## **Review for Chapter 4: Structures and Properties of Substances**

You are responsible for the following material:

1. **Terms:** You should be able to <u>write</u> definitions for the following terms. A complete definition includes an example or an additional piece of information about the term. (2 marks each)

orbital first ionization energy ionic bond mass number atomic radius covalent bond atomic number metallic bonding coordinate covalent bond isoelectronic delocalized electrons van der Waal's attractions isotope hydrogen bonding alloy London dispersion forces electronegavity allotrope

- 2. Chapter 3 review: (assigned before Chapter 3 quiz, on SCH 4UI web page)
- 3. Chapter 4 review (p. 209 211): Q 2, 3, 6, 8, 9, 13 17, 19, 20, 24 27, 29 31
- 4. **Unit 2 Review (p. 214-217):** Q 1 10, 13 19, 21 32, 35 38, 40 43, 45, 47 53

It is not necessary to write full answers to all review questions. Read through the review and do enough questions that you can recognize the question types and can answer them fairly quickly, especially drawing Lewis structures and predicting molecular shape.

Be able to apply what we have learned. For example, predict four physical properties of phosgene (COCl<sub>2</sub>), an extremely toxic compound that has been used for chemical warfare.

## **Practice Multiple Choice Questions:**

- In which of the following molecules is oxygen the central atom?
   NO<sub>2</sub> c) OF<sub>2</sub>
   N<sub>2</sub>O d) POCℓ
   Based on VSEPR theory, what is the predicted molecular shape of SCℓ<sub>2</sub>?
   linear c) tetrahedral
   T- shaped d) bent (V-shaped)
   Based on VSEPR theory, what is the predicted molecular shape of CCℓ<sub>4</sub>?
   trigonal pyramidal c) tetrahedral
- b) T- shaped
   d) square planar
   4. Based on VSEPR theory, what is the predicted molecular shape of ICl<sub>4</sub><sup>1-</sup>ion?
- a) triangular planar c) tetrahedral
- b) octahedral d) square planar
- 5. Which of the following is/are non-polar molecules?
  - I)  $NC\ell_3$
  - II) BF<sub>3</sub>
  - III) PCl<sub>5</sub>
- a) I and II onlyb) II and III onlyc) II onlyd) I, II and III
- 6. Arrange the species in order of **decreasing** H N H bond angle:
- a)  $NH_2^{1-} > NH_3 > NH_4^{1+}$  c)  $NH_3 > NH_2^{1-} > NH_4^{1+}$
- b)  $NH_3 > NH_4^{1+} > NH_2^{1-}$  d)  $NH_4^{1+} > NH_3 > NH_2^{1-}$

7. In the Lewis structure for the BrF <sub>4</sub> <sup>-</sup> the central atom?	ion, how many lone pairs of electrons are placed around
a) 0	c) 2
b) 1	d) 3
<ul> <li>8. Which species has a Lewis structur</li> <li>a) NH<sub>2</sub><sup>1-</sup></li> </ul>	e with only one lone pair of valence electrons?  c) H <sub>2</sub> S
b) H <sub>3</sub> O <sup>1+</sup>	d) CH <sub>4</sub>
0) 1130	u) C114
<ul><li>9. Which of these characteristics desc</li><li>I) it has a trigonal planar shape</li><li>II) it has polar bonds</li><li>III) it is a non-polar molecule</li></ul>	ribe the $PC\ell_3$ molecule?
a) II only	c) I and III only
b) I and II only	d) II and III only
<ul><li>10. Which compound is expected to ha</li><li>a) CsF</li><li>b) RbF</li></ul>	ve the <b>lowest</b> melting point?  c) KF  d) NaF
11 Which of the following molecules	is the only one which can bond with an expanded octet?
a) SO <sub>3</sub>	c) NF <sub>3</sub>
b) NO <sub>3</sub> <sup>-</sup>	d) CO <sub>3</sub> <sup>2-</sup>
<i>b)</i> 1(0)	<b>a</b> ) 203
<ul><li>12. In order to have resonance structure</li><li>a) a Noble gas as the central atom</li><li>b) only single bonds</li><li>c) an expanded valence</li><li>d) both single and double bonds between</li></ul>	
13. Which molecule is polar?	
a) ClF <sub>3</sub>	c) AsCl <sub>5</sub>
b) XeCl <sub>4</sub>	d) SF <sub>6</sub>
-,	
14. The bonds in ozone, $O_3$ , are best re	epresented as:
a) two single bonds	c) one single and one double bond
b) two double bonds	d) resonance structures of a single and double bond
15. How many resonance structures mu	
a) none b) 1	c) 2 d) 3
16. The H – O – H bond angle in wate	r is:
a) 109.5°	c) > 109.5 °
b) < 109.5 °	d) 180°
17. Which of the following hydrogen l	nalides is predicted to have the <b>highest</b> boiling point?
a) HI	c) HCl
b) HBr	d) HF
•	
18. Which substance has a dipole mon	nent?
a) CH <sub>4</sub>	c) PH <sub>3</sub>
b) BeH <sub>2</sub>	d) $BH_3$

