Recitation Worksheet Nine

Name: Key UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: mine is jmj81738). Do *not* enter your 81x number.
- Download this worksheet and print it if you have a printer. Write the answers in the answer boxes and show your work when appropriate. Using the instructions in the Welcome module on eLC, convert your worksheet to a PDF and then upload it to Gradescope. If you have an iPhone or Android device, you can scan and upload directly through the Gradescope app. The pages must be in the correct order or Gradescope will not be able to read it.
- If you do not have a printer, download the worksheet and type your answers in the answer boxes and upload it to Gradescope. Write your work on separate sheets of paper, convert these pages to a PDF using the instructions in the Welcome module on eLC, then upload them to the dropbox on eLC for this worksheet.
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- Answers must be written in the corresponding answer box or no credit will be awarded.
- This worksheet is due no later than **11:59 PM on the Friday of the recitation week.**
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- **You must show your work to receive credit.**

1. Most helium in nature is the ^4He isotope, with a precise molar mass of 4.00260 g/mol. The ^3He isotope (molar mass = 3.01603 g/mol) is used in ultracold systems, and is separated from bulk helium by effusion. What is the relative rate (ratio) of effusion of ^3He relative to ^4He?

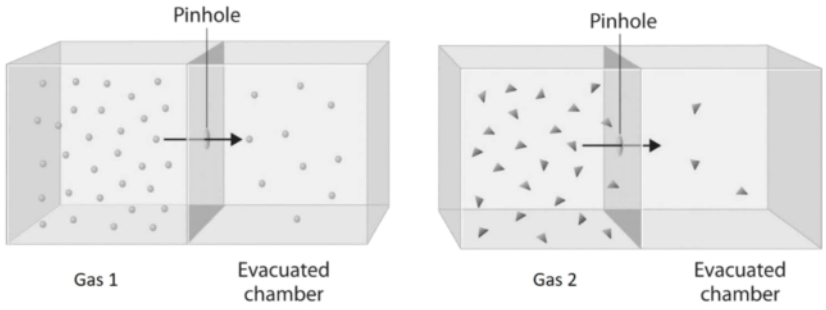
C

A. 0.753518
B. 0.868054
C. 1.15200
D. 1.32711
E. 1.76122

$$\frac{^3He}{^4He} = \frac{\sqrt{4.002608\ g/mol}}{\sqrt{3.01603\ g/mol}}$$

$$= 1.15200$$

2. In the image below, both gases have been allowed to effuse for the same amount of time. Which gas has the **higher** molar mass?



B

lower effusion rate

A. Gas 1
B. Gas 2
C. Both gases have the same molar mass
D. It's impossible to tell based on the image

3. Which of the following statements are true regarding the van der Waals equation? Select all that apply.

BC

A. The van der Waals constant "a" corrects for temperature
B. The van der Waals constant "b" corrects for volume
C. The smaller the van der Waals constant "a", the more ideally the gas behaves
D. The larger the van der Waals constant "b", the more ideally the gas behaves
E. The R constant 8.314 J/mol · K is the only constant that may be used in the equation

4. A real gas will behave most like an ideal gas under which of the following conditions?

B

A. 1 atm and 273 K
B. 1 atm and 298 K
C. 2 atm and 273 K
D. 10 atm and 298 K

Low P, high T

(1) $E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\cdot s)(3.00\times10^{8}\ \frac{m}{s})}{285\times10^{-9}\ m} = 6.974737\times10^{-15}\ J/photon$

5. What is the energy of 1.00 mole of photons with a wavelength of 285 nm?

~~4.02E5~~ J/mol

4.20e5

(2) $6.974737\times10^{-15}\ \frac{J}{photon} \times \frac{6.022\times10^{23}\ photons}{1\ mol}$

6. In the film *Star Wars Episode I: The Phantom Menace*, Jedi Master Qui-Gon Jinn uses a lightsaber that emits red light (λ = 700 nm). His padawan, Obi-Wan Kenobi, uses a lightsaber that emits blue light (λ = 462 nm). Both lightsabers emit the same number of photons per second. Based on this information, complete the following statements with (A) smaller than, (B) larger than, or (C) equal to. Only answer with the capital letter of your choice.

