enthalpy?

(A) CN-(B) O₂ (C) SO₂ (D) SO₃ (E) CO₂ 12. Which of the following statements best describes the relationship between bond length and bond strength for a series of compounds involving bonds between the same two atoms?

(A) The greater the bond strength, the longer the bond.

- (B) The greater the bond strength, the shorter the bond.
- (C) Bond length and bond strength are not related.
- (D) The relationship between bond length and bond strength depends on other factors.

13. Of the bonds C–C, C=C, and C \equiv C, the C–C bond is _____.

(A) strongest/shortest
(B) strongest/longest
(C) weakest/longest
(D) weakest/shortest
(E) intermediate in both strength and length

14. Which of the following molecules has the shortest bond length?

(A) N₂ (B) O₂ (C) Cl₂ (D) Br₂ (E) I₂

15. Arrange the following bonds in order of increasing bond strength.

- (A) C-I < C-Br < C-CI < C-F(B) C-F < C-CI < C-Br < C-I(C) C-Br < C-I < C-CI < C-F(D) C-I < C-Br < C-F < C-CI(E) none of the above orders is correct
- 16. Which of the following pairs of bonded atoms would be expected to have the longest bond length?
 - (A) C-N (B) C-S (C) C-B (D) C-F (E) C-C

Part B: Lewis Structures, Hybridization, and Bond Order

17. There are ______ valence electrons in the Lewis structure of CH₃CH₂Cl.

(A) 14 (B) 12 (C) 18 (D) 20 (E) 10

18. A valid Lewis structure of ______ cannot be drawn without violating the octet rule.

(A) NF₃
(B) IF₃
(C) PF₃
(D) SbF₃
(E) SO₄²⁻

19. There are _____ unhybridized p atomic orbitals in an sp-hybridized carbon atom.

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

20. Which of the following molecules would require Pi bonds in the lewis structure?

I. SO₂ II.H₂O III.NO₂-(A) I only (B) II only (C) III only

(D) I and II only (E) I, II, and III

21. Pi bonding occurs in each of the following species EXCEPT

(A) CO₂ (B) C₂H₄ (C) CN⁻ (D) C₆H₆ (E) CH₄ 22. The only substance listed below that contains ionic, σ , and π bonds is:

- (A) Na₂CO₃ (B) HClO₂ (C) H₂O (D) CO₂ (E) NaCl
- 23. The central iodine atom in the ICl₄- ion, has ____ nonbonded electron pairs and ____ bonded electron pairs in its valence shell.
 - (A) 2,2 (B) 3,1 (C) 1,3 (D) 3,2 (E) 2,4

24. Which of the following is a correct Lewis structure?



25. Which of the following is NOT a correct Lewis dot structure?

(A) (B) (C) (D)

 $:N \equiv N$: $:C \equiv O$: $[:N \equiv O$:] $H \rightarrow C \equiv N$:

26. There can be four equivalent best resonance structures of ______.

- (A) NO₂-(B) NO₃-(C) SO₃²⁻ (D) SO₄²⁻ (E) BrO₃-
- 27. How many equivalent resonance forms can be drawn for CO₃²⁻(carbon is the central atom)?

(A) 1

- (B) 2
- (C) 3
- (D)4 (E)0

28. Which of the following has a bond order of 2?

(A) Li₂ (B) B₂ (C) N₂ (D) O₂ (E) F₂

29. Which of the following has bond order of 1.5?

(A) HCN
(B) BF₃
(C) N₃
(D) C₂H₂
(E) NOF

30. Which of the following would have the shortest C-C bond length?

(A) CH₃CH₃
(B) CH₂CH₂
(C) CHCH
(D) CH₃CH₂OH
(E) All have the same bond lengths

31. How many σ -bonds and π -bonds, respectively, are in a CO₂ molecule?

(A) 1 σ -bond and 2 π -bonds (B) 2 σ -bonds and 0 π -bonds (C) 2 σ -bonds and 2 π -bonds (D) 2 σ -bonds and 4 π -bonds (E) 4 σ -bonds and 0 π -bonds

