Recitation Worksheet Ten: Exam Three Review

Name: Key | UGA ID:

Textbook:
Chemistry & Chemical Reactivity
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Instructions:
- This recitation worksheet is a review for Exam Three.
- Exam coverage: Ch. 6, 7, 8.1-8.2, lattice energy.
- You **do not** need to submit it to Gradescope.
- The answer key has been posted with this worksheet to eLC.
- The **recitation session during the exam week (October 28-31) is still mandatory**. Your attendance will be recorded.
- A periodic table and formula sheet are attached to the end of this worksheet.

1. What is the energy of 1.00 mole of photons with a wavelength of 285 nm? Report your answer in **scientific notation**.

[4.20] × 10^[5] J/mol

$$E = \frac{hc}{\lambda} = \frac{(6.626e{-}34 \text{ J}\cdot\text{s})(3e8 \text{ m/s})}{(285 e{-}9 \text{ m})}$$

$$= 6.974737 e{-}19 \text{ J/photon}$$

$$\left(\frac{6.974737 e{-}19 \text{ J}}{\text{photon}}\right) \times \left(\frac{6.022e23 \text{ photon}}{1 \text{ mol}}\right)$$

2. In the film *Star Wars Episode I: The Phantom Menace*, Jedi Master Qui-Gon Jinn uses a lightsaber that emits green light (λ = 517 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.

$c = \lambda \nu \rightarrow \nu = c/\lambda$

$\downarrow \lambda \quad \uparrow \nu$

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

$E = \frac{hc}{\lambda}$ $\quad \downarrow \lambda \quad \uparrow E$

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

vis. light < infrared (in terms of λ)

3. 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 any that apply and answer using capital letters with no spaces (e.g. ABCDE).

[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

4. In a photoelectric experiment a particular metal is found to have a threshold frequency (ν^0) of 8.20 × 10^{14} Hz.
↳ 8.20 e14 s⁻¹

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

366	nm

$c = \lambda \nu \rightarrow \lambda = c/\nu$

$= 3e8 \text{ m/s} / 8.20e14 \text{ s}^{-1}$

$= 3.658537e-7 \text{ m}$

$= 366 \text{ nm}$

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)? Report your answer in **scientific notation**.

1.21 × 10^-10 m

mass of electron = 9.105e-31 kg
↓
on formula sheet!

$J = kg \cdot m^2/s^2$

keep in kg!

$\lambda = \frac{h}{mv} = \frac{6.626e-34 \text{ J}\cdot\text{s}}{(9.105e-31 \text{ kg})(6.00e6 \text{ m/s})}$

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

C

A. n = 1 → n = 6 → not emission
B. n = 6 → n = 2 → larger energy
C. n = 6 → n = 3
D. n = 3 → n = 6 → not emission
E. n = 1 → n = 2 → not emission

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

C

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

↓m ↑λ

↓v ↑λ

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.

7. What are the essential points of Bohr's theory of the structure of the hydrogen atom? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

ACD

A. An electron may move from one orbit to another by absorbing or emitting a photon of light with the exact correct energy content.
B. Each orbit of the atom corresponds to a specific number of electrons that are fixed at that energy level.
C. Each orbit of the atom has a specific energy level.
D. Electrons have circular orbits.
E. Electrons have elliptical orbits.
F. Ions are able to accept and give off electrons by having an even number in their outer valence shell.

8. Arrange the following types of electromagnetic radiation in order of **increasing** wavelength.

Ultraviolet, Microwaves, Visible, Gamma rays, Infrared

B

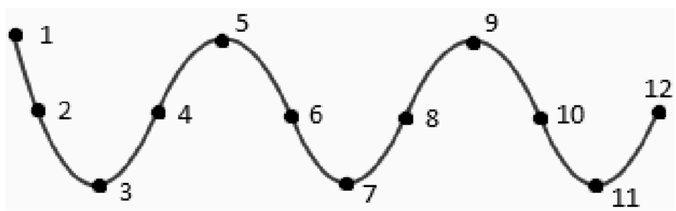
A. Ultraviolet < Microwaves < Visible < Gamma rays < Infrared
B. Gamma rays < Ultraviolet < Visible < Infrared < Microwaves
C. Gamma rays < Infrared < Visible < Ultraviolet < Microwaves
D. Microwaves < Infrared < Visible < Ultraviolet < Gamma rays
E. Gamma rays < Ultraviolet < Visible < Microwaves < Infrared

9. Which of the following properties or attributes do light and electrons **not** share?

C

A. The capacity to be diffracted
B. Frequency
C. A ground state
D. Particle-like behavior
E. More than one of the above

10. Reference the figure below. If the frequency of the wave were to *decrease*, which of the following statements would be **true**? Assume the velocity of the wave remains constant.