I. The frequency of the light emitted from Obi-Wan's lightsaber is [B] that of Qui-Gon's lightsaber.

$c = \lambda\nu \rightarrow \nu = \frac{c}{\lambda}$

$\lambda\downarrow, \uparrow\nu$

II. The energy of the light emitted from Obi-Wan's lightsaber is [B] that of Qui-Gon's lightsaber.

$E = \frac{hc}{\lambda}$

$\lambda\downarrow, \uparrow E$

III. Both lightsabers have a wavelength that is [A] that of a lightsaber that emits infrared radiation.

visible light < infrared (in terms of wavelength)

7. Consider an experiment in which a low-frequency light is unsuccessful in the emission of electrons from a metal. Based on the principles of the photoelectric effect, which of the following statements below is/are true? Select all that apply.

DE

A. Increasing the intensity of the light will eventually cause electron emission
B. Decreasing the intensity of the light will eventually cause electron emission
C. Increasing the wavelength of the light will eventually cause electron emission
D. Decreasing the wavelength of the light will eventually cause electron emission
E. Increasing the frequency of the light will eventually cause electron emission
F. Decreasing the frequency of the light will eventually cause electron emission

8. In a photoelectric experiment a particular metal is found to have a threshold frequency (ν^0) of 8.20×10^{14} Hz.

$= 8.20E14\ s^{-1}$

I. What is the longest wavelength of light (in nm) that could eject an electron from this metal in a photoelectric apparatus?

$c = \lambda\nu \rightarrow \lambda = \frac{c}{\nu}$

$= \frac{3.00 \times 10^8\ \frac{m}{s}}{8.20 \times 10^{14}\ \frac{1}{s}}$

$= 3.658537 \times 10^{-7}\ m \times \frac{10^9\ nm}{m}$

366 nm

II. A particular electron is ejected from the metal with a velocity of 6.00×10^6 m/s. What is the de Broglie wavelength of this electron (in m)?

mass of electron = 9.109E-31 kg on formula sheet!

1.21E-10 m

$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ J \cdot s}{(9.109 \times 10^{-31}\ kg)(6.00 \times 10^6\ \frac{m}{s})}$

$J = kgm^2s^{-2}$

9. Of the following transitions in the Bohr hydrogen atom, the _____ transition results in the emission of the lowest-energy photon.

C

A. $n = 1 \rightarrow n = 6$ not emission
B. $n = 6 \rightarrow n = 2$ lesser emission
C. $n = 6 \rightarrow n = 3$ ✓
D. $n = 3 \rightarrow n = 6$ not emission
E. $n = 1 \rightarrow n = 2$ not emission

10. Which of the following statements regarding the Bohr model of the atom are **true**? Select all that apply.

AE

A. Electrons occupy specific orbits that are at fixed distances from the nucleus.
B. Electrons become excited by emitting photons.
C. Electrons in the ground state may absorb a photon of any wavelength to become excited to a new energy level.
D. The emission spectrum of hydrogen contains a continuum of colors. *actually discrete lines
E. Emission spectra have distinct lines because energy levels are quantized

11. According to the theory of wave-particle duality, under what conditions will a particle have the **longest** wavelength?

C

$\lambda = \frac{h}{mv}$

$\downarrow m \uparrow \lambda$

$\downarrow v \uparrow \lambda$

A. A particle with large mass and high velocity.
B. A particle with small mass and high velocity.
C. A particle with small mass and low velocity.
D. A particle with large mass and low velocity.

12. Which of the following quantum numbers describes the size and energy of an orbital?

B

A. m_ℓ
B. n
C. m
D. m_s
E. ℓ

13. Which of the following are valid, degenerate sets of quantum numbers? Write all answers that meet the criteria in capital letters with no spaces in the answer box (e.g. ABCDE).

DE

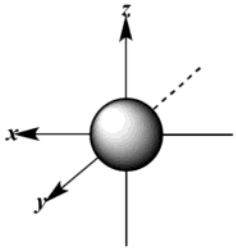
n, ℓ, m_ℓ, m_s

A. (2, 1, -2, ½) invalid m_ℓ
B. (3, 0, -1, -½) invalid m_ℓ
C. (3, 0, 0, ½) valid but not degenerate
D. (2, 1, 0, ½)
E. (2, 1, -1, -½) valid and degenerate

14. An illustration of an orbital is provided below. What is/are the possible value(s) for m_ℓ for the orbital below?

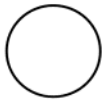
A

A. 0
B. -1, 0, +1
C. -2, -1, 0, +1, +2
D. 0, +1, +2
E. -2, 0, +1



"s" orbital
so $\ell = 0$, $m_\ell = 0$

15. Use the images below to answer each of the following questions.



$\ell = 0$

A

$\ell = 1$

B

$\ell = 2$

C

I. Which of these orbitals are valid when n = 2? More than one may apply.

AB

0,1 (n-1 upper limit)