19. All of these molecules are polar <b>except</b> : (all sp	· · · · · · · · · · · · · · · · · · ·
<ul><li>a) H<sub>2</sub>O</li><li>b) CO<sub>2</sub></li></ul>	c) OF <sub>2</sub> d) SO <sub>2</sub>
,	
20. Which substance has the lowest boiling point?	
<ul><li>a) HCℓ</li><li>b) H<sub>2</sub>S</li></ul>	c) PH <sub>3</sub> d) SiH <sub>4</sub>
b) п <sub>2</sub> S	u) 31n <sub>4</sub>
21. Which of the following molecules have/has at I) $SF_4$ II) $IC\ell_3$ all molecules have an expanding $XeO_2C\ell_2$	least one lone electron pair (LP) on the central atom? anded valence
III) $XeO_2C\ell_2$	
a) II only	c) I and III only
b) I and II only	d) I, II and III
22. Which <b>bond</b> is most polar?	
a) F - O	c) F-C(
b) F – S	d) F – F
23. Which <b>molecule</b> is most polar?	\ V.E
a) SO <sub>2</sub> (octet rule)	c) XeF <sub>2</sub>
b) CO <sub>2</sub> (octet rule)	d) $PC\ell_5$
24. All of the following species are trigonal pyram an expanded valence)	nidal in shape except: (none of these molecules has
a) $SO_3^{2-}$	c) BF <sub>3</sub>
b) NH <sub>3</sub>	d) $H_3O^+$
<ul> <li>25. In which compounds does hydrogen bonding of I) ammonia, NH<sub>3</sub></li> <li>II) hydrogen peroxide, H<sub>2</sub>O<sub>2</sub></li> <li>III) methane, CH<sub>4</sub></li> <li>IV) phosphine, PH<sub>3</sub></li> </ul>	occur? (all species obey the octet rule)
a) I, II, III and IV	c) III and IV only
b) I and II only	d) I and IV only
26. Which is the correct VSEPR notation for amm	ionia NH <sub>2</sub> ?
a) $AX_3E_0$	c) $AX_3E_2$
b) $AX_3E_1$	d) $AX_3E_3$
27. What is the central atom in the Lewis diagram	
a) hydrogen	c) nitrogen
b) carbon	d) HCN is linear; it has no central atom
28. What is the correct VSEPR notation for OF <sub>2</sub> ?	
a) $AX_2E_0$	c) $AX_2E_2$
b) $AX_2E_1$	d) $AX_0E_2$
29. How many lone pairs of electrons are found on	the central atom in the molecule XeF <sub>4</sub> ?
a) 0	c) 2
b) 1	d) 3