A

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

$(\downarrow \nu = \uparrow \lambda)$

A. The distance between points 6 and 8 would increase.
B. The distance between points 3 and 7 would decrease.
C. The distance between points 4 and 10 would remain the same.
D. The amplitude of the wave would increase.
E. The speed of light would decrease.

11. Which of the following are **true**? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

BC

A. The energy of an electron in an orbit is positive and the energy of an electron after it has left (ionized) from an atom is equal to 0
B. When an electron moves from a higher energy level to a lower energy level, light is emitted
C. The emission spectrum of a particular element is unique and can be used to identify the element
D. Since electrons have mass, we must always consider them to have exclusively particle-like properties and to never have wave-like properties

12. What is the frequency (in Hz) of a photon with a wavelength of 3.45×10^{-5} cm?

B

$c = \lambda \nu$

$3e8 \text{ m/s} = (3.45e\text{-}5 \text{ cm} \times (\frac{1 \text{ m}}{100 \text{ cm}}))(\nu)$

A. 1.15×10^{-11} Hz
B. 8.70×10^{14} Hz
C. 1.15×10^{-15} Hz
D. 8.70×10^{10} Hz
E. 8.70×10^{12} Hz
F. 1.15×10^{-13} Hz

13. Which of the following would have the *longest* de Broglie wavelength?

A

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

A. An electron moving at 1% of the speed of light → smallest m and v
B. An electron moving at 10% of the speed of light
C. A proton moving at 1% of the speed of light
D. A proton moving at 10% of the speed of light
E. A neutron moving at 1% of the speed of light
F. A neutron moving at 10% of the speed of light

14. Calculate the energy change (in J) of an electron that relaxes from the n = 8 energy level to the n = 2 energy level using the Bohr model of a hydrogen atom.

B

$\Delta E = -2.18e{-18}\ J \times \left(\frac{1}{2^2} - \frac{1}{8^2}\right)$

A. -8.18 × 10^{-19} J
B. -5.11 × 10^{-19} J
C. 5.11 × 10^{-19} J
D. 8.18 × 10^{-19} J

15. An excited hydrogen atom with an electron in the n = 5 state emits light having a frequency of 6.90 × 10^{14} s^{-1}. Determine the principal quantum level (n) for the final state in this electronic transition.

2

$E = h\nu = (6.626 \times 10^{-34}\ J \cdot s)(6.90 \times 10^{14}\ s^{-1})$

$= 4.57194 \times 10^{-19}\ J$

$\Delta E = -2.18 \times 10^{-18}\ J \times \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

$-4.57194 \times 10^{-19}\ J = -2.18 \times 10^{-18}\ J \times \left(\frac{1}{n_f^2} - \frac{1}{5^2}\right)$

$-4.57194 \times 10^{-19}\ J = \frac{-2.18 \times 10^{-18}\ J}{n_f^2} + 8.72 \times 10^{-20}$

$-5.44394 \times 10^{-19}\ J = \frac{-2.18 \times 10^{-18}\ J}{n_f^2}$

$n_f^2 = 4.004453 \rightarrow n_f = \sqrt{4.004453} = 2$

16. Heisenberg's uncertainty principle states that...

C

A. matter and energy are really the same thing
B. it is impossible to know anything with certainty
C. it is impossible to know both the exact position and momentum of an electron
D. there can only be one uncertain digit in a reported number
E. it is impossible to know how many electrons there are in an atom

17. What is **false** about an electron moving at 13% of the speed of light? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

CD

A. The more precisely you know its momentum, the less precisely you can know its position
B. Its wavelength is 1.9×10^{-11} m
C. Its wavelength is shorter than that of a proton travelling at the same speed
D. You can know both precisely where the electron is at any one time and the speed it is currently moving at
E. It exhibits both wave and particle properties

18. Which of the following is **false** about the modern view of wave-particle duality?

E

A. All matter has wave-like properties, but only subatomic particles are small enough for them to be important
B. The more precisely you know the position of a particle, the less precisely you can know its momentum
C. A neutron moving at 25% of the speed of light would have a characteristic wavelength
D. There is uncertainty in the position of the Eiffel tower if we know its exact momentum
E. None of the above are false

19. Consider a source of orange light that has a wavelength of 640 nm. How many photons are in a flash of this light if 1.53×10^{14} pJ of energy is emitted? Report your answer in **scientific notation**.

4.9 × 10^20 photons

↳ E_{total}

$$1.53 \times 10^{14}\ \text{pJ} \times \left(\frac{10^{-12-0}\ \text{J}}{1\ \text{pJ}}\right) = 153\ \text{J}$$

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J·s})(3 \times 10^{8}\ \text{m/s})}{640\ \text{nm} \times \left(\frac{10^{-9-0}\ \text{m}}{1\ \text{nm}}\right)}$$

$$= 3.1059375 \times 10^{-19}\ \text{J/photon}$$

$$\frac{E_{total}}{E_{photon}} = \frac{153\ \text{J}}{3.1059375 \times 10^{-19}\ \text{J/photon}} = 4.92604 \times 10^{20}\ \text{photons}$$

20. Consider a laser source that has a wavelength of 551 nm. If this particular laser emits 4.08×10^{-2} J of energy per minute, how many photons are emitted from this laser per second?