II. Which of these orbitals are valid when ℓ = 1? More than one may apply.

B

only "p" orbitals

III. Which of these orbitals has the largest number of possible values for m_ℓ?

C

$-\ell,\ldots,+\ell$ so $\ell = 2$ gives five (-2,-1,0,1,2)

IV. If each of these orbitals has the same n, which is highest in energy in an iron atom?

C

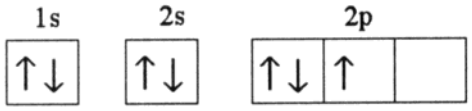
$Fe=1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

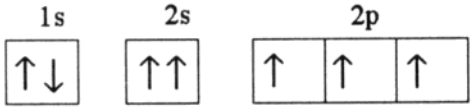
highest energy

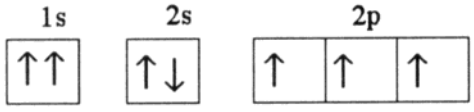
16. Which one of the following is the correct electron configuration for a ground-state nitrogen atom?

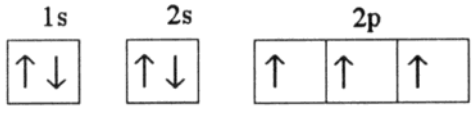
D

$1s^2 2s^2 2p^3$

A. 

B. 

C. 

D. 

E. None of the above are correct.

17. What is the noble gas core electron configuration for bismuth (Bi)?

A

A. [Xe] $6s^2 4f^{14} 5d^{10} 6p^3$

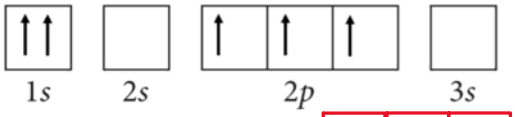
B. [Xe] $6s^2 5f^{14} 5d^{10} 6p^3$

C. [Xe] $6s^2 6f^{14} 6d^{10} 6p^3$

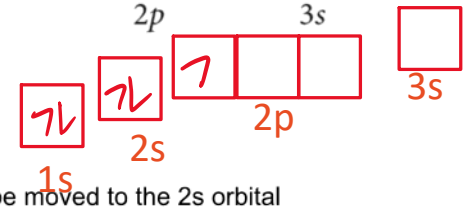
D. [Xe] $6s^2 4f^{14} 5d^{10} 6p^3$

E. [Xe] $6s^2 4f^{15} 5d^9 6p^3$

18. Consider the orbital diagram illustrated below. What correction(s) should be made to the electron filling? Select all that apply.



EH



A. One of the 1s electrons should be moved to the 2s orbital
B. Two of the 1s electrons should be moved to the 2s orbital (both spin up)
C. Two of the 1s electrons should be moved to the 2s orbital (one spin up, one spin down)
D. Two of the 2p electrons should be moved to the 2s orbital (both spin up)
E. Two of the 2p electrons should be moved to the 2s orbital (one spin up, one spin down)
F. One of the 1s electrons should be moved to the 3s orbital
G. One of the 2p electrons should be moved to the 3s orbital
H. One of the 1s electrons should be switched from spin up to spin down
I. One of the 2p electrons should be switched from spin up to spin down
J. There are no corrections that need to be made

19. Which of the following represents an excited state electron configuration of selenium (Se)? Select all that apply.

BC

A. $[Ar]\ 4s^2 3d^{10} 4p^4$ ground state
B. $[Ar]\ 4s^2 3d^9 4p^5$ √
C. $[Ar]\ 4s^2 3d^{10} 4p^3 6s^1$ √
D. $[Ar]\ 4s^2 3d^{10} 4p^5$ ion
E. $[Ar]\ 4s^2 3d^{10} 4p^3$ ion

20. The identity of the atom or ion with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ could be:

D

A. chromium in an excited state.
B. manganese in an excited state.
C. a vanadium cation.
D. chromium. -exception, not excited state
E. iron.

21. Which element in the third period of the periodic table has three valence electrons? Write the chemical symbol (e.g. He).

Al

22. How many core electrons does chlorine have? Answer with an integer (e.g. 7).

10

23. Based on the following electron configuration, what ion is likely to form? Write your answer with the charge and integer (e.g. +5).

