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CHEM 20 A. Fall 2016. **MIDTERM EXAM 1** Your Name: Simon Rufer

ID number: 804 806 731

Problem	Maximum number of points	Points earned
1	10	8
2	10	10
3	20	~~19~~ 19
4	20	16
5	20	16
6	20	20
Total	100	89

Please refrain from talking to each other, and using internet, or cell phones. You may use a calculator. All necessary constants are provided here, for your convenience. The exam consists of 5 pages and 6 problems. Make sure to CLEARLY write your name and ID number at the top of the front page.

Good luck!

Periodic Table of the Elements

Ground State Electron Configurations

http://chemistry.about.com
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About Chemistry

1A												3A	4A	5A	6A	7A	8A
1 H	2A																2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3B	4B	5B	6B	7B		8B		1B	2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo

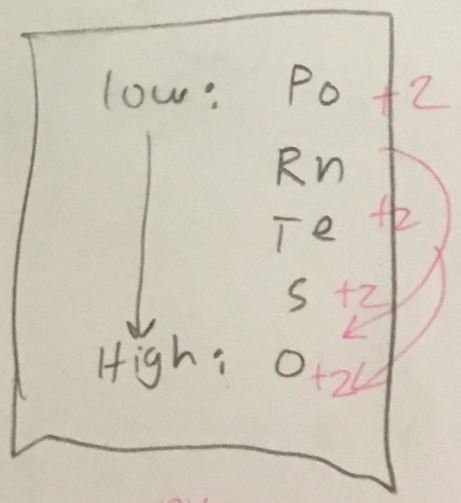
Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

* values are based on theory and are not verified

8/10

1. (10 points) Using only the Periodic Table arrange the following elements in order of increasing ionization energy: oxygen, sulfur, tellurium, polonium, and radon.

energy to take off an electron



either

Po Te S O Rn

or

Po Te S Rn O

2

10

2. (10 points) Using only the Periodic Table arrange the following elements in order of increasing electronegativity: N, Ti, Cs, Cl.

low EN : Cs
Ti
N
Cl
High EN:

19

3. (20 points) The HBr molecule in the gas phase has the experimentally measured dipole moment of 0.82 D, and the interatomic distance of 1.41 Å.

(i) Calculate the partial charges on atoms in HBr.

(ii) Calculate how ionic (in %) the H-Br bond is.

(iii) How covalent is the H-Br bond (in %)?

$$\mu = \delta q \cdot Re$$

$$(0.82D) \cdot (3.34 \times 10^{-30}\ C\,m/D) = \delta q \cdot (1.41 \times 10^{-10}\ m)$$

i) $\boxed{\delta q = \pm 1.9 \times 10^{-20}\ C}$ / $H^{\delta+} - Br^{\delta-}$ -1

$$\mu = \delta q \cdot Re$$

ii) theoretical $\mu = \dfrac{(1.602 \times 10^{-19} C) \cdot (1.41 \times 10^{-10}\ m)}{(3.34 \times 10^{-30})\ C\,m/D} = 6.76\ D$

% ionicity $= \dfrac{\text{actual } \mu}{\text{theoretical } \mu} = \dfrac{0.82D}{6.76D} = \boxed{12\%\ \text{ionic}}$ /

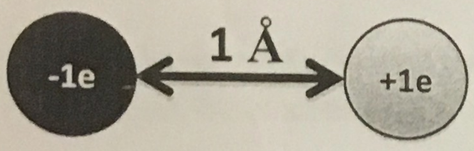
3

iii) % covalent = 1 − % ionic = 1 − .1213 = $\boxed{88\%\ \text{covalent}}$

16

4. (20 points) Consider the following configurations of point charges (in vacuum), and characterize them as bound (when the total Coulomb energy of the system is negative, which indicates attraction), unbound (repulsion), or non-bound (when there is no force acting on the atoms and the Coulomb energy is zero).

