Chem 14A-2 Su2021 90 MINUTES
Exam 1

Honor Statement:

On my honor and character, I confirm that I am adhering to all academic codes of conduct. This includes, but not limited to: not consulting with any other students or individuals during the exam time, not using any other websites/textbooks besides the ebook and CCLE, not using any apps/communication platforms whatsoever.

Sign here:

Have a scientific calculator ready to go!!!

**FOR ALL CONSTANTS AND ATOMIC MASSES, USE ONLY the 6th or 7th edition of Atkins, Jones and Laverman.**

FOR CALCULATION QUESTIONS, SHOW ALL OF YOUR WORK. IF NO WORK IS PROVIDED, NO CREDIT WILL BE PROVIDED.

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Exam 1

1. Aluminum reacts with chlorine gas to form aluminum chloride: (12 pts)

   $2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$

   0.235 g Al reacts with 1.15 g $Cl_2$. How much product is expected to form? Report your answer in grams to the correct number of significant figures. SHOW YOUR WORK.

   1.15 g $Cl_2$ x (1mol $Cl_2$ / 70.90 g $Cl_2$) x (2 mol $AlCl_3$ / 3 mol $Cl_2$) = 0.0108 mol $AlCl_3$

   0.235 g Al x (1mol Al / 26.98 g Al) = 0.00871 mol Al = 0.00871 mol AlCl3 since 1:1 mole ratio Al: $AlCl_3$

   Therefore, Al is the limiting reactant.

   0.00871 mol AlCl3 x (133.33 g AlCl3/ 1 mol AlCl3 ) = 1.16 g $AlCl_3$

2. Find the velocity (in m/s) of an electron emitted by a metal whose threshold frequency is $2.25 \times 10^{14}\ s^{-1}$ when it is exposed to visible light of wavelength 514.5 nm. Report your answer to the correct number of significant figures. SHOW YOUR WORK.

(16 pts)

Threshold energy $h\nu = 1.491 \times 10^{-19}$ J

Incident energy = $hc/\lambda = 3.648 \times 10^{-19}$ J

$\frac{1}{2} mv^2 = 3.648 \times 10^{-19}\ J - 1.491 \times 10^{-19}\ J = 2.157 \times 10^{-19}\ J$

$v^2 = 4.736 \times 10^{11}\ m^2/s^2$

$v = 6.88 \times 10^5$ m/s – $7.22 \times 10^5$ m/s range accepted

3. Suppose that in an alternate universe, the possible values of $\ell$ were the integer values from 0 to *n*. Assuming no other differences from this universe, how many orbitals would exist in each of the following levels? Enter your number in the box below each part. (12 pts total, 4 pts each)
   a) $n = 1$ b) $n = 2$ c) $n = 3$

| | | |
|---|---|---|
| 4 | 9 | 16 |

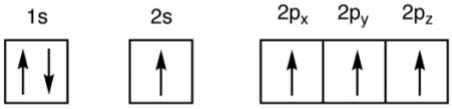
| | Our universe | alternate universe |
|---|---|---|
| n = 1 | $\ell = 0$ | $\ell = 0, 1$ |
| n = 2 | $\ell = 0,1$ | $\ell = 0,1,2$ |
| n = 3 | $\ell = 0,1,2$ | $\ell = 0,1,2,3$ |
| n = 4 | $\ell = 0,1,2,3$ | $\ell$ l = 0,1,2,3,4 |

4. Rank the following chemical species by size. Use a "1" for the largest, a "2" for the second largest…all the way to a "5" for the smallest. (10 pts)

| Cs | $Se^{2-}$ | Kr | Sr | $Rb^{1+}$ |
|---|---|---|---|---|
| 1 | 3 | 4 | 2 | 5 |

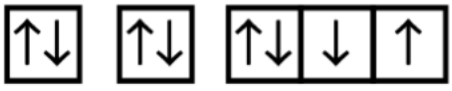
5. Place an "X" in the box next to each configuration that resembles an excited state.
   (16 pts total, 4 pts each)

$1s^2 2s^2 2p^6 3s^2 3p^5 4s^2$ [ ]




[ ] X

$[Ar]4s^2 3d^{10} 4p^3$ [ ]



[ ] X

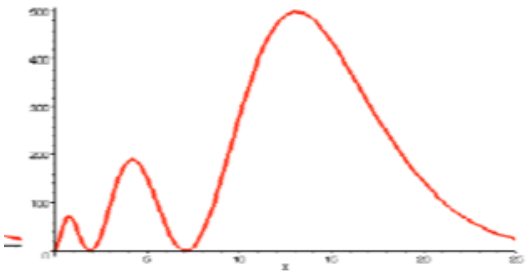
6. An electron in the *n* = 7 level of the hydrogen atom relaxes to a lower energy level, emitting 397 nm light. What is the value of *n* to which the electron relaxed? SHOW YOUR WORK.

(12 pts)

$\nu = R(1/n_1^2 - 1/n_2^2) = c/\lambda = 7.552 \times 10^{14}$ Hz

$n_1 = 2$

7. Consider the following radial distribution function. (10 pts total)



Place an "X" in the box underneath each atomic orbital whose radial distribution function ***may*** match what is shown above. Ignore the numbers on the x and y axes.

| 1s | 2s | 3s | 4s |
|---|---|---|---|
| ☐ | ☐ | X | ☐ |

| 4p | 4d | 5s | 5p |
|---|---|---|---|
| X | ☐ | ☐ | ☐ |

| 5d | 5f |
|---|---|
| X | ☐ |

8. Consider the following data: (12 pts)

   $1^{st}$ ionization energy of calcium = 590 kJ/mol
   $1^{st}$ ionization energy of gallium = 577 kJ/mol

   Explain why this difference is not what is predicted by periodic trends. Do not just give a positional answer (zero points)!

   Calcium has a higher IE than gallium. The reason lies in electron configuration.

   Ca = $[Ar]4s^2$

   Ga = $[Ar]4s^2 3d^{10} 4p^1$

   Gallium's outermost electron is $4p^1$. Calcium's is $4s^2$. Calcium's electron-electron repulsion is outweighed by the higher energy level of a 4p subshell. Because of this, the 4p electron is slightly easier to remove.