32. There is/are _____ σ bond(s) in the molecule below.



33. In the H-C≡N molecule, the hybridization of carbon is _____ and the hybridization of nitrogen is _____.

(A) sp, sp (B) s²p, sp (C) sp, sp² (D) sp², sp² (E) sp³, sp

34. The hybridization of the carbon atom labeled x in the molecule below is _____.

35. The hybrid orbital set used by the central atom in NCl₃ is _____.

(A) sp (B) sp² (C) sp³ (D) sp³d (E) sp³d²

36. What is the formal charge of the oxygen atom of the following compound?

(A) +3 (B) +1 (C) -2 (D) -3	н—ö—н Н
(E) 0	

37. The formal charge on carbon in the molecule below is _____.

(A) 0	••	••
(B)+1	0=0	C = 0
(C) +2	••	••
(D)+3		
(E) -1		

38. What is the formal charge on nitrogen in the molecule below?

(A) 0 (B) +1 (C) +2 (D) +3 (E) -1

Part C: Molecular Shapes and Dipole Moments

39. The basis of the VSEPR model of molecular bonding is ______.

- (A) regions of electron density on an atom will organize themselves so as to maximize *s*-character
- (B) regions of electron density in the valence shell of an atom will arrange themselves so as to maximize overlap
- (C) atomic orbitals of the bonding atoms must overlap for a bond to form
- (D) electron pairs in the valence shell of an atom will arrange themselves so as to minimize repulsions
- (E) hybrid orbitals will form as necessary to, as closely as possible, achieve spherical symmetry
- 40. According to VSEPR theory, if there are 5 pairs of electrons in the valence shell of an atom, they will be arranged in a(n) _____ geometry.
 - (A) octahedral
 (B) linear
 (C) tetrahedral
 (D) trigonal planar
 (E) trigonal bipyramidal
- 41. According to VSEPR theory, if there are 4 pairs of electrons in the valence shell of an atom, they will be arranged in a(n) _____ geometry.
 - (A) octahedron(B) straight line(C) tetrahedron(D) trigonal plane(E) trigonal bipyramid
- 42. The molecular geometry of the H_3O^+ ion is _____.

(A) linear
(B) tetrahedral
(C) bent
(D) trigonal pyramidal
(E) octahedral

43. The molecular geometry of the SiH₂Cl₂ molecule is ______.

(A) trigonal planar
(B) tetrahedral
(C) trigonal pyramidal
(D) octahedral
(E) T-shaped

44. The molecular geometry of the PHCl₂ molecule is ______.

- (A) bent (B) trigonal planar (C) trigonal pyramidal (D) tetrahedral
 - (E) T-shaped

45. The molecular geometry of the SF₂ molecule is _____.

(A) linear
(B) bent
(C) trigonal planar
(D) tetrahedral
(E) octahedral

46. The molecular geometry of the right-most carbon in the molecule below is ______.

- (A) trigonal planarHO(B) trigonal bipyramidal||(C) tetrahedral|(D) octahedralH(E) T-shaped|
- 47. A molecule has a central atom surrounded by 2 lone pairs and 3 atoms. The best description for the shape of the molecule is

(A) trigonal bipyramidal.
(B) octahedral.
(C) trigonal planar.
(D) T-shaped.
(E) see-saw.

48. SF₄ will have _____ lone pair(s) and a _____ molecular geometry.

(A) one; seesaw(B) two; square pyramidal(C) one; T-shaped(D) two; square planar

49. Which of the five basic geometries for molecules and ions has the smallest bond angle?

(A) linear
(B) planar triangular
(C) tetrahedral
(D) octahedral
(E) These all have the same bond angles.

50. The bond angle in Cl₂O is expected to be approximately

- (A) 90 degrees.
 (B) 109.5 degrees.
 (C) 120 degrees.
 (D) 145 degrees.
 (E) 180 degrees.
- 51. The smallest F—P—F bond angle in PF₆ ion is
 - (A) 90 degrees.
 (B) 109.5 degrees.
 (C) 120 degrees.
 (D) 145 degrees.
 (E) 180 degrees
- 52. The bond angles marked a, b, and c in the molecule below are about _____, ____, and _____, respectively.
 - (A) 90°, 90°, 90°
 (B) 120°, 120°, 90°
 (C) 120°, 120°, 109.5°
 (D) 109.5°, 120°, 109.5°
 (E) 109.5°, 90°, 120°

:0: н :0: || | || н-N-С-С-С-С-О-н а | b | с

53. Of the following species, _____ will have bond angles of 120°.

(A) PH₃
(B) ClF₃
(C) NCl₃
(D) BCl₃
(E) All of these will have bond angles of 120°.

