Chemistry 20-A
Dr. E.R. Scerri
Mid Term Exam
November, 2014

50 minutes

PROBLEM	SCORE	Max Score
1	14	14
2	6	12
3	16	16
4	9	12
total	45	54

(**Last name** first) Mortel Dominic

Signature DMortel

ID # 904 287 174

Name _____

Instructions: **This exam has 4 questions plus a periodic table at end of exam. Verify you have the right number of pages before you begin. Different questions carry different numbers of points. Write your name on each page.** Raise your hand if you don't understand a question. **SHOW YOUR WORK!** No credit will be given for an unsubstantiated or illegible answer. Write legibly, use proper units throughout and use significant figures in all answers. Good luck!

Possibly useful information:

12 inches = 1 foot, 2.54 cm = 1 inch.

$h = 6.63 \times 10^{-34}$ J sec $N_o = 6.02 \times 10^{23}$ mol^{-1} $c = 3.00 \times 10^{8}$ m sec^{-1}

$m_e = 9.11 \times 10^{-31}$ kg 1 a.m.u. $= 1.66 \times 10^{-27}$ kg 1 Å $= 10^{-10}$ m

$g = 9.81$ m/s 1 eV $= 1.602 \times 10^{-19}$ J

$V_{electrostatic}(r) \propto Q_1Q_2/r$; K.E. $= 1/2mv^2 = p^2/2m$

$F = -\Delta V/\Delta r$ $\lambda\nu = c$ $\Delta E = E_f - E_i = \varepsilon_{photon} = h\nu$ $h\nu = h\nu_o +$ K. E.(electron)

$\lambda_{mass} = \frac{h}{mv} = \frac{h}{p}$ $\Delta p \Delta x \geq \frac{h}{4\pi}$

Probability density $= |\Psi_n(r)|^2$

$E_n = -(2.18 \times 10^{-18}\text{ J})\, Z^2/n^2$

$r_n = (0.529\text{ Å})n^2/Z_{eff}$

$n - \ell - 1$ spherical (radial) nodes; ℓ angular nodes; $n - 1$ total nodes

Bond order = (# bonding e- - # antibonding e-)/2

Spectrochemical series (abbreviated) $Cl^- > F^- > H_2O > NH_3 > en > CN^-$

Name _____

1. Consider the following unbalanced equation

$$4\ (NH_4)_3PO_4 + 3\ Pb(NO_3)_4 \rightarrow Pb_3(PO_4)_4 + 12\ NH_4NO_3$$

Assume that 40.0 g of $(NH_4)_3PO_4$ are reacted with 25.0 g of $Pb(NO_3)_4$.

How many grams of NH_4NO_3 will be produced assuming that the yield for the reaction is 68% ? Assume the following approximate molecular masses for the four substances in the above reaction, from left to right, 149, 455, 991 and 80 amu. (10 points)

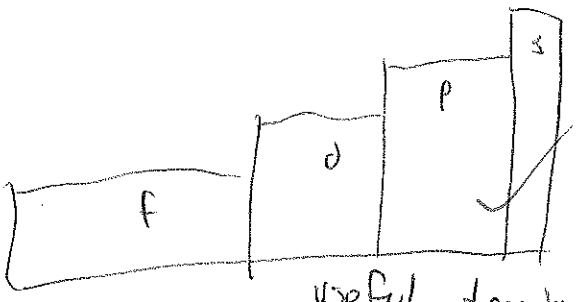
$40.0\text{ g } (NH_4)_3PO_4 \left| \frac{1\text{ mol}}{149\text{ g}} \right| \frac{12\text{ mol}}{4\text{ mol}} = .805\text{ mol}$ ✓ 10/10

limiting reagent

$25.0\text{ g } Pb(NO_3)_4 \left| \frac{1\text{ mol}}{455\text{ g}} \right| \frac{12\text{ mol}}{3\text{ mol}} = .220\text{ mol } NH_4NO_3 \left| \frac{80}{1\text{ mol}} \right| = 17.6\text{ g} \times .68$

$= 12.0\text{ g } NH_4NO_3$ ✓

1(b) Sketch a left-step periodic table and mention it's possible advantages and disadvantages (4)



This table can easily show which atoms ~~[illegible]~~ have valence e⁻ in each orbital, however it doesn't show useful trends like orbital radius or ionization energy, like the middle-long form can. It also doesn't help to see the # of valence e⁻ of each atom

4/4 ✓ ✓ ✓ 3

Name _____

2(a). In quantum mechanics the operator for linear momentum in the x direction is given by

$$p_x = -i\hbar\,(\partial / \partial x)$$

Use this formula to write an expression for the part of the Hamiltonian that corresponds to the kinetic energy of a particle moving in the x direction. Show each step you take. (As you may recall, the Hamiltonian is the operator H which acts on the wavefunction to give the total energy times the wavefunction or; $H\psi = E\psi$). (4 points)

$KE = \frac{1}{2}mv^2$ $\quad mv = p$ $\quad KE = \frac{1}{2}pv$ $\quad v = \frac{\partial}{\partial x}$ $\quad \hbar = \frac{h}{2\pi}$