B

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ J \cdot s)(3 \times 10^{8}\ m/s)}{551\ nm \times \left(\frac{10^{-9}\ m}{1\ nm}\right)}$$

$$= 3.60762 \times 10^{-19}\ J/photon$$

A. 6.01×10^{-21} photons/sec
B. 1.88×10^{15} photons/sec
C. 2.29×10^{12} photons/sec
D. 6.80×10^{-14} photons/sec
E. 6.79×10^{18} photons/sec

$$\frac{4.08 \times 10^{-2}\ J}{minute} \times \frac{photon}{3.60762 \times 10^{-19}\ J} \times \frac{1\ minute}{60\ seconds}$$

21. A microwave oven uses electromagnetic radiation with a wavelength of 12.0 cm to excite water molecules in food items in order to heat them up. A particular veggie burger requires 29.3 kJ of heat to be ready to eat. How long (s) does the microwave oven need to run so that the veggie burger is ready to eat? The microwave oven emits 7.250×10^{26} photons/sec. Report your answer in **standard notation**.

24.4

s

$$\lambda = 12.0\ cm \times \left(\frac{10^{-2}\ m}{1\ cm}\right) = 0.120\ m$$

$$E = \frac{hc}{\lambda} = \frac{(6.626e{-34}\ J \cdot s)(3e8\ m/s)}{0.120\ m} = 1.6565e{-24}\ J/photon$$

$$29.3\ kJ \times \frac{1000\ J}{1\ kJ} \times \frac{photon}{1.6565e{-24}\ J} \times \frac{seconds}{7.250 \times 10^{26}\ photons}$$

22. 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

23. Which of the following is/are a valid set of quantum numbers? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

F

A. (1, 0, 0, 1)
B. (1, 3, 3, ½)
C. (3, 2, 3, -½)
D. (5, -1, 1, ½)
E. (2, 1, -1, 0)
F. (4, 3, 1, -½)
G. More than one of the above sets are valid

24. Which of the following is/are a valid set of quantum numbers? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

CFG

A. (-3, 3, -2, ½)
B. (0, 2, -1, ½)
C. (4, 3, 0, ½)
D. (5, 3, 2, 2)
E. (5, 2, 3, -½)
F. (20, 1, -1, ½)
G. (142, 3, 3, -½)

these are valid n values!

25. Which of the following sets of quantum numbers are **both** valid and degenerate (for all questions about degeneracy, assume you are dealing with a multi-electron atom unless specified otherwise)? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

DG

A. (3, 3, -2, ½) → not valid
B. (5, 2, -1, ½) 5d
C. (4, 3, 0, ½) 4f
D. (5, 3, 2, -½) 5f
E. (5, 2, 3, -½) → not valid
F. (5, 3, 4, ½) → not valid
G. (5, 3, 0, -½) 5f

26. Which of the following lists of quantum numbers include only sets that are **both** valid and degenerate (for all questions about degeneracy, assume you are dealing with a multi-electron atom unless specified otherwise)?

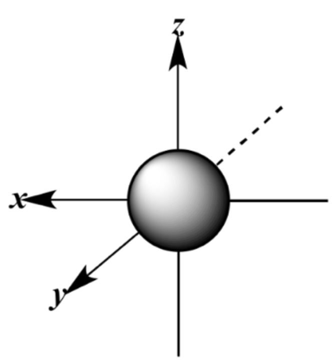
D

A. (3, 2, 1, ½) and (3, 1, 0, -½)
B. (9, 3, -1, -½), (9, 4, -2, ½), and (9, 3, 3, ½)
C. (5, 5, 3, ½) and (5, 3, 2, -½)
D. (9, 3, -1, -½) and (9, 3, 3, ½) 9f orbitals
E. There are no groups given that have only sets which are both valid and degenerate

27. 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

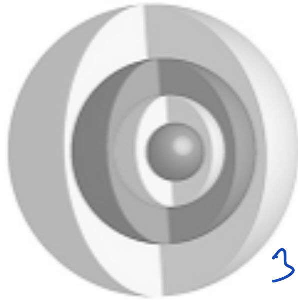


s orbital → $\ell = 0$

$m_\ell = 0$

28. What is a possible set of quantum numbers for the pictured electron orbital? Note: there is a node between each layer.

