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CHM 2353

Midterm 1

9-Oct-2012

Family name: _____

Given name: _____

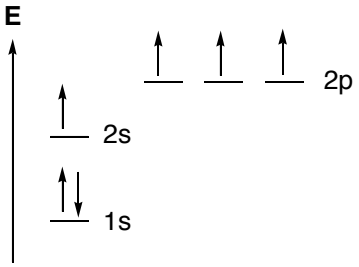
Student number _____

Midterm: 1h : 15min

Question	1	2	3	4	5	6	7	8	Total
Points	10	5	5	10	6	4	10	10	60
Remarks									

1) (10 points) a) A student draws the orbital energy diagram below to a carbon atom. This diagram does not follow one of the rules (circle one):

- UNCERTAINTY principle
- HUND's rule
- **AUFBAU principle**
- PAULI's principle of exclusion



b) Abbreviated electron configuration Mn^{II} cation is:

$[Ar]3d^5$

c) Family (or group) of elements ___***noble gas***_____ was not included in the original version of Mendeleev's periodic table because these elements were not discovered in 1871.

d) Of the following, which has the highest second ionization energy?

Mg Al **Na** Si

e) Distinguish between a mineral, an ore and a rock

Minerals – solid inorganic substances occurring in nature having a definite chemical composition and characteristic crystalline structure.

Ore: a mineral or rock containing a sufficiently high concentration of an element to constitute an economically feasible source from which the element can be recovered.

Rocks – contain mixtures of minerals in varying proportions

2) (5 pts) Complete and balance the following chemical reactions:

a) $Ca_3(PO_4)_2 + 2\ H_2SO_4 \rightarrow CaO\ (s) + CO_2\ (g)$

b) $CaCO_3\ (s) \xrightarrow{900^oC} CaO\ (s) + CO_2\ (g)$

c) $SO_3\ (g) + H_2O \rightarrow H_2SO_4\ (l)$

d) $S_8\ (s) + 8\ O_2\ (g) \rightarrow 8\ SO_2\ (g)$

e) How NaOH is prepared industrially?

$$2\ NaCl\ (aq) + 2\ H_2O\ (l) \xrightarrow{\text{electric current}} 2\ NaOH\ (aq) + Cl_2\ (g) + H_2\ (aq)$$

3) (5 points) a) What are the major characteristics of a metal

1.All except Hg are solid at room temperature
2.Most have a silvery shine
3.Can be easily shaped (malleable) and drawn (ductile)
4.Are good conductors of heat and electricity

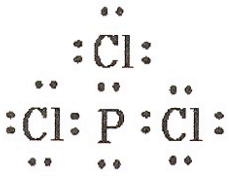
b) Which one, NaCl or NaI, would be expected to have higher melting point? Explain your reasoning.

NaCl, because Cl is smaller then iodine; the charge is more concentrated (charge density is higher) and the ionic attraction will be stronger in NaCl than in NaI. The stronger the ionic attraction, the higher the temperature needed to melt the ionic lattice.

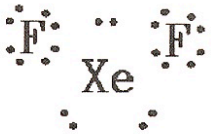
4) (10 points)
a) Construct electron-dot diagrams for:

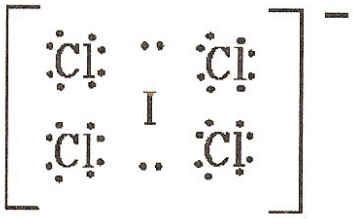
a) oxygen difluoride
b) phosphorus trichloride
c) xenon difluoride
d) ICl_4^-

(a)



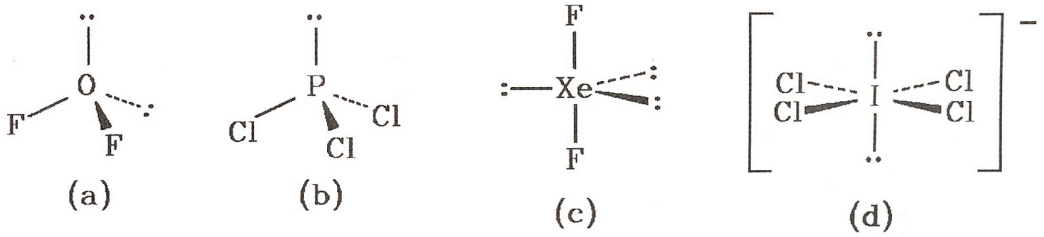
(b)





b) For each of the previous molecule in this question, determine the electron pair arrangement and the molecular shape according to the VSEPR theory.

