CHEM 1054 Exam 2. ~~Due Friday~~
Name Key

I affirm that I have neither given nor received unauthorized aid on this assignment.

Useful information: Formal Charge = $E_{valence} - (E_{nonbonding} + \#_{bonds})$, $\lambda\nu = c$, c= 3.00 x 10^8 m/s, $E=h\nu$ $\lambda = \frac{h}{mv}$, $\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$, R_H = 0.01097 nm^{-1}, 1 Hz = 1/s, h=6.626 x 10^{-34} Js,

(1)(4 points) How much $CaCl_2$ (in g) is in a 375 mL of 0.100 M $CaCl_2$ solution?

$(0.375L)\left(\frac{0.100 moles}{L}\right) = 0.0375$ moles $CaCl_2$ FW = 110.98 g/mol

$(0.0375 moles)(110.98 \frac{g}{mole}) = \boxed{4.16 g}$

(2)(4 points) A 0.500 M solution, 20.0 L in size needs to be prepared from a 14.5 M stock solution. How would you do this?

$\left(\frac{0.500 moles}{L}\right)(20.0L) = 10.0$ moles

$\frac{10.0 moles}{14.5 \frac{moles}{L}} = 0.690 L$ of 14.5 M stock solution

(3)(6 points) $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$

(a) A 25.00 mL solution of H_3PO_4 was titrated with 15.55 mL of 0.1000 M NaOH. What is the concentration of the H_3PO_4 solution?

$\left(\frac{0.1000 moles}{L}\right)(0.01555L) = 1.555 \times 10^{-3}$ moles NaOH

$(1.555 \times 10^{-3} moles NaOH)\left(\frac{1 mole H_3PO_4}{3 moles NaOH}\right) = 5.183 \times 10^{-4}$ moles H_3PO_4

$\frac{5.183 \times 10^{-4} moles}{0.0250 L} = \boxed{2.073 \times 10^{-2} M}$

(b) What mass of H_3PO_4 is in 1.00 L of solution?

2.073×10^{-2} mole x 98.00 g/mol = $\boxed{2.032 g}$

(4)(4 points) Define the following

(a) the Pauli Exclusion Principle

No 2 electrons in the same atom can have the same set of 4 quantum numbers

(b) the Aufbau Principle Fill electrons from the lowest energy orbital to highest energy.

(5)(4 points) List the four quantum numbers for an electron and the name of the quantum number

n principal

ℓ angular momentum

m_ℓ magnetic

m_s spin

(6)(3 points) List the possible quantum numbers for the following orbitals (may be a range for some quantum numbers)

(a) 3s $n=3$ $\ell=0$ $m_\ell=0$, $m_s=\pm\frac{1}{2}$

(b) 5p $n=5$ $\ell=1$ $m_\ell=-1, 0, \text{or } 1$ $m_s=\pm\frac{1}{2}$

(c) 4d $n=4$ $\ell=2$ $m_\ell=-2,-1,0,1,2$ $m_s=\pm\frac{1}{2}$

(7)(4 points) Write out the ground state electron configuration for the following atoms or ions (do not use the noble gas shortcut)

(a) O $1s^2 2s^2 2p^4$

(b) S^{2-} $1s^2 2s^2 2p^6 3s^2 3p^6$

(c) Na^+ $1s^2 2s^2 2p^6$

(d) Br $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

(8)(2 points) Label each of the following as a ground state, an excited state, or an impossible electron configuration

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ground state

(b) $1s^2 2s^2 2p^6 3s^1 3p^2$ excited state

(9)(2 points) Which of the following should have the largest first ionization energy?

Al, Sc, O, C, K O

(10) (2 points) Place the following in order of increasing electronegativity

K, F, Li, O, Cs Cs, K, Li, O, F

(11)(4 pts) Certain ham radio's are called '10 meter rigs'. This refers to a wavelength of 10 meters. What is the frequency of the radio?

$\lambda \nu = c$

$(10\,m)\,\nu = 3.00 \times 10^8\ m/s$

$\nu = \frac{3.00 \times 10^8\ m/s}{10\,m} = 3.00 \times 10^7\ 1/s = 30\ MHz$

(12_3)(2 pts) How do we know that light is composed of particles called photons?

Einstein found that it was when investigating the photoelectric effect.

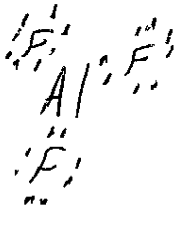
(13)(4 points) What wavelength of light is emitted when and electron falls from the n=6 level to the n=3 level of a hydrogen atom?

$\frac{1}{\lambda} = 0.01097 \frac{1}{nm}\left(\frac{1}{3^2} - \frac{1}{6^2}\right) = 9.14 \times 10^{-4} \frac{1}{nm}$ $\boxed{\lambda = 1093\ nm}$

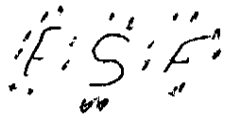
(14)(9 points) Draw the best Lewis Dot Structure for each of the following species.

(a) AlF_3

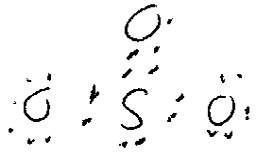
Al 3e⁻
3F 21e⁻
24e⁻



(b) SF_2 S 6e⁻
2F 14e⁻
20e⁻

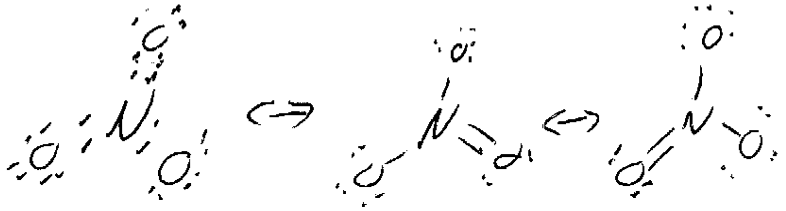


(c) SO_3^{2-} S 6e⁻
3O 18e⁻
−2 2e⁻
26e⁻



(Extra Credit) (4 points) Draw the best Lewis Dot Structure and all resonance contributors for NO_3^-

N 5e⁻
3O 18e⁻
−1 1e⁻
24e⁻



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(1)(4 points) How much $CaCl_2$ (in g) is in a 37.5 mL of 0.100 M $CaCl_2$ solution?