B



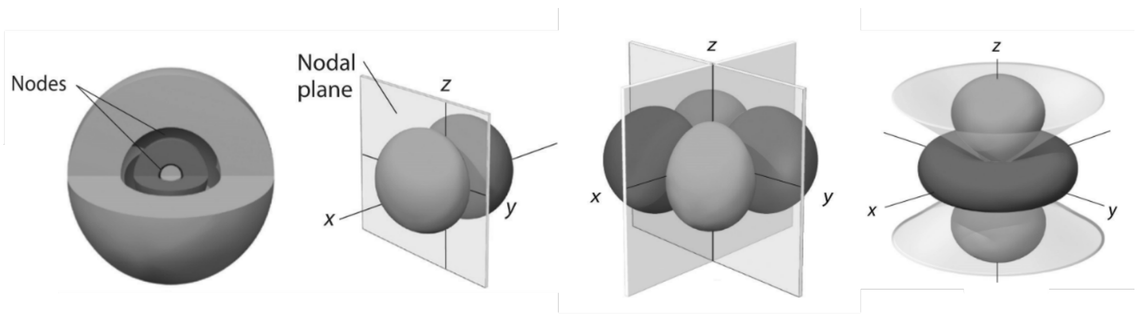
3 nodes

nodes = n - 1 → n = 4

s orbital, l = 0

A. (1, 0, 0, ½)
B. (4, 0, 0, -½)
C. (4, 1, 0, -½)
D. (3, 2, 0, ½)
E. (3, 1, 0, ½)

29. Which of the following orbitals would be degenerate?



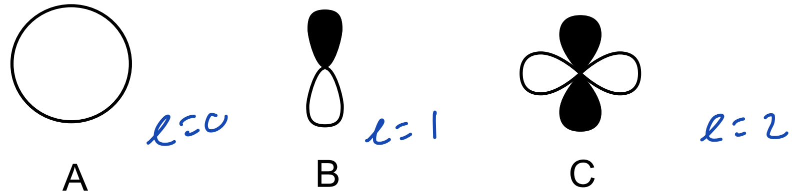
A B C D

A: 2 nodes 3s
B: 1 node 2p
C: 2 nodes 3d
D: 2 nodes 3d

C

A. A and C
B. A, C, and D
C. C and D
D. B and D
E. B, C, and D
F. All of them are degenerate
G. None of them are degenerate

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



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

A B

ℓ=0, 1

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

B

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

C

ℓ=2

m_ℓ= -2, -1, 0, 1, 2

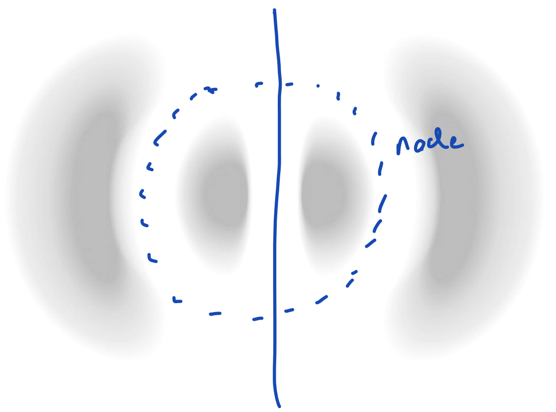
IV. If each of these orbitals has the same n, which is highest in energy in an iron atom?

C

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

↑ highest energy

31. Which of the following sets of quantum numbers could describe an electron in the orbital pictured below?



p orbital → $\ell = 1$

2 nodes → $n = 3$

B

A. (3, 2, -1, -½)
B. (3, 1, 0, ½)
C. (2, 1, 1, ½)
D. (4, 1, 0, -½)
E. (4, 2, -2, ½)

32. How many orbitals are in the f-subshell?

D

↳ $\ell = 3$

A. 1
B. 3
C. 5
D. 7
E. 10
F. 14

orbitals → $2\ell + 1$
$2(3) + 1 = 7$

if $\ell = 3$, $m_\ell = -3, -2, -1, 0, +1, +2, +3$
7 orientations (7 orbitals)

33. In a $4d_{xy}$ orbital, how many values of m_s are possible?

↳ 1 orbital, 2 e⁻'s

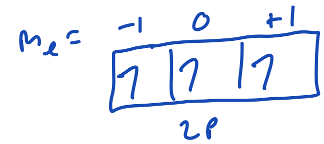
B

A. 1
B. 2
C. 4
D. 5
E. 10

↿⇂ $4d_{xy}$ ↳ $m_s = \pm 1/2$

34. Which set of quantum numbers correctly describes the three 2p electrons in a nitrogen atom?

↳ n = 2
ℓ = 1 (p orbital)
m_ℓ = -1, 0, +1



D

A. (2, 1, 1, ½); (2, 1, 1, ½); (2, 1, 1, ½)
B. (2, 0, 0, ½); (2, 0, 0, ½); (2, 0, 0, ½)
C. (2, 1, -1, ½); (2, 0, 0, ½); (2, 1, 1, ½)
D. (2, 1, -1, ½); (2, 1, 0, ½); (2, 1, 1, ½)

35. Which set of quantum numbers is valid **and** is correctly matched to an orbital designation?

E

A. (6, 3, 2, -½); ~~6d~~ 6f
B. (2, 0, -1, ½); 2s
C. (3, 3, -1, 1); 3f
D. (4, 2, 2, -½); ~~4p~~ 4d
E. (5, 1, 0, -½); 5p

36. 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] $6s^2 4f^{15} 5d^9 6p^3$

37. Which of the following represents an excited state electron configuration of selenium? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

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] $4s^2 3d^{10} 4p^5$

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

} ions

38. 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:

↳ exception, not excited state

D

A. chromium in an excited state
B. manganese in an excited state
C. a vanadium cation
D. chromium
E. iron

39. Based on the following electron configuration, what ion is likely to form? Answer with an integer and sign (e.g. +4, -2).