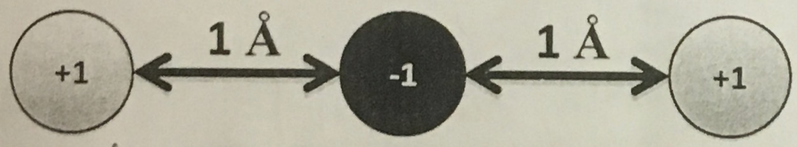
Hint: use the formula for the Coulomb energy: $V = q_1 q_2 / 4\pi\varepsilon_0 r$, and remember that it is additive, i.e. interaction between every possible pair of charges adds to the total Coulomb energy of the system.



$$V = \left(\frac{(-e)\cdot(+e)}{4\pi\ \varepsilon_0\ (1.0\times10^{-10}\ m)} \right) \cdot 2$$

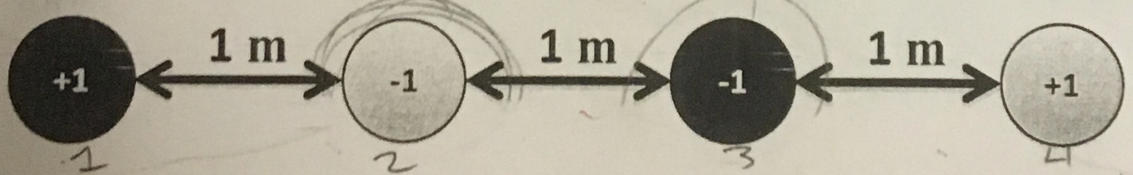
V is negative, configuration is bound ✓

$$V = \frac{-2e^2}{4\pi\varepsilon_0 (1.0\times10^{-10} m)}$$



$$V = \left(\frac{-(1.602\times10^{-19})(1.602\times10^{-19})}{4\pi\ \varepsilon_0\ (1.0\times10^{-10})} + \frac{(1.602\times10^{-19})(1.602\times10^{-19})}{4\pi\ \varepsilon_0\ (2.0\times10^{-10})} \right) \cdot 2$$

$V = -2.31\times10^{-14}$ V is negative, configuration is bound ✓



$$\sum V_1 = \frac{-e^2}{4\pi\varepsilon_0} + \frac{-e^2}{8\pi\varepsilon_0} + \frac{e^2}{12\pi\varepsilon_0} = (-.292)\left(\frac{e^2}{\pi\varepsilon_0}\right)$$

$$\sum V_2 = \frac{-e^2}{4\pi\varepsilon_0} + \frac{e^2}{4\pi\varepsilon_0} + \frac{-e^2}{8\pi\varepsilon_0} = \left(-\frac{1}{8}\right)\left(\frac{e^2}{\pi\varepsilon_0}\right)$$

$$\sum V_3 = \frac{-e^2}{4\pi\varepsilon_0} + \frac{e^2}{4\pi\varepsilon_0} + \frac{-e^2}{8\pi\varepsilon_0} = \left(-\frac{1}{8}\right)\left(\frac{e^2}{\pi\varepsilon_0}\right)$$

$$\sum V_4 = \frac{-e^2}{4\pi\varepsilon_0} + \frac{-e^2}{8\pi\varepsilon_0} + \frac{e^2}{12\pi\varepsilon_0} = (-.292)\left(\frac{e^2}{\pi\varepsilon_0}\right)$$

$$\sum V_x = (-.83)\left(\frac{e^2}{\pi\varepsilon_0}\right)$$

Because $\sum V_x$ is negative, the configuration is bound ✓

of Mathematics

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5. (20 points) How many H atoms would each of the following atoms would like to bind, in order to obey the octet rule:

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(i) I [1]

(ii) Al [5] 3 (like Boron)

(iii) He [0]

(iv) Te [2]

(v) H [1]

6. (20 points) Draw the Lewis structure for NO_2 molecule (it is a bent ONO structure). Does the N atom have a complete, overcomplete, or incomplete octet?

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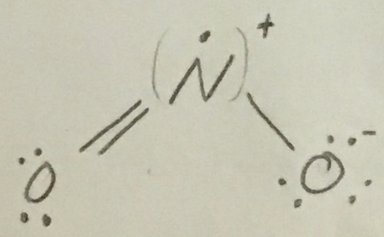

[incomplete octet]