$(0.0375\,L)\left(\frac{0.100\,mole}{L}\right) = 3.75\times10^{-3}\,moles\ CaCl_2$ $CaCl_2$ FM = 110.98 g/mole

$(3.73\times10^{-3}\,mole)(110.98\,g/mole) = 0.416\,g$

(2)(4 points) A 0.500 M solution, 2.00 L in size needs to be prepared from a 14.5 M stock solution. How would you do this?

$\left(\frac{0.500\,mole}{L}\right)(2.00\,L) = 1.00\,mole$ ∴ 69.0 mL of 14.5 M stock needed

$\frac{1.00\,mole}{14.5\,mole/L} = 0.0690\,L$

(3)(6 points) $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$

(a) A 25.00 mL solution of H_3PO_4 was titrated with 15.55 mL of 0.0100 M NaOH. What is the concentration of the H_3PO_4 solution?

$(0.01555\,L)(0.0100\,M) = 1.56\times10^{-4}\,moles\ NaOH$

$1.56\times10^{-4}\,moles\ NaOH \times \frac{1\,mole\ H_3PO_4}{3\,moles\ NaOH} = 5.18\times10^{-5}\,moles\ H_3PO_4$

$\frac{5.18\times10^{-5}\,moles}{0.0250\,L} = 2.07\times10^{-3}\,M$

(b) What mass of H_3PO_4 is in 1.00 L of solution?

$2.07\times10^{-3}\,moles \times 98.00\,g/mole = 0.203\,g$

(4)(4 points) Define the following

(a) the Pauli Exclusion Principle

(b) the Aufbau Principle

(5)(4 points) List the four quantum numbers for an electron and the name of the quantum number

n principal

ℓ angular momentum

m_ℓ magnetic

m_s spin

(6)(3 points) List the possible quantum numbers for the following orbitals (may be a range for some quantum numbers)

(a) 3p $n=3$ $\ell=1$ $m_\ell = -1, 0, \text{or } 1$ $m_s = \pm\frac{1}{2}$

(b) 5s $n=5$ $\ell=0$ $m_\ell=0$ $m_s = \pm\frac{1}{2}$

(c) 4d $n=4$ $\ell=2$ $m_\ell = -2, -1, 0, 1, \text{or } 2$ $m_s = \pm\frac{1}{2}$

(7)(4 points) Write out the ground state electron configuration for the following atoms or ions (do not use the noble gas shortcut)

(a) O^{2-} $1s^2 2s^2 2p^6$

(b) S $1s^2 2s^2 2p^6 3s^2 3p^4$

(c) Na $1s^2 2s^2 2p^6 3s^1$

(d) Br^- $1s^2 2s^2 2p^6 3s^1 3p^6 4s^2 3d^{10} 4p^6$

(8)(2 points) Label each of the following as a ground state, an excited state, or an impossible electron configuration

(a) $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$ excited state

(b) $1s^2 2s^2 2p^6 3s^2 3p^2$ ground state

(9)(2 points) Place the following elements in order from smallest to largest atomic radii.

Al, Sc, O, C, K O, C, Al, K, Sc

(10) (2 points) Place the following in order of increasing electronegativity

K, F, Li, O, Cs

Li

Cs, K, Li, O, F

(11)(4 pts) Certain ham radio's are called '2 meter rigs'. This refers to a wavelength of 2 meters. What is the frequency of the radio?

$\lambda \nu = c$

$2m\ \nu = 3.00 \times 10^8 \frac{m}{s}$

$\nu = \frac{3.00 \times 10^8 \frac{m}{s}}{2m} = 1.5 \times 10^8 \frac{m}{s} = 150 MHz$

(12)(2 pts) How do we know that light is composed of particles called photons?

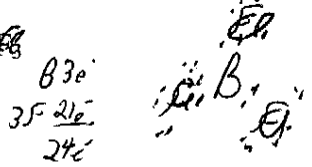
Einstein found this when investigating the photoelectric effect.

(13) (4 points) What wavelength of light is emitted when and electron falls from the n=6 level to the n=1 level of a hydrogen atom?

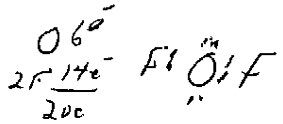
$\frac{1}{\lambda} = 0.01097\,nm^{-1}\left(\frac{1}{1^2} - \frac{1}{6^2}\right) = 0.01066\,nm^{-1}$ $\lambda = 938\,nm$

(14)(9 points) Draw the best Lewis Dot Structure for each of the following species.

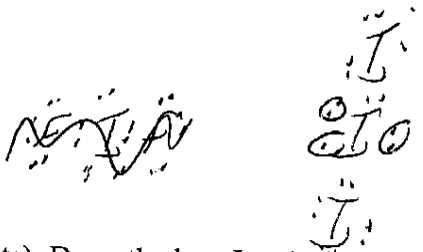
(a) BF_3



(b) OF_2



(c) I_3^-



(Extra Credit) (4 points) Draw the best Lewis Dot Structure and all resonance contributors for NO_3^-