-1

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

-1 ↳ [Kr] $5s^2 4d^{10} 5p^6$ or [Xe]

40. Which electron configuration represents an atom that would form a 2- anion?

B

A. [Ar] $4s^2 3d^3$
B. [Ar] $4s^2 3d^{10} 4p^4$ → Se ; Se^{2-} → [Ar] $4s^2 3d^{10} 4p^6$
C. [Ar] $4s^2$
D. [Ar] $4s^2 3d^8$
E. [Ar] $4s^2 3d^{10} 4p^1$

41. Based on the electron configuration for silver, why does it always have a 1+ ion?

D

[Kr] $5s^1 4d^{10}$

A. The 4d subshell is at a higher energy than the 5s subshell, so it wants to lose one electron from 4d
B. The 5s subshell is half-filled, so silver gains an electron to fill it
C. The 4d subshell is one electron away from full, so silver gains an electron to fill it
D. Silver only has one 5s electron to lose, resulting in a 1+ ion when it loses its highest shell
E. None of the above explains why silver makes a 1+ ion

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

D

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: [Xe] $6s^2 4f^{14} 5d^2$
Hf^{2+} (remove 6s e^-s)
Hf^{4+} (remove 6s e^-s, then 5d e^-s)

43. Which of the following best describes the complete electron configuration of phosphide? ↳ P^{3-}

A

A. $1s^2 2s^2 2p^6 3s^2 3p^6$
B. $1s^2 2s^2 2p^6$
C. $1s^2 2s^2 2p^6 3s^2 3p^3$
D. $1s^2 2s^2 2p^6 3s^2$
E. $1s^2 2s^2 2p^6 3s^2 3p^3 3d^3$

44. Which of the following correctly represents a valid excited state electron configuration for the given element?

F

A. Ga: [Ar] $4s^2 3d^{10} 4p^1$ → ground state
B. Ag: [Kr] $5s^1 4d^{10}$
C. F: [He] $2s^2 2p^4$ → incorrect # of e⁻s
D. Hf: [Xe] $6s^2 5f^{13} 5d^2 8s^1$ → invalid
E. More than one of the options above is a valid excited state
F. None of the above is a valid excited state

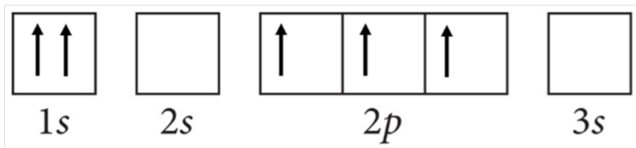
45. Consider a hypothetical transition metal with the noble gas electron configuration below. What is the most probable charge that will form from this element? A hypothetical noble gas "Ng" is given in the brackets below. Answer with an integer and sign (e.g. +4, -2).

[Ng] $10s^1 9d^{10}$ → neutral

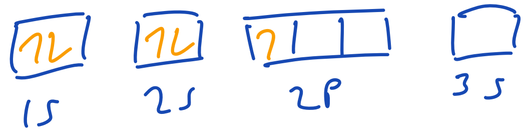
+1

ion (+1 charge): [Ng] $9d^{10}$

46. Consider the orbital diagram illustrated below. What correction(s) should be made to the electron filling? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

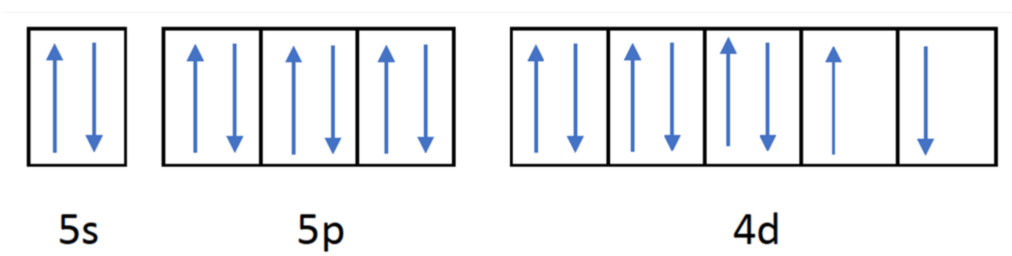


EH



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

47. Which of the following are **true** statements regarding the generic row 5 orbital diagram below? Select any that apply and answer using capital letters with no spaces (e.g. ABCDE).