- 54. The central iodine atom in the ICl₄- ion, has ____ nonbonded electron pairs and ____ bonded electron pairs in its valence shell.
 - (A) 2,2 (B) 3,1
 - (C) 1,3
 - (D) 3,2
 - (E) 2,4

55. A polar molecule must have the following characteristics

- I. Asymmetrical
- II. polar bonds
- III. Identical electron domains
- (A) I (B) II (C) II (D) I and II (E) I, II, and III

56. Of the molecules below, _____ is polar.

(A) SbF₅ (B) AsH3 (C) I₂ (D) SF₆ (E) CH4

57. Of the molecules below, only _____ is nonpolar.

(A) CO₂ (B) H₂O (C) NH₃ (D) HCl (E) TeCl₂

58. Of the molecules below, only _____ is nonpolar.

(A) BF₃
(B) NF₃
(C) IF₃
(D) PBr₃
(E) BrCl₃

59. Of the following molecules, only _____ is polar.

(A) CCl₄ (B) BCl₃ (C) NCl₃ (D) BeCl₂ (E) Cl₂

60. Which of the following molecules will have a net dipole moment?

- I. PCl₃
- II. CH₃F
- III. CBr₂F₂
- $IV. \quad O_2$

(A) IIand IV only(B) Iand III only(C) III and IV only(D) I, II and III only

61. Which of the following molecules has a dipole moment?

(A) H₂O (B) Br₂ (C) CCl₄ (D) CO₂ (E) CH₄

62. Of the following molecules, which has the largest dipole moment?

(A) CO (B) CO₂ (C) O₂ (D) HF (E) F₂

63. Which one of the following substances is more likely to dissolve in CCl₄?

(A) CBr₄
(B) HBr
(C) HCl
(D) CH₃CH₂OH
(E) NaCl

Part D: Intermolecular Forces

- 64. The strength of London dispersion forces between like-molecules depends on ______ and _____.
 - (A) molecular mass, polarizability
 (B) polarizability, electronegativity
 (C) molecular mass, volatility
 (D) size, shape
 (E) vapor pressure, size

65. What is the predominant intermolecular force in CBr₄?

(A) London-dispersion forces
(B) ion-dipole attraction
(C) ionic bonding
(D) dipole-dipole attraction
(E) hydrogen-bonding

66. Which one of the following derivatives of ethane has the highest boiling point?

 $\begin{array}{c} (A) C_2 Br_6 \\ (B) C_2 F_6 \\ (C) C_2 I_6 \\ (D) C_2 C I_6 \\ (E) C_2 H_6 \end{array}$

67. Based on molecular mass and dipole moment of the five compounds in the table below, which should have the highest boiling point?

<u>Substance</u>	<u>Molecular Mass (amu)</u>	Dipole Moment (D)
Propane, CH ₃ CH ₂ CH ₃	44	0.1
Dimethylether, CH ₃ OCH ₃	46	1.3
Methylchloride, CH ₃ Cl	50	1.9
Acetaldehyde, CH ₃ CHO	44	2.7
Acetonitrile, CH ₃ CN	41	3.9
 (A) CH₃CH₂CH₃ (B) CH₃OCH₃ (C) CH₃Cl (D) CH₃CHO 		

(E) CH₃CN

68. Of the following, _____ has the highest boiling point.

(A) N₂ (B) Br₂ (C) H₂ (D) Cl₂ (E) O₂

69. Which of the following BEST explains why neopentane hase the lowest boiling point?

Common Name	<i>n</i> -pentane	isopentane	neopentane
Structure	H H H H H H-C-C-C-C-C-H H H H H H H H H H H	н н-с-н н н н-с-н нн н-с	
Formula	C_5H_{12}	$C_{5}H_{12}$	$C_{5}H_{12}$
Boiling Point ∘C	36.0	27.7	9.5

(A) neopentane is more polarized due to having fewer electrons

(B) N-pentane is more polarized due to having more electrons

(C) They all have equal numbers of electrons but neopentane has less surface area

(D) neopentane and n-pentane have equal numbers of electrons but n-pentane has more surface area

70. Which of the following would be expected to have the highest heat of vaporization?

(A) He₂ (B) Ar (C) PH₃ (D) O₂ (E) Ne

71. Which one of the following exhibits dipole-dipole attraction between molecules?

(A) XeF₄ (B) AsH₃ (C) CO₂ (D) BCl₃ (E) Cl₂

- 72. When NaCl dissolves in water, aqueous Na⁺ and Cl⁻ ions result. The force of attraction that exists between Na⁺ and H₂O is called a(n) ______ interaction.
 - (A) dipole-dipole(B) ion-ion(C) hydrogen bonding(D) ion-dipole(E) London dispersion force

73. Which of the following would have the lowest boiling point?

(A) HI (B) I₂ (C) Br₂ (D) F₂ (E) C₃H₈

74. Hydrogen bonding is a special case of _____.

- (A) London-dispersion forces(B) ion-dipole attraction(C) dipole-dipole attractions(D) none of these(E) ion-ion interactions
- 75. Which one of the following substances will have hydrogen bonding as one of its intermolecular forces?



