Chem 105 Exam 1

Name _____

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This exam is schedule for 75 minutes and I anticipate it to take the full time allotted. You are free to leave if you finish.

In multiple part problems, points awarded will not be penalized for incorrect answer on previous parts, so simply **move on if you get stuck on one part**.

Always neatly show work for partial credit.

Completely stuck on a problem, you can "buy" hints for points.

1. Identify the SI Units for each of the following:

Area of a circle → m^2

Density → kg/m^3

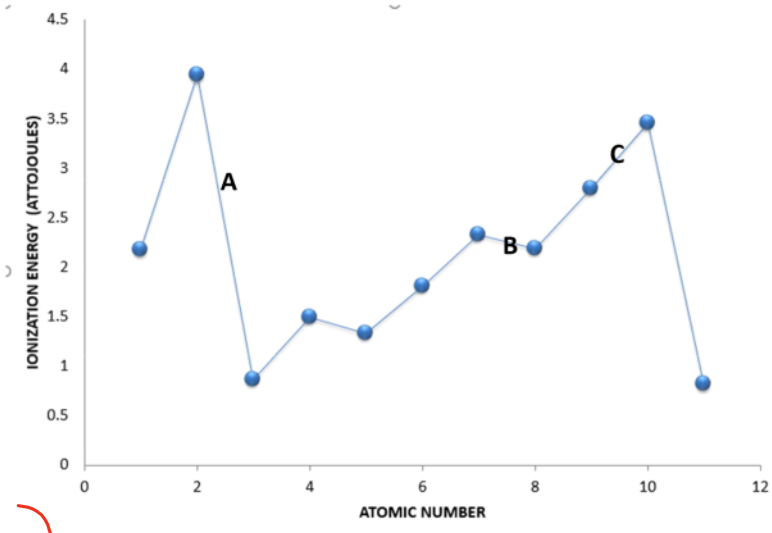
Frequency → s^{-1} or Hz

Temperature → K

2. As atoms increase in size, A increases more quickly than Z. Explain why.

mass # = protons + neutrons ↑ only protons ↑

3. Consider the ionization energies observed to the right. How can you justify the changes seen in A, B, and C.



A: follows Coulomb's law
- moving to shell 2 increases radius

B. opposes general trend
- explained with e⁻ configs → creating favorable e⁻ config is good. destroying stable config = bad

N: $1s^2 2s^2 2p^3 \rightarrow 1s^2 2s^2 2p^2$
stable → unstable

O: $1s^2 2s^2 2p^4 \rightarrow 1s^2 2s^2 2p^3$
unstable → stable

C. follows expected trend → increasing Z means increasing E.

4. What is meant by particle-wave duality and why is it important? Be specific.

particles in motion have the properties of a wave
when they interact with a surface, they have the properties of a particle

5. Calculate the frequency of a photon with energy of 1.826×10^{-12} μJ.

$1.826 \times 10^{-12}\ \mu J \left| \frac{10^{-6} J}{1\ \mu J} \right. = 1.826 \times 10^{-18} J$

$\nu = \frac{E}{h} = \frac{1.826 \times 10^{-18} J}{6.626 \times 10^{-34} Js} = 2.76 \times 10^{15}\ s^{-1}$

6. How many neutrons are present in the nucleus of the ^{113}In? Note: this element has an atomic number of 49.

$113 - 49 = 64$

7. For each element, select the most correct group from this list: halogen, transition metal, metalloid, alkali metal, noble gas, alkali earth metal

Sodium (Z = 11) alkali metal

Arsenic (Z = 33) metalloid

Bromine (Z = 35) halogen

Copper (Z = 29) transition metal

8. What is meant by "quantization of energy"? Be specific.

electrons are confined to specific energies when interacting with the nucleus of an atom

9. Determine the **energy and wavelength** of the photon needed to move an electron from the ground state of a hydrogen atom to the 6th energy level. Report your answer in SI units.

$E_1 = -2.18 \times 10^{-18} J$

$E_6 = \frac{-2.18 \times 10^{-18} J}{6^2} = -6.06 \times 10^{-20} J$

$\Delta E = E_6 - E_1 = 2.119 \times 10^{-18} J = E_{photon}$

$\lambda = \frac{hc}{E} = 9.37 \times 10^{-8}\ m$

10. Consider an electron found in the 4th shell in an orbital shaped like the one you see to the right.

a. What type of orbital is this electron in? 4d orbital

b. Determine **two** sets of quantum numbers that could describe this electron.