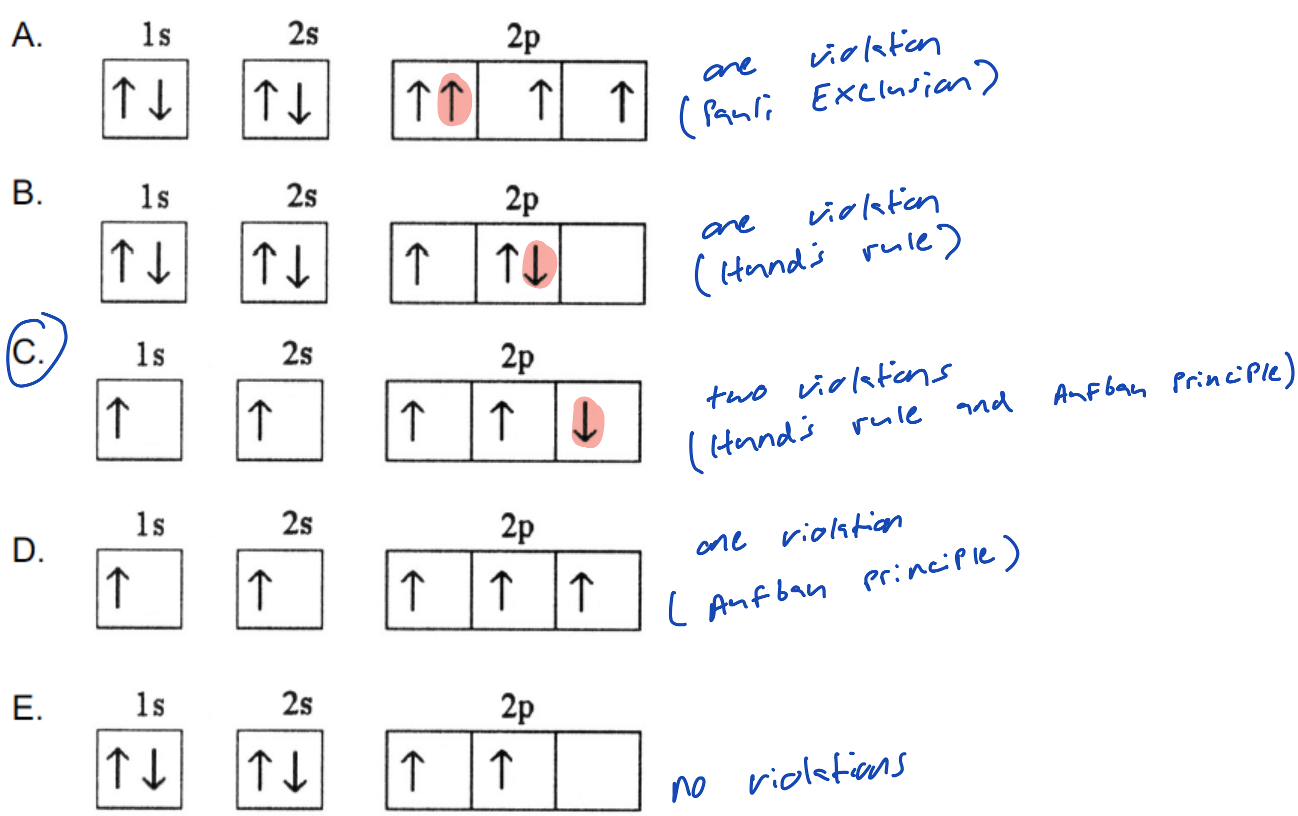


AC

A. 4d should be fully filled before starting to fill 5p
B. 4d should be fully filled before starting to fill 5s
C. The singly filled 4d electrons should have parallel spins
D. 4f should be pictured and filled after 4d

48. Which of the following orbital diagrams represents a violation of *two* filling rules?

C



49. Which element in the third period of the periodic table has three valence electrons? Write the chemical symbol in the box below (e.g. H, Br, etc.).

Al

50. How many core electrons does chlorine have? Answer by using an integer (e.g. 0, 1, etc.).

10

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

D

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

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

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

52. Which of the following ions is paramagnetic?

B

A. Cl^- → [Ne] $3s^2 3p^6$
B. Mn^{5+} → [Ar] $3d^2$ → 2 unpaired e⁻'s
C. Te^{2-} → [Kr] $5s^2 4d^{10} 5p^6$
D. Cr^{6+} → [Ar]
E. Y^{3+} → [Kr]

53. Which of the following atoms contains the most unpaired electrons?

C

A. Hf
B. As
C. Mn
D. K
E. Y

Hf: [Xe] $6s^2 4f^{14} 5d^2$ — 5d — 2 unpaired e^-'s

As: [Ar] $4s^2 3d^{10} 4p^3$ — 4p — 3 unpaired e^-'s

Mn: [Ar] $4s^2 3d^5$ — 3d — 5 unpaired e^-'s

K: [Ar] $4s^1$ — 4s — 1 unpaired e^-

Y: [Kr] $5s^2 4d^1$ — 4d — 1 unpaired e^-

54. 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.