76. Which one of the following substances will <u>not</u> have hydrogen bonding as one of its intermolecular forces?



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77. Of the following substances, _____ has the <u>highest</u> boiling point.

(A) H₂O (B) CO₂ (C) CH₄ (D) Kr (E) NH₃

78. The liquefied hydrogen halides have the normal boiling points given below. The relatively high boiling point of HF can be correctly explained by which of the following?

(A) HF gas is more ideal.
(B) HF is the strongest acid.
(C) HF molecules have a smaller dipole moment.
(D) HF is much less soluble in water.

(E) HF molecules tend to form hydrogen bonds.

Hydrogen Halide	Normal Boiling	
HF	+19	
HCl	- 85	
HBr	- 67	
HI	- 35	

- 79. CH₃CH₂OH boils at 78 °C and CH₃OCH₃ boils at 24 °C, although both compounds have the same composition. This difference in boiling points may be attributed to a difference in
 - (A) molecular mass(B) density(C) specific heat(D) hydrogen bonding(E) heat of combustion
- 80. In which of the following molecules is hydrogen bonding likely to be the most significant component of the total intermolecular forces?
 - (A) CH_4 (B) $C_5H_{11}OH$ (C) $C_6H_{13}NH_2$ (D) CH_3OH (E) CO_2

81. $C_{12}H_{26}$ molecules are held together by _____.

(A) ion-ion interactions(B) hydrogen bonding(C) ion-dipole interactions(D) dipole-dipole interactions(E) dispersion forces

82. Viscosity is _____.

(A) the "skin" on a liquid surface caused by intermolecular attraction

(B) the resistance to flow

(C) the same as density

(D) inversely proportional to molar mass

(E) unaffected by temperature

83. The property responsible for the "beading up" of water is ______.

(A) density(B) viscosity(C) vapor pressure(D) surface tension(E) hydrogen bonding

84. The substance with the largest heat of vaporization is ______.

(A) I₂ (B) Br₂ (C) Cl₂ (D) F₂ (E) O₂

85. Which compound should have the lowest vapor pressure at a temperature at which all these substances are in the liquid state?

(A) CH₃-CH₂-F
(B) CH₃-CH₂-CH₃
(C) CH₃-CH₂-CH₂-CH₃
(D) CH₃-CH₂-O-H
(E) CH₃-O-CH₃

86. Given the following substances and their normal boiling points, in °C:

C: 43.8 °C D: 93.7 °C M: 56.7 °C T: 83.5 °C R: 63.6 °C

Which ranking correctly lists some of these substances in order of decreasing vapor pressure at 20 $^\circ C?$

(A) C > R > D (B) D > T > R (C) R > M > D (D) C > D > M (E) D > R > M 87. A volatile liquid is one that _____.

(A) is highly flammable(B) is highly viscous(C) is highly hydrogen-bonded(D) is highly cohesive(E) readily evaporates

88. Of the following, _____ is the most volatile.

(A) CBr₄ (B) CCl₄ (C) CF₄ (D) CH₄ (E) C₆H₁₄

89. In general, the vapor pressure of a substance increases as ______ increases.

(A) surface tension(B) molecular weight(C) hydrogen bonding(D) viscosity(E) temperature

Answers

1. C	25. E	49. C	73. E
2. C	26. A	50. B	74. B
3. D	27. E	51. A	75. D
4. B	28. C	52. D	76. C
5. D	29. C	53. A	77. B
6. B	30. D	54. D	78. D
7. D	31. C	55. B	79. D
8. D	32. D	56. A	80. C
9. B	33. E	57. D	81. D
10. B	34. D	58. D	82. A
11. C	35. C	59. E	83. E
12. D	36. C	60. D	84. E
13. E	37. C	61. B	85. A
14. A	38. A	62. A	86. D
15. B	39. B	63. A	87. E
16. C	40. C	64. C	88. B
17. A	41. B	65. D	89. D
18. A	42. A	66. A	90. A
19. B	43. E	67. D	91. D
20. E	44. D	68. A	92. A
21. D	45. E	69. A	93. E
22. B	46. C	70. C	94. C
23. C	47. D	71. A	95. E
24. D	48. B	72. C	