Sample

CHEM 1A Winter 2021: Sample Midterm #2

Lecturer: Prof. Fokwa
February 18, 2021
Time: 1 h

Please note: This test has a total of 125 points (Part I) and 5 pts bonus question (Part II). The test covers chapters 1, 2 and 3.
Allowed for the test are: a blanc paper sheet, a copy of the periodic table given on the sample mid-term and below, a pen and a scientific calculator (non-graphing).

Part I: Multiple Choices (5 pts each; 125 pts in total)

_____ 1. Which of the following is *not* a possible set of quantum numbers for an electron?
a. $n = 3, \ell = 2, m_e = -1$
b. $n = 2, \ell = 2, m_e = 0$
c. $n = 4, \ell = 1, m_e = 1$
d. $n = 1, \ell = 0, m_e = 0$
e. $n = 2, \ell = 1, m_e = 1$

____ 2. A certain shell is known to have a total of 16 orbitals. Which shell is it?
a. $n = 4$
b. $n = 16$
c. $n = 8$
d. $n = 2$

____ 3. What is the ground-state electron configuration of a Cl^- ion?
a. $1s^2 2s^2 2p^6 3s^2 3p^4$
b. $1s^2 2s^2 2p^6 3s^2 3p^5$
c. $1s^2 2s^2 2p^6 3s^2 3p^6$
d. $1s^2 2s^2 2p^6 3s^2 3p^2$
e. $1s^2 2s^2 2p^6 3s^2 3p^8$

____ 4. If the principal quantum number is seven ($n = 7$) and the angular momentum quantum number is three ($\ell = 3$), which of the following values is *not* an allowed value of the magnetic quantum number (m_l)?
a. 0
b. 1
c. 2
d. –3
e. 4

____ 5. What is the correct name for $FeCl_3$? Fe is a transition element.
a. iron chloride
b. iron trichloride
c. ferrum trichloride
d. ferric trichloride
e. iron (III) chloride

____ 6. Which of the following molecular compounds has an *incorrect* formula or is *not* named correctly?
a. CCl_4, carbon tetrachloride
b. P_2N_5, phosphorus pentanitride
c. SF_6, sulfur hexafluoride
d. NO_2, nitrogen dioxide
e. SO, sulfur monoxide

____ 7. Which one of these formula–name combinations is *not* correct?
a. diphosphorus tetroxide: P_2O_4
b. tetraphosphorus nanoxide: P_4O_9
c. diphosphorus pentoxide: P_2O_5
d. tetraphosphorus heptoxide: P_4O_6
e. phosphorus monoxide: PO

____ 8. Zinc oxide is found in ointments for the skin. What formula best describes this compound, which has Zn as a doubly charged cation?

a. ZnO
b. Zn_2O
c. ZnO_2
d. Zn_2O_2
e. Zn_2O_3

____ 9. Which statement provides the best description of a covalent bond?

a. A high electron density between two positively charged atomic nuclei serves to attract the nuclei to each other.
b. The negative charge on one atom is attracted to the positive charge on a second atom.
c. Two or more electrons are attracted to each other, thereby holding the atoms together.
d. Two atomic nuclei are attracted to each other by the strong nuclear force.
e. Two atomic nuclei are attracted to each other by the Coulomb force.

____ 10. The formula for a lutetium carbonate compound is $Lu_2(CO_3)_3$. What would be the formula for a lutetium nitrate compound given that the charge of lutetium is the same in both compounds?

a. $LuNO_3$
b. $Lu(NO_3)_2$
c. $Lu(NO_3)_3$
d. Lu_2NO_3
e. $Lu_2(NO_3)_3$

____ 11. Which statement about σ and π bonds is correct?

a. A π bond is twice as strong as a σ bond.
b. A π bond has cylindrical symmetry about the internuclear axis.
c. A π bond, as in ethylene, is described by the overlap of hybridized atomic orbitals.
d. A double bond, as in ethylene (C_2H_4), consists of a π bond and a σ bond.
e. Hydrogen forms π bonds when it bonds to other atoms.

____ 12. Which of the following is an example of a nonpolar covalent bond?

a. C—S
b. Na—Na
c. O—F
d. C—C
e. C—O

____ 13. The following Lewis symbol corresponds to which ion?

a. F^-
b. O^-
c. C^{2-}
d. B^{3+}
e. N^{2-}

____ 14. Which of the following has the most valence electrons?

a. HF
b. NS
c. CN^-
d. ArF
e. ArF^+

____ 15. How many lone pairs are there in ClO^-?

a. 1
b. 2
c. 3
d. 4
e. 6

____ 16. Indicate which molecule contains the largest number of nonbonding electrons.

a. H_2
b. CO
c. N_2
d. NO
e. O_2

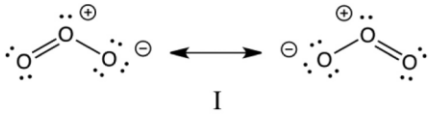
____ 17. What types of bonds form between the chlorine and oxygen atoms of the chlorite ion (ClO_2^-) to minimize the formal charge?

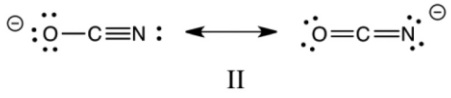
a. single
b. between single and double
c. double
d. triple
e. ionic

____ 18. Resonance structures indicate that _____

a. there is more than one allotropic form of a compound.
b. more than one ionic form of a compound exists.
c. the electronic structure is an average or superposition of the diagrams.
d. more than one isotopic form of an element exists in the molecule.
e. the molecule jumps back and forth between two or more different electronic structures.