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

D

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

56. 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

57. 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 any that apply and answer using capital letters with no spaces (e.g. ABCDE).

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.

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

A

S^{2-} : 18 e⁻'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

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

59. 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

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

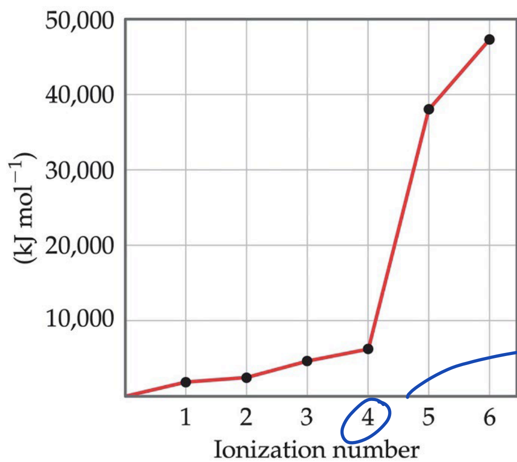
IE_1 = 312 kJ/mol
IE_2 = 418 kJ/mol
IE_3 = 561 kJ/mol
IE_4 = 691 kJ/mol
IE_5 = 10,124 kJ/mol
IE_6 = 49,459 kJ/mol

removal of core e⁻'s

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)

61. Consider the graph below that illustrates the ionization energies of an unknown element. Based on this information, what period 2 element is likely represented here?



→ 4 valence e⁻'s

C

A. Beryllium
B. Boron
C. Carbon
D. Nitrogen
E. Oxygen
F. Fluorine

62. Which of the following atoms is expected to have the *smallest* first ionization energy?

B

A. Ca → group 2 exception
B. Ga → group 13 exception
C. Ge
D. As
E. Se

63. Which equation represents the *fourth* ionization energy of Se?

C

A. $Se + e^{-} \rightarrow Se^{-}$
B. $Se^{+} + e^{-} \rightarrow Se$
C. $Se^{3+} \rightarrow Se^{4+} + e^{-}$
D. $Se \rightarrow Se^{+} + e^{-}$

64. It is observed that the electron attachment enthalpy of sulfur (-200. kJ/mol) is more favorable than the electron attachment enthalpy 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 attachment enthalpy 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

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

B

Group 2 exception

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

66. Which statement is **true** about an element with the generic valence electron configuration ns^2np^4?

A. This element is diamagnetic.
B. The element's ionic radius would be smaller than its atomic radius.
C. It has a more negative electron attachment enthalpy than an element with the generic electron configuration ns^2np^2 when 'n' is the same number.
D. It has a less positive first ionization energy than an element with the generic electron configuration ns^2 when 'n' is the same number.
E. None of the above are true

67. Which of the following statements about periodic trends is/are **true**?

**Option C should read "The less favorable electron attachment enthalpy for group 15 elements *compared to group 14 elements* is due to the decreased stability associated with a half-filled p subshell in the neutral atom". This is still a false answer.

A. The size of an atom increases across a period because of increased effective nuclear charge
B. Ionization energy decreases down a group because of increased effective nuclear charge
** C. The less favorable electron attachment enthalpy for group 15 elements is due to the decreased stability associated with a half-filled p subshell in the neutral atom
D. Period 2 elements have a more favorable electron attachment enthalpy compared to period 3 elements because of their smaller atomic orbitals
E. More than one of the above are true
F. None of the above are true

68. Which of the following elements has both an electron attachment enthalpy and an ionization energy that is involved in an exception to the general trends?

D

A. C
B. F
C. Si
D. S
E. None of the above

lower than expected ionization energy; more favorable electron attachment enthalpy (vs row 2)

69. For period 2 of the periodic table, which group contains the element with the highest Z_{eff}?

B

A. Group 1 because it has the lowest number of valence electrons
B. Group 17 because it has the highest number of protons with the same core electrons as the rest of period 2
C. Group 2 because it has the highest amount of s electrons, which experience penetration
D. Group 15 because it has a full s subshell and a half-full p subshell

70. 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

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

B

A. NaCl
B. MgO → largest magnitude of charge
C. KBr
D. $SrBr_2$

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

A

A. BeO
B. BaO
C. NaBr
D. BaS
E. CsI

greater magnitude of charge

BeO has smaller ionic radii

73. 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

74. Which of the following bonds below is the most *nonpolar*?

C

A. P—Cl
B. As—F
C. P—S
D. As—N
E. P—O

75. Consider the following bonds: Br—I, Te—Br, As—Cl, and P—S. Which of the following bonds is most polar based on periodic trends?

