General Chemistry 1 *(CHEM 1141)*

Shawnee State University – Fall 2024

December 5, 2024

Exam # 3 A

Name KEY

Please print your full name, and the exam version (3 A) that you have on the scantron sheet!
(Bubble in the best answer choice for each question on the scantron sheet in pencil!)

Please ☑ check the box next to your correct section number.

Section #:

- ❒ 1. (Mon Lab, 11:10 AM – 1:55 PM) } **Fleeman**
- ❒ 2. (Wed Lab, 11:10 AM – 1:55 PM) } **Fleeman**
- ❒ 3. (Tue Lab, 11:00 AM – 1:50 PM) } **Napper**
- ❒ 4. (Thu Lab, 11:00 AM – 1:50 PM) } **Napper**

Multiple Choice:	_____	**/ 50**
Q21:	_____	**/ 10**
Q22:	_____	**/ 10**
Q23:	_____	**/ 10**
Q24:	_____	**/ 10**
Q25:	_____	**/ 10**
BONUS:	_____	**/ 3**
TOTAL:	_____	**/ 100**

Each problem in this section (multiple choice) is worth 2.5 points!

Q1. Which is an **impossible** set of quantum numbers (n, l, m_l, m_s) for an electron in an atom?

A) (1, 1, 0, +½)

B) (2, 0, 0, −½)

C) (4, 2, −1, +½)

D) (3, 2, −2, −½)

$n = 1, 2, 3, \ldots$

$l = 0, \ldots, n-1$

$m_l = -l, \ldots, 0, \ldots, +l$

$m_s = \pm 1/2$

Q2. The region of the electromagnetic spectrum with a **longer** wavelength than microwave is referred to as:

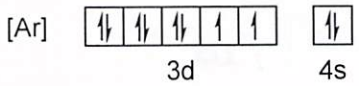
A) ultraviolet

B) infrared

C) gamma

D) radio

Q3. Which gas phase atom or ion has the following orbital diagram?



A) Fe^{3+}

B) Ni

C) Zn^{2+}

D) Fe

Q4. Which of the terms below accurately describe the energy associated with the following process:

$$Li(g) \longrightarrow Li^+(g) + e^-$$

A) electron affinity

B) ionization energy

C) electronegativity

D) binding energy

Q5. The **energy** of a photon of light with a frequency of 1.2×10^{12} Hz is:

A) 2.5×10^{-4} J

B) 5.2×10^{-23} J

C) 7.1×10^{-18} J

D) 8.0×10^{-22} J

$E = h\nu$

$= 6.626 \times 10^{-34}\ J \cdot s \times 1.2 \times 10^{12}\ s^{-1}$

Q6. Which electron transition in a hydrogen atom would result in the **emission** of the **highest frequency** light?

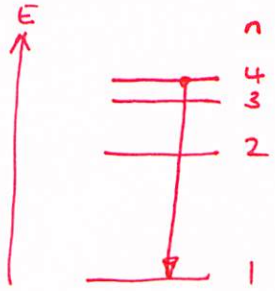
A) $n = 1 \longrightarrow n = 3$

B) $n = 1 \longrightarrow n = 4$

C) $n = 4 \longrightarrow n = 1$

D) $n = 3 \longrightarrow n = 1$

$\nu \uparrow \quad E \uparrow$



Q7. The principle that states that it is impossible to know with complete certainty both the position and momentum of a particle is named after which scientist?

A) Schrödinger

B) Heisenberg

C) Einstein

D) Bohr

Heisenberg Uncertainty Principle

Q8. Which substance requires an element with an **expanded** octet when writing its Lewis structure?

