EXAM B

CHEM 1A Winter 2021: 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. The formula for a terbium phosphate compound is $Tb_3(PO_4)_4$. What would be the formula for a terbium sulfate compound given that the charge of terbium is the same in both compounds?

a. $Tb_2(SO_3)_3$
b. $Tb(SO_4)_2$
c. $Tb(SO_3)_2$
d. $Tb_3(SO_4)_4$
e. $Tb(SO_4)_3$

____ 2. Identify the binary compound that has polar bond and is a radical.

a. H_2O
b. BO
c. CaF_2
d. N_2O
e. CO_2

____ 3. Name the following oxides of nitrogen in this sequence: NO, N_2O, NO_2, N_2O_4.

a. nitrox, dinitrox, nitridiox, dinitritetrox
b. mononitrogen monoxide, dinitrogen monoxide, mononitrogen dioxide, dinitrogen tetraoxide
c. nitrogen monoxide, dinitrogen monoxide, nitrogen dioxide, dinitrogen tetroxide
d. nitrogen oxide, nitrogen(II) oxide, nitrogen oxide(II), nitrogen(II) oxide(IV)
e. nitrous oxide, nitric oxide, nitrogen dioxide, nitrogen tetraoxide

____ 4. What is the formula for calcium nitride?

a. CaN
b. Ca_2N_3
c. Ca_2N
d. Ca_3N_2
e. CaN_2

____ 5. Which of the following is a possible set of quantum numbers for a 3*d* orbital?

a. $n = 3$, $\ell = 1$, $m_e = -1$
b. $n = 3$, $\ell = 0$, $m_e = 0$
c. $n = 3$, $\ell = 2$, $m_e = 3$
d. $n = 3$, $\ell = 2$, $m_e = 0$
e. $n = 3$, $\ell = 1$, $m_e = 2$

____ 6. Which combination of quantum numbers is possible for an atom with five orbitals in one subshell?

a. $n = 1$, $\ell = 0$
b. $n = 2$, $\ell = 2$
c. $n = 3$, $\ell = 2$
d. $n = 4$, $\ell = 4$
e. $n = 5$, $\ell = 0$

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____ 7. Buffer solutions that maintain certain levels of pH or acidity are widely used in biochemical experiments. One common buffer system uses sodium dihydrogenphosphate and sodium monohydrogenphosphate. What are the formulas of these two compounds?

a. $Na(HPO_4)$ and $Na(HPO_4)_2$
b. $Na_2(HPO_4)_2$ and $Na_2(HPO_4)$
c. $Na_2H_2PO_4$ and $NaHPO_4$
d. $NaPO_4$ and $NaHPO_4$
e. NaH_2PO_4 and Na_2HPO_4

____ 8. Aqua regia is a mixture of hydrochloric acid and nitric acid that is capable of dissolving gold. What are the formulas of these acids?

a. $HClO$, HNO_4
HCl, HNO_3
c. HCl, HNO_2
d. $HClO_4$, HNO_3
e. HCl, HNO

____ 9. Which one of the following ionic compounds has an *incorrect* formula or is *not* named correctly? Co and Cu are transition elements.

Cu_2S, copper(I) sulfide
b. Co_2O_3, cobalt(III) oxide
c. CoO_2, cobalt(IV) oxide
CoO, cobalt oxide
e. MgS, magnesium sulfide

____ 10. Which anion is *not* labeled correctly?

a. NO_2^- nitrite
b. SO_4^{2-} sulfate
c. Cl^- chloride
d. SO_3^{2-} sulfite
e. All are labeled correctly.

____ 11. Which of the following molecular ions has 3 valence electrons?

a. H_2^+
b. He_2^+
c. C_2^+
d. B_2^+
e. O_2^-

____ 12. Which of the following molecules does *not* contain a triple bond?

a. N_2
b. HCN
c. C_2H_2
d. SO_2
e. CO

____ 13. What is the ground state electron configuration for the most stable anion of sulfur?

a. $1s^22s^22p^4$
b. $1s^22s^22p^63s^23p^4$
c. $[He]2s^22p^4$
d. $[Ar]$
e. $1s^22s^22p^5$

____ 14. Compared with the atomic radius of oxygen, the atomic radius of sulfur is ____________

a. smaller because the n quantum number increases.
b. larger because the n quantum number increases.
c. smaller because the atomic number (nuclear charge) increases.
d. larger because the ℓ quantum number increases.
e. about the same because in both cases, the nuclear charge equals the number of electrons.