____ 19. Which of the following pairs of Lewis structures are *not* resonance structures of one another?


I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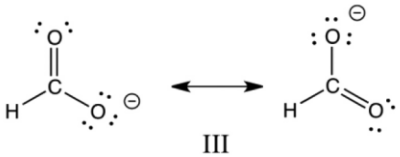
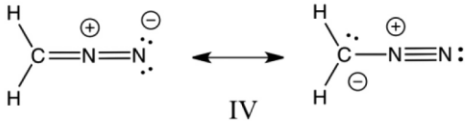
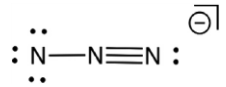
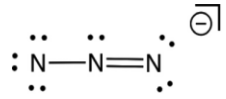
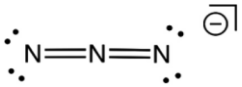
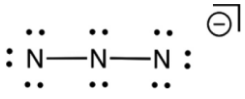

III


IV

a. I
b. II
c. III
d. IV
e. All pairs are resonance structures.

____ 20. Based on consideration of formal charges, which of the following is the most stable Lewis structure for the azide ion (N_3^-)?

a. 
b. 
c. 
d. 

____ 21. The Fe^{3+} transition metal ion has how many *d* electrons?

a. 0
b. 3
c. 4
d. 5
e. 8

____ 22. Which arrangement is in the correct order of increasing radii?

a. $Cs < Mn^{2+} < Mn$
b. $Ra < Li < Li^+$
c. $P < P^{3-} < As^{3-}$
d. $Cr < Cr^{3+} < Ca$
e. $H < He^+$

____ 23. Which arrangement is *not* in the correct order of decreasing first ionization energy?

a. B > Al > In
b. As > P > N
c. Cl > Si > Na
d. Li > K > Cs
e. Br > As > Ga

____ 24. Which bond is the least polar?

a. H—C
b. H—N
c. H—O
d. H—Cl
e. H—F

____ 25. How many of these atoms or ions have no unpaired electrons?

N, O, Na^+, N^{3-}, Sc

a. 1
b. 2
c. 3
d. 4
e. 5

Part II: Bonus Question (5 pts)

_____ 26. O–S–S–O has three resonance Lewis structures that complete the octet for all the atoms. Which statements about these structures are correct?

I. All are equivalent.
II. All are nonequivalent.
III. Two are equivalent, and one is nonequivalent.
IV. The formal charges on all the atoms are zero in at least one structure.
V. All the bonds have double-bond character.

a. II and IV
b. I and IV
c. III and V
d. I and V
e. III, IV, and V

Sample

Useful equation, constants and conversions:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$c = \lambda\nu$ (λ is wavelength; ν is frequency; $c = 2.998\times 10^8$ m/s)

$$E = h\nu \qquad E = \frac{hc}{\lambda}\ ; \quad \lambda = \frac{hc}{E} = \frac{hc}{mc^2} = \frac{h}{mc} = \frac{h}{mu}$$

$$\frac{1}{\lambda} = \left(1.097\times 10^{-2}\text{nm}^{-1}\right)\left(\frac{1}{n_1^{\,2}} - \frac{1}{n_2^{\,2}}\right) \quad ; \quad \Delta E = -2.178\times 10^{-18}\ \text{J}\left(\frac{1}{n_{\text{final}}^{\,2}} - \frac{1}{n_{\text{initial}}^{\,2}}\right)$$

h = 6.626 x 10–34 J•s (Planck's constant); Avogadro's number N = 6.022x10^{23}/mol

$KE_{electron} = h\nu - \Phi$, where Φ = work function.

Mean: $\bar{x} = \frac{\sum_i (x_i)}{n}$; Standard deviation(s): $s = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}}$

$$\text{Percent Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Beer's aw: $A = \varepsilon \cdot b \cdot c$

Molarity: $M = \frac{n}{V}$

Bond Order = (# bonding e$^-$ – # antibonding e$^-$)/2

Mass solute: $m_{\text{solute}} = V \times M \times \mathcal{M}$

Dilution equation: $V_{\text{initial}} \times M_{\text{initial}} = V_{\text{dilute}} \times M_{\text{dilute}}$

Potential energy (PE): PE = $m \times g \times h$
(m = mass; g = acceleration due to gravity; h = vertical distance)
Kinetic energy (KE): $KE = {}^1/_2 mu^2$ (m = mass; u = velocity)
Total energy = PE + KE

Electrostatic Potential Energy: $E_{el} \propto \frac{(Q_1 \times Q_2)}{d}$

Internal energy: $\Delta E = q + w = q - P\Delta V$

$\Delta H = \Delta E + P\Delta V$; $\Delta H_{rxn} = \frac{q_{rxn}}{\text{mol rxn}}$

Heat capacity: $q = C\,\Delta T$
Specific heat (c_s): $q = mc_s\Delta T$
Molar heat capacity (c_p): $q = nc_p\Delta T$
Phase change: $q = n\Delta H_{fus}$; $q = n\Delta H_{vap}$

Clapeyron Equation $\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ Gas constant: R = 8.314 J/(mol K) = 0.08206 atm L/(mol K)

$h = \frac{2T\cos\theta}{r\rho g}$ g = acceleration = 9.8 m/s^2; ρ is the density; T = surface tension; r = radius of the tube;

ϑ = contact angle between the liquid and the tube.

1 H 1.008																1 H 1.008	2 He 4.003
3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Ti 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Ha (268)	106 Sg (271)	107 Bh (272)	108 Hs (270)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

58 Ce 140.1	59 Pr 140.1	60 Nd 144.2	61 Pm 144.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lw (262)