a) tetrahedral, V-Shaped
b) tetrahedral, trigonal pyramidal
c) trigonal bipyramidal, linear
d) octahedral, square planar



c) For each of these polyatomic molecule in this question, determine if they are polar or non polar

a) polar
b) polar
c) non polar
d) non polar

5) (6 points) Which one of each of the following pairs will be smaller? Explain your reasoning in each case.

a) K or K^+
b) K^+ or Ca^{2+}
c) Br^- or Rb^+

(a) K^+, because the radius will be determined by the inner orbitals (2s and 2p) while the radius of K is determined by the 3s orbital.
(b) Ca^{2+}, because the ions are isoelectronic but calcium has one more proton, and hence a higher Z_{eff} and a smaller ionic radius.
(c) Rb^+, because again the ions are isoelectronic, and hence a higher Z_{eff} and smaller iconic radius.

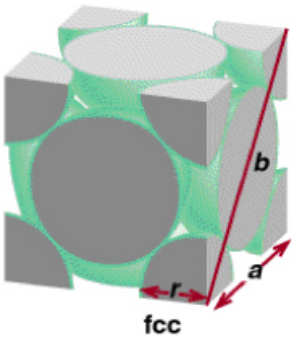
6) (4 points) For the elements Sodium and Magnesium, which has the higher first ionization energy? Second ionization energy? Third ionization energy

Election configuration: Na $1s^2\ 2s^2\ 2p^6\ 3s^1$; Mg = $1s^2\ 2s^2\ 2p^6\ 3s^2$. Because the 2s electrons of magnesium experience a higher effective nuclear charge than those of sodium, magnesium will have the higher first ionization energy. For sodium, the second electron to be removed will come from the inner 2p orbitals. Hence it will be sodium that has the higher second ionization energy. In both cases, the third electron to be removed will come from the 2p orbitals. The 2p electron of magnesium will experience the higher effective nuclear charge. Thus magnesium will have the higher third ionization energy.

7) (10 points) (this may not be covered in time for midterm 1)

a) In a face centered cubic unit cell, the atoms are usually touch across the diagonal of the face. If the atomic radius is r, calculate the length of each side of the unit cell. How many atoms are in a face centered cubic cell?

face-centered cubic



fcc

$b = 4r$

$b^2 = a^2 + a^2$

$16r^2 = 2a^2$

$a = \sqrt{8}r$

Four atoms in a face centered cubic cell

b) The atoms in silver metal are arranged in a face-centered cubic unit cell. Calculate the radius of a silver atom if the density of silver is 10.50g.cm^{-3}

A face-centered cubic unit cell contains four atoms.

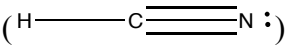
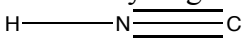
$$\text{Thus mass} = \frac{4 \times 107.9 \text{ g} \cdot \text{mol}^{-1}}{6.02 \times 10^{23} \text{ mol}^{-1}} = 7.17 \times 10^{-22} \text{ g}$$

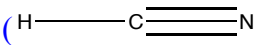
$$\text{Volume} = \frac{7.17 \times 10^{-22} \text{ g}}{10.50 \text{ g} \cdot \text{cm}^{-3}} = 6.83 \times 10^{-23} \text{ cm}^3 = 6.83 \times 10^{7} \text{ pm}^3$$

Length of side $= \sqrt[3]{(6.83 \times 10^{7} \text{ pm}^3)} = 409$ pm

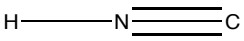
Using the result from 4.17, radius of silver atom = (409 pm)/(2.83) = 145 pm.

8) (10 points) Which is the most stable form? Explain why.

a) Which isomer is more stable? Hydrogen Cyanide () or hydrogen isocyanide ()

Use formal charges: Hydrogen Cyanide ()

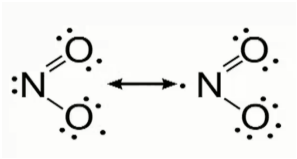
Formal charge on C=0; on N= 0

Whereas in the case of hydrogen isocyanide ():

Formal charge on C=1; on N= +1

Therefore Hydrogen Cyanide would be the sable form

b) Which resonance structure is more stable?