a)	Which of the following will have the highest me $SO_2$ $SiO_2$	c)	g point? (all species obey the octet rule) $CO_2$ $CS_2$
31.	Graphite, diamond and buckminsterfullerene are	e ex	amples of:
	isotopes		isomers
	allotropes		resonance structures
32.	Identify all type(s) of inter-molecular attractions  I) ion – ion attractions  II) dipole – dipole attractions  III) hydrogen bonds  IV) London dispersion forces	s tha	at exist in a pure sample of NH <sub>3</sub> :
a)	I and IV	c)	II, III and IV
b)	II and IV	d)	IV only
33. a)	Which of the following atoms is capable of form Si	ning c)	•
b)			all of the above
<ul><li>a)</li><li>b)</li><li>c)</li></ul>	Which of the following is true about ionic comp ionic substances are made up of elements with vionic substances are made up of elements with vionic substances contain metal elements so they ionic substances form discrete, individual molecular contains and contains are made up of elements with vionic substances form discrete, individual molecular contains and contains a contain metal elements are the contains and contains a contain metal elements.	ery ery cor	similar electronegativities different electron affinities nduct electricity as solids
35.	In which of the following substances are the ele	ectro	ons most delocalized?
	pure magnesium as a solid		pure carbon as a diamond
	pure neon as a gas		pure chlorine as a liquid
36.	Scandium has a higher melting point than potass	siun	n because:
a)	Sc has a higher shielding effect	c)	Sc has larger atoms
a)	Sc has a lower net nuclear attraction	d)	Sc has more valence electrons
37.	When cobalt and nickel are melted, mixed toget	her	and cooled, they will form:
a)	an ionic compound	c)	an interstitial alloy
b)	a network solid	d)	a substitutional alloy
38.	Brass (75% copper and 25% zinc) is an example	e of	an:
a)	alloy		ionic compound
	element		allotrope
39.	Which pure metal is harder?		
a)		c)	Mo
b)			Pd
40.	Which of the following elements forms a hexago	ona	l crystal lattice structure?
	silver		iron
b)	cobalt	-	oxygen

41. a) b)	Which of the following elements forms sp <sup>3</sup> hybron beryllium	c)	orbitals? silicon phosphorus
a)	Which of the following will have the highest bo $N \equiv N$ N = N	c)	energy? $N-N$ these bonds all have the same bond energy
a)	Calculate the percent ionic character of the $K-$ about $2.14\%$ about $21.4\%$	Br bc)	
a)	A bond has 30% ionic character. This bond is: pure covalent polar covalent	c) d)	ionic metallic
45.	According to the Lewis structures below, which	cor	mpound(s) will form resonance structures?
I)	$\begin{bmatrix} \vdots \vdots \\ $	,	$\begin{bmatrix} \vdots \vdots$
	:ö— s —ö:		н— с — о:
	I only I, III and IV only c) I, II and III only d) II, III and IV only	7	
a)	Which of the following is a correct ionization re $Na^{1+} \rightarrow Na + e$ - $Al \rightarrow Al^{3+} + 3e$ -	eacti c) d)	on? $Ca + 2 e^{-} \rightarrow Ca^{2+}$ $C\ell \rightarrow C\ell^{1-} + e^{-}$
47.	Which of the following is/are considered to be v I) pure covalent bonds II) polar covalent bonds III) dipole-dipole attractions IV) hydrogen bonds V) London dispersion forces	an (	der Waal's forces?
	I and II I, II and IV		III, IV and V I, II, III, IV and V

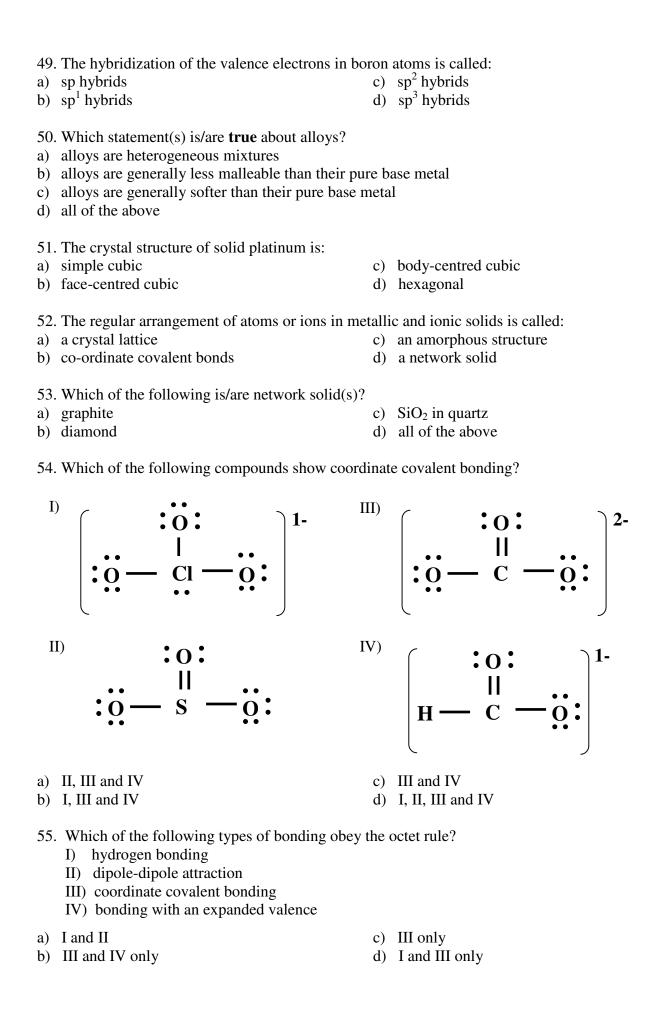
48. Which characteristic of metallic bonding explains why metals can conduct electricity?