A) $BeCl_2$

B) C_2H_2

C) SF_2

D) IF_3

$I + F_3$

$7 + 7 \times 3 = 28$

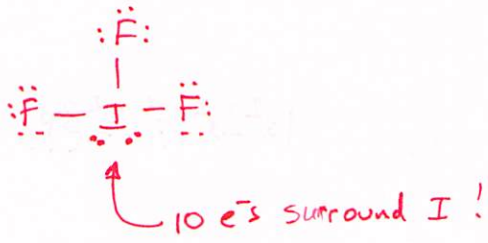
-6

22

-18

4

-4 /all



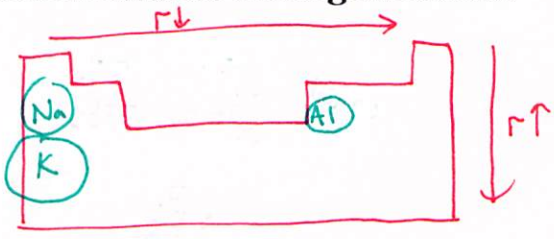
Q9. Which set of atoms is arranged correctly from **smallest to largest** radius?

A) Na < K < Al

B) K < Na < Al

C) Na < Al < K

D) Al < Na < K



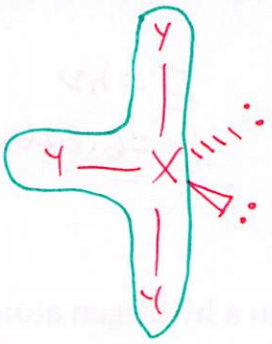
Q10. The name of the **molecular geometry** around an atom with three bonds and two lone pairs is:

A) trigonal bipyramidal

B) trigonal planar

C) t-shaped

D) see-saw



Q11. Theobromine, $C_7H_8N_4O_2$, is a component of dark chocolate. Determine the number of **valence electrons** for theobromine.

A) 72

B) 54

C) 68

D) 36

Q12. Which of the following set of quantum numbers describes a **4d orbital**?

A) $n = 4,\ l = 2,\ m_l = -2,\ m_s = +½$

B) $n = 4,\ l = 2,\ m_l = -3,\ m_s = +½$

C) $n = 4,\ l = 1,\ m_l = +1,\ m_s = +½$

D) $n = 4,\ l = 3,\ m_l = -2,\ m_s = +½$

l	0	1	2	3
code	s	p	d	f

m_l: $-l, \ldots, +l$

so for d, m_l: −2, −1, 0, 1, or +2

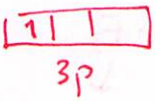
Q13. Which of the following atoms has **one** unpaired electron in its ground-state configuration?

A) Mg

B) Al $1s^2 2s^2 2p^6 3s^2 3p^1$

C) Mn

D) P



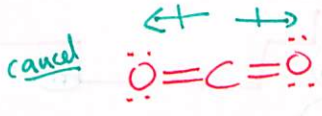
Q14. Which of the following species is **polar**?

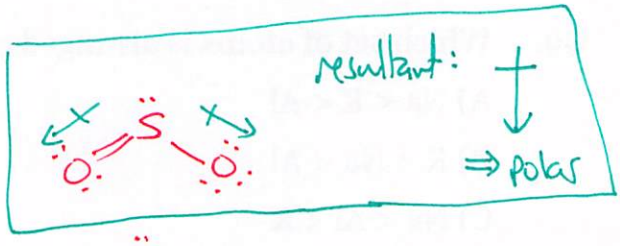
A) CO_2

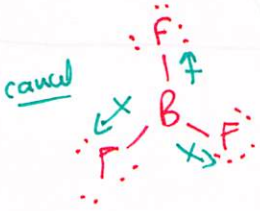
B) BF_3

C) SO_2

D) SiF_4







↑ = bond dipoles

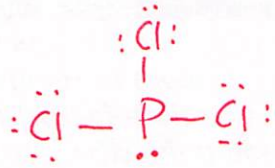
Q15. How many **lone pairs** of electrons are around the central atom in PCl_3?

A) 0

B) 1

C) 2

D) 3



Q16. Which of the following molecules contain a **triple bond**?

A) NH_3

B) O_3

C) N_2H_4

D) CO

:C≡O:

Q17. Which of the following bonds would be expected to have the **shortest** length?

A) C≡C

B) C=C

C) C–C

D) C–H

strong / short

weak / long

Q18. The molecular geometry with the **smallest** bond angle is:

A) linear

B) trigonal planar

C) tetrahedral

D) octahedral

Q19. Which of the following is **isoelectronic** with Ba^{2+}?