____ 15. Which statement provides the best description of an ionic bond?

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

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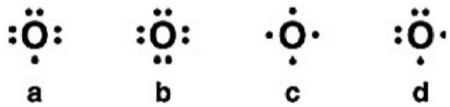
_____ 16. How many of these atoms or ions have no unpaired electrons?

Ti, N, Na^+, O^{2-}, N^{3-}

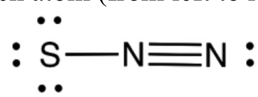
a. 1
b. 2
c. 3
d. 4
e. 5

_____ 17. Which of the following is the correct Lewis symbol for the oxide anion (O^{2-})?



a. **a**
b. **b**
c. **c**
d. **d**

_____ 18. What is the formal charge of each atom (from left to right) in the following resonance structure of SN_2?



a. 0, 0, 0
b. −1, +1, 0
c. −2, +1, 0
d. −2, −1, +1
e. −1, −1, +1

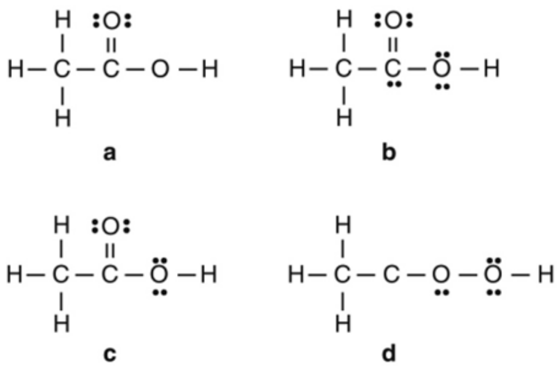
_____ 19. Which of the following is most likely a polar covalent bond?
a. Na—Cl
~~b. H—H~~
c. C—N
d. K—F
e. Mg—O

_____ 20. For the series methane, ammonia, and water, the bond angle increases in the following order: $H_2O < NH_3 < CH_4$. This trend is due to _________
a. a decreasing effective nuclear charge.
b. an increase in atomic radius.
c. a decrease in the number of lone pairs.
d. an increase in the polarity of the molecules.
e. an increasing effective nuclear charge.

_____ 21. How many lone-pair electrons are on each of the nitrogen atoms in the Lewis structure for dinitrogen tetroxide (N_2O_4)?
a. 3
b. 2
c. 4
d. 1
e. 0

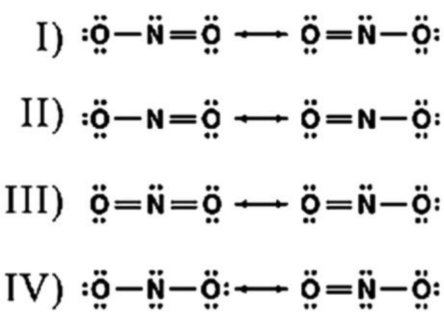
_____ 22. Which of the following compounds has a square pyramid geometry? Cl, Br and I are all halogens.
a. ICl_3
b. SiF_4
c. PCl_5
d. PH_3
e. BrF_5

____ 23. Vinegar is a solution of acetic acid (CH_3COOH) and water. Which of the following is the correct Lewis structure for acetic acid?



a. **a**
b. **b**
c. **c**
d. **d**

____ 24. Nitrite (NO_2^-) is an important nutrient in the eutrophic zone of the ocean. Which of the following is the correct set of resonance Lewis structures for this ion?



a. I
b. II
c. III
d. IV

____ 25. Which bond is the least polar?

a. H—O
b. H—N
c. H—Cl
d. H—B
~~e. H—F~~

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

Useful equation, constants and conversions:

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

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

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

$\frac{1}{\lambda} = (1.097\times10^{-2}\text{nm}^{-1})\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$; $\Delta E = -2.178\times10^{-18}\text{ J}\left(\frac{1}{n_{\text{final}}^2}-\frac{1}{n_{\text{initial}}^2}\right)$

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

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

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

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_{initial} x M_{initial} = V_{dilute} x M_{dilute}

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

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

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

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

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: $q = n\Delta H_{\text{fus}}$; $q = n\Delta H_{\text{vap}}$

Clapeyron Equation $\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{\text{vap}}}{R}\left(\frac{1}{T_1}-\frac{1}{T_2}\right)$ 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;

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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)