$[Kr]\ 5s^2 4d^{10} 5p^5$

-1

$[Kr]5s^2 4d^{10} 5p^6$ or [Xe]

24. Hafnium (Hf) can have multiple oxidation states, such as Hf^{2+} and Hf^{4+}. What are the electron configurations of these ions?

D

$[Xe]6s^2 4f^{14} 5d^2$

A. Hf^{2+}: $[Xe]\ 6s^2\ 4f^{12}\ 5d^2$
   Hf^{4+}: $[Xe]\ 6s^2\ 4f^{10}\ 5d^2$

B. Hf^{2+}: $[Xe]\ 6s^2\ 4f^{14}$
   Hf^{4+}: $[Xe]\ 4f^{14}$

C. Hf^{2+}: $[Xe]\ 6s^2\ 4f^{14}\ 5d^4$
   Hf^{4+}: $[Xe]\ 6s^2\ 4f^{14}\ 5d^6$

D. Hf^{2+}: $[Xe]\ 4f^{14}\ 5d^2$
   Hf^{4+}: $[Xe]\ 4f^{14}$

E. Hf^{2+}: $[Xe]\ 6s^2\ 4f^{14}\ 5d^2\ 6p^2$
   Hf^{4+}: $[Xe]\ 6s^2\ 4f^{14}\ 5d^2\ 6p^4$

Hf^{2+} (remove 2 valence e^-s, $6s^2$)
Hf^{4+} (remove 4 valence e^-s, $6s^2$ then $5d^2$)

Ni: $[Ar]4s^2 3d^8$

Ni^{2+}: $[Ar]3d^8$ 

25. Which of the following statements are true for a Ni^{2+} ion?

D

A. The ion is diamagnetic
B. The ion is diamagnetic with one unpaired electron
C. The ion is paramagnetic with one unpaired electron
D. The ion is paramagnetic with two unpaired electrons
E. The ion is paramagnetic with three unpaired electrons
F. The ion is paramagnetic with four unpaired electrons

26. Which of the following statements is true?

B

A. Outer electrons efficiently shield one another from nuclear charge.
B. Core electrons effectively shield outer electrons from nuclear charge.
C. Valence electrons are the most difficult of all electrons to remove.
D. Core electrons have the lowest ionization energies of all electrons.
E. Valence electrons in the outermost shell of all elements have the highest ionization energy.

27. Which of the following elements has the smallest atomic radius?

D

A. N
B. Na
C. Al
D. F
E. Rb

28. The atomic radius of main-group elements generally increases down a group. Which of the following options best explains this behavior?

D

A. Effective nuclear charge increases down a group
B. Effective nuclear charge decreases down a group
C. Effective nuclear charge zigzags down a group
D. The principal quantum number of the valence orbitals increases
E. Both effective nuclear charge increases down a group and the principal quantum number of the valence orbitals increases

29. Two particles with the same number of protons and neutrons have atomic radii of 110 pm (Particle A) and 280 pm (Particle B). Which of the following statements regarding particles A and B is/are true? Select all that apply.

CD

A. Particle A is probably a metal, and Particle B is probably a nonmetal.
B. Particle A has more valence electrons than particle B.
C. The valence electrons in Particle A experience a larger effective nuclear charge than the valence electrons in Particle B.
D. Particle B could be an anion of Particle A.
E. Particle B could be a cation of Particle A.

30. Consider the following ions: S^{2-}, Cl^{-}, K^{+}, and Ca^{2+}. Which of these ions will have the largest ionic radii?

A

S^{2-} = 18e's, 16 protons
Cl^{-} = 18 e's, 17 protons
K^{+} = 18 e's, 19 protons
Ca^{2+} = 18 e's, 20 protons

isoelectronic series:
- look at number of protons
- least = biggest

A. S^{2-}
B. Cl^{-}
C. K^{+}
D. Ca^{2+}
E. Both K^{+} and Ca^{2+} because they have the same n value

31. Which of the options provided below accurately rank the atoms in order of increasing first ionization energies (i.e. the lowest first ionization energy given first)?

B

Remember group 2/group 13 exceptions

A. K < Ca < Ga < Ge
B. K < Ga < Ca < Ge
C. Ca < K < Ga < Ge
D. Ca < K < Ge < Ga
E. K < Ga < Ca < Ge
F. Ga < K < Ca < Ge

32. Consider a hypothetical atom with the following ionization energies given below. Based on this information, how many valence electrons does this atom likely have?