A) Sr^{2+}

same # e⁻s

B) La^{+}

C) I^{-}

D) Rn

Q20. The number of **oscillations** a wave makes per second (unit time) is its:

A) frequency

B) wavelength

C) amplitude

D) speed

Each problem in this section (short answer) is worth 10 points!
All work must be shown to receive credit!
You must use the factor–label (conversion–factor) method for all conversions!
Be sure to include units where applicable!
All numeric answers must be rounded to the correct number of significant figures!

Q21. An electron in a rubidium (Rb) atom undergoes a transition that results in the **absorption** of light with a wavelength of 781 nm.

(This is a ruby-red color and is explains how the element got its name!)

(A) Calculate the energy in Joules that this corresponds to.

$E = h\nu = \frac{6.626\times10^{-34}\ J\cdot s \times 3.00\times10^{8}\ m/s}{781\times10^{-9}\ m} = 2.55\times10^{-19}\ J$

$= \frac{hc}{\lambda}$ +1 +1 (2)

(B) Did the electron transition to a higher-energy level or a lower-energy level? Explain!

higher. +1

E must increase if photon is absorbed. +1 (2)

(C) Write out the full electron configuration for a ground-state atom of rubidium.

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

(D) Write out the orbital diagram for rubidium using an appropriate noble gas core.

[Kr] $\boxed{\uparrow}$ 5s (2)

(E) Are rubidium atoms diamagnetic or paramagnetic? Explain!

paramagnetic. +1 Has unpaired e's. +1 (2)

/10

Q22. (A) Explain why elements in the **same group** have similar chemical properties?

Same # valence e⁻s

2

(B) What happens to the atomic radius for atoms as you go from left to right on the periodic table?

Decreases

2

(C) Explain WHY you see this trend in part (B) above. **Write complete, grammatically correct, sentences for your explanation!**

There is an increase in #p^+ in nucleus causing a greater attraction between e⁻s + nucleus, resulting in a smaller atom.

2

(D) Using an appropriate noble gas core, write out the electron configuration for the Co^{2+} ion.

[Ar] $3d^7$

2

2 e⁻s are lost from valence (n=4, 4s) before core (n=3, 3d)

(E) What is the name of the law/principle that states that all electrons in an atom must have different sets of quantum numbers?

Pauli exclusion principle

2

+1 +1

Q23. Predict the molecular geometry and polarity of BrF_5.

Include the following information in your answer:

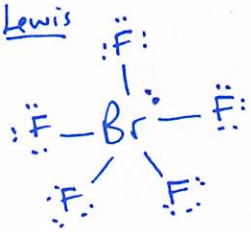
- ☐ A count of the total number of valence electrons
- ☐ A valid Lewis structure
- ☐ A sketch of the geometry of the molecule using line/dash/wedge notation
- ☐ The value of the bond angle(s) written out
- ☐ The name of the **molecular** geometry
- ☐ A clear **explanation** of why the molecule BrF_5 is polar or nonpolar

Count

BrF_5

$7 + 7 \times 5 = 42e^-$

Lewis



Geom/VSEPR

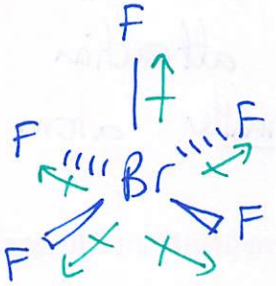
6 reps

e^- geom: octahedral

mol geom: square pyramidal

Polarity

Polar, since sum of bond dipoles $\neq 0$

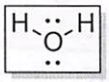


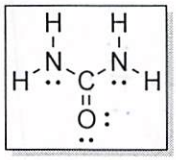
resultant: ↑

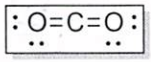
Q24. Use bond energies to estimate ΔH for the reaction:

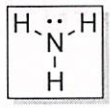
$$\mathbf{H_2O(g) + N_2H_4CO(g) \rightarrow CO_2(g) + 2\ NH_3(g)}$$

given the valid Lewis structures:

H_2O 

N_2H_4CO 

CO_2 

NH_3 

Bond	Energy (kJ/mol)	Bond	Energy (kJ/mol)
O—H	467	C—N	305
N—H	391	C=O	745
C—H	413	C=O (in CO_2)	799

$\Delta H \approx \sum$ bonds broken $- \sum$ bonds made

$\approx [2\times O\text{-}H + \cancel{4}\times N\text{-}H + 2\times C\text{-}N + 1\times C{=}O] - [2\times C{=}O + \cancel{6}\,3\times N\text{-}H]$ (CO_2; 2 molecules! 3 bonds in each.)

$\approx [2\times 467\ kJ/mol + 2\times 305\ kJ/mol + 745\ kJ/mol] - [2\times 799\ kJ/mol + 2\times 391\ kJ/mol]$

$\approx -91\ kJ/mol$

Q25. Draw Lewis structures for the following compounds and determine the formal charge of the **highlighted atoms in each compound.** Show your work for determining the formal charges.

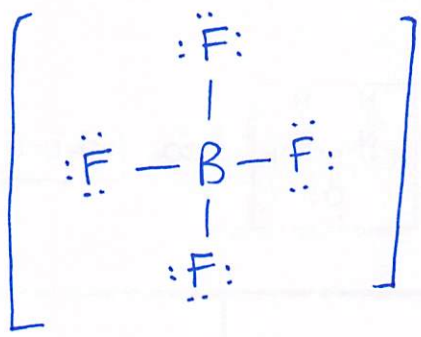
(A) $\mathbf{B}F_4^-$

$3 + 4\times7 + 1 = 32\,e^-$

-8

-24

0



	B
orig	3
now	4
FC	−1

(B) $\mathbf{I}Cl_4^+$

$7 + 4\times7 - 1 = 34\,e^-$

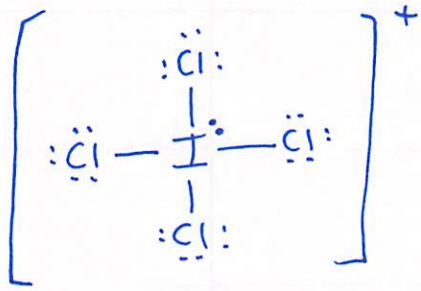
-8

-24

2

-2

0



	I
orig	7
now	6
FC	+1

(C) $\mathbf{S}O_3$

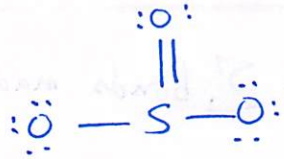
$6 + 3\times6 = 24\,e^-$

-6

18

-18

0



	S
orig	6
now	4
FC	+2

(D) $H\mathbf{C}N$

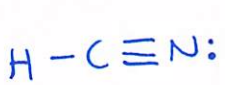
$1 + 4 + 5 = 10$

-4

6

-6

0



	N
orig	5
now	5
FC	0

3 Point Bonus Question

Sketch out the shape for an "s" and a "p" orbital.

s 

p 

Exam checklist:

(Check the boxes to certify the following:)

- ❒ My full name is written legibly on the front page
- ❒ My correct lab section has been indicated on the front page
- ❒ My full name is written legibly on the scantron sheet
- ❒ My exam version (A, B, C, or D) is written on the scantron sheet
- ❒ I have shown work for all problems (where appropriate), paying attention to
  - Significant figures / decimal places
  - Units
- ❒ I have used the conversion-factor method for all conversions
- ❒ If I have torn off the back page (periodic table), I will not turn it in with my exam!

Thank you from the Chemistry Professors and Good Luck!

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Useful information:

$c = \nu\lambda$ $\quad E = h\nu$ $\quad c = 3.00 \times 10^8$ m/s $\quad h = 6.626 \times 10^{-34}$ J·s

$E_n = -R_H\left(\frac{1}{n^2}\right)$ $\quad R_H = 2.18 \times 10^{-18}$ J $\quad \lambda = \frac{h}{mu}$

$N_A = 6.022 \times 10^{23}$ mol^{-1}