4, 2, 2, +½ 4, 2, 2, −½

11. Identify an element would have an **excited state** electron with this set of quantum numbers [4, 2,-2, ½].

4d ← 5s ← ground state only Sr & Rb are possible

12. Write the **ground state** electron configuration for each of the following. You may use shorthand notation for. **Circle the valence electrons on each atom.**

a. Silicon [Ne] 3s² 3p²

b. Silver (Z=47) [Kr] 5s¹ 4d¹⁰

c. Bismuth (Z=83) [Xe] 6s² 4f¹⁴ 5d¹⁰ 6p³

Don't forget to circle the valence electrons!

13. Is silicon paramagnetic or diamagnetic? Clearly explain how you arrived at your answer.

3p ↑ ↑ — paramagnetic – unpaired

14. The emission spectrum of a magnesium atom includes a photon at 102.6 nm. This emission is the result of relaxation of an electron from the 1st excited state to the ground state.

d. Identify the initial and final orbitals for this transition.

$1s^2 2s^2 2p^6 3s^2$ final 3p → 3s

e. What is the difference in energy between the two orbitals you identified above?

$E = \frac{hc}{\lambda} = 1.93 \times 10^{-18}\ J = \Delta E$

Answer one question from this page

15. When a photon with a wavelength of 202.2 nm strikes a potassium atom, an electron is ejected travelling at 1469 Mm/s. What is the threshold energy of potassium?

16. Indium has two stable isotopes. Using the information in the table, determine the abundance of the ^{113}In isotope:

Isotope	Exact Mass (amu)
Indium-113	112.904
Indium-115	114.904

15. $1469\ \frac{Mm}{s} \left| \frac{10^6\ m}{1\ Mm} \right. = 1.469 \times 10^9\ m/s$

$E_K = \frac{1}{2}(9.109 \times 10^{-31}\ kg)(1.469 \times 10^9\ m/s)^2 =$

$E_K = 9.828 \times 10^{-13}\ J$

$\lambda = 202.2\ nm \left| \frac{10^{-9}\ m}{1\ nm} \right. = 2.022 \times 10^{-7}\ m$ $\quad E_{photon} = \frac{hc}{\lambda} = 9.824 \times 10^{-19}\ J$

$\phi = E_{photon} - E_K = -9.83 \times 10^{-13}\ J$

°C

16. $X + Y = 1 \quad X = 1 - Y$

$112.904X + 114.904Y = 114.82$

$112.904(1-Y) + 114.904Y = 114.82$

$112.90 - 112.904Y + 114.904Y = 114.82$

$1.916 = 2Y$

$Y = 0.958 = 95.8\%$

$X = 1 - Y = 0.042 = 4.2\%$

17. The first 8 ionization energies of element "X" are shown below (in aJ – note 1 aJ = 10^{-18} J).

IE_1	IE_2	IE_3	IE_4	IE_5	IE_6	IE_7	IE_8
1.68	3.17	4.84	8.24	10.42	35.32	42.23	49.60

Explain why the ionization energies are getting larger.

Removing 1 e^- decreases the # of e^--e^- repulsions, so each remaining e^- can be more strongly interacting with the nucleus

How many valence electrons does X have? Briefly justify your answer.

(5) Ionizing the 6th e^- takes much more energy meaning that it must be a core e^-

What group does X belong to?

Group 15 (or 5A) – under Nitrogen

18. The density of ^{75}As is 5.727 g mL^{-1}. Assuming atoms are prefect spheres, calculate the radius and report it in SI units.

^{75}As

$$33 \text{ protons} \left| \frac{1.673 \times 10^{-27} \text{ kg}}{1 \text{ proton}} \right. = 5.524 \times 10^{-26} \text{ kg}$$

$$42 \text{ neutrons} \left| \frac{1.675 \times 10^{-27} \text{ kg}}{1 \text{ neutron}} \right. = 7.035 \times 10^{-26} \text{ kg}$$

$$33 \ e^- \left| \frac{9.109 \times 10^{-31} \text{ kg}}{1 \ e^-} \right. = 3 \times 10^{-29} \text{ kg}$$

As → mass = $1.254 \times 10^{-25} \text{ kg} \left| \frac{10^3 \text{ g}}{1 \text{ kg}} \right. = 1.252 \times 10^{-22} \text{ g}$

$$1.265 \times 10^{-22} \text{ g} \left| \frac{1 \text{ mL}}{5.727 \text{ g}} \right. = 2.193 \times 10^{-23} \text{ mL} \left| \frac{1 \text{ cm}^3}{1 \text{ mL}} \right. = 2.193 \times 10^{-23} \text{ cm}^3$$

$$r^3 = \frac{3V}{4\pi} = \frac{3(2.193 \times 10^{-23} \text{ cm}^3)}{4\pi} \quad r = \sqrt[3]{5.24 \times 10^{-24} \text{ cm}^3} = 1.7 \times 10^{-8} \text{ cm} \left| \frac{10^{-2} \text{ m}}{1 \text{ cm}} \right. = \boxed{1.7 \times 10^{-10} \text{ m}}$$