IE_1 = 312 kJ/mol
IE_2 = 418 kJ/mol
IE_3 = 561 kJ/mol
IE_4 = 691 kJ/mol
IE_5 = 10,124 kJ/mol
IE_6 = 49,459 kJ/mol

removal of core electrons

D

A. 1 valence electron
B. 2 valence electrons
C. 3 valence electrons
D. 4 valence electrons
E. 5 valence electrons
F. 6 valence electrons (due to a total of 6 different ionization energies present)

33. It is observed that the electron affinity of sulfur (-200. kJ/mol) is more favorable than the electron affinity of oxygen (-141 kJ/mol). Which of the following reasonably explains this observation?

C

A. Sulfur is more electronegative than oxygen, so it attracts electrons more strongly
B. Sulfur has a smaller ionization energy than oxygen, and electron affinity is opposite of ionization energy
C. Sulfur has a larger atomic radius than oxygen so the electrons experience less electron-electron repulsion
D. Sulfur has a smaller effective nuclear charge than oxygen, so it is better able to shield added electrons

34. Which of the following elements given below would have the **most positive (i.e. least favorable)** electron affinity?

B

A. Na
B. Mg
C. P
D. Si
E. Cl

Group 2 exception

35. Barium is predicted to have a higher polarizability than strontium, calcium, or magnesium. Which of the following options below best supports this?

C

A. Barium's larger atomic mass increases its polarizability
B. Barium's smaller atomic mass increases its polarizability
C. Barium's larger atomic radius increases its polarizability
D. Barium's smaller atomic radius increases its polarizability

36. Rank the atoms N, O, Si, and P in order of increasing electronegativity. Format your answer with a greater than sign (e.g. X < Y < Z).

Si < P < N < O

37. Which of the following compounds would have the largest lattice energy released upon formation (i.e. the most positive, or strongest, associated lattice energy).

B

largest magnitude of charge and smaller ionic radii

A. NaCl
B. MgO
C. KBr
D. $SrBr_2$

38. In which of the molecules below is the carbon-carbon distance the **shortest**?

B

A. $H_2C=CH_2$
B. $HC\equiv CH$ — triple bond shortest
C. H_3C-CH_3
D. $H_2C=C=CH_2$
E. $H_3C-CH_2-CH_3$

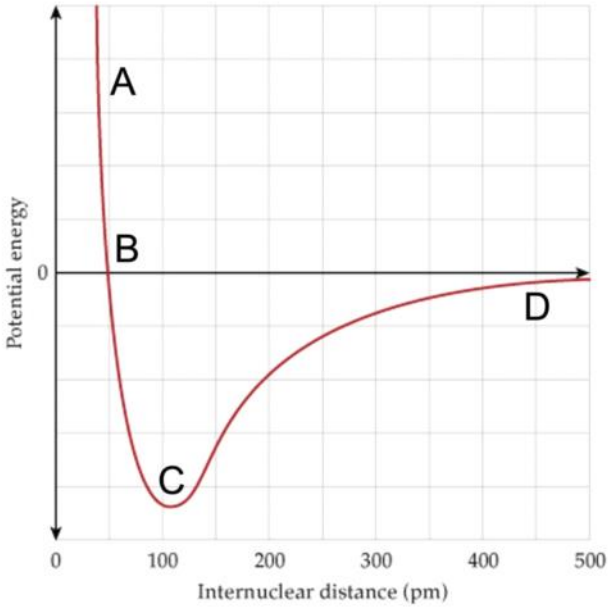
39. Of the bonds C-N, C=N, and C≡N...the C-N bond is _____.

D

single bond

A. strongest/shortest
B. strongest/longest
C. weakest/shortest
D. weakest/longest
E. intermediate in both strength and length

Answer questions 40-42 using the potential energy diagram for the methane molecule (CH_4) below.



40. At which point in the graph is the methane molecule most stable?

C

A. Around Point A because it is at the highest potential energy
B. Around Point B because it is at a zero potential energy
C. Around Point C because it is at the lowest potential energy
D. Around Point D because it is at the farthest internuclear distance

41. At which point in the graph are the proton-proton repulsions and electron-electron repulsions most prevalent?

A

A. Around Point A because it is at the highest potential energy
B. Around Point B because it is at a zero potential energy
C. Around Point C because it is at the lowest potential energy
D. Around Point D because it is at the farthest internuclear distance

42. At which point in the graph are the proton-proton repulsions and electron-electron repulsions most negligible?

D

A. Around Point A because it is at the highest potential energy
B. Around Point B because it is at a zero potential energy
C. Around Point C because it is at the lowest potential energy
D. Around Point D because it is at the farthest internuclear distance