Structure on the left has one unpaired electron on the oxygen whereas the structure on the right contain one unpaired electron on the nitrogen.

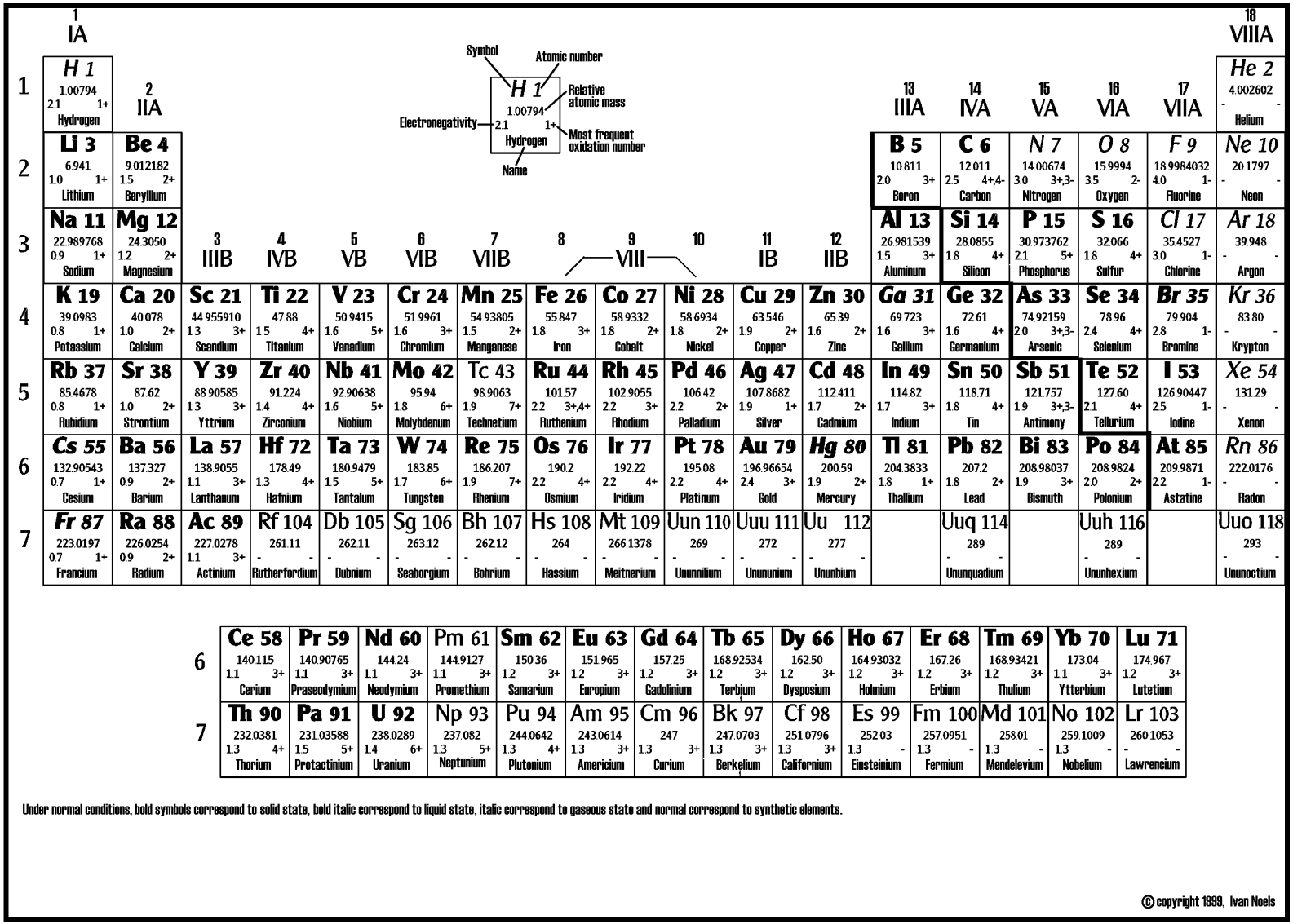
Structure on the left: formal charges are zero on each atom

Structure on the right: nitrogen has +1 as formal charge

Oxygen with two lone pairs has a formal charge of 0

Oxygen with three lone pairs has a formal charge of -1

Therefore structure on the left be more stable and will contribute more towards the resonance structure.