C

A. Br—I
B. Te—Br
C. As—Cl
D. P—As
E. Polarity cannot be determined in the absence of quantitative values assigned to each element

76. Which bond shows its partial charges labeled correctly?

B

Assign based on electronegativity
(δ+ less electronegative ; δ- more electronegative)

A. δ+ Cl—I δ-
B. δ+ S—Cl δ-
C. δ+ O—N δ-
D. δ+ C—B δ-
E. δ+ Se—Ge δ-

77. How many electron dots surround Sb^{3-} in its correct Lewis symbol? Answer by using an integer (e.g. 0, 1, etc.). ↳ 8 valence e⁻'s

8

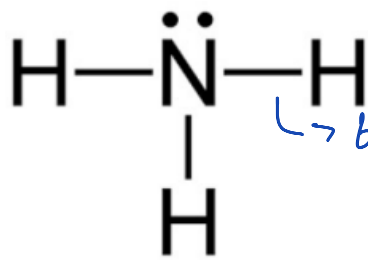
:Sb:

78. How many bonds is arsenic likely to make based on its Lewis symbol? Answer by using an integer (e.g. 0, 1, etc.). ↳ 5 valence e⁻'s

3

·As·

79. How many lone pairs are around the nitrogen in the Lewis structure below? How many bonding pairs? Answer by using an integer (e.g. 0, 1, etc.).

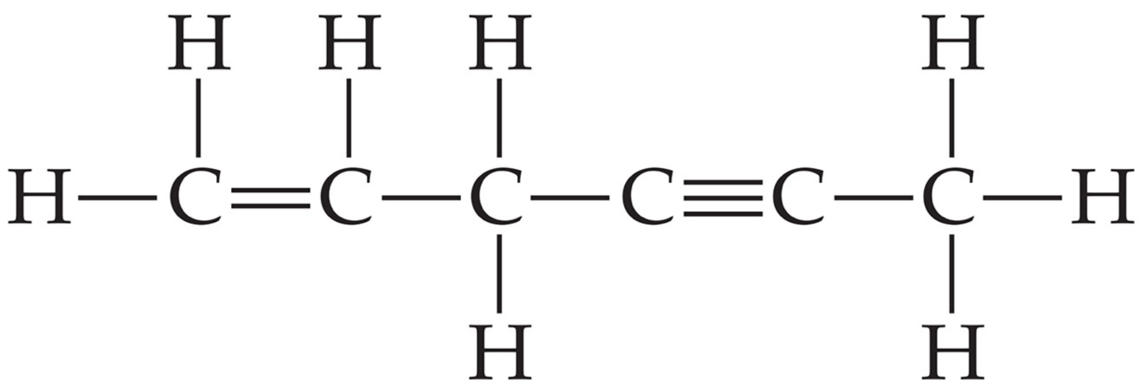


↳ bonding pair

I. Lone pairs: 1

II. Bonding pairs: 3

80. Consider the Lewis structure given below. How many bonding pairs are present? Single bonds? Double bonds? Non-bonding (lone) pairs?



I. Non-bonding (lone) pairs: 0

II. Bonding pairs: 16

III. Single bonds: 11

III. Double bonds: 1

IV. Triple bonds: 1

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Cs 132.91	56 Ba 137.33		72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]		104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [269]	109 Mt [277]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 $kg \cdot m^2/s^2$
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 $kg/m \cdot s^2$
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} J·sec
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: $9.109 \text{ x } 10^{-31}$ kg
Mass of a proton: $1.673 \text{ x } 10^{-27}$ kg
RH = $2.18 \text{ x } 10^{-18}$ J
Specific heat of water = 4.184 J/g·K
Avogadro's number: 6.022×10^{23}
F = 96485 J/(V·mol e^-)
$K_w = 1.0 \times 10^{-14}$ at 25 °C
$k_b = 1.381 \times 10^{-23}$ J/K

Equations
$(P + a(n^2/V^2)) \cdot (V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT

$$KE = \frac{3}{2}RT$$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$$\Delta E = -2.18 \times 10^{-18} J\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution} = P_{solvent}\,X_{solvent}$
$P_{solution} = \sum P_j = \sum P_j X_j$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$\Delta S = q_{rev}/T$
$\Delta G = \Delta G° + RT \cdot \ln Q$
R=8.314 J/mol.K
$\Delta G° = -RT \cdot \ln K$
$\Delta G = -nFE_{cell}$
$E°_{cell} = RT/nF \ln K$
$E°_{cell} = (0.0257/n) \ln K = (0.0592/n) \log K$
$E_{cell} = E°_{cell} - (RT/nF) \ln Q$
$E_{cell} = E°_{cell} - (0.0257/n) \ln Q$
Electrolysis: Q (total charge) = I × t = n × F

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H°_{rxn}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$