$H = -\frac{i}{2}\hbar v \frac{\partial}{\partial x}$

$= -\frac{i\hbar}{2}\frac{\partial^2}{\partial x^2}$ $\quad \frac{-i\hbar}{4\pi}\frac{\partial^2}{\partial x^2} = \frac{n}{1}$

+2

and ☹ v is actually $\frac{\partial x}{\partial t}$

2(b). Explain and show mathematically why the following expression,

$$\psi(x) = A \sin kx$$

is a possible solution to the Schrödinger equation for a particle moving in a 1-D box. The Schrödinger equation for this system is,

$$\partial^2 / \partial x^2 (\psi(x)) = -[(8\pi^2 mE)/h^2]\,\psi(x) \qquad (4 \text{ points})$$

$\frac{\partial}{\partial x}$ $\quad \frac{\partial^2}{\partial x^2}$

$\psi(x) = A\sin(kx)$

$\psi'(x) = kA\cos(kx)$

$\psi''(x) = k^2 A \sin(kx)$

it fulfills the equation because the second derivative of the function is itself $\sin(kx)$

+4

2(c). If the kinetic energy of an electron is known to lie between 1.59×10^{-19} J and 1.61×10^{-19} J what is the smallest distance within which it can be known to lie (4 points)

$\lambda = \frac{h}{mv}$ $\quad KE = \frac{1}{2}m_e v^2$ $\quad \frac{2KE}{v_1} = m_e v$ $\quad v_1 = \sqrt{\frac{2KE}{m_e}} = 591000$ m/s

$\lambda_1 = \frac{h}{m_e v_1} = 1.23$ nm

$v_2 =$

$\lambda_2 = \frac{h}{m_e v_2} = 1.22$ nm

1.23
−1.22
.01 nm

Name _____

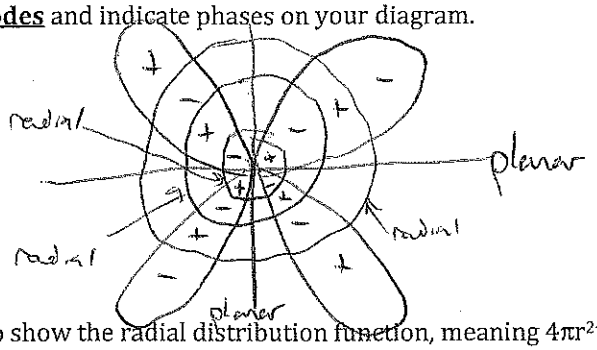
0 1 2 3
s p d f

3(a). How many planar nodes and radial nodes are present in any 6d orbitals? (2)

Planar 2 Radial 3

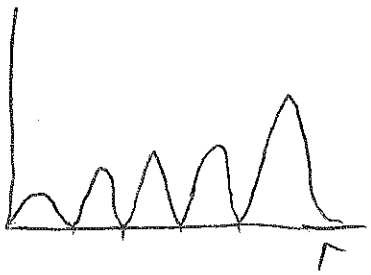
5 total
2 planar
3 radial

Draw **all the nodes** and indicate phases on your diagram. (3)



3(b). Draw a graph to show the radial distribution function, meaning $4\pi r^2\psi^2$ versus r, for a 5s orbital. (3)

$4\pi r^2\psi^2$



3

3(c). What is the wavelength of a spectral line due to a transition between the n = 3 and = 7 levels of an ion of O^{+7}? (4)

$$E = -R_\infty(8^2)\left(\frac{1}{9} - \frac{1}{49}\right) = \frac{hc}{\lambda} = 1.26\times10^{-17}\,J$$

$$= \quad 15.7\,nm$$

4

3(d) Explain why ionization energy shows a decrease between the following elements, (4)

(i) arsenic & selenium

Arsenic has a p orbital with 3 electrons one in each subleval, adding another to get selenium puts two e^- into one subleval increasing e^-e^- repulsion, decreasing energy

2

(ii) magnesium to aluminum

one e^- ~~more than~~ magnesium will create a new p shell and so elements in the same group as Al only have one e^- in outer shell which has lower ionization energy compared to the full s shell of Mg

2

Name _____

9/12

Each part is worth 2 points.

4(a). Why is it strictly incorrect to write the configuration of manganese as [Ar] $4s^2\ 3d^5$?

+2 For manganese, the 3d orbital is lower energy than 4s.

4(b). What is the configuration of the Cu^+ ion ?

+2 $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ (loses 4s)

4(c). What connection, if any, is there between the answer to 4b and part 4a ?

For Cu^+, it lost the 4s electron because it was higher energy
+2 than 3d, when you ionize you take away the outermost e^-
which is why Mn should be $[Ar]3d^5 4s^2$ to show it loses 4s e's first

4(d). Why is the configuration of potassium [Ar] $4s^1$ rather than [Ar] $3d^1$?

For potassium, the 4s orbital is lower energy
+2 than the 3d orbital so following Aufbau it goes into 4s first

4(f). What is unique about the configuration of the palladium atom (Pd) ?

+1 It skips the 5s orbital completely. IDK!!!

4(g). Explain why the atom of yttrium (Y) can show greater stability by adopting a configuration of [Kr] $4d^1 5s^2$ rather than [Kr] $4d^3$?

+0 The full 5s shell is less unstable compared
to having 3 out of 10 in the d shell.