1 IA
18 VIIIA
2 IIA
13 IIIA
14 IVA
15 VA
16 VIA
17 VIIA
3 IIIB
4 IVB
5 VB
6 VIB
7 VIIB
8
9 VIII
10
11 IB
12 IIB
Symbol
Atomic number
Relative atomic mass
Electronegativity
Most frequent oxidation number
Name
H 1
1.00794
2.1
1+
Hydrogen
He 2
4.002602
Helium
Li 3
6.941
1.0
1+
Lithium
Be 4
9.012182
1.5
2+
Beryllium
B 5
10.811
2.0
3+
Boron
C 6
12.011
2.5
4+,4-
Carbon
N 7
14.00674
3.0
3+,3-
Nitrogen
O 8
15.9994
3.5
2-
Oxygen
F 9
18.9984032
4.0
1-
Fluorine
Ne 10
20.1797
Neon
Na 11
22.989768
0.9
1+
Sodium
Mg 12
24.3050
1.2
2+
Magnesium
Al 13
26.981539
1.5
3+
Aluminum
Si 14
28.0855
1.8
4+
Silicon
P 15
30.973762
2.1
5+
Phosphorus
S 16
32.066
1.8
4+
Sulfur
Cl 17
35.4527
3.0
1-
Chlorine
Ar 18
39.948
Argon
K 19
39.0983
0.8
1+
Potassium
Ca 20
40.078
1.0
2+
Calcium
Sc 21
44.955910
1.3
3+
Scandium
Ti 22
47.88
1.5
4+
Titanium
V 23
50.9415
1.6
5+
Vanadium
Cr 24
51.9961
1.6
3+
Chromium
Mn 25
54.93805
1.5
2+
Manganese
Fe 26
55.847
1.8
3+
Iron
Co 27
58.9332
1.8
2+
Cobalt
Ni 28
58.6934
1.8
2+
Nickel
Cu 29
63.546
1.9
2+
Copper
Zn 30
65.39
1.6
2+
Zinc
Ga 31
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1.6
3+
Gallium
Ge 32
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1.6
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Germanium
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Arsenic
Se 34
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2.4
4+
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Br 35
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2.8
1-
Bromine
Kr 36
83.80
Krypton
Rb 37
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0.8
1+
Rubidium
Sr 38
87.62
1.0
2+
Strontium
Y 39
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1.3
3+
Yttrium
Zr 40
91.224
1.4
4+
Zirconium
Nb 41
92.90638
1.6
5+
Niobium
Mo 42
95.94
1.8
6+
Molybdenum
Tc 43
98.9063
1.9
7+
Technetium
Ru 44
101.57
2.2
3+,4+
Ruthenium
Rh 45
102.9055
2.2
3+
Rhodium
Pd 46
106.42
2.2
2+
Palladium
Ag 47
107.8682
1.9
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Cd 48
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In 49
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1.7
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Indium
Sn 50
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Tin
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1.9
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Antimony
Te 52
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2.1
4+
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Xe 54
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W 74
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Tungsten
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1.9
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Rhenium
Os 76
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2.2
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Osmium
Ir 77
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2.2
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Hg 80
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1.9
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Tl 81
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Thallium
Pb 82
207.2
1.8
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Lead
Bi 83
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1.9
3+
Bismuth
Po 84
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2.0
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Polonium
At 85
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1-
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Radon
Fr 87
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Francium
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0.9
2+
Radium
Ac 89
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1.1
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Rf 104
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Db 105
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Dubnium
Sg 106
263.12
Seaborgium
Bh 107
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Bohrium
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Mt 109
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Uun 110
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Uuu 111
272
Unununium
Uu 112
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Ununbium
Uuq 114
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Ununquadium
Uuh 116
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Ununhexium
Uuo 118
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Ununoctium
Ce 58
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Cerium
Pr 59
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3+
Praseodymium
Nd 60
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1.2
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Curium
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1.3
3+
Berkelium
Cf 98
251.0796
1.3
3+
Californium
Es 99
252.03
1.3
-
Einsteinium
Fm 100
257.0951
1.3
-
Fermium
Md 101
258.01
1.3
-
Mendelevium
No 102
259.1009
1.3
-
Nobelium
Lr 103
260.1053
-
-
Lawrencium
6
7
Under normal conditions, bold symbols correspond to solid state, bold italic correspond to liquid state, italic correspond to gaseous state and normal correspond to synthetic elements.
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