a) delocalized electrons

c) small numbers of valence electrons

b) relatively low ionization energies

d) dipole- dipole attractions



<ul><li>a) high EN and high IE</li><li>b) low EN and low IE</li></ul>		high EN and low IE low EN and high IE
57. Which of the following would be classified as in  I) covalent bonds  II) hydrogen bonds  III) ionic bonds  IV) dipole-dipole attractions  V) London dispersion forces	ntra	-molecular attractions?
<ul><li>a) I, II and III only</li><li>b) II, IV and V only</li></ul>		I and III only IV and V only
58. Select the term which best describes the series		
a) transition metals		representative elements
b) metalloids	d)	inner transition metals
59. Which element has the <b>largest</b> atomic radius?		
a) Na	c)	Ar
b) Rb	d)	I
60. Which of the following terms accurately descri	ibes	the energy associated with the reaction:
$Li(g) \rightarrow Li^{+}(g) + e^{-}$		
a) electron affinity	c)	lattice energy
b) ionization energy	d)	electronegativity
61. The ion that contains 24 protons, 26 neutrons ar		
a) ${}^{50}V^{3+}$		<sup>26</sup> Cr <sup>2+</sup>
b) ${}^{50}\text{Cr}^{2+}$	d)	$^{50}\text{Fe}^{2+}$
62. Which of these isoelectronic species has the sm	nalle	est radius?
a) Br		$\mathrm{Se}^{2-}$
b) Rb <sup>+</sup>	e)	they are isoelectronic so they are the same size
c) $Sr^{2+}$		
63. Which of the following elements has the greate	est a	ttraction for electrons in a covalent bond?
a) Ge		As
b) Se	d)	Br
64. Which one of the formulas for ionic compound		
a) NaF <sub>2</sub>		$Cs_2S$
b) CaSe	d)	$\mathrm{SrC}\ell_2$
65. Which is classified as a non-polar covalent bon	nd?	
a) the H – Br bond in HBr	c)	the P – C $\ell$ bond in PC $\ell_3$
b) the $N - C\ell$ bond in $NC\ell_3$	<u>d</u> )	the N – H bond in NH <sub>3</sub>

66. Which one of the compounds below is most li	ikely to be ionic?
a) GaAs	c) CCl <sub>4</sub>
b) $ScC\ell_3$	d) $C\ell O_2$
67. In the Lewis structure for OF <sub>2</sub> , the number of	f lone pairs around the central oxygen atom is:
a) 0	c) 1
b) 2	d) 3
68. The Lewis structure of the SO <sub>2</sub> molecule is be equivalent structures.	est represented as a resonance hybrid of
a) 2	c) 4
b) 3	d) this molecule does not exhibit resonance
69. Which one of the following is an exception to	the octet rule?
a) PCl <sub>3</sub>	c) CBr <sub>4</sub>
b) BF <sub>3</sub>	d) AsH <sub>3</sub>
70. Which molecule has a linear arrangement of a	all component atoms?
a) H <sub>2</sub> O	c) BF <sub>3</sub>
b) CO <sub>2</sub>	d) NH <sub>3</sub>
71. The $H - N - H$ bond angle in $NH_4^{1+}$ is:	
a) 90°	c) >109.5°
b) 109.5°	d) <109.5°
72. Which of the following species is planar?	
a) NH <sub>3</sub>	c) $H_3O^+$
b) $SO_3^{2-}$	d) NO <sub>3</sub>
73. What kind of hybrid orbitals are utilized by th	
a) $sp^1$	c) $sp_{s}^{2}$
b) $sp^3$	d) $sp^3d$
74. Which of the following four molecules are po	olar: PH <sub>3</sub> OF <sub>2</sub> HF SO <sub>3</sub> ?
a) only PH <sub>3</sub> and HF	c) only SO <sub>3</sub>
b) only HF and OF <sub>2</sub>	d) only PH <sub>3</sub> , OF <sub>2</sub> and HF
75. Which molecule is non-polar?	
a) H <sub>2</sub> Se	c) BeH <sub>2</sub>
b) PF <sub>3</sub>	d) SO <sub>2</sub>
76. Which of the following statements is/are true  I) the molecular shape is trigonal planar  II) there is one lone pair on P  III) the bonding electrons on P are sp <sup>2</sup> hybrid  IV) PCl <sub>3</sub> is a polar molecule  V) PCl <sub>3</sub> contains polar bonds	
a) I, III and V only	c) II, III and IV
b) II, IV and V	d) I, II and IV

<ul> <li>77. The F - S - F bond angles in SF<sub>6</sub> are:</li> <li>a) 109.5°</li> <li>b) 90°</li> </ul>	c) 120° d) 90° and 180°
a) metallic bonding	c) London dispersion forces
<ul><li>b) hydrogen bond</li><li>79. What type of inter-molecular force holds nitro</li><li>a) ionic bonding</li></ul>	<ul> <li>d) covalent bonding</li> <li>gen (N<sub>2</sub>) molecules together in liquid nitrogen?</li> <li>c) London dispersion forces</li> </ul>
<ul><li>b) hydrogen bonding</li><li>80. Which of the following compounds exhibit hy</li></ul>	d) dipole-dipole interaction
<ul> <li>a) both AsH<sub>3</sub> and H<sub>2</sub>Te</li> <li>b) both CH<sub>4</sub> and H<sub>2</sub>Te</li> </ul>	<ul> <li>c) both AsH<sub>3</sub> and CH<sub>3</sub>NH<sub>2</sub></li> <li>d) both CH<sub>3</sub>NH<sub>2</sub> and HF</li> </ul>
<ul> <li>81. Which statement is false?</li> <li>a) covalent compounds generally have lower melted</li> <li>b) covalent compounds generally melt at lower tector</li> <li>c) polar covalent compounds generally have lowed</li> <li>d) the melting point of metallic solids increases as</li> </ul>	mperatures than metallic solids or melting points than pure covalent compounds
<ul> <li>82. Which of the following compounds would be</li> <li>a) BaF<sub>2</sub></li> <li>b) BaBr<sub>2</sub></li> </ul>	expected to have the <b>highest</b> melting point? c) $BaC\ell_2$ d) $BaI_2$
<ul><li>83. A crystalline solid has a high melting point, no</li><li>a) ionic solid</li><li>b) network solid</li></ul>	odour, and is an electrolyte. This substance is a(n): c) metallic solid d) polar covalent solid
84. Which physical property most clearly distinguisubstances?	shes between polar and non-polar covalent
<ul><li>a) their solubility in water</li><li>b) the presence of an odour</li></ul>	<ul><li>c) the ability of the solid to conduct electricity</li><li>d) the ability of the solution to conduct electricity</li></ul>
85. Which statements is/are true about network sol  I) they are soluble in water  II) they have low melting points  III) they have distinctive odours  IV) they are electrolytes	ids?
<ul><li>a) I and II</li><li>b) I and III</li></ul>	<ul><li>c) IV only</li><li>d) none of these statements is true</li></ul>
<ul><li>86. Solid graphite can conduct electricity because:</li><li>a) it is an electrolyte</li><li>b) it is a network solid</li></ul>	<ul><li>c) it has delocalized electrons</li><li>d) all of the above</li></ul>
<ul> <li>87. Which of the following compounds is predicted</li> <li>a) Na<sub>2</sub>O</li> <li>b) M<sub>g</sub>O</li> </ul>	d to have the highest melting point?  c) Al <sub>2</sub> O <sub>3</sub> d) P <sub>2</sub